U.S. DEPARTMENT OF ENERGY
PITTSBURGH ENERGY TECHNOLOGY CENTER

DIRECT COAL LIQUEFACTION
BASELINE DESIGN
AND
SYSTEM ANALYSIS

CONTRACT NO. DEAC22 90PC89857

FINAL REPORT ON BASELINE AND IMPROVED BASELINE

VOLUME VI

Part II Appendices (C through N)

MARCH 1993
PITTSBURGH, PENNSYLVANIA

Bechtel

3000 Post Oak Boulevard
Houston, Texas 77056-6503
Mailing address: P.O. Box 2166
Houston, Texas 77252-2166

March 8, 1993

U. S. Department of Energy
Pittsburgh Energy Technology Center
Mail Stop 922-H
P. O. Box 10940
Pittsburgh, PA 15236

Attention: Mr. Swenam Lee
Project Manager

Subject: D.O.E. Coal Liquefaction
Base Line Design and System Analysis
Contract No. DE-AC22 90PC89857
Bechtel Job No. 20952
Final Report on Study
Letter No. BLD-139

Dear Mr. Lee:

Attached for your files are three copies of Part I and Part II appendices of the Volume VI, Final Report. As described in the Table of Contents of Volume VI, Final Report there are fourteen appendices, grouped together in two parts. Part I includes appendices A and B whereas part II contains appendices C through N.

Volume VI addresses the process simulation model for baseline and options. The appendices incorporate the updates reflecting the improved baseline case.

Copies to other members of DOE, as required by the contract are sent directly to each of them.

Sincerely yours,

Syamal K. Poddar
Project Manager

SKP:tr
Attachment

cc: Martin Byrnes, DOE/PETC
Robert Hamilton, DOE/PETC
A. Schachtschneider, AMOCO (2)
File
Gilbert V. McGurl, DOE/PETC
Joanne Wastek, DOE/PETC

TABLE OF CONTENTS

TABLE OF CONTENTS

APPENDICES - PART II

C. ASPEN/SP DIRECT COAL LIQUEFACTION PROCESS SIMULATION MODEL SUPPLEMENTAL FORTRAN LISTINGS C-1

D. MISCELLANEOUS FILE LISTINGS D-1
The ASP.BAT File D-3
The DCLRPT.BAT File D-4
The DCLSTART.REP File D-7

E. MANAGEMENT SUMMARY REPORT FOR THE BASELINE DESIGN E-1

F. ASPEN/SP PROCESS SIMULATION MODEL INPUT FILE FOR OPTION 1 -- LIQUEFACTION FEED COAL CLEANING BY HEAVY MEDIA SEPARATION F-1

G. ASPEN/SP PROCESS SIMULATION MODEL INPUT FILE FOR OPTION 2 -- LIQUEFACTION FEED COAL CLEANING BY SPHERICAL AGGLOMERATION G-1

H ASPEN/SP PROCESS SIMULATION MODEL INPUT FILE FOR OPTION 3 -- THERMAL-CATALYTIC LIQUEFACTION REACTOR CONFIGURATION H-1

I. ASPEN/SP PROCESS SIMULATION MODEL INPUT FILE FOR OPTION 4 -- CATALYTIC-CATALYTIC LIQUEFACTION REACTOR WITH VENT GAS SEPARATION I-1

J. ASPEN/SP PROCESS SIMULATION MODEL INPUT FILE FOR OPTION 5 -- FLUID COKING OF VACUUM BOTTOMS J-1

K. ASPEN/SP PROCESS SIMULATION MODEL INPUT FILE FOR OPTION 6 -- STEAM REFORMING OF NATURAL GAS FOR HYDROGEN PRODUCTION K-1

L. ASPEN/SP PROCESS SIMULATION MODEL INPUT FILE FOR OPTION 7 -- NAPHTHA REFORMING L-1

M. ASPEN/SP PROCESS SIMULATION MODEL INPUT FILE FOR THE KINETIC REACTOR MODEL M-1

N. ASPEN/SP FORTRAN USER BLOCK MODELS FOR THE KINETIC REACTOR MODEL N-1

APPENDIX C

APPENDIX C

ASPEN/SP DIRECT COAL LIQUEFACTION PROCESS SIMULATION MODEL SUPPLEMENTAL FORTRAN LISTINGS

ASPEN/SP DIRECT COAL LIQUEFACTION PROCESS

SIMULATION MODEL SUPPLEMENTAL FORTRAN LISTINGS

Editorial Note
In the following listing, whenever TOF occurs between single quote marks (') in a FORMAT statement, it represents the IBM PC top of form character (ASCII character 012).

```
C  File OTHERS.FOR
C
C     This file contains the following subroutines which are required
C     by most of the ASPEN/SP user Fortran models for the direct coal
C     liquefaction plant model developed under DOE contract no.
C     DE-AC22 90PC89857.
C       USRCCN   Subroutine for the locating the relative conventional
C                component number.
C       USRUCO   Subroutine for calculating, saving and reporting the
C                utilities, capital and operating costs for the plant.
C       USRUC1   Subroutine for calculating, saving and reporting the
C                utilities, capital and operating costs for the plant.
C       GETSTR   Subroutine for finding the stream bead information.
C       USR31T   Subroutine to summarize the plant utilities. -- This
C                routine totals all the utilites and prints a summary
C                table for all plants.
C       USRBD1   User BLOCK DATA routine to initialize the items in
C                named COMMON /USRCO1/ and /USRCO3/.
C       USRSR1  Subroutine to write the major plant streams.
C       USRSR2  Subroutine to write the total plant installed costs.
C       USRSR3  Subroutine to write the LOTUS spreadsheet economics
C               model input file, DCL1.PRN
C
C     Last revision - January 6, 1993.
C
C$ USRCCN
      SUBROUTINE USRCCN (CID, NSQ)
C
C     Adapted from ASPEN subroutine NSQCC - 11/25/90.
C     Last revision - May 18, 1991.
C
C     PURPOSE: To find the sequence number of a conventional component.
C
C     Calling sequence:
C
C              CALL USRCCN (CID, NSQ)
C
C     Variables used:
C       Variable  I/O  Type     Dimension     Description
C         CID      I    C          -          Component ID
C         NSQ      O    I          -          Sequence number
C
C     Subroutines called:
```

```
C        Name - LOCATI
C        Description - Locates an integer bead.
C
C     Specifications, declarations, data statements, etc.
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      CHARACTER*4 CID
      INTEGER*4 ID
C
      COMMON /NCOMP/ NCC    ,NNCC   ,NC     ,NAC    ,NACC   ,
     1                      NVCP   ,NVNCP  ,NVACC  ,NVANCC
C     End COMMON /NCOMP/ 10-13-78
C
      COMMON /PPCTBL/ NBCV, NBNC, NBAC, NBACC, NBCVAL,NBNCAL
C     End COMMON /PPCTBL/  9-15-79
C
      COMMON /PLEX/ IB(1)
      DIMENSION B(1)
      EQUIVALENCE (IB(1), B(1))
C     End COMMON /PLEX/ 10-13-78
C
      DIMENSION CID(2), ID(2)
C
C     Convert the character string to an integer.
      READ (CID(1),100) ID(1)
      READ (CID(2),100) ID(2)
  100 FORMAT(A4)
C
C     Locate integer address of conventional component symbol table.
      IF (NBCV .EQ. 0)  GO TO 220
      LBC = LOCATI (NBCV)
C
C     Go through conventional component symbol table for a match of ID.
      DO 210 INC = 1, NCC
         NSQ = INC
C        Check if IDs are identical.
         IF ((IB(LBC + 2 * (INC - 1)) .EQ. ID(1)) .AND.
     1       (IB(LBC + 2 * INC - 1) .EQ. ID(2)))   GO TO 999
  210 CONTINUE
C
C     No match of IDs or NBCV = 0  - set NSQ = 0 upon return.
  220 NSQ = 0
C
  999 RETURN
      END
C
C$ USRUCO
      SUBROUTINE USRUCO (NHSTRY, NOUT, IPASS, ID, PNAME, INT1, INT3,
     1  KTEST, CON, CAP, KUNITS )
C
C     This subroutine
C         1.  Calculates the Utilities, ISBL field costs and Operating
C             costs for the Fortran user block models,
C         2   Saves the key results in named COMMON /USRC01/.
C         3.  Writes the results to the Plant Summary Report, if
C             requested, on the results pass (i.e., when IPASS = 4).
```

```
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - May 26, 1992.
C
C     Calling arguments:
C     NHSTRY = Logical unit number of the history file.
C     NOUT   = Logical unit number of the plant output report file.
C     IPASS  = The results pass flag.
C     ID     = Plant internal identification number.
C     PNAME  = Plant name (CHARACTER * 6)
C     INT1   = User block output report control switch.
C              0 => Write the complete user block summary report.
C              1 => Skip the capital cost section of the report.
C              2 => Skip the capital cost and utilities sections of the
C                   report.
C              3 => Skip writing the entire user block summary report.
C     INT3   = Number of operating duplicate trains, excluding spares.
C              If INT3 = 0, the minimun number of duplicate trains will
C                be determined so that the capacity of each train does
C                not exceed the maximum train capacity specified by
C                variable CON(32).
C              If INT3 > 0, this number of duplicate trains will be
C                used.
C     KTEST  = Switch for controlling the printing to the history file.
C     CON()  = Vector of plant parameters for calculating the utilities,
C              capital costs and operating costs as a function of plant
C              capacity as defined by the CAP variable.
C       CON(1)   = Constant factor for the power consumption, kw.
C       CON(2)   = Power consumption per CAP unit, kw/(CAP units).
C       CON(3)   = Constant factor for the 900 psig / 750 F steam
C                  consumption, Mlbs/hr.
C       CON(4)   = 900 psig / 750 F steam consumption per CAP unit,
C                  (Mlbs/hr)/(CAP units).
C       CON(5)   = Constant factor for the 900 psig saturated steam
C                  consumption, Mlbs/hr.
C       CON(6)   = 900 psig saturated steam consumption per CAP unit,
C                  (Mlbs/hr)/(CAP units).
C       CON(7)   = Constant factor for the 600 psig / 720 F steam
C                  consumption, Mlbs/hr.
C       CON(8)   = 600 psig / 720 F steam consumption per CAP unit,
C                  (Mlbs/hr)/(CAP units).
C       CON(9)   = Constant factor for the 600 psig saturated steam
C                  consumption, Mlbs/hr.
C       CON(10)  = 600 psig saturated steam consumption per CAP unit,
C                  (Mlbs/hr)/(CAP units).
C       CON(11)  = Constant factor for the 150 psig saturated steam
C                  consumption, Mlbs/hr.
C       CON(12)  = 150 psig saturated steam consumption per CAP unit,
C                  (Mlbs/hr)/(CAP units).
C       CON(13)  = Constant factor for the 50 psig saturated steam
C                  consumption, Mlbs/hr.
C       CON(14)  = 50 psig saturated steam consumption per CAP unit,
C                  (Mlbs/hr)/(CAP units).
C       CON(15)  = Constant factor for the plant fuel consumption,
```

```
C                   MM BTU/hr.
C       CON(16)  = Plant fuel consumption per CAP unit,
C                  (MM BTU/hr)/(CAP units).
C       CON(17)  = Constant factor for the cooling water consumption,
C                  Mgal/hr.
C       CON(18)  = Cooling water consumption per CAP unit,
C                  (Mgal/hr)/(CAP units).
C       CON(19)  = Constant factor for the process water consumption,
C                  Mgal/hr.
C       CON(20)  = Process water consumption per CAP unit,
C                  (Mgal/hr)/(CAP units).
C       CON(21)  = Constant factor for the nitrogen consumption,
C                  MM SCF/hr of N2.
C       CON(22)  = Nitrogen consumption per CAP unit,
C                  (MM SCF/hr of N2)/(CAP units).
C       CON(23)-
C        CON(28) = Future use.
C       CON(29)  = Constant factor for the number of operators per
C                  day, operators/day.
C       CON(30)  = Number of operators per day per operating train,
C                  (operators/day)/train.
C       CON(31)  = Reference capacity of a single train as defined by
C                  the key flow rate in CAP units for the calculation
C                  of the ISBL field cost of a single train as a
C                  function of train capacity.
C       CON(32)  = Maximum size of a single train as defined by the key
C                  flow rate in CAP units.
C       CON(33)  = Minimum size of a single train as defined by the key
C                  flow rate in CAP units.
C       CON(34)  = Constant A in the plant ISBL field cost equation.
C       CON(35)  = Constant B in the plant ISBL field cost equation.
C       CON(36)  = Constant E in the plant ISBL field cost equation.
C       CON(37)  = Constant F in the plant ISBL field cost equation.
C       CON(38)  = Number of spare trains.
C       CON(39) -
C        CON(50) = Future use.
C     CAP    = Total capacity of all duplicate trains expressed as
C              the key flow rate in CAP units.
C     KUNITS = Code for the CAP units of the key flow rate in the
C              PUNITS vector.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON /USRC01/ PLNTID(32), UTIL(32,15), CAPCST(32,7), OPCST(32,5)
C
C     PLNTID(J)    = Plant identification information (CHARACTER * 6),
C                    where
C                    J is the internal plant identification number.
C                      1 => Plant 1, Coal cleaning and preparation plant.
C                      2 => Plant 2, Coal liquefaction plant.
C                      3 => Plant 3, Gas plant.
C                      4 => Plant 4, Naphtha hydrotreating plant.
C                      5 => Plant 5, 350-850 F distillate hdrotreating
C                           plant.
```

```
C                    6 => Plant 6.1, Hydrogen purification by membrane
C                         permeation plant.
C                    7 => Plant 6.2, Hydrogen purification by PSA
C                         (Pressure Swing Adsorption) plant.
C                    8 => Plant 8., ROSE-SR solids/liquids extraction
C                         plant.
C                    9 => Plant 7 - Naphtha reformer.
C                   10 => Plant 8.1-02, Fluid coking plant.
C                   11 => Plant 9.-01, Hydrogen production by coal
C                         gasification plant.
C                   12 => Plant 9.-03, Hydrogen production by steam
C                         reforming of natural gas plant.
C                   13 => Plant 10, Air separation plant.
C                   14 => Plant 11, Sulfur recovery plant.
C                   15 => Plant 38, Ammonia recovery plant.
C                   16 => Plant 39, Phenol recovery plant.
C                   17 => Plant 1.4, Coal grinding and drying plant.
C                   18 => Plant 31, Steam and power generation plant.
C                   19 => Commom users and OSBL users.
C                   20 => Plant 1G - Coal cleaning for gasification.
C                   21 => Plants 31.1 and 31.4 - Fulidized bed
C                         combustor and steam turbine generator.
C                   22 - 32 => Future use.
C     UTIL(J,K)    = Plant utilities consumptions, where
C                  J is the internal plant identification number,
C                    see PLANTID for the meaning of the J values.
C                  K designates the specific utility.
C                    1 => Power consumption, Kilowatts.
C                    2 => 900 psig / 750 F steam consumption,
C                         Mlbs/hr.
C                    3 => 900 psig saturated steam consumption,
C                         Mlbs/hr.
C                    4 => 600 psig / 720 F steam consumption,
C                         Mlbs/hr.
C                    5 => 600 psig saturated steam consumption,
C                         Mlbs/hr.
C                    6 => 150 psig saturated steam consumption,
C                         Mlbs/hr.
C                    7 => 50 psig saturated steam consumption,
C                         Mlbs/hr.
C                    8 => Fuel consumption, MM BTUs/hr.
C                    9 => Cooling water consumption, Mgal/hr.
C                   10 => Process water consumption, Mgal/hr.
C                   11 => Nitrogen consumption, MM SCF/hr of N2.
C                   12 => Future use.
C                   13 => Future use.
C                   14 => Future use.
C                   15 => Future use.
C     CAPCST(J,K) = Plant capital costs, where
C                  J is the internal plant identification number,
C                    see PLANTID for the meaning of the J values.
C                  K designates the following items.
C                    1 => Number of operating duplicate trains,
C                         excluding spares.
C                    2 => Capacity of each individual operating
```

```
C                                duplicate train in the appropriate units
C                                for the plant.
C                           3 => ISBL field cost of the first duplicate train
C                                in MM$.
C                           4 => Total ISBL field cost of all duplicate
C                                trains, including spares in MM$.
C                           5 => Number of spare trains.
C                           6 => Total installed capital cost of all duplicate
C                                trains, including spares in MM$.
C                           7 => Future use.
C     OPCST(J,K)  = Plant operating costs, where
C                   J is the internal plant identification number,
C                     see PLANTID for the meaning of the J values.
C                   K designates the following items.
C                     1 => Total number of operators/day.
C                     2 => Future use.
C                     3 => Future use.
C                     4 => Future use.
C                     5 => Future use.
C
C     Local variable declaration statements.
      DIMENSION CON(50), PUNITS(9)
C
      DIMENSION PPV(15)
C     PPV(J) is the Plant Property Vector, where
C           1 => Power consumption, Kilowatts.
C           2 => 900 psig / 750 F steam consumption, Mlbs/hr.
C           3 => 900 psig saturated steam consumption, Mlbs/hr.
C           4 => 600 psig / 720 F steam consumption, Mlbs/hr.
C           5 => 600 psig saturated steam consumption, Mlbs/hr.
C           6 => 150 psig saturated steam consumption, Mlbs/hr.
C           7 => 50 psig saturated steam consumption, Mlbs/hr.
C           8 => Fuel consumption, MM BTUs/hr.
C           9 => Cooling water consumption, Mgal/hr.
C          10 => Process water consumption, Mgal/hr.
C          11 => Nitrogen consumption, MM SCF/hr of N2.
C          12 => Future use.
C          13 => Future use.
C          14 => Future use.
C          15 => Future use.
C
      DIMENSION PCA(2,3)
C     PCA(J,K) is the Plant Cost Array, where
C       J = Property for each plant
C           1 => Plant or train capacity.
C           2 => Plant or train cost.
C       K = Total or duplicate train identifier
C           1 => Total of all duplicate trains.
C           2 => First train.
C           3 => All subsequent trains.
C
      CHARACTER * 6  PLNTID
      CHARACTER * 6  PNAME, BLANK6, MISSNG
      CHARACTER * 22 PUNITS
C
```

```
      DATA BLANK6 / '      ' /
      DATA MISSNG / '???   ' /
C
      DATA PUNITS / 'UNKNOWN UNITS          ',
     1   'MLBS/HR                ',
     2   'MLBS/HR DRY CLEAN COAL',
     3   'MM SCF/HR              ',
     4   'MM SCF/HR OF H2        ',
     5   'MM SCF/HR OF O2        ',
     6   'MLBS/HR OF NH3         ',
     7   'MLBS/HR OF PHENOL      ',
     8   'MLBS/HR MAIN FEED      ' /
C
C
C     Input variable error checking.
      IF ( ID .LE. 0 .OR. ID .GE. 33 )  THEN
        WRITE (NHSTRY, 801) ID
  801   FORMAT ( // ' SEVERE ERROR - Subroutine USRUCO has been ',
     1  'called with an invalid plant' /
     2  '  internal identification number (ID) of', I8 /
     3  '  EXECUTION IS BEING TERMINATED.' // )
        STOP
      ENDIF
C
      IF ( PNAME .EQ. BLANK6 )  THEN
        WRITE (NHSTRY, 802)  ID, MISSNG
  802   FORMAT ( // ' WARNING - Subroutine USRUCO has been called ',
     1    'with a missing plant name' /
     2    '  (PNAME) for the plant with the internal ',
     3    'identification number of', I4 /
     4    2X, A6, ' is being substituted for the plant name.' //)
          PNAME = MISSNG
       ENDIF
C
      IF ( CAP .LT. 0.0D0 )  THEN
        WRITE (NHSTRY, 803)  PNAME
  803   FORMAT ( // ' WARNING - Subroutine USRUCO has been called ',
     1    'with a negative key stream ' /
     2    '  flow rate (CAP) for plant ', A6 /
     3    '  The utilities consumptions, ISBL field costs and ',
     4    'operating cost' /
     5    '  calculations for this plant are being skipped.' //)
        GO TO 999
      ENDIF
C
      IF ( KUNITS.LE.0 .OR. KUNITS.GE.10 )  THEN
        WRITE (NHSTRY, 804)  PNAME, KUNITS
  804   FORMAT ( // ' WARNING - Subroutine USRUCO has been called ',
     1    'with an invalid value of the' /
     2    '  code (KUNITS) for the units of the key stream ',
     3    'flow rate for plant ', A6 /
     4    '  of', I4 /
     5    '  KUNITS is being set to 1, and execution is continuing.'//)
        KUNITS = 1
      ENDIF
```

```
C
C
C     Load the reference, maximum and minimum capacities of a single
C     train expressed as the key flow rate in CAP units into the
C     appropriate variables.
      PREFF = CON(31)
      PMAXF = CON(32)
      PMINF = CON(33)
C
C     If it has not been specified by the user in variable INT3,
C     calculate the number of operating duplicate trains, excluding
C     spares (NPLT), based on the maximum key flow rate.  However, if
C     the maximum key flow rate has not been specified, set the number
C     of operating duplicate trains to 1.
      NPLT = INT3
      IF ( (NPLT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
          NPLT = CAP / PMAXF
          IF ( (MOD(CAP, PMAXF)) .GT. 0.0D0 )  NPLT = NPLT + 1
        ELSE
          IF ( NPLT .EQ. 0 )   NPLT = 1
      ENDIF
C
C     Calculate the key flow rate in CAP units for each of the
C     individual duplicate trains.
      XPLANT = NPLT
      PFLOW = CAP / XPLANT
      PCA(1,1) = CAP
      PCA(1,2) = PFLOW
      PCA(1,3) = PFLOW
C
C     Plant Utilities Report Calculations
C     Calculate the total plant utilities consumptions as a function
C     of the key stream flow rate by the following equation.
C
C         Ui = Ai + Bi * TFLOW
C
C     Where;
C       Ui      = Consumption of utility i.
C                 Note; Positive values indicate consumption (import)
C                       and negative values indicate production
C                       (export).
C       TFLOW   = Total key flow rate for all duplicate plants in CAP
C                 units.
C       Ai, Bi  = Constants for the calculation of the consumption of
C                 utility i.
C     and
C       Subscript i designates the following utilities.
C         i = 1 => Power consumption in Kilowatts.
C             2 = 900 psig / 750 F steam in Mlbs/hr.
C             3 = 900 psig saturated steam in Mlbs/hr.
C             4 = 600 psig / 720 F steam in Mlbs/hr.
C             5 = 600 psig saturated steam in Mlbs/hr.
C             6 = 150 psig saturated steam in Mlbs/hr.
C             7 = 50 psig saturated steam in Mlbs/hr.
C             8 = Fuel in MM BTU/hr.
```

```
C             9 = Cooling water in Mgal/hr.
C            10 = Process water in Mgal/hr.
C            11 = Nitrogen in MM SCF/hr of N2.
C            12 = Future use.
C            13 = Future use.
C            14 = Future use.
C            15 = Future use.
C
C     Calculate all the utitities consumptions, and save them in the
C     Plant Property Vector, PPV(J).
      DO 20 J = 1, 15
        K = 2 * J
        PPV(J) = CON(K-1) + CON(K) * CAP
   20 CONTINUE
C
C     Plant ISBL Field Cost Report Calculations.
C     Set up the constants in the plant costing equation.
      A = CON(34)
      B = CON(35)
      E = CON(36)
      F = CON(37)
C
C     The total plant ISBL field cost is calculated by the following
C     equations as a function of the capacity of each duplicate
C     train (PFLOW) and the number of duplicate trains (N).
C
C         TCOST = FCOST + (N - 1) * SCOST
C         FCOST = A + B * (PFLOW/REFFLOW)**E
C         SCOST = F * FCOST
C
C     Where;
C       TCOST   = Total ISBL field cost of all duplicate trains; i.e.,
C                 total ISBL field cost of the plant.
C       FCOST   = ISBL field cost of the first train.
C       SCOST   = ISBL field cost of each subsequent duplicate train.
C       PFLOW   = Key flow rate of a single plant used to scale the
C                 the ISBL field cost of a single train as a function
C                 of train capacity.
C       REFFLOW = Key flow rate of a single plant that is being used
C                 to scale the ISBL field cost of a single train as a
C                 function of train capacity.
C       N       = Total number of duplicate trains.
C       A, B, E and F are constants in the above plant ISBL field cost
C                 equations.
C
C   Notes:
C     1.  Constant A is a fixed ISBL field cost associated with a
C         single train.
C     2.  Constant B is the variable ISBL field cost of a single train
C         of capacity REFFLOW.
C     3.  The sum of constants A and B is the ISBL field cost of a
C         single train of capacity REFFLOW.
C     4.  Constant E is the cost scaling exponent for calculating the
C         ISBL field cost of a single train as a function of plant
C         capacity.
```

```
C     5.  Constant F is a ISBL field cost reduction factor for
C         construction of duplicate trains.
C
C     Calculate the ISBL field cost of the first train.
      PCA(2,2) = A + B * (PFLOW/PREFF)**E
C     Calculate the ISBL field cost of all subsequent duplicate trains.
      PCA(2,3) = F * PCA(2,2)
C     Calculate the ISBL field cost of the total plant including any
C     spare trains.
      PCA(2,1) = PCA(2,2) + (XPLANT + CON(38) - 1.0) * PCA(2,3)
C
C
C     Calculate the total number of operators/day.  Do not include a
C     set of operators for any spare trains.
      XPLTS = XPLANT
      OPERS = CON(29) + XPLTS * CON(30)
C
C
C     If this is NOT the report pass, save the results in named
C     COMMON /USRC01/.
      IF ( IPASS .NE. 4 )  THEN
        PLNTID(ID) = PNAME
        DO 30 J = 1, 15
          UTIL(ID,J) = PPV(J)
   30   CONTINUE
        CAPCST(ID,1) = XPLANT
        CAPCST(ID,2) = PFLOW
        CAPCST(ID,3) = PCA(2,2)
        CAPCST(ID,4) = PCA(2,1)
        CAPCST(ID,5) = CON(38)
        OPCST(ID,1) = OPERS
        OPCST(ID,2) = 0.0D0
        OPCST(ID,3) = 0.0D0
        OPCST(ID,4) = 0.0D0
        OPCST(ID,5) = 0.0D0
      ENDIF
C
C
C     If this is the report pass, write the results to the plant
C     summary report.
      IF ( IPASS .EQ. 4 )  THEN
C
C       Don't write the utilities section of the summary report if the
C       ouput report control switch, INT1, is 2 or larger.
        IF ( INT1 .LE. 1 )   THEN
          WRITE (NOUT, 821) (PPV(J), J = 1, 11)
  821     FORMAT ( // 1X, 'PLANT UTILITIES CONSUMPTIONS' /
     1      2X, 'POWER, KW                    ', F18.0 /
     2      2X, '900 PSIG/750 F STEAM, MLBS/HR', F18.1 /
     3      2X, '900 PSIG SATD STEAM, MLBS/HR ', F18.1 /
     4      2X, '600 PSIG/720 F STEAM, MLBS/HR', F18.1 /
     5      2X, '600 PSIG SATD STEAM, MLBS/HR ', F18.1 /
     6      2X, '150 PSIG SATD STEAM, MLBS/HR ', F18.1 /
     7      2X, '50 PSIG SATD STEAM, MLBS/HR  ', F18.1 /
     8      2X, 'PLANT FUEL, MM BTUS/HR       ', F18.2 /
```

```
     9      2X, 'COOLING WATER, MGAL/HR        ', F18.2 /
     A      2X, 'PROCESS WATER, MGAL/HR        ', F18.2 /
     B      2X, 'NITROGEN, MM SCF/HR OF N2     ', F18.2 )
          WRITE (NOUT, 822)  OPCST(ID,1)
  822     FORMAT ( / 2X, 'TOTAL PLANT OPERATORS/DAY    ', F18.1 )
        ENDIF
C
C       Don't write the plant cost section of the summary report if the
C       ouput report control switch, INT1, is 1 or larger.
C       has a value of 1 or more.
        IF ( INT1 .LE. 0 )   THEN
          WRITE (NOUT, 831)
  831     FORMAT (// 28X, 'PLANT COSTING INFORMATION' )
C         Get the number of duplicate trains in an integer variable.
          NDUP = CON(38) + 0.001D0
          N = NPLT + NDUP
          IF ( INT3 .GE. 1 )  THEN
              WRITE (NOUT, 832)  N
  832         FORMAT (/ 1X, 'TOTAL NUMBER OF DUPLICATE TRAINS', I16,
     1          1X, '(SPECIFIED)' )
            ELSE
              WRITE (NOUT, 833)  N
  833         FORMAT (/ 1X, 'TOTAL NUMBER OF DUPLICATE TRAINS', I16 )
          ENDIF
          IF ( NDUP .GE. 1 )  THEN
            WRITE (NOUT, 834)  NDUP
  834       FORMAT (1X, 'INCLUDING', I2, ' SPARE TRAIN(S)' )
          ENDIF
          WRITE (NOUT, 835)  PUNITS(KUNITS), PMAXF, PUNITS(KUNITS),
     1      PMINF
  835     FORMAT (1X, 'MAXIMUM SIZE, ', A22, F12.3 /
     1      1X, 'MINIMUM SIZE, ', A22, F12.3 )
C         Set up the number of items to write on each line.
          NWRIT = 1
          IF ( N .GE. 2 )  THEN
            NWRIT = 3
            WRITE (NOUT, 836)
  836       FORMAT (/ 44X, 'TOTAL',  6X, 'FIRST', 3X, 'SUBSEQUENT' )
          ENDIF
          WRITE (NOUT, 837)  PUNITS(KUNITS), (PCA(1,J), J = 1, NWRIT)
  837     FORMAT (1X, 'CAPACITY, ', A22, 5X, 2F11.3, F13.3 )
          WRITE (NOUT, 838)  (PCA(2,J), J = 1, NWRIT)
  838     FORMAT (1X, 'PLANT ISBL FIELD COST, MM$', 11X, 2F11.3, F13.3)
C
C         If the calculated plant size is below the specified minimum
C         plant size, write a warning message.
          IF ( (PCA(1,1).LT.PMINF) .OR. (PCA(1,2).LT.PMINF) )
     1      WRITE (NOUT, 840)
  840     FORMAT (/ ' WARNING - THE ABOVE PLANT COSTS MAY BE IN',
     1      ' ERROR SINCE THE CALCULATED' /
     2      11X, 'TRAIN SIZE IS BELOW THE SPECIFIED MINIMUM TRAIN ',
     3      'SIZE.')
C
C         If the calculated plant size is above the specified maximum
C         plant size, write a warning message.
```

```
          IF ( ( (NPLT.EQ.1) .AND. (PCA(1,1).GT.PMAXF)) .OR.
     1       (PCA(1,2).GT.PMAXF) )   WRITE (NOUT, 841)
  841     FORMAT (/ ' WARNING - THE ABOVE PLANT COSTS MAY BE IN',
     1      ' ERROR SINCE THE CALCULATED' /
     2      11X, 'TRAIN SIZE IS ABOVE THE SPECIFIED MAXIMUM TRAIN ',
     3      'SIZE.')
        ENDIF
C
      ENDIF
C
  999 RETURN
      END
C
C$ USRUC1
      SUBROUTINE USRUC1 (NHSTRY, NOUT, IPASS, ID, PNAME, INT1, INT3,
     1  KTEST, CON, CAPC, CAPU, KUNITS )
C
C     This subroutine is similar to USRUCO except that the ISBL field
C     costs are based on one flow rate, and the utilities and operating
C     costs are based on a different one.
C
C     This subroutine
C         1.  Calculates the Utilities, ISBL field costs and Operating
C             costs for the Fortran user block models,
C         2   Saves the key results in named COMMON /USRCO1/.
C         3.  Writes the results to the Plant Summary Report, if
C             requested, on the results pass (i.e., when IPASS = 4).
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - October 24, 1992.
C
C     Calling arguments:
C     NHSTRY = Logical unit number of the history file.
C     NOUT   = Logical unit number of the plant output report file.
C     IPASS  = The results pass flag.
C     ID     = Plant internal identification number.
C     PNAME  = Plant name (CHARACTER * 6)
C     INT1   = User block output report control switch.
C              0 => Write the complete user block summary report.
C              1 => Skip the capital cost section of the report.
C              2 => Skip the capital cost and utilities sections of the
C                   report.
C              3 => Skip writing the entire user block summary report.
C     INT3   = Number of operating duplicate trains, excluding spares.
C              If INT3 = 0, the minimun number of duplicate trains will
C                be determined so that the capacity of each train does
C                not exceed the maximum train capacity specified by
C                variable CON(32).
C              If INT3 > 0, this number of duplicate trains will be
C                used.
C     KTEST  = Switch for controlling the printing to the history file.
C     CON()  = Vector of plant parameters for calculating the utilities,
C              capital costs and operating costs as a function of plant
C              capacity as defined by the CAP variable.
```

```
C       CON(1)   = Constant factor for the power consumption, kw.
C       CON(2)   = Power consumption per CAPU unit, kw/(CAPU units).
C       CON(3)   = Constant factor for the 900 psig / 750 F steam
C                  consumption, Mlbs/hr.
C       CON(4)   = 900 psig / 750 F steam consumption per CAPU unit,
C                  (Mlbs/hr)/(CAPU units).
C       CON(5)   = Constant factor for the 900 psig saturated steam
C                  consumption, Mlbs/hr.
C       CON(6)   = 900 psig saturated steam consumption per CAPU unit,
C                  (Mlbs/hr)/(CAPU units).
C       CON(7)   = Constant factor for the 600 psig / 720 F steam
C                  consumption, Mlbs/hr.
C       CON(8)   = 600 psig / 720 F steam consumption per CAPU unit,
C                  (Mlbs/hr)/(CAPU units).
C       CON(9)   = Constant factor for the 600 psig saturated steam
C                  consumption, Mlbs/hr.
C       CON(10)  = 600 psig saturated steam consumption per CAPU unit,
C                  (Mlbs/hr)/(CAPU units).
C       CON(11)  = Constant factor for the 150 psig saturated steam
C                  consumption, Mlbs/hr.
C       CON(12)  = 150 psig saturated steam consumption per CAPU unit,
C                  (Mlbs/hr)/(CAPU units).
C       CON(13)  = Constant factor for the 50 psig saturated steam
C                  consumption, Mlbs/hr.
C       CON(14)  = 50 psig saturated steam consumption per CAPU unit,
C                  (Mlbs/hr)/(CAPU units).
C       CON(15)  = Constant factor for the plant fuel consumption,
C                  MM BTU/hr.
C       CON(16)  = Plant fuel consumption per CAPU unit,
C                  (MM BTU/hr)/(CAPU units).
C       CON(17)  = Constant factor for the cooling water consumption,
C                  Mgal/hr.
C       CON(18)  = Cooling water consumption per CAPU unit,
C                  (Mgal/hr)/(CAPU units).
C       CON(19)  = Constant factor for the process water consumption,
C                  Mgal/hr.
C       CON(20)  = Process water consumption per CAPU unit,
C                  (Mgal/hr)/(CAPU units).
C       CON(21)  = Constant factor for the nitrogen consumption,
C                  MM SCF/hr of N2.
C       CON(22)  = Nitrogen consumption per CAPU unit,
C                  (MM SCF/hr of N2)/(CAPU units).
C       CON(23)-
C        CON(28) = Future use.
C       CON(29)  = Constant factor for the number of operators per
C                  day, operators/day.
C       CON(30)  = Number of operators per day per operating train,
C                  (operators/day)/train.
C       CON(31)  = Reference capacity of a single train as defined by
C                  the key flow rate in CAPC units for the calculation
C                  of the ISBL field cost of a single train as a
C                  function of train capacity.
C       CON(32)  = Maximum size of a single train as defined by the key
C                  flow rate in CAPC units.
C       CON(33)  = Minimum size of a single train as defined by the key
```

```
C                   flow rate in CAPC units.
C       CON(34)  = Constant A in the plant ISBL field cost equation.
C       CON(35)  = Constant B in the plant ISBL field cost equation.
C       CON(36)  = Constant E in the plant ISBL field cost equation.
C       CON(37)  = Constant F in the plant ISBL field cost equation.
C       CON(38)  = Number of spare trains.
C       CON(39) -
C        CON(50) = Future use.
C     CAPC   = Total capacity of all duplicate trains expressed as
C              the key flow rate in CAPC units for the capital cost
C              and number of plants clculations only.
C     CAPU   = Total capacity of all duplicate trains expressed as
C              the key flow rate in CAPU units for the utilities
C              calculations only.
C     KUNITS = Code for the CAPC OR CAPU units of the key flow rate in
C              the PUNITS vector.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON /USRC01/ PLNTID(32), UTIL(32,15), CAPCST(32,7), OPCST(32,5)
C
C     PLNTID(J)   = Plant identification information (CHARACTER * 6),
C                   where
C                   J is the internal plant identification number.
C                     1 => Plant 1, Coal cleaning and preparation plant.
C                     2 => Plant 2, Coal liquefaction plant.
C                     3 => Plant 3, Gas plant.
C                     4 => Plant 4, Naphtha hydrotreating plant.
C                     5 => Plant 5, 350-850 F distillate hdrotreating
C                          plant.
C                     6 => Plant 6.1, Hydrogen purification by membrane
C                          permeation plant.
C                     7 => Plant 6.2, Hydrogen purification by PSA
C                          (Pressure Swing Adsorption) plant.
C                     8 => Plant 8., ROSE-SR solids/liquids extraction
C                          plant.
C                     9 => Plant 7 - Naphtha reformer.
C                    10 => Plant 8.1-02, Fluid coking plant.
C                    11 => Plant 9.-01, Hydrogen production by coal
C                          gasification plant.
C                    12 => Plant 9.-03, Hydrogen production by steam
C                          reforming of natural gas plant.
C                    13 => Plant 10, Air separation plant.
C                    14 => Plant 11, Sulfur recovery plant.
C                    15 => Plant 38, Ammonia recovery plant.
C                    16 => Plant 39, Phenol recovery plant.
C                    17 => Plant 1.4, Coal grinding and drying plant.
C                    18 => Plant 31, Steam and power generation plant.
C                    19 => Commom users and OSBL users.
C                    20 => Plant 1G - Coal cleaning for gasification.
C                    21 => Plants 31.1 and 31.4 - Fulidized bed
C                          combustor and steam turbine generator.
C                    22 - 32 => Future use.
C     UTIL(J,K)   = Plant utilities consumptions, where
```

```
C                    J is the internal plant identification number,
C                      see PLANTID for the meaning of the J values.
C                    K designates the specific utility.
C                      1 => Power consumption, Kilowatts.
C                      2 => 900 psig / 750 F steam consumption,
C                           Mlbs/hr.
C                      3 => 900 psig saturated steam consumption,
C                           Mlbs/hr.
C                      4 => 600 psig / 720 F steam consumption,
C                           Mlbs/hr.
C                      5 => 600 psig saturated steam consumption,
C                           Mlbs/hr.
C                      6 => 150 psig saturated steam consumption,
C                           Mlbs/hr.
C                      7 => 50 psig saturated steam consumption,
C                           Mlbs/hr.
C                      8 => Fuel consumption, MM BTUs/hr.
C                      9 => Cooling water consumption, Mgal/hr.
C                     10 => Process water consumption, Mgal/hr.
C                     11 => Nitrogen consumption, MM SCF/hr of N2.
C                     12 => Future use.
C                     13 => Future use.
C                     14 => Future use.
C                     15 => Future use.
C     CAPCST(J,K) = Plant capital costs, where
C                    J is the internal plant identification number,
C                      see PLANTID for the meaning of the J values.
C                    K designates the following items.
C                      1 => Number of operating duplicate trains,
C                           excluding spares.
C                      2 => Capacity of each individual operating
C                           duplicate train in the appropriate units
C                           for the plant.
C                      3 => ISBL field cost of the first duplicate train
C                           in MM$.
C                      4 => Total ISBL field cost of all duplicate
C                           trains, including spares in MM$.
C                      5 => Number of spare trains.
C                      6 => Total installed capital cost of all duplicate
C                           trains, including spares in MM$.
C                      7 => Future use.
C     OPCST(J,K)  = Plant operating costs, where
C                    J is the internal plant identification number,
C                      see PLANTID for the meaning of the J values.
C                    K designates the following items.
C                      1 => Total number of operators/day.
C                      2 => Future use.
C                      3 => Future use.
C                      4 => Future use.
C                      5 => Future use.
C
C     Local variable declaration statements.
      DIMENSION CON(50), PUNITS(9)
C
      DIMENSION PPV(15)
```

```
C     PPV(J) is the Plant Property Vector, where
C           1 => Power consumption, Kilowatts.
C           2 => 900 psig / 750 F steam consumption, Mlbs/hr.
C           3 => 900 psig saturated steam consumption, Mlbs/hr.
C           4 => 600 psig / 720 F steam consumption, Mlbs/hr.
C           5 => 600 psig saturated steam consumption, Mlbs/hr.
C           6 => 150 psig saturated steam consumption, Mlbs/hr.
C           7 => 50 psig saturated steam consumption, Mlbs/hr.
C           8 => Fuel consumption, MM BTUs/hr.
C           9 => Cooling water consumption, Mgal/hr.
C          10 => Process water consumption, Mgal/hr.
C          11 => Nitrogen consumption, MM SCF/hr of N2.
C          12 => Future use.
C          13 => Future use.
C          14 => Future use.
C          15 => Future use.
C
      DIMENSION PCA(2,3)
C     PCA(J,K) is the Plant Cost Array, where
C       J = Property for each plant
C           1 => Plant or train capacity.
C           2 => Plant or train cost.
C       K = Total or duplicate train identifier
C           1 => Total of all duplicate trains.
C           2 => First train.
C           3 => All subsequent trains.
C
      CHARACTER * 6  PLNTID
      CHARACTER * 6  PNAME, BLANK6, MISSNG
      CHARACTER * 22 PUNITS
C
      DATA BLANK6 / '      ' /
      DATA MISSNG / '???   ' /
C
      DATA PUNITS / 'UNKNOWN UNITS         ',
     1   'MLBS/HR               ',
     2   'MLBS/HR DRY CLEAN COAL',
     3   'MM SCF/HR             ',
     4   'MM SCF/HR OF H2       ',
     5   'MM SCF/HR OF O2       ',
     6   'MLBS/HR OF NH3        ',
     7   'MLBS/HR OF PHENOL     ',
     8   'MLBS/HR MAIN FEED     ' /
C
C
C     Input variable error checking.
      IF ( ID .LE. 0 .OR. ID .GE. 33 )  THEN
        WRITE (NHSTRY, 801) ID
  801   FORMAT ( // ' SEVERE ERROR - Subroutine USRUC1 has been ',
     1  'called with an invalid plant' /
     2  '  internal identification number (ID) of', I8 /
     3  '  EXECUTION IS BEING TERMINATED.' // )
        STOP
      ENDIF
C
```

```
      IF ( PNAME .EQ. BLANK6 )  THEN
        WRITE (NHSTRY, 802)  ID, MISSNG
  802   FORMAT ( // ' WARNING - Subroutine USRUC1 has been called ',
     1    'with a missing plant name' /
     2    '  (PNAME) for the plant with the internal ',
     3    'identification number of', I4 /
     4    2X, A6, ' is being substituted for the plant name.' //)
          PNAME = MISSNG
       ENDIF
C
      IF ( CAPU .LT. 0.0D0 .OR. CAPC .LT. 0.0D0 )   THEN
        WRITE (NHSTRY, 803)  PNAME
  803   FORMAT ( // ' WARNING - Subroutine USRUC1 has been called ',
     1    'with a negative key stream ' /
     2    '  flow rate (either CAPC or CAPU) for plant ', A6 /
     3    '  The utilities consumptions, ISBL field costs and ',
     4    'operating cost' /
     5    '  calculations for this plant are being skipped.' //)
        GO TO 999
      ENDIF
C
      IF ( KUNITS.LE.0 .OR. KUNITS.GE.10 )  THEN
        WRITE (NHSTRY, 804)  PNAME, KUNITS
  804   FORMAT ( // ' WARNING - Subroutine USRUC1 has been called ',
     1    'with an invalid value of the' /
     2    '  code (KUNITS) for the units of the key stream ',
     3    'flow rate for plant ', A6 /
     4    '  of', I4 /
     5    '  KUNITS is being set to 1, and execution is continuing.'//)
        KUNITS = 1
      ENDIF
C
C
C     Load the reference, maximum and minimum capacities of a single
C     train expressed as the key flow rate in CAPC units into the
C     appropriate variables.
      PREFF = CON(31)
      PMAXF = CON(32)
      PMINF = CON(33)
C
C     If it has not been specified by the user in variable INT3,
C     calculate the number of operating duplicate trains, excluding
C     spares (NPLT), based on the maximum key flow rate.  However, if
C     the maximum key flow rate has not been specified, set the number
C     of operating duplicate trains to 1.
      NPLT = INT3
      IF ( (NPLT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
          NPLT = CAPC / PMAXF
          IF ( (MOD(CAPC, PMAXF)) .GT. 0.0D0 )  NPLT = NPLT + 1
        ELSE
          IF ( NPLT .EQ. 0 )   NPLT = 1
      ENDIF
C
C     Calculate the key flow rate in CAPC units for each of the
C     individual duplicate trains.
```

```
      XPLANT = NPLT
      PFLOW = CAPC / XPLANT
      PCA(1,1) = CAPC
      PCA(1,2) = PFLOW
      PCA(1,3) = PFLOW
C
C     Plant Utilities Report Calculations
C     Calculate the total plant utilities consumptions as a function
C     of the key stream flow rate by the following equation.
C
C         Ui = Ai + Bi * TFLOW
C
C     Where;
C       Ui     = Consumption of utility i.
C                Note; Positive values indicate consumption (import)
C                      and negative values indicate production
C                      (export).
C       TFLOW  = Total key flow rate for all duplicate plants in CAPU
C                units.
C       Ai, Bi = Constants for the calculation of the consumption of
C                utility i.
C     and
C       Subscript i designates the following utilities.
C         i = 1 => Power consumption in Kilowatts.
C             2 = 900 psig / 750 F steam in Mlbs/hr.
C             3 = 900 psig saturated steam in Mlbs/hr.
C             4 = 600 psig / 720 F steam in Mlbs/hr.
C             5 = 600 psig saturated steam in Mlbs/hr.
C             6 = 150 psig saturated steam in Mlbs/hr.
C             7 = 50 psig saturated steam in Mlbs/hr.
C             8 = Fuel in MM BTU/hr.
C             9 = Cooling water in Mgal/hr.
C            10 = Process water in Mgal/hr.
C            11 = Nitrogen in MM SCF/hr of N2.
C            12 = Future use.
C            13 = Future use.
C            14 = Future use.
C            15 = Future use.
C
C     Calculate all the utitities consumptions, and save them in the
C     Plant Property Vector, PPV(J).
      DO 20 J = 1, 15
        K = 2 * J
        PPV(J) = CON(K-1) + CON(K) * CAPU
   20 CONTINUE
C
C     Plant ISBL Field Cost Report Calculations.
C     Set up the constants in the plant costing equation.
      A = CON(34)
      B = CON(35)
      E = CON(36)
      F = CON(37)
C
C     The total plant ISBL field cost is calculated by the following
C     equations as a function of the capacity of each duplicate
```

```
C     train (PFLOW) and the number of duplicate trains (N).
C
C         TCOST = FCOST + (N - 1) * SCOST
C         FCOST = A + B * (PFLOW/REFFLOW)**E
C         SCOST = F * FCOST
C
C     Where;
C       TCOST   = Total ISBL field cost of all duplicate trains; i.e.,
C                 total ISBL field cost of the plant.
C       FCOST   = ISBL field cost of the first train.
C       SCOST   = ISBL field cost of each subsequent duplicate train.
C       PFLOW   = Key flow rate of a single plant used to scale the
C                 the ISBL field cost of a single train as a function
C                 of train capacity.
C       REFFLOW = Key flow rate of a single plant that is being used
C                 to scale the ISBL field cost of a single train as a
C                 function of train capacity.
C       N       = Total number of duplicate trains.
C       A, B, E and F are constants in the above plant ISBL field cost
C                 equations.
C
C   Notes:
C     1.  Constant A is a fixed ISBL field cost associated with a
C         single train.
C     2.  Constant B is the variable ISBL field cost of a single train
C         of capacity REFFLOW.
C     3.  The sum of constants A and B is the ISBL field cost of a
C         single train of capacity REFFLOW.
C     4.  Constant E is the cost scaling exponent for calculating the
C         ISBL field cost of a single train as a function of plant
C         capacity.
C     5.  Constant F is a ISBL field cost reduction factor for
C         construction of duplicate trains.
C
C     Calculate the ISBL field cost of the first train.
      PCA(2,2) = A + B * (PFLOW/PREFF)**E
C     Calculate the ISBL field cost of all subsequent duplicate trains.
      PCA(2,3) = F * PCA(2,2)
C     Calculate the ISBL field cost of the total plant including any
C     spare trains.
      PCA(2,1) = PCA(2,2) + (XPLANT + CON(38) - 1.0) * PCA(2,3)
C
C
C     Calculate the total number of operators/day.  Do not include a
C     set of operators for any spare trains.
      XPLTS = XPLANT
      OPERS = CON(29) + XPLTS * CON(30)
C
C
C     If this is NOT the report pass, save the results in named
C     COMMON /USRC01/.
      IF ( IPASS .NE. 4 )  THEN
        PLNTID(ID) = PNAME
        DO 30 J = 1, 15
          UTIL(ID,J) = PPV(J)
```

```
   30   CONTINUE
        CAPCST(ID,1) = XPLANT
        CAPCST(ID,2) = PFLOW
        CAPCST(ID,3) = PCA(2,2)
        CAPCST(ID,4) = PCA(2,1)
        CAPCST(ID,5) = CON(38)
        OPCST(ID,1) = OPERS
        OPCST(ID,2) = 0.0D0
        OPCST(ID,3) = 0.0D0
        OPCST(ID,4) = 0.0D0
        OPCST(ID,5) = 0.0D0
      ENDIF
C
C
C     If this is the report pass, write the results to the plant
C     summary report.
      IF ( IPASS .EQ. 4 )  THEN
C
C       Don't write the utilities section of the summary report if the
C       ouput report control switch, INT1, is 2 or larger.
        IF ( INT1 .LE. 1 )   THEN
          WRITE (NOUT, 821) (PPV(J), J = 1, 11)
  821     FORMAT ( // 1X, 'PLANT UTILITIES CONSUMPTIONS' /
     1      2X, 'POWER, KW                    ', F18.0 /
     2      2X, '900 PSIG/750 F STEAM, MLBS/HR', F18.1 /
     3      2X, '900 PSIG SATD STEAM, MLBS/HR ', F18.1 /
     4      2X, '600 PSIG/720 F STEAM, MLBS/HR', F18.1 /
     5      2X, '600 PSIG SATD STEAM, MLBS/HR ', F18.1 /
     6      2X, '150 PSIG SATD STEAM, MLBS/HR ', F18.1 /
     7      2X, '50 PSIG SATD STEAM, MLBS/HR  ', F18.1 /
     8      2X, 'PLANT FUEL, MM BTUS/HR       ', F18.2 /
     9      2X, 'COOLING WATER, MGAL/HR       ', F18.2 /
     A      2X, 'PROCESS WATER, MGAL/HR       ', F18.2 /
     B      2X, 'NITROGEN, MM SCF/HR OF N2    ', F18.2 )
          WRITE (NOUT, 822)  OPCST(ID,1)
  822     FORMAT ( / 2X, 'TOTAL PLANT OPERATORS/DAY    ', F18.1 )
        ENDIF
C
C       Don't write the plant cost section of the summary report if the
C       ouput report control switch, INT1, is 1 or larger.
C       has a value of 1 or more.
        IF ( INT1 .LE. 0 )   THEN
          WRITE (NOUT, 831)
  831     FORMAT (// 28X, 'PLANT COSTING INFORMATION' )
C         Get the number of duplicate trains in an integer variable.
          NDUP = CON(38) + 0.001D0
          N = NPLT + NDUP
          IF ( INT3 .GE. 1 )  THEN
              WRITE (NOUT, 832)  N
  832         FORMAT (/ 1X, 'TOTAL NUMBER OF DUPLICATE TRAINS', I16,
     1          1X, '(SPECIFIED)' )
            ELSE
              WRITE (NOUT, 833)  N
  833         FORMAT (/ 1X, 'TOTAL NUMBER OF DUPLICATE TRAINS', I16 )
          ENDIF
```

```
          IF ( NDUP .GE. 1 )  THEN
            WRITE (NOUT, 834)  NDUP
  834       FORMAT (1X, 'INCLUDING', I2, ' SPARE TRAIN(S)' )
          ENDIF
          WRITE (NOUT, 835)  PUNITS(KUNITS), PMAXF, PUNITS(KUNITS),
     1      PMINF
  835     FORMAT (1X, 'MAXIMUM SIZE, ', A22, F12.3 /
     1      1X, 'MINIMUM SIZE, ', A22, F12.3 )
C         Set up the number of items to write on each line.
          NWRIT = 1
          IF ( N .GE. 2 )  THEN
            NWRIT = 3
            WRITE (NOUT, 836)
  836       FORMAT (/ 44X, 'TOTAL',  6X, 'FIRST', 3X, 'SUBSEQUENT' )
          ENDIF
          WRITE (NOUT, 837)  PUNITS(KUNITS), (PCA(1,J), J = 1, NWRIT)
  837     FORMAT (1X, 'CAPACITY, ', A22, 5X, 2F11.3, F13.3 )
          WRITE (NOUT, 838)  (PCA(2,J), J = 1, NWRIT)
  838     FORMAT (1X, 'PLANT ISBL FIELD COST, MM$', 11X, 2F11.3, F13.3)
C
C         If the calculated plant size is below the specified minimum
C         plant size, write a warning message.
          IF ( (PCA(1,1).LT.PMINF) .OR. (PCA(1,2).LT.PMINF) )
     1      WRITE (NOUT, 840)
  840     FORMAT (/ ' WARNING - THE ABOVE PLANT COSTS MAY BE IN',
     1      ' ERROR SINCE THE CALCULATED' /
     2      11X, 'TRAIN SIZE IS BELOW THE SPECIFIED MINIMUM TRAIN ',
     3      'SIZE.')
C
C         If the calculated plant size is above the specified maximum
C         plant size, write a warning message.
          IF ( ( (NPLT.EQ.1) .AND. (PCA(1,1).GT.PMAXF)) .OR.
     1       (PCA(1,2).GT.PMAXF) )   WRITE (NOUT, 841)
  841     FORMAT (/ ' WARNING - THE ABOVE PLANT COSTS MAY BE IN',
     1      ' ERROR SINCE THE CALCULATED' /
     2      11X, 'TRAIN SIZE IS ABOVE THE SPECIFIED MAXIMUM TRAIN ',
     3      'SIZE.')
        ENDIF
C
      ENDIF
C
  999 RETURN
      END
C
C$ GETSTR
C$ #1 BY: KEW DATE: 12/02/86  FIRST ABSORB
C------------------------------------------------------------------
C
C *--------------------------------------------------------------*
C *                       ****  NOTICE  ****                     *
C *--------------------------------------------------------------*
C
C %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
C
C           THIS CODE IS PART OF THE VAX SYSTEM DEVELOPED AT
```

```
C    MORGANTOWN ENERGY TECHNOLOGY CENTER, MORGANTOWN, WEST VIRGINIA
C
C  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
C
C-----------------------------------------------------------------------
C
      SUBROUTINE GETSTR ( ID , NB, LB, NBD, LBD)
C
C     NAME OF MODULE:  GETSTR
C
C     MODULE TITLE:  GET STREAM BEAD INFO
C
C     PURPOSE:  THIS IS A ROUTINE TO GET A STREAM BEAD NUMBER GIVEN THE
C               ID OF THE STREAM.  SIMILAR TO MOST OTHER ELEMENTARY ID
C               LOCATOR ROUTINES.  ALSO RETURNS THE STREAM BEAD OFFSET
C               IN THE PLEX AND THE BEAD NUMBER AND OFFSET OF THE STREAM
C               CLASS DESCRIPTOR BEAD.  THE ROUTINE USES THE STANDARD
C               ASPEN FORM OF THE ID (IN INTEGER FORMAT).  AN ASSIGNMENT
C               STATEMENT WILL PUT THE STREAM NAME IN THE PROPER FORM AS
C               FOLLOWS:
C
C               ID(1) = 'STRE'
C               ID(2) = 'AM  '
C
C     TASK, SUBSYSTEM, SYSTEM:  UOS, SP
C
C     WRITTEN BY:  K. WILLIAMS          DATE WRITTEN: 12/02/86
C
C     READ BY:                          DATE READ:
C
C     APPROVED BY:                      DATE APPROVED:
C
C     CALLING SEQUENCE:
C
C             CALL GETSTR ( ID, NB, LB, NBD, LBD)
C
C     VARIABLES USED:
C
C      VARIABLES IN ARGUMENT LIST
C
C        VARIABLE I/O TYPE-SPEC DIMENSION     DESCRIPTION AND RANGE
C           ID     I   I           2          CHARACTER REP OF ID IN
C                                             LEFT JUSTIFIED FORM
C           NB     O   I           -          STREAM BEAD NUMBER
C                                             = -1 IF NOT FOUND
C           LB     O   I           -          STREAM BEAD OFFSET IN PLEX
C                                             = -1 IF NOT FOUND
C           NBD    O   I           -          STREAM CLASS DESCRIPTOR
C                                             BEAD OF LOCATED STREAM
C                                             = -1 IF NOT FOUND
C           LBD    O   I           -          STREAM CLASS DESCRIPTOR
C                                             BEAD OFFSET IN PLEX
C                                             = -1 IF NOT FOUND
C
C      IMPORTANT INTERNAL VARIABLES
```

```
C
C        VARIABLE I/O TYPE-SPEC DIMENSION     DESCRIPTION AND RANGE
C
C     SUBROUTINES CALLED:
C
C        NAME - LOCATI
C        DESCRIPTION - LOCATE AN INTEGER BEAD
C
C     FILES:
C
C        FILE NAME -            -  TITLE -
C        FORTRAN UNIT NUMBER -     -  I/O -
C        CREATED BY / USED BY -
C        SEQUENCED ON -
C        ACCESS MODE -
C        DESCRIPTION -
C
C        SPECIFICATIONS, DECLARATIONS, DATA STATEMENTS, ETC.
C
      DIMENSION ID(2)
      COMMON /PLEX/ IB(1)
C
      LPB = LOCATI(2)
      LSBH = LPB + 64
      CALL UNLOCK(2)
C
C         INITIALIZE FIRST BEAD NUMBER TO CHECK
C
      NB = IB(LSBH)
C
C         OUTSIDE OF CHECK LOOP
C
   10 CONTINUE
C
C         CHECK IF NO CHAIN OR IF AT END (NOT FOUND)
C
      IF (NB .EQ. 0) THEN
         NB = -1
         NBD = -1
         LB = -1
         LBD = -1
         RETURN
      ELSE
         LBI = LOCATI (NB)
      ENDIF
C
C         COMPARE THE ID'S
C
      IF ((ID(1) .EQ. IB(LBI + 5)) .AND.
     &    (ID(2) .EQ. IB(LBI + 6))      ) THEN
C
C         GOT A MATCH, SO GET THE INFO
C
         LB = LBI
         NBD = IB(LBI+8)
```

```
         LBD = LOCATI(NBD)
         CALL UNLOCK(NB)
         CALL UNLOCK(NBD)
         RETURN
      ELSE
C
C         NO MATCH, SO UPDATE NB AND TRY AGAIN
C
         NBN = IB(LBI)
         CALL UNLOCK (NB)
         NB = NBN
         GO TO 10
      END IF
C
      END
C
C$ USR31T
      SUBROUTINE USR31T (NHSTRY, NOUT, IPASS, INT1, INT2, KTEST)
C
C     This subroutine totals all the utilites for all the plants and
C     writes a summary table.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - May 27, 1992.
C
C     Calling arguments:
C     NHSTRY = Logical unit number of the history file.
C     NOUT   = Logical unit number of the plant output report file.
C     IPASS  = The results pass flag.
C     INT1   = User block output report control switch.
C              0 => Write the complete user block summary report.
C              1 => Skip the capital cost section of the report.
C              2 => Skip the capital cost and utilities sections of the
C                   report.
C              3 => Skip writing the entire user block summary report.
C     INT2   = User block summary report destination control switch.
C              0 => Write the complete user block summary report
C                   to the normal ASPEN/SP output report file.
C              1 => Write the complete user block summary report
C                   to a separte user block output report file on
C                   logical unit 62.
C     KTEST  = Switch for controlling the printing to the history file.
C
C     Important variables in COMMON /USRC01/.
C     PLNTID(J) = Plant identification information (CHARACTER * 6),
C                 where
C                 J is the internal plant identification number.
C                    1 => Plant 1, Coal cleaning and preparation plant.
C                    2 => Plant 2, Coal liquefaction plant.
C                    3 => Plant 3, Gas plant.
C                    4 => Plant 4, Naphtha hydrotreating plant.
C                    5 => Plant 5, 350-850 F distillate hdrotreating
C                         plant.
C                    6 => Plant 6.1, Hydrogen purification by membrane
```

```
C                          permeation plant.
C                     7 => Plant 6.2, Hydrogen purification by PSA
C                          (Pressure Swing Adsorption) plant.
C                     8 => Plant 8., ROSE-SR solids/liquids extraction
C                          plant.
C                     9 => Plant 7 - Naphtha reformer.
C                    10 => Plant 8.1-02, Fluid coking plant.
C                    11 => Plant 9.-01, Hydrogen production by coal
C                          gasification plant.
C                    12 => Plant 9.-03, Hydrogen production by steam
C                          reforming of natural gas plant.
C                    13 => Plant 10, Air separation plant.
C                    14 => Plant 11, Sulfur recovery plant.
C                    15 => Plant 38, Ammonia recovery plant.
C                    16 => Plant 39, Phenol recovery plant.
C                    17 => Plant 1.4, Coal grinding and drying plant.
C                    18 => Plant 31, Steam and power generation plant.
C                    19 => Commom users and OSBL users.
C                    20 => Plant 1G - Coal cleaning for gasification.
C                    21 => Plants 31.1 and 31.4 - Fulidized bed
C                          combustor and steam turbine generator.
C                    22 - 32 => Future use.
C     UTIL(J,K) = Plant utilities consumptions, where J is the internal
C                 plant identification number (see PLANTID for the
C                 meaning of the J values) and K designates the
C                 specific utility.
C                   1 => Power consumption, Kilowatts.
C                   2 => 900 psig / 750 F steam consumption, Mlbs/hr.
C                   3 => 900 psig saturated steam consumption, Mlbs/hr.
C                   4 => 600 psig / 720 F steam consumption, Mlbs/hr.
C                   5 => 600 psig saturated steam consumption, Mlbs/hr.
C                   6 => 150 psig saturated steam consumption, Mlbs/hr.
C                   7 => 50 psig saturated steam consumption, Mlbs/hr.
C                   8 => Fuel consumption, MM BTUs/hr.
C                   9 => Cooling water consumption, Mgal/hr.
C                  10 => Process water consumption, Mgal/hr.
C                  11 => Nitrogen consumption, MM SCF/hr.
C                  12 => Future use.
C                  13 => Future use.
C                  14 => Future use.
C                  15 => Future use.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON /USRC01/ PLNTID(32), UTIL(32,15), CAPCST(32,7), OPCST(32,5)
C
C     Local variable declarations.
      DIMENSION TOT(15)
C
      CHARACTER * 6  PLNTID, BLANK6
C
      DATA BLANK6 / '      ' /
C
C
```

```
C     Initialize the TOT vector to accumulate the utility totals.
      DO 50 J = 1, 15
        TOT(J) = 0.0
   50 CONTINUE

C     Count the number of plants present and total the utilities.
      NPLNTS = 0
      DO 60 J = 1, 32
        IF ( PLNTID(J) .NE. BLANK6 )  THEN
           NPLNTS = NPLNTS + 1
           DO 57 K = 1, 15
             TOT(K) = TOT(K) + UTIL(J,K)
   57      CONTINUE
        ENDIF
   60 CONTINUE
C
C
      IF ( IPASS .EQ. 4 ) THEN
C
C       Write the heading for the Utilities Summary Table.
        WRITE (NOUT, 801)
  801   FORMAT ( / 28X, 'UTILITIES  SUMMARY' / )
C
C       Write the first of the two utilities summary tables.
        WRITE (NOUT, 802)
  802   FORMAT ( 39X, 'COOLING', 6X,'PROCESS' /
     1    1X, 'PLANT', 7X, 'POWER', 9X, 'FUEL', 9X, 'WATER', 8X,
     2    'WATER', 6X, 'NITROGEN' /
     3    2X, 'NO.', 9X, 'KW', 8X, 'MMBTUS/HR', 6X, 'MGAL/HR', 6X,
     4    'MGAL/HR', 5X, 'MMSCF/HR'  )
C
        DO 100 J = 1, 32
          IF ( PLNTID(J) .NE. BLANK6 )  WRITE (NOUT, 803) PLNTID(J),
     1      UTIL(J,1), UTIL(J,8), UTIL(J,9), UTIL(J,10), UTIL(J,11)
  100   CONTINUE
  803   FORMAT ( 1X, A6, 1X, F10.0, F15.3, 2F13.2, F13.3 )
        WRITE (NOUT, 804) TOT(1), TOT(8), TOT(9), TOT(10), TOT(11)
  804   FORMAT ( 1X, 'TOTAL', 2X, F10.0, F15.3, 2F13.2, F13.3 )
C
C       Write the second utility summary table containg the steams.
        WRITE (NOUT, 805)
  805   FORMAT (/ 9X, 23('-'), ' STEAM, MLBS/HR ', 24('-') /
     1    1X, 'PLANT', 3X, '900 PSIG', 3X, '900 PSIG', 3X, '600 PSIG',
     2    3X, '600 PSIG', 3X, '150 PSIG', 4X, '50 PSIG' /
     3    2X, 'NO.', 6X, '750 F', 7X, 'SATD', 6X, '720 F', 7X, 'SATD',
     4    7X, 'SATD', 7X, 'SATD' )
C
        DO 105 J = 1 , 32
          IF ( PLNTID(J) .NE. BLANK6 )  WRITE (NOUT, 806) PLNTID(J),
     1      (UTIL(J,K), K = 2, 7)
  105   CONTINUE
  806   FORMAT ( 1X, A6, F10.1, 5F11.1 )
        WRITE (NOUT, 807)  (TOT(K), K = 2, 7)
  807   FORMAT ( 1X, 'TOTAL', F11.1, 5F11.1 )
      ENDIF
```

```
C
C     Write the note at the bottom of the page.
      WRITE (NOUT, 808)
  808 FORMAT ( / '  POSITIVE VALUES DESIGNATE NET CONSUMPTION, AND ',
     1  'NEGATIVE VALUES' /
     2  2X, 'DESIGNATE NET PRODUCTION.' /
     3  2X, '600 PSIG STEAM AT 720 F IS USED TO SATISFY THE 600 ',
     4  'PSIG SATURATED' /
     5  2X, 'STEAM DEMAND.' )
C
C     To avoid a MS Fortran error message, use the unused arguments.
      J = INT1 + INT2 + NHSTRY + KTEST
C
      RETURN
      END
C
C$ USRBD1
      BLOCKDATA USRBD1
C
C     This BLOCK DATA routine initializes named COMMON /USRC01/.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - May 27, 1992.
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON /USRC01/ PLNTID(32), UTIL(32,15), CAPCST(32,7), OPCST(32,5)
C
C     Named COMMON /USRC01/ contains the calculated plant results.
C
      COMMON /USRC02/ IDX(100), XPACK(100)
C
C     Named COMMON /USRC02/ contains the vectors IDX and XPACK which
C     are required for the calculation of the stream average molecular
C     weight using subroutine CPACK and function AVEMW.  They are placed
C     in a named common block only to save space.
C
      COMMON /USRC03/ FIN(5,4), FOUT(20,4), PGAS, PPWR
C
C     Named COMMON /USRC03/ contains the calculated inlet and outlet
C     stream flow rates.
C
      CHARACTER * 6  PLNTID
C
      DATA PLNTID / 32 * '      ' /
      DATA UTIL   / 480 * 0.0D0 /
      DATA CAPCST / 224 * 0.0D0 /
      DATA OPCST  / 160 * 0.0D0 /
C
      DATA FIN    / 20 * 0.0D0 /
      DATA FOUT   / 80 * 0.0D0 /
      DATA PGAS   / 0.0D0 /
      DATA PPWR   / 0.0D0 /
C
```

```
      END
C
C$ USRSR1
      SUBROUTINE USRSR1 (NOUT)
C
C     Subroutine to write the major input and output streams.
C
C     Last revision - October 19, 1992.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Calling arguments:
C     NOUT   = Logical unit number of the plant output report file.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON /USRC01/ PLNTID(32), UTIL(32,15), CAPCST(32,7), OPCST(32,5)
C
C     See subroutine USRUCO for the definition of the items in named
C     common block /USRC01/.
C
      COMMON /USRC03/ FIN(5,4), FOUT(20,4), PGAS, PPWR
C
C     FIN(J,K)  = Overall complex input, where
C                   J designates the stream
C                     1  => ROM coal.
C                     2  => Natural gas for hydrogen production.
C                     3  => Natural gas for power generation.
C                   4-5 => Future use.
C                   K designates the following items.
C                     1  => Mlbs/hr.
C                     2  => Tons/day.
C                     3  => MM SCF/hr.
C                     4  => Bbls/day.
C
C     FOUT(J,K) = Overall complex input, where
C                   J designates the stream
C                     1   => LPG (propane).
C                     2   => Butanes.
C                     3   => Naphtha.
C                     4   => Light distillate.
C                     5   => Heavy distillate.
C                     6   => Gas Oil.
C                     7   => Refuse.
C                     8   => Ash stream from the gasification unit or
C                            fluid bed combustor.
C                     9   => Future use.
C                    10   => Ammonia
C                    11   => Phenol
C                    12   => Sulfur
C                   13-20 => Future use.
C                   K designates the following items.
C                     1  => Mlbs/hr.
C                     2  => Tons/day.
```

```
C                    3  => MM SCF/hr.
C                    4  => Bbls/day.
C
C     PGAS is the purchased natural gas rate for power production in
C       MSCF/hr.
C     PPWR is the purchased electricity in Megawatts/hr.
C
      COMMON /USRC04/ MODE
C
C     COMMON /USRC04/ contains the Plant 2 MODE switch which indicates
C     the Plant 2 calculation option in use.  Generally MODE is the
C     option plus 10.  It is not loaded for all options.
C
      DIMENSION SUM(4)
C
      CHARACTER * 6  PLNTID
      CHARACTER * 6  BLNK6
C
      DATA BLNK6 / '      ' /
C
C
C     Get the natural gas rate for fuel in Mlbs/hr from MSCF/hr.
      FIN(3,1) = PGAS * 16.0426D0 / 379.495D0
C
C     Total power consumption in Megawatt-hrs.
      ELECT = 24.0D0 * PPWR
C
C     Convert stream flow rates from Mlbs/hr to tons/day.
      DO 10 J = 1, 5
        FIN(J,2) = FIN(J,1) * 24.0D0 / 2.0D0
   10 CONTINUE
      DO 20 J = 1,20
        FOUT(J,2) = FOUT(J,1) * 24.0D0 / 2.0D0
   20 CONTINUE
C
C     Convert the natural gas rates to MM SCF/hr.
      FIN(2,3) = FIN(2,1) * 0.001D0 * 379.495D0 / 16.0426D0
      FIN(3,3) = FIN(3,1) * 0.001D0 * 379.495D0 / 16.0426D0
C
C     Calculate the barrels/day of the liquid products assuming the
C     liquid densities given in the Task II Topical Report of Dec.
C     1991 (Volume I) and draft Volume III of Jan. 1992.
      FOUT(1,4) = FOUT(1,1) * 4407. / 32.422
      FOUT(2,4) = FOUT(2,1) * 3541. / 29.45
C     The naphtha stream.
      IF ( PLNTID(9) .EQ. BLNK6 )   THEN
C         Hydrotreated naphtha.
          FOUT(3,4) = FOUT(3,1) * 19195. / 224.288
        ELSE
C         Reformer product naphtha, the reformate.
          FOUT(3,4) = FOUT(3,1) * 17188. / 208.780
      ENDIF
      FOUT(4,4) = FOUT(4,1) * 7803. / 99.876
      FOUT(5,4) = FOUT(5,1) * 21635. / 300.288
      FOUT(6,4) = FOUT(6,1) * 13310. / 193.646
```

```
C
C     The High Space Velocity Option
      IF ( MODE .EQ. 18 )  THEN
C       Calculate the barrels/day of the liquid products using the
C       liquid densities developed for this case.
C       The naphtha stream.
        IF ( PLNTID(9) .EQ. BLNK6 )   THEN
C           Hydrotreated naphtha.
            FOUT(3,4) = FOUT(3,1) * 18519. / 203.280
          ELSE
C           Reformer product naphtha, the reformate.
            FOUT(3,4) = FOUT(3,1) * 17188. / 208.780
        ENDIF
        FOUT(4,4) = FOUT(4,1) * 7403. / 91.510
        FOUT(5,4) = FOUT(5,1) * 27590. / 360.259
        FOUT(6,4) = FOUT(6,1) * 21370. / 292.152
      ENDIF
C
C     Sum the outputs.
      DO 54 J = 1, 4
        SUM(J) = 0.0D0
   54 CONTINUE
      DO 60 K = 1, 20
        SUM(1) = SUM(1) + FOUT(K,1)
        SUM(2) = SUM(2) + FOUT(K,2)
        IF ( K .LE. 6 )   THEN
          SUM(4) = SUM(4) + FOUT(K,4)
        ENDIF
   60 CONTINUE
C
      WRITE (NOUT, 501)
  501 FORMAT ( 'TOF' /
     1  25X, 'MANAGEMENT SUMMARY REPORT' //
     1  1X, 'MAJOR INPUT AND OUTPUT STREAMS' //
     2  1X, 'INPUT', 13X, 'MLBS/HR', 6X, 'TONS/DAY' )
C
      GAS = FIN(2,3) + FIN(3,3)
      WRITE (NOUT, 502)  FIN(1,1), FIN(1,2), GAS
  502 FORMAT ( 2X, 'ROM COAL*', F15.3, F14.0 /
     1  2X, 'NATURAL GAS, MM SCF/HR', F28.3 )
C
      IF ( PPWR .GE. 0.0D0 )  WRITE (NOUT, 503)  ELECT
  503 FORMAT ( 2X, 'ELECTRIC POWER, MEGA-WH/SD', F24.3 )
C
      WRITE (NOUT, 511)
  511 FORMAT ( / 1X, 'OUTPUT', 12X, 'MLBS/HR', 6X, 'TONS/DAY', 7X,
     1  'BBL/DAY' )
C
      WRITE (NOUT, 512)  (FOUT(J,1), FOUT(J,2), FOUT(J,4), J = 1, 6)
  512 FORMAT ( 2X, 'PROPANE ', F16.3, F14.0, F13.0 /
     1  2X, 'BUTANES ', F16.3, F14.0, F13.0 /
     2  2X, 'NAPHTHA ', F16.3, F14.0, F13.0 /
     3  2X, 'LT DIST ', F16.3, F14.0, F13.0 /
     4  2X, 'HVY DIST', F16.3, F14.0, F13.0 /
     5  2X, 'GAS OIL ', F16.3, F14.0, F13.0 )
```

```
C
      WRITE (NOUT, 513)  (FOUT(J,1), FOUT(J,2), J = 7, 8),
     1  (FOUT(J,1), FOUT(J,2), J = 10, 12)
  513 FORMAT ( 2X, 'REFUSE* ', F16.3, F14.0 /
     1  2X, 'ASH*    ', F16.3, F14.0 /
     2  2X, 'AMMONIA ', F16.3, F14.0 /
     3  2X, 'PHENOL  ', F16.3, F14.0 /
     4  2X, 'SULFUR  ', F16.3, F14.0 )
C
      WRITE (NOUT, 514) SUM(1), SUM(2), SUM(4)
  514 FORMAT ( 2X, 'TOTAL   ', F16.3, F14.0, F13.0 )
C
      X = - ELECT
      IF ( PPWR .LT. 0.0D0 )  WRITE (NOUT, 516)  X
  516 FORMAT ( / 2X, 'ELECTRIC POWER, MEGA-WH/SD', F24.3 )
C
      WRITE (NOUT, 520)
  520 FORMAT ( / 2X, '* STREAM FLOW RATES ARE ON A DRY BASIS.' )
C
C
      RETURN
      END
C
C$ USRSR2
      SUBROUTINE USRSR2 (NOUT, LOSBL, LPLANT, OPTN6, XOF)
C
C     Subroutine to calculate the total installed costs for each
C     plant from the ISBL field costs and write these costs.
C
C     Last revision - January 6, 1993.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Calling arguments:
C     NOUT   = Logical unit number of the plant output report file.
C     LOSBL  = OSBL logic calculation switch
C              0 => Use baseline case OSBL costing logic.
C              1 => Use option case OSBL costing logic.
C     LPLANT = Designates whether this is the first or Nth plant.
C              Used in baseline case OSBL costing logic and in home
C              office and engineering costing logic.
C              0 => First plant.
C              1 => Nth plant.
C     OPTN6  = Option 6 switch.  Option 6 is the H2 production by
C              reforming of natural gas.
C              0.0 => Option 6 is not in use.
C              1.0 => Option 6 is in use - Use revised OSBL costs
C                     based on redesigned utilities plant (Plant 31).
C     XOF    = Ratio of extra and OSBL operators per dedicated plant
C              operator.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON /USRC01/ PLNTID(32), UTIL(32,15), CAPCST(32,7), OPCST(32,5)
```

```
C
C     See subroutine USRUCO for the definition of the items in named
C     common block /USRC01/.
C
      COMMON /USRC04/ MODE
C
C     COMMON /USRC04/ contains the Plant 2 MODE switch which indicates
C     the Plant 2 calculation option in use.  Generally MODE is the
C     option plus 10.  It is not loaded for all options.
C
      DIMENSION AOSBL(32)
C
      CHARACTER * 6  PLNTID
      CHARACTER * 6  BLNK6
C
      DATA BLNK6 / '      ' /
C
C
C     Calculate the total ISBL field costs of all simulated plants,
C     the allocated OSBL costs for each plant and the total OSBL costs.
      TISBL = 0.0D0
      TOSBL = 0.0D0
      DO 10 J = 1, 32
        IF ( PLNTID(J) .NE. BLNK6 )  THEN
            TISBL = TISBL + CAPCST(J,4)
            IF ( LOSBL .EQ. 0 )  THEN
C               Use OSBL baseline costing logic - First plant.
                IF ( LPLANT .LE. 0 )
     1            AOSBL(J) = CAPCST(J,4) * 870.4 / 2231.7
C               Use OSBL baseline costing logic - Nth plant.
                IF ( LPLANT .GE. 1 )
     1            AOSBL(J) = CAPCST(J,4) * 870.4 / 1975.2
              ELSE
C               Use OSBL option costing logic.
                AOSBL(J) = CAPCST(J,4) * 870.4 / 2334.615
            ENDIF
C           Special OSBL calculations for Option 6.
            IF ( OPTN6 .GE. 0.99D0 )
     1        AOSBL(J) = CAPCST(J,4) * 793.4 / 2334.615
C
C           Special OSBL calculations for High Space Velocity Option.
            IF ( MODE .EQ. 18 )  THEN
              AOSBL(J) = CAPCST(J,4) * 888.333/ 1990.2
              IF ( OPTN6 .GE. 0.99D0 )  THEN
C               Special OSBL calculations for Option 6.
C               Calculate the apportioned Option 6 OSBL cost from the
C               Baseline with Option 6 case, and apportion using the
C               calculate baseline OSBL for both cases.
                X1 = 1692.700 * 793.4 / 2334.615
                X2 = X1 * 888.333 / 870.4
                AOSBL(J) = CAPCST(J,4) * X2 / 1692.700
              ENDIF
            ENDIF
C
            TOSBL = TOSBL + AOSBL(J)
```

```
          ELSE
            AOSBL(J) = 0.0D0
        ENDIF
   10 CONTINUE
C
C     The total installed plant costs including OSBL allocation,
C     home office and engineering, and contingency.
      DO 20 J = 1, 32
        IF ( PLNTID(J) .NE. BLNK6 )  THEN
            HO = (CAPCST(J,4) + AOSBL(J)) * 339.0 / (2334.615 + 870.4)
            IF ( LPLANT .GE. 1 )  HO = 0.8 * HO
            CONT = (CAPCST(J,4) + AOSBL(J)) * 456.2 / (2334.615 + 870.4)
            CAPCST(J,6) = CAPCST(J,4) + AOSBL(J) + HO + CONT
          ELSE
            CAPCST(J,6) = 0.0D0
        ENDIF
   20 CONTINUE
C
C
C     Write out the ISBL field and total installed capital costs.
      WRITE (NOUT, 501)
  501 FORMAT ( /// 1X, 'ISBL FIELD AND TOTAL INSTALLED COSTS ',
     1  '(INCLUDING OSBL COSTS)' /
     2  15X, 'NUMBER OF PLANTS', 8X, 'PLANT COST, MM$,' /
     3  3X, 'PLANT ', 5X, 'OPERATING', 3X, 'SPARES', 8X, 'ISBL',
     4  6X, 'TOTAL' )
C
      SUM4 = 0.0D0
      SUM6 = 0.0D0
      DO 80 J = 1, 32
        IF ( PLNTID(J) .NE. BLNK6 )  THEN
          SUM4 = SUM4 + CAPCST(J,4)
          SUM6 = SUM6 + CAPCST(J,6)
          NOPER = CAPCST(J,1)
          NSPARE = CAPCST(J,5)
          WRITE (NOUT, 503) PLNTID(J), NOPER, NSPARE, CAPCST(J,4),
     1      CAPCST(J,6)
  503     FORMAT ( 3X, A6, I10, I10, 6X, F10.3, F10.3 )
        ENDIF
   80 CONTINUE
C
      WRITE (NOUT, 504) SUM4, SUM6
  504 FORMAT ( 3X, 'TOTAL', F37.3, F10.3 // )
C
C     Calculate and write the number of operators.
      DOPERS = 0.0D0
      DO 90 J = 1, 32
        IF ( PLNTID(J) .NE. BLNK6 )  THEN
C         Total number of dedicated operators/day.
          DOPERS = DOPERS + OPCST(J,1)
        ENDIF
   90 CONTINUE
C
C     Extra and OSBL operators.
      XOPERS = XOF * DOPERS
```

```
      NDOPERS = DOPERS + 0.5
      NXOPERS = XOPERS + 0.5
      NTOPERS = NDOPERS + NXOPERS
      WRITE (NOUT, 506)  NDOPERS, NXOPERS, NTOPERS
  506 FORMAT ( / 3X, 'DEDICATED PLANT OPERATORS', I8 /
     1  3X, 'EXTRA AND OSBL OPERATORS ', I8 /
     2  3X, 'TOTAL OPERATORS          ', I8 )
C
      RETURN
      END
C
C$ USRSR3
      SUBROUTINE USRSR3 (NOUT, OPTN6, XOF)
C
C     Subroutine to write the input file to the LOTUS spreadsheet
C     economics model.
C
C     Last revision - October 22, 1992.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Calling arguments:
C     NOUT   = Logical unit number of the plant output report file.
C     OPTN6  = Option 6 switch.  Option 6 is the H2 production by
C              reforming of natural gas.
C              0.0 => Option 6 is not in use.
C              1.0 => Option 6 is in use - Use revised OSBL costs
C                     based on redesigned utilities plant (Plant 31).
C     XOF    = Ratio of extra and OSBL operators per dedicated plant
C              operator.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON /USRC01/ PLNTID(32), UTIL(32,15), CAPCST(32,7), OPCST(32,5)
C
C     See subroutine USRUCO for the definition of the items in named
C     common block /USRC01/.
C
      COMMON /USRC03/ FIN(5,4), FOUT(20,4), PGAS, PPWR
C
C     See subroutine USRSR1 for the definition of the items in named
C     common block /USRC01/.
C
      COMMON /USRC04/ MODE
C
C     COMMON /USRC04/ contains the MODE switch which indicates the
C     calculation option in use.  Generally MODE is the option plus
C     10.  It is not loaded for all options.
C
C
      CHARACTER * 6  PLNTID
      CHARACTER * 6  BLNK6
C
      DATA BLNK6 / '      ' /
```

```
C
C
C     Calculate some totals from the individual plant items.
      TCAP = 0.0D0
      OPERS = 0.0D0
      DO 10 J = 1, 32
        IF ( PLNTID(J) .NE. BLNK6 )  THEN
C         Total installed capital cost.
          TCAP = TCAP + CAPCST(J,6)
C         Total number of dedicated operators/day.
          DOPERS = DOPERS + OPCST(J,1)
        ENDIF
   10 CONTINUE
C
C     Extra and OSBL operators.
      XOPERS = XOF * DOPERS
      NDOPERS = DOPERS + 0.5
      NXOPERS = XOPERS + 0.5
      NTOPERS = NDOPERS + NXOPERS
C
C     Total power consumption in Megawatt-hrs.
      ELECT = 24.0D0 * PPWR
C     Total natural gas purchase rate in MM SCF/hr.
      GAS = FIN(2,3) + FIN(3,3)
C
C     Estimate the raw water make-up rate in g/m as a linear function
C     of the ROM coal consumption in TPSD..
      GPM = FIN(1,2) * 12042.0D0 / 29036.0D0
      IF ( OPTN6 .GE. 0.99D0 )  GPM = FIN(1,2) * 16608.0D0 / 21377.0D0
      IF ( MODE .EQ. 13 )  GPM = FIN(1,2) * 11891.0D0 / 26757.0D0
      IF ( MODE .EQ. 15 )  GPM = FIN(1,2) * 10171.0D0 / 23421.0D0
      IF ( MODE .EQ. 18 )  GPM = FIN(1,2) * 11710.0D0 / 32552.0D0
      IF ( MODE .EQ. 18 .AND. OPTN6 .GE. 0.99D0 )
     1  GPM = FIN(1,2) * 13745.0D0 / 23299.0D0
C
      X = 0.001D0 * FIN(1,2)
      WRITE (NOUT, 501) X
  501 FORMAT ( ' ROM COAL FEED RATE, MTSD            ', F10.3 )
C
      X = 0.001D0 * FOUT(7,2)
      WRITE (NOUT, 502) X
  502 FORMAT ( ' COAL CLEANING REFUSE RATE, MTSD     ', F10.3 )
C
      X = 0.001D0 * FOUT(8,2)
      WRITE (NOUT, 503) X
  503 FORMAT ( ' ASH PRODUCTION RATE, MTSD           ', F10.3 )
C
      X = 24.0D0 * GAS
      WRITE (NOUT, 504) X
  504 FORMAT ( ' NATURAL GAS RATE, MMMBTU/SD         ', F10.3 )
C
      WRITE (NOUT, 505) ELECT
  505 FORMAT ( ' ELECTRICITY PURCHASE, MEGA-WH/SD    ', F10.3 )
C
      X = 24.0D0 * 60.0D0 * GPM / 1.0D6
```

```
      WRITE (NOUT, 506) X
  506 FORMAT ( ' RAW WATER MAKE-UP, MMGSD            ', F10.3 )
C
      X = 0.001D0 * FOUT(3,4)
      WRITE (NOUT, 507) X
  507 FORMAT ( ' NAPHTHA PRODUCTION, MBSD            ', F10.3 )
C
      X = 0.001D0 * FOUT(4,4)
      WRITE (NOUT, 508) X
  508 FORMAT ( ' LT.DIST.PRODUCTION, MBSD            ', F10.3 )
C
      X = 0.001D0 * FOUT(5,4)
      WRITE (NOUT, 509) X
  509 FORMAT ( ' HVY.DIST. PRODUCTION, MBSD          ', F10.3 )
C
      X = 0.001D0 * FOUT(6,4)
      WRITE (NOUT, 510) X
  510 FORMAT ( ' GAS OIL PRODUCTION, MBSD            ', F10.3 )
C
      X = 0.001D0 * FOUT(1,4)
      WRITE (NOUT, 511) X
  511 FORMAT ( ' LIQUID PROPANE PRODUCTION, MBSD     ', F10.3 )
C
      X = 0.001D0 * FOUT(2,4)
      WRITE (NOUT, 512) X
  512 FORMAT ( ' MIXED BUTANES PRODUCTION, MBSD      ', F10.3 )
C
      X = 0.001D0 * FOUT(10,2)
      WRITE (NOUT, 513) X
  513 FORMAT ( ' AMMONIA PRODUCTION, MTSD            ', F10.3 )
C
      X = 0.001D0 * FOUT(11,2)
      WRITE (NOUT, 514) X
  514 FORMAT ( ' PHENOL PRODUCTION, MTSD             ', F10.3 )
C
      X = 0.001D0 * FOUT(12,2)
      WRITE (NOUT, 515) X
  515 FORMAT ( ' SULFUR PRODUCTION, MTSD             ', F10.3 )
C
      WRITE (NOUT, 521) NTOPERS
  521 FORMAT ( ' NUMBER OF OPERATORS/BOARDMEN        ', I10 )
C
      WRITE (NOUT, 522) TCAP
  522 FORMAT ( ' TOT.INSTALLED CAPITAL, $MM (E-YR)   ', F10.3 )
C
      RETURN
      END
```

APPENDIX D

APPENDIX D

MISCELLANEOUS FILE LISTINGS

MISCELLANEOUS FILE LISTINGS

This appendix provides listings of three files that are required to execute the complete ASPEN/SP simulation of the baseline design.

1. **ASP.BAT** - This batch file executes the ASPEN/SP process simulation program and automatically includes the OTHERS.OBJ file when linking the executable module for the simulation. This file should be placed in the ASPENSP/BAT subdirectory.

2. **DCLRPT.BAT** - This batch file combines all the individual plant summary report files written by the ASPEN/SP process simulation program into the summary report file called ALL.REP. This file should be placed in the ASPENSP/BAT subdirectory also.

3. **DCLSTART.REP** - This file contains the title page of the summary report file, ALL>REP, that is prepared by the DCLRPT.BAT file. This file must be placed in the ASPENSP/BAT subdirectory.

The ASP.BAT file

```
@ECHO OFF
REM  Batch file to run ASPEN/SP and include the OTHERS.OBJ file in the
REM  Fortran linking step.
REM    %1 = Fortran user block file name.
REM
IF %1a == a GOTO NOARGS
IF EXIST %1.OBJ GOTO ASPEN
ECHO
ECHO
ECHO ASP cannot find the %1.OBJ file you specified.
ECHO Please check your input and try again.
ECHO
ECHO
GOTO END
:ASPEN
ASPEN %1 OTHERS
GOTO END
:NOARGS
ECHO
ECHO
ECHO ASP requires the file name of the Fortran user block model as an
argument.
ECHO The correct format is as follows:  ASP fn
ECHO
ECHO
:END
```

The DCLRPT.BAT file

```
@ECHO OFF
REM   Batch file to combine all the individual plant summary reports
REM   into a single file called ALL.REP, and optionally print this file
REM   when the single calling argument is not blank.
REM
REM   Use:  Call this batch file by
REM               DCLRPT [ ARG
REM         When ARG is NOT blank, all the individual plant summary
REM         reports will be printed.
REM
REM   Prepared under DOE contract no. DE-AC22 90PC89857.
REM
REM   Last revision - June 29, 1992.
REM
REM  If an old ALL.REP file is present, delete it.
IF EXIST ALL.REP  ERASE ALL.REP
REM
REM  Heading page.
COPY ALL.REP+\ASPENSP\BAT\DCLSTART.REP ALL.REP > NUL
REM
REM  The Summary Report Page.
IF EXIST DCLSUM.REP  COPY ALL.REP+DCLSUM.REP ALL.REP > NUL
IF EXIST DCLSUM.REP  ERASE DCLSUM.REP > NUL
REM
REM  Plant 1 - Coal Cleaning and Preparation Plant - Baseline Case -
REM   Coal Cleaning by Jigs for liquefaction.
IF EXIST DCL01B.REP  COPY ALL.REP+DCL01B.REP ALL.REP > NUL
IF EXIST DCL01B.REP  ERASE DCL01B.REP > NUL
REM
REM  Plant 1 - Coal Cleaning and Preparation Plant - Alternate Case 1 -
REM    Coal Cleaning by Heavy Media Separation for liquefaction.
IF EXIST DCL01A1.REP  COPY ALL.REP+DCL01A1.REP ALL.REP > NUL
IF EXIST DCL01A1.REP  ERASE DCL01A1.REP > NUL
REM
REM  Plant 1 - Coal Cleaning and Preparation Plant - Alternate Case 2 -
REM    Coal Cleaning by Heavy Media Separation and Spherical Agglomeration
REM    for liquefaction.
IF EXIST DCL01A2.REP  COPY ALL.REP+DCL01A2.REP ALL.REP > NUL
IF EXIST DCL01A2.REP  ERASE DCL01A2.REP > NUL
REM
REM  Plant 1 - Coal Cleaning and Preparation Plant - Baseline Case -
REM   Coal Cleaning by Jigs for gasification.
IF EXIST DCL01G.REP  COPY ALL.REP+DCL01G.REP ALL.REP > NUL
IF EXIST DCL01G.REP  ERASE DCL01G.REP > NUL
REM
REM  Plant 1.4 - Coal Grinding and Drying Plant
IF EXIST DCL01D.REP  COPY ALL.REP+DCL01D.REP ALL.REP > NUL
IF EXIST DCL01D.REP  ERASE DCL01D.REP > NUL
REM
REM  Plant 2 - Coal Liquefaction Plant.
IF EXIST DCL02.REP  COPY ALL.REP+DCL02.REP ALL.REP > NUL
IF EXIST DCL02.REP  ERASE DCL02.REP > NUL
```

```
REM
REM  Plant 3 - Gas Plant.
IF EXIST DCL03.REP  COPY ALL.REP+DCL03.REP ALL.REP > NUL
IF EXIST DCL03.REP  ERASE DCL03.REP > NUL
REM
REM  Plant 4 - Naphtha Hydrotreater.
IF EXIST DCL04.REP  COPY ALL.REP+DCL04.REP ALL.REP > NUL
IF EXIST DCL04.REP  ERASE DCL04.REP > NUL
REM
REM  Plant 5 - Gas-oil Hydrotreater.
IF EXIST DCL05.REP  COPY ALL.REP+DCL05.REP ALL.REP > NUL
IF EXIST DCL05.REP  ERASE DCL05.REP > NUL
REM
REM  Plant 6.1 - Hydrogen Purification by Membrane Permeation Plant.
IF EXIST DCL61.REP  COPY ALL.REP+DCL61.REP ALL.REP > NUL
IF EXIST DCL61.REP  ERASE DCL61.REP > NUL
REM
REM  Plant 6.2 - Hydrogen Purification by Pressure Swing Absorption.
IF EXIST DCL62.REP  COPY ALL.REP+DCL62.REP ALL.REP > NUL
IF EXIST DCL62.REP  ERASE DCL62.REP > NUL
REM
REM  Plant 7 - Naphtha Reformer Plant.
IF EXIST DCL07.REP  COPY ALL.REP+DCL07.REP ALL.REP > NUL
IF EXIST DCL07.REP  ERASE DCL07.REP > NUL
REM
REM  Plant 8.1 - ROSE-SR Unit.
IF EXIST DCL81.REP  COPY ALL.REP+DCL81.REP ALL.REP > NUL
IF EXIST DCL81.REP  ERASE DCL81.REP > NUL
REM
REM  Plant 8.2 - Fluid Coking Plant.
IF EXIST DCL82.REP  COPY ALL.REP+DCL82.REP ALL.REP > NUL
IF EXIST DCL82.REP  ERASE DCL82.REP > NUL
REM
REM  Plant 9 - Hydrogen Production by Coal Gasification Plant.
IF EXIST DCL09.REP  COPY ALL.REP+DCL09.REP ALL.REP > NUL
IF EXIST DCL09.REP  ERASE DCL09.REP > NUL
REM
REM  Plant 9.1 - Hydrogen Production by Natural Gas Reforming Plant.
IF EXIST DCL91.REP  COPY ALL.REP+DCL91.REP ALL.REP > NUL
IF EXIST DCL91.REP  ERASE DCL91.REP > NUL
REM
REM  Plant 10 - Air Separation Plant.
IF EXIST DCL10.REP  COPY ALL.REP+DCL10.REP ALL.REP > NUL
IF EXIST DCL10.REP  ERASE DCL10.REP > NUL
REM
REM  Plant 11 - Sulfur Plant.
IF EXIST DCL11.REP  COPY ALL.REP+DCL11.REP ALL.REP > NUL
IF EXIST DCL11.REP  ERASE DCL11.REP > NUL
REM
REM  Plant 31 - Utilities Plant.
IF EXIST DCL31.REP  COPY ALL.REP+DCL31.REP ALL.REP > NUL
IF EXIST DCL31.REP  ERASE DCL31.REP > NUL
REM
REM  Plant 38 - Ammonia Recovery Plant.
IF EXIST DCL38.REP  COPY ALL.REP+DCL38.REP ALL.REP > NUL
```

```
IF EXIST DCL38.REP  ERASE DCL38.REP > NUL
REM
REM  Plant 39 - Phenol Plant.
IF EXIST DCL39.REP  COPY ALL.REP+DCL39.REP ALL.REP > NUL
IF EXIST DCL39.REP  ERASE DCL39.REP > NUL
REM
REM  Plant 31.1 & 31.4 - Fluidized Bed Combustor and Steam Turbine Gen.
IF EXIST DCLA6.REP  COPY ALL.REP+DCLA6.REP ALL.REP > NUL
IF EXIST DCLA6.REP  ERASE DCLA6.REP > NUL
REM
REM  If there is an argument on the command line, print ALL.REP, else quit
IF %1. == . GOTO END
PRINT ALL.REP
:END
ECHO
```

The DCLSTART.REP file

U. S. DEPARTMENT OF ENERGY

PITTSBURGH ENERGY TECHNOLOGY CENTER

DIRECT COAL LIQUEFACTION BASELINE

DESIGN AND SYSTEMS ANALYSIS

CONTRACT NO. DEAC22 90PC89857

PLANT SUMMARY REPORTS

APPENDIX E

APPENDIX E

MANAGEMENT SUMMARY REPORT

FOR THE BASELINE DESIGN

U. S. DEPARTMENT OF ENERGY

PITTSBURGH ENERGY TECHNOLOGY CENTER

DIRECT COAL LIQUEFACTION BASELINE DESIGN AND SYSTEMS ANALYSIS

CONTRACT NO. DEAC22 90PC89857

PLANT SUMMARY REPORTS

MANAGEMENT SUMMARY REPORT

MAJOR INPUT AND OUTPUT STREAMS

INPUT	MLBS/HR	TONS/DAY	
ROM COAL*	2419.603	29035.	
NATURAL GAS, MM SCF/HR			3.511
ELECTRIC POWER, MEGA-WH/SD			.000

OUTPUT	MLBS/HR	TONS/DAY	BBL/DAY
PROPANE	32.453	389.	4411.
BUTANES	29.474	354.	3544.
NAPHTHA	224.437	2693.	19208.
LT DIST	99.947	1199.	7809.
HVY DIST	300.474	3606.	21648.
GAS OIL	193.779	2325.	13319.
REFUSE*	483.921	5807.	
ASH*	234.335	2812.	
AMMONIA	20.342	244.	
PHENOL	2.686	32.	
SULFUR	61.762	741.	
TOTAL	1683.609	20203.	69939.

* STREAM FLOW RATES ARE ON A DRY BASIS.

ISBL FIELD AND TOTAL INSTALLED COSTS (INCLUDING OSBL COSTS)

	NUMBER OF PLANTS		PLANT COST, MM$,	
PLANT	OPERATING	SPARES	ISBL	TOTAL
1. -00	5	0	90.997	160.849
2	5	0	932.196	1647.780
3	1	0	25.295	44.712
4	1	0	15.605	27.583
5	1	0	74.039	130.873
6.1	1	0	152.625	269.784
6.2	1	0	.000	.000
8.1	1	0	42.213	74.618
9	5	0	263.613	465.971
10	5	0	191.012	337.638
11	4	0	46.723	82.590
38	1	0	40.146	70.964
39	1	0	13.334	23.569
1.4	10	0	87.499	154.667
31	0	0	.000	.000
OTHERS	0	0	.000	.000
TOTAL			1975.297	3491.598

DEDICATED PLANT OPERATORS	309
EXTRA AND OSBL OPERATORS	106
TOTAL OPERATORS	415

PLANT 1 - SUMMARY REPORT
COAL CLEANING AND PREPARATION PLANT
COAL CLEANING BY JIGS FOR LIQUEFACTION

	FEED COAL	CLEAN COAL	MIDDLING	REFUSE
DRY COAL, MLBS/HR	2419.603	1935.683	.000	483.921
WATER, MLBS/HR	210.505	166.004	.000	44.501
OTHERS, MLBS/HR	.000			.000
TOTAL, MLBS/HR	2630.108	2101.687	.000	528.422
WASTE WATER, MLBS/HR	.000			
ULTIMATE ANALYSIS, WT%				
CARBON	61.10	71.05	.00	21.31
HYDROGEN	4.20	4.80	.00	1.80
NITROGEN	1.20	1.43	.00	.28
CHLORINE	.10	.05	.00	.30
SULFUR	5.10	3.20	.00	12.70
OXYGEN	6.60	8.00	.00	1.00
ASH	21.70	11.47	.00	62.61
TOTAL	100.00	100.00	.00	100.00

PLANT UTILITIES CONSUMPTIONS	
POWER, KW	8289.
900 PSIG/750 F STEAM, MLBS/HR	.0
900 PSIG SATD STEAM, MLBS/HR	.0
600 PSIG/720 F STEAM, MLBS/HR	.0
600 PSIG SATD STEAM, MLBS/HR	.0
150 PSIG SATD STEAM, MLBS/HR	.0
50 PSIG SATD STEAM, MLBS/HR	.0
PLANT FUEL, MM BTUS/HR	.00
COOLING WATER, MGAL/HR	.00
PROCESS WATER, MGAL/HR	47.10
NITROGEN, MM SCF/HR OF N2	.00
TOTAL PLANT OPERATORS/DAY	48.0

PLANT COSTING INFORMATION

TOTAL NUMBER OF DUPLICATE TRAINS	5
MAXIMUM SIZE, MLBS/HR DRY CLEAN COAL	390.000
MINIMUM SIZE, MLBS/HR DRY CLEAN COAL	200.000

	TOTAL	FIRST	SUBSEQUENT
CAPACITY, MLBS/HR DRY CLEAN COAL	1935.683	387.137	387.137
PLANT ISBL FIELD COST, MM$	90.997	18.199	18.199

PLANT 1.4 - SUMMARY REPORT
COAL CLEANING AND PREPARATION PLANT
COAL GRINDING AND DRYING

	FEED COAL	CLEAN COAL	MIDDLING	REFUSE
DRY COAL, MLBS/HR	1425.167	1425.167	.000	.000
WATER, MLBS/HR	122.222	28.503	.000	.000
OTHERS, MLBS/HR	.000			.000
TOTAL, MLBS/HR	1547.389	1453.670	.000	.000
WASTE WATER, MLBS/HR	93.719			
ULTIMATE ANALYSIS, WT%				
CARBON	71.05	71.05	.00	.00
HYDROGEN	4.80	4.80	.00	.00
NITROGEN	1.43	1.43	.00	.00
CHLORINE	.05	.05	.00	.00
SULFUR	3.20	3.20	.00	.00
OXYGEN	8.00	8.00	.00	.00
ASH	11.47	11.47	.00	.00
TOTAL	100.00	100.00	.00	.00

PLANT UTILITIES CONSUMPTIONS	
POWER, KW	12114.
900 PSIG/750 F STEAM, MLBS/HR	.0
900 PSIG SATD STEAM, MLBS/HR	.0
600 PSIG/720 F STEAM, MLBS/HR	.0
600 PSIG SATD STEAM, MLBS/HR	.0
150 PSIG SATD STEAM, MLBS/HR	.0
50 PSIG SATD STEAM, MLBS/HR	.0
PLANT FUEL, MM BTUS/HR	486.00
COOLING WATER, MGAL/HR	14.40
PROCESS WATER, MGAL/HR	.00
NITROGEN, MM SCF/HR OF N2	4503.74
TOTAL PLANT OPERATORS/DAY	17.0

PLANT COSTING INFORMATION

TOTAL NUMBER OF DUPLICATE TRAINS	10
MAXIMUM SIZE, MLBS/HR DRY CLEAN COAL	145.000
MINIMUM SIZE, MLBS/HR DRY CLEAN COAL	50.000

	TOTAL	FIRST	SUBSEQUENT
CAPACITY, MLBS/HR DRY CLEAN COAL	1425.167	142.517	142.517
PLANT ISBL FIELD COST, MM$	87.499	8.750	8.750

PLANT 2 - SUMMARY REPORT
COAL LIQUEFACTION PLANT

LIQUEFACTION REACTOR SECTION

FRESH MAF COAL CONVERSION, % 92.790

INLET AND OUTLET COMPONENT FLOW RATES, MLBS/HR

COMPONENT	INLET	OUTLET
H2	99.930	21.706
N2	1.329	1.329
O2	.000	.000
H2S	.000	36.091
CO	.210	.962
CO2	.000	1.755
NH3	.000	17.539
H2O	1102.050	1221.291
HCL	.000	.000
COS	.000	.000
CH4	7.695	30.926
C2H6	4.299	22.354
C3H8	3.332	22.523
IC4H10	.726	2.241
NC4H10	.726	9.185
IC5H12	.094	.382
NC5H12	.094	1.700
T125	.107	40.433
T175	.121	40.447
T225	.134	40.460
T275	.147	40.473
T325	.159	40.485
T375	.005	47.413
T425	.006	47.414
T475	.000	80.203
T525	.000	80.203
T575	.000	80.203
T625	.000	80.203
T675	.095	67.514
T725	.095	67.514
T775	.095	67.514
T825	.095	67.514
T875	.589	3.366
T925	.589	3.366
T975	.589	3.366
T1000+	536.915	642.840
I1000+	.000	.000
COAL	1425.167	.000
URCOAL	.000	254.474
SLAG	.000	.000
OTHERS	.000	.000
TOTAL	3185.391	3185.391

PLANT 2 - SUMMARY REPORT (CONTINUED)
COAL LIQUEFACTION PLANT

OUTLET STREAMS, MLBS/HR

COMPONENT	H2 GAS	LO P GAS	NAPHTHA	GAS-OIL	BOTTOMS
H2	17.211	4.495	.000	.000	.000
N2	.930	.399	.000	.000	.000
O2	.000	.000	.000	.000	.000
H2S	10.110	10.210	.115	.000	.000
CO	.673	.289	.000	.000	.000
CO2	.860	.398	.000	.000	.000
NH3	2.416	.200	.000	.000	.000
H2O	1.253	3.946	1.983	.000	.000
HCL	.000	.000	.000	.000	.000
COS	.000	.000	.000	.000	.000
CH4	18.237	12.675	.010	.000	.000
C2H6	10.037	12.182	.135	.000	.000
C3H8	6.577	15.165	.780	.000	.000
IC4H10	.458	1.139	.644	.000	.000
NC4H10	.308	7.851	1.026	.000	.000
IC5H12	.218	.021	.143	.000	.000
NC5H12	.116	.213	1.372	.000	.000
T125	.000	5.305	33.941	1.099	.000
T175	.000	5.307	33.952	1.100	.000
T225	.000	5.308	33.963	1.100	.000
T275	.000	5.310	33.974	1.100	.000
T325	.000	5.312	33.984	1.101	.000
T375	.000	.135	1.579	39.673	.000
T425	.000	.135	1.579	39.673	.000
T475	.000	.006	.000	79.247	.000
T525	.000	.006	.000	79.247	.000
T575	.000	.006	.000	79.247	.000
T625	.000	.006	.000	79.247	.000
T675	.000	.000	.000	67.419	.095
T725	.000	.000	.000	67.419	.095
T775	.000	.000	.000	67.419	.095
T825	.000	.000	.000	67.419	.095
T875	.000	.000	.000	.000	3.366
T925	.000	.000	.000	.000	3.366
T975	.000	.000	.000	.000	3.366
T1000+	.000	.000	.000	.000	642.840
I1000+	.000	.000	.000	.000	.000
COAL	.000	.000	.000	.000	.000
URCOAL	.000	.000	.000	.000	254.474
SLAG	.000	.000	.000	.000	.000
OTHERS	.000	.000	.000	.000	.000
TOTAL	69.403	96.020	179.181	671.511	907.793

- CONTINUED ON NEXT PAGE -

PLANT 2 - SUMMARY REPORT (CONTINUED)
COAL LIQUEFACTION PLANT

OVERALL STREAM BALANCE

	FLOW, MM SCF/HR	FLOW MLBS/HR	TEMP, DEG F	PRESS, PSIA
INLET STREAMS				
HYDROGEN FEED	19.115	119.295	100.3	3290.0
COAL FEED		1453.670	70.0	14.7
SOLVENT		.001	500.0	500.0
ROSE-SR EXTRACT		539.061	300.0	115.0
WATER		1073.364	126.0	3200.0
TOTAL INPUT	19.115	3185.391		
OUTLET STREAMS				
H2 GAS TO PLT 6	4.084	69.403	130.0	2985.0
GASES TO PLT 3	1.805	96.020	130.0	65.0
NAPHTHA		179.181	140.0	16.0
GAS OIL		671.511	110.0	30.0
ROSE-SR FEED		907.773	688.0	28.0
SOUR WATER		1261.483	100.0	30.0
TOTAL OUTPUT	5.889	3185.371		

PLANT UTILITIES CONSUMPTIONS

POWER, KW	58990.
900 PSIG/750 F STEAM, MLBS/HR	.0
900 PSIG SATD STEAM, MLBS/HR	.0
600 PSIG/720 F STEAM, MLBS/HR	5.6
600 PSIG SATD STEAM, MLBS/HR	-149.1
150 PSIG SATD STEAM, MLBS/HR	-90.1
50 PSIG SATD STEAM, MLBS/HR	56.1
PLANT FUEL, MM BTUS/HR	1089.99
COOLING WATER, MGAL/HR	485.70
PROCESS WATER, MGAL/HR	154.20
NITROGEN, MM SCF/HR OF N2	.04
TOTAL PLANT OPERATORS/DAY	40.0

PLANT COSTING INFORMATION

TOTAL NUMBER OF DUPLICATE TRAINS	5
MAXIMUM SIZE, MLBS/HR DRY CLEAN COAL	285.050
MINIMUM SIZE, MLBS/HR DRY CLEAN COAL	30.000

	TOTAL	FIRST	SUBSEQUENT
CAPACITY, MLBS/HR DRY CLEAN COAL	1425.167	285.033	285.033
PLANT ISBL FIELD COST, MM$	932.196	186.439	186.439

EQUIPMENT SUMMARY
Plant 2 - Coal Liquefaction

All Sizes Are Based on a Single Train Plant.

Reactors and Vessels

Equipment No.	Equipment Description	Length (T-T in ft)	Diameter (ID in ft)
COAL SLURRY PREPARATION			
2.1- C101	Slurry Vortex Mx Tnk Innr Shll	11.0	11.0
	Slurry Vortex Mx Tnk Outr Shll	16.0	13.0
2.1- C102	Slurry Surge Tank	43.0	18.0
2.1- C103	Slurry Surge Tank Vent Scrubbr	32.0	4.0
2.1- C104	Scrubber Overhead Receiver	9.0	3.0
REACTOR SYSTEM			
2.3- C105	Coal Liquefaction - Stage 1	85.5	15.0
2.4- C106	Coal Liquefaction - Stage 2	85.5	15.0
PRIMARY SEPARATION			
2.5- C107	Hot High Pressure Separator	22.5	10.5
2.5- C108	Hot Low Pressure Separator	26.0	9.5
2.5- C109	Recycle Slurry Hold Drum	24.0	9.5
2.5- C110	Warm High Pressure Separator	19.0	9.5
2.5- C111	Warm Low Pressure Separator	22.5	6.5
2.5- C112	Recy Slry Hold Drm Cond Accum	12.0	3.0
2.5- C113	Cold High Pressure Separator	27.0	9.5
2.5- C114	Cold Low Pressure Separator	26.0	6.5
2.5- C115	Wash Water Drum	24.5	7.0
2.5- C116	Sour Water Drum	26.5	7.5
2.5- C117	Compressor Knockout Drum	13.0	6.5
CRUDE PRODUCT FRACTIONATION - ATMOSPHERIC TOWER			
2.6- C117	Feed Flash Drum	29.5	10.5
2.6- C120	Overhead Accumulator	26.0	6.5
2.6- C121	Vent Gas Compress Knockout	8.0	4.0
CRUDE PRODUCT FRACTIONATION - VACUUM TOWER			
2.6- C124	Vacuum Jet Condenser Accum	16.0	4.0
2.6- C125	Vent Gas Compress Knockout	8.0	4.0

EQUIPMENT SUMMARY (Continued)
Plant 2 - Coal Liquefaction

All Sizes Are Based on a Single Train Plant.

Pumps

Equipment No.	Equipment Description	Flow Rate (gpm)	Brake Horsepower
COAL SLURRY PREPARATION			
2.1- G101	Scrubber Condenser Product	1.0	1.0
2.1- G102	Scrubber Sour Water	15.0	1.0
2.1- G103	Coal Slurry Booster Pump	1100.0	70.0
REACTION SYSTEM			
2.3- G105	Slurry Charge	535.0	3450.0
2.3- G108	Stage 1 Ebullating	------ Proprietary ------	
2.4- G109	Stage 2 Ebullating	------ Proprietary ------	
PRIMARY SEPARATION			
2.5- G110	Slurry Recycle Pump	1625.0	120.0
2.5- G111	Recy Slr Hld Drm Cnd Acumm Liq	15.0	1.0
2.5- G112	Recy Slr Dr Cnd ac Sour Water	1.0	1.0
2.5- G113	Sour Water Drum Pump	630.0	20.0
2.5- G114	Wash Water LP Pump	455.0	30.0
2.5- G115	Wash Water HP Pump	215.0	545.0
CRUDE PRODUCT FRACTIONATION - ATMOSPHERIC TOWER			
2.6- G116	Atmos Heater Charge	1145.0	150.0
2.6- G117	Reflux Naphtha Product	370.0	50.0
2.6- G118	AGO Product	120.0	45.0
2.6- G119	Bottoms Product	1110.0	150.0
2.6- G120	Atmos Ovhd Accum Sour Water	15.0	50.0
CRUDE PRODUCT FRACTIONATION - VACUUM TOWER			
2.6- G121	LVGO Pumparound	1500.0	50.0
2.6- G122	HVGO Pumparound	120.0	50.0
2.6- G123	HVGO Product	85.0	100.0
2.6- G124	Bottoms Product	455.0	100.0
2.6- G125	Vacuum Jet Accum Sour Water	90.0	50.0
2.6- G126	Vacuum Jet Accum Product	5.0	50.0

Plant 2 - Coal Liquefaction
ISBL field Cost Summary

The following ISBL field cost summary by plant section is based on the baseline design configuration of independent processing trains. The following costs are for a single train. These costs are based on the ISBL cost of the first train when multiple trains are present.

Plant Section	Description	ISBL Train Cost, MM$
1	Coal Slurry Preparation	4.7
2	Coal Slurry Heating	19.5
3	First Stage Reaction	66.1
4	Second Stage Reaction	46.6
5	Primary Separation	35.0
6	Product Fractionation	10.2
7	Recycle Gas Compression	4.2
	Total	186.4

PLANT 3 - SUMMARY REPORT
THE GAS PLANT

INLET STREAM SUMMARY

INLET STREAMS, MLBS/HR

COMPONENT	NAPHTHA	GAS	TOTAL
H2	.000	2.249	2.249
NH3	.000	.000	.000
H2O	1.983	.000	1.983
H2S	.115	.000	.115
CO	.000	.752	.752
N2	.000	1.318	1.318
CO2	.000	.000	.000
CH4	.010	32.498	32.508
C2H6	.135	26.402	26.537
C3H8	.780	31.771	32.551
IC4H10	.644	13.770	14.415
NC4H10	1.026	15.611	16.638
IC5H12	.143	6.841	6.984
NC5H12	1.372	7.946	9.318
T125	33.941	4.991	38.932
T175	33.952	4.980	38.932
T225	33.963	4.969	38.932
T275	33.974	4.959	38.933
T325	33.984	4.949	38.933
T375	1.579	.036	1.614
T425	1.579	.035	1.614
T475	.000	.000	.000
500+ F	.000	.000	.000
TOTAL	179.181	164.077	343.258
MM SCF/HR		2.190	
BBL/HR	681.398		
MM SCF/HR OF DRY C4-			2.039

- CONTINUED ON NEXT PAGE -

PLANT 3 - SUMMARY REPORT (CONTINUED)
THE GAS PLANT

OUTLET STREAM SUMMARY

OUTLET STREAMS, MLBS/HR

COMPONENT	SOUR GAS	FUEL GAS	PROPANE	BUTANES	LEAN OIL
H2	.000	2.249	.000	.000	.000
NH3	.000	.000	.000	.000	.000
H2O	.038	.000	.000	.000	.000
H2S	.115	.000	.000	.000	.000
CO	.000	.752	.000	.000	.000
N2	.000	1.318	.000	.000	.000
CO2	.000	.000	.000	.000	.000
CH4	.010	32.496	.002	.000	.000
C2H6	.135	25.962	.432	.008	.000
C3H8	.780	.048	31.303	.420	.000
IC4H10	.644	.026	.653	13.008	.083
NC4H10	1.026	.112	.063	15.318	.118
IC5H12	.123	1.482	.000	.329	5.049
NC5H12	1.184	1.757	.000	.391	5.986
T125	.131	.617	.000	.000	38.183
T175	.131	.617	.000	.000	38.184
T225	.131	.617	.000	.000	38.184
T275	.131	.617	.000	.000	38.184
T325	.131	.617	.000	.000	38.185
T375	.000	.002	.000	.000	1.613
T425	.000	.000	.000	.000	1.614
T475	.000	.000	.000	.000	.000
500+ F	.000	.000	.000	.000	.000
TOTAL	4.710	69.292	32.453	29.474	205.383
MM SCF/HR	.031	1.578	.280	.192	
BBL/HR					786.090

SOUR WATER 1.946 MLBS/HR 233.4 GAL/HR

- CONTINUED ON NEXT PAGE -

PLANT 3 - SUMMARY REPORT (CONTINUED)
THE GAS PLANT

PLANT UTILITIES CONSUMPTIONS	
POWER, KW	913.
900 PSIG/750 F STEAM, MLBS/HR	.0
900 PSIG SATD STEAM, MLBS/HR	.0
600 PSIG/720 F STEAM, MLBS/HR	.0
600 PSIG SATD STEAM, MLBS/HR	396.6
150 PSIG SATD STEAM, MLBS/HR	.0
50 PSIG SATD STEAM, MLBS/HR	17.2
PLANT FUEL, MM BTUS/HR	-1472.80
COOLING WATER, MGAL/HR	1317.12
PROCESS WATER, MGAL/HR	.00
NITROGEN, MM SCF/HR OF N2	.00
TOTAL PLANT OPERATORS/DAY	8.0

PLANT COSTING INFORMATION

TOTAL NUMBER OF DUPLICATE TRAINS	1
MAXIMUM SIZE, MM SCF/HR	5.000
MINIMUM SIZE, MM SCF/HR	.300
CAPACITY, MM SCF/HR	2.039
PLANT ISBL FIELD COST, MM$	25.295

PLANT 4 - SUMMARY REPORT
NAPHTHA HYDROTREATER

REACTOR SUMMARY

COMPONENT	REACTOR INLET MLBS/HR	REACTOR INLET BBLS/HR	REACTOR OUTLET MLBS/HR	REACTOR OUTLET BBLS/HR
H2	2.501		1.965	
NH3	.000		.412	
H2O	18.776		19.896	
H2S	.000		.021	
N2	.034		.034	
CH4	.003		1.089	
C2H6	.013		.741	
C3H8	.049		.749	
IC4H10	.139	.7	1.519	7.7
NC4H10	.181	.9	1.584	7.7
IC5H12	5.512	25.2	4.972	22.7
NC5H12	6.524	29.5	5.984	27.1
T125	38.975	156.9	35.609	143.3
T175	38.975	152.2	35.609	139.1
T225	38.974	147.6	35.609	134.9
T275	38.974	143.2	35.608	130.9
T325	38.974	139.0	35.608	127.0
T375	1.803	6.2	7.600	26.3
T425	1.804	6.1	7.601	25.5
T475	.007	.0	.005	.0
500+ F	.021	.1	.020	.1
TOTAL	232.237	807.6	232.237	792.2
COMPONENT GROUPS				
BUTANES	.320	1.6	3.103	15.4
PENTANES	12.036	54.7	10.955	49.8
C6 - 350 F	194.871	738.9	178.044	675.1
350+ F	3.634	12.4	15.227	51.9
TOTAL C4+	210.861	807.6	207.328	792.2

C5+ HETROATOM STATISTICS

ELEMENT	REACTOR INLET LBS/HR	REACTOR INLET WT %	REACTOR OUTLET LBS/HR	REACTOR OUTLET WT %	% REMOVAL
SULFUR	1.99	.01000	.00	.00000	99.990
NITROGEN	33.93	.17092	.00	.00002	99.988
OXYGEN	99.98	.50365	.50	.00259	99.500

MAKEUP HYDROGEN RATE 584.1 SCF/BBL OF C5+ FEED
CHEMICAL HYDROGEN CONSUMPTION 125.0 SCF/BBL OF C5+ FEED

- CONTINUED ON NEXT PAGE -

PLANT 4 - SUMMARY REPORT (CONTINUED)
NAPHTHA HYDROTREATER

STREAM SUMMARY

INLET AND OUTLET STREAMS, MLBS/HR

COMPONENT	TOTAL INLET	GASES	NAPHTHA	SOUR H2O
H2	2.501	1.965	.000	.000
NH3	.000	.090	.000	.323
H2O	18.776	.093	.000	19.803
H2S	.000	.000	.000	.021
N2	.034	.034	.000	.000
CH4	.003	1.089	.000	.000
C2H6	.013	.741	.000	.000
C3H8	.049	.749	.000	.000
IC4H10	.139	1.414	.105	.000
NC4H10	.181	1.400	.183	.000
IC5H12	5.512	.147	4.824	.000
NC5H12	6.524	.177	5.806	.000
T125	38.975	.088	35.522	.000
T175	38.975	.088	35.521	.000
T225	38.974	.088	35.521	.000
T275	38.974	.088	35.520	.000
T325	38.974	.088	35.520	.000
T375	1.803	.000	7.600	.000
T425	1.804	.000	7.601	.000
T475	.007	.000	.005	.000
T525	.007	.000	.007	.000
T575	.007	.000	.007	.000
T625	.007	.000	.007	.000
T675	.000	.000	.000	.000
T725	.000	.000	.000	.000
T775	.000	.000	.000	.000
T825	.000	.000	.000	.000
T875	.000	.000	.000	.000
T925	.000	.000	.000	.000
T975	.000	.000	.000	.000
T1000+	.000	.000	.000	.000
TOTAL	232.237	8.340	203.749	20.147

FLOW, MM SCF/HR		.438	
FLOW, BBL/HR			775.097
FLOW, GAL/MIN			40.687

SULFUR, WT PPM	.0
NITROGEN, WT PPM	.2
OXYGEN, WT PPM	24.5

- CONTINUED ON NEXT PAGE -

PLANT 4 - SUMMARY REPORT (CONTINUED)
NAPHTHA HYDROTREATER

PLANT UTILITIES CONSUMPTIONS	
POWER, KW	1073.
900 PSIG/750 F STEAM, MLBS/HR	.0
900 PSIG SATD STEAM, MLBS/HR	.0
600 PSIG/720 F STEAM, MLBS/HR	.0
600 PSIG SATD STEAM, MLBS/HR	26.6
150 PSIG SATD STEAM, MLBS/HR	.0
50 PSIG SATD STEAM, MLBS/HR	.0
PLANT FUEL, MM BTUS/HR	74.03
COOLING WATER, MGAL/HR	153.90
PROCESS WATER, MGAL/HR	2.28
NITROGEN, MM SCF/HR OF N2	.00
TOTAL PLANT OPERATORS/DAY	8.0

PLANT COSTING INFORMATION

TOTAL NUMBER OF DUPLICATE TRAINS	1
MAXIMUM SIZE, MLBS/HR	400.000
MINIMUM SIZE, MLBS/HR	50.000
CAPACITY, MLBS/HR	210.541
PLANT ISBL FIELD COST, MM$	15.605

PLANT 5 - SUMMARY REPORT
GAS-OIL HYDROTREATER

REACTOR SUMMARY

COMPONENT	REACTOR INLET MLBS/HR	REACTOR INLET BBLS/HR	REACTOR OUTLET MLBS/HR	REACTOR OUTLET BBLS/HR
H2	18.503		8.202	
NH3	.000		1.761	
H2O	36.407		41.124	
H2S	.000		.230	
N2	.304		.304	
CH4	.000		8.190	
C2H6	.000		7.659	
C3H8	.000		11.882	
IC4H10	.000	.0	10.916	55.4
NC4H10	.000	.0	5.878	28.5
IC5H12	.000	.0	9.883	45.2
NC5H12	.000	.0	9.883	44.7
C6 - 300 F	4.399	16.9	17.335	66.7
T325	1.101	3.9	4.335	15.5
T375	39.673	137.3	51.174	177.1
T425	39.673	133.3	51.175	171.9
T475	79.247	258.6	75.226	245.5
T525	79.247	251.4	75.226	238.6
T575	79.247	244.5	75.226	232.1
T625	79.247	238.1	75.226	226.0
T675	67.419	197.5	44.421	130.1
T725	67.419	192.8	44.421	127.1
T775	67.419	188.6	44.421	124.2
T825	67.419	184.7	44.421	121.7
T875	.000	.0	2.736	7.4
T925	.000	.0	2.736	7.2
T975	.000	.0	2.736	7.1
T1000+	.000	.0	.000	.0
TOTAL	726.725	2047.7	726.725	2072.1
BUTANES	.000	.0	16.794	83.9
PENTANES	.000	.0	19.766	89.9
C6 - 350 F	5.500	20.9	21.670	82.2
350 - 450 F	79.346	270.6	102.349	349.0
450 - 650 F	316.988	992.6	300.904	942.2
650 - 850 F	269.677	763.7	177.682	503.2
850+ F	.000	.0	8.208	21.7
TOTAL C4+	671.511	2047.7	647.373	2072.1

C6+ HETROATOM STATISTICS

ELEMENT	REACTOR INLET LBS/HR	REACTOR INLET WT %	REACTOR OUTLET LBS/HR	REACTOR OUTLET WT %	% REMOVAL
SULFUR	23.37	.03480	1.75	.00287	92.500
NITROGEN	169.98	.25313	25.16	.04119	85.200
OXYGEN	429.17	.63911	10.30	.01686	97.600

MAKEUP HYDROGEN RATE 1701.1 SCF/BBL OF C6+ FEED
CHEMICAL HYDROGEN CONSUMPTION 947.0 SCF/BBL OF C6+ FEED

- CONTINUED ON NEXT PAGE -

PLANT 5 - SUMMARY REPORT (CONTINUED)
GAS-OIL HYDROTREATER

STREAM SUMMARY

INLET AND OUTLET STREAMS, MLBS/HR

COMPONENT	TOTAL INLET	RX GAS	GASES	NAPHTHA
H2	18.503	6.630	1.573	.000
NH3	.000	.056	.118	.000
H2O	36.407	.707	1.208	.000
H2S	.000	.002	.008	.000
N2	.304	.212	.092	.000
CH4	.000	5.840	2.346	.000
C2H6	.000	3.877	3.743	.000
C3H8	.000	4.207	7.673	.000
IC4H10	.000	2.700	8.197	.019
NC4H10	.000	1.191	4.624	.063
IC5H12	.000	1.048	5.841	2.995
NC5H12	.000	1.048	5.841	2.995
T125	1.099	.048	.318	2.617
T175	1.100	.048	.318	2.618
T225	1.100	.048	.318	2.618
T275	1.100	.048	.319	2.618
T325	1.101	.048	.319	2.618
T375	39.673	.011	.085	.764
T425	39.673	.011	.085	.764
T475	79.247	.000	.001	.000
T525	79.247	.000	.001	.000
T575	79.247	.000	.001	.000
T625	79.247	.000	.001	.000
T675	67.419	.000	.000	.000
T725	67.419	.000	.000	.000
T775	67.419	.000	.000	.000
T825	67.419	.000	.000	.000
T875	.000	.000	.000	.000
T925	.000	.000	.000	.000
T975	.000	.000	.000	.000
T1000+	.000	.000	.000	.000
TOTAL	726.725	27.777	43.027	20.688
FLOW, MM SCF/HR		1.528	.646	
FLOW, BBL/HR				82.484
SULFUR, WT PPM				1.6
NITROGEN, WT PPM				59.0
OXYGEN, WT PPM				28.9

- OUTLET STREAMS ARE CONTINUED ON NEXT PAGE -

PLANT 5 - SUMMARY REPORT (CONTINUED)
GAS-OIL HYDROTREATER

STREAM SUMMARY

OUTLET STREAMS (CONTINUED), MLBS/HR

COMPONENT	350-450F	450-650F	650-850F	SOUR-H2O
H2	.000	.000	.000	.000
NH3	.000	.000	.000	1.587
H2O	.000	.168	.000	39.041
H2S	.000	.000	.000	.220
N2	.000	.000	.000	.000
CH4	.000	.000	.000	.004
C2H6	.000	.038	.000	.002
C3H8	.000	.000	.000	.002
IC4H10	.000	.000	.000	.000
NC4H10	.000	.000	.000	.000
IC5H12	.000	.000	.000	.000
NC5H12	.000	.000	.000	.000
T125	1.342	.006	.000	.002
T175	1.342	.006	.000	.002
T225	1.342	.006	.000	.002
T275	1.343	.006	.000	.002
T325	1.343	.006	.000	.002
T375	45.692	4.552	.000	.071
T425	45.692	4.552	.000	.071
T475	.463	66.619	8.137	.006
T525	.463	66.619	8.137	.006
T575	.463	66.619	8.137	.006
T625	.463	66.619	8.137	.006
T675	.000	6.164	38.257	.000
T725	.000	6.164	38.257	.000
T775	.000	6.164	38.257	.000
T825	.000	6.164	38.257	.000
T875	.000	.001	2.735	.000
T925	.000	.001	2.735	.000
T975	.000	.001	2.735	.000
T1000+	.000	.000	.000	.000
TOTAL	99.947	300.474	193.779	41.034
FLOW, BBL/HR	342.860	936.190	556.985	
FLOW, GAL/MIN				84.208
SULFUR, WT PPM	5.7	19.8	56.6	
NITROGEN, WT PPM	242.0	391.1	559.5	
OXYGEN, WT PPM	123.9	654.3	218.2	

- CONTINUED ON NEXT PAGE -

PLANT 5 - SUMMARY REPORT (CONTINUED)
GAS-OIL HYDROTREATER

PLANT UTILITIES CONSUMPTIONS	
POWER, KW	2181.
900 PSIG/750 F STEAM, MLBS/HR	.0
900 PSIG SATD STEAM, MLBS/HR	.0
600 PSIG/720 F STEAM, MLBS/HR	.0
600 PSIG SATD STEAM, MLBS/HR	65.1
150 PSIG SATD STEAM, MLBS/HR	-33.9
50 PSIG SATD STEAM, MLBS/HR	.0
PLANT FUEL, MM BTUS/HR	162.11
COOLING WATER, MGAL/HR	494.03
PROCESS WATER, MGAL/HR	.00
NITROGEN, MM SCF/HR OF N2	.00
TOTAL PLANT OPERATORS/DAY	4.0

PLANT COSTING INFORMATION

TOTAL NUMBER OF DUPLICATE TRAINS	1
MAXIMUM SIZE, MLBS/HR	800.000
MINIMUM SIZE, MLBS/HR	150.000
CAPACITY, MLBS/HR	671.511
PLANT ISBL FIELD COST, MM$	74.039

PLANT 6.1 - SUMMARY REPORT
HYDROGEN PURIFICATION BY MEMBRANE PERMEATION

COMPONENT FLOW RATES, LBS/HR

COMPONENT	INLET	H2-RICH	SOUR GAS	REJECT GAS
H2	23840.5	10450.0	.0	13390.6
N2	1142.3	.0	.0	1142.3
H2S	10112.4	.0	10112.4	.0
CO	672.9	.0	.0	672.9
CO2	860.3	.0	860.3	.0
NH3	2471.6	.0	2471.6	.0
H2O	1959.6	.0	1779.3	180.3
CH4	24076.4	11.0	.0	24065.4
C2H6	13913.4	.0	.0	13913.4
C3H8	10784.2	.0	.0	10784.2
IC4H10	3158.1	.0	.0	3158.1
NC4H10	1498.6	.0	.0	1498.6
IC5H12	1265.5	.0	.0	1265.5
NC5H12	1163.7	.0	.0	1163.7
200+ F	260.5	.0	.0	260.5
TOTAL	97180.0	10461.0	15223.6	71495.4
FLOW, MM SCF/HR	5.611	1.968	.213	3.431
TEMPERATURE, F	131.5	100.0	250.0	111.0
PRESSURE, PSIA	2690.0	3290.0	14.7	500.0
H2 FLOW, MM SCF/HR	4.488	1.967		2.521
MOLE % HYDROGEN	79.986	99.987		73.473

- CONTINUED ON NEXT PAGE -

PLANT 6.1 - SUMMARY REPORT (CONTINUED)
HYDROGEN PURIFICATION BY MEMBRANE PERMEATION

PLANT UTILITIES CONSUMPTIONS	
POWER, KW	24108.
900 PSIG/750 F STEAM, MLBS/HR	.0
900 PSIG SATD STEAM, MLBS/HR	.0
600 PSIG/720 F STEAM, MLBS/HR	.0
600 PSIG SATD STEAM, MLBS/HR	.0
150 PSIG SATD STEAM, MLBS/HR	.0
50 PSIG SATD STEAM, MLBS/HR	4.0
PLANT FUEL, MM BTUS/HR	.00
COOLING WATER, MGAL/HR	84.02
PROCESS WATER, MGAL/HR	1.68
NITROGEN, MM SCF/HR OF N2	.00
TOTAL PLANT OPERATORS/DAY	12.0

PLANT COSTING INFORMATION

TOTAL NUMBER OF DUPLICATE TRAINS	1
MAXIMUM SIZE, MM SCF/HR OF H2	2.500
MINIMUM SIZE, MM SCF/HR OF H2	.500
CAPACITY, MM SCF/HR OF H2	1.967
PLANT ISBL FIELD COST, MM$	152.625

PLANT 6.2 - SUMMARY REPORT
HYDROGEN PURIFICATION BY PRESSURE SWING ABSORPTION

INLET STREAM COMPONENT FLOW RATES, LBS/HR

COMPONENT	MIXED GAS	FROM P6.1	TOTAL
H2	8033.5	13390.6	21424.0
N2	524.7	1142.3	1667.0
H2S	10333.3	.0	10333.3
CO	289.1	672.9	961.9
CO2	397.8	.0	397.8
NH3	407.8	.0	407.8
H2O	5284.3	180.3	5464.6
CH4	16119.9	24065.4	40185.3
C2H6	16800.9	13913.4	30714.3
C3H8	24367.6	10784.2	35151.8
IC4H10	11393.3	3158.1	14551.4
NC4H10	14901.1	1498.6	16399.7
IC5H12	6132.7	1265.4	7398.1
NC5H12	7414.3	1163.7	8577.9
T125	5435.8	.0	5435.8
T175	5437.7	.0	5437.7
200+ F	18822.8	260.5	19083.3
TOTAL	152096.6	71495.4	223591.9
FLOW, MM SCF/HR	2.912	3.430	6.342
TEMPERATURE, F	91.9	111.0	
PRESSURE, PSIA	55.0	500.0	

OUTLET STREAM COMPONENT FLOW RATES, LBS/HR

COMPONENT	H2-RICH	SOUR GAS	REJECT GAS	NAPHTHA
H2	19175.2	.0	2248.8	.0
N2	349.3	.0	1317.7	.0
H2S	.0	10333.3	.0	.0
CO	209.6	.0	752.3	.0
CO2	.0	397.8	.0	.0
NH3	.0	407.8	.0	.0
H2O	5464.6	.0	.0	.0
CH4	7684.0	.0	32498.2	3.0
C2H6	4299.0	.0	26402.3	13.0
C3H8	3331.8	.0	31771.0	49.1
IC4H10	725.6	.0	13770.4	55.3
NC4H10	725.6	.0	15611.4	62.7
IC5H12	94.2	.0	6841.0	462.9
NC5H12	94.2	.0	7946.0	537.7
T125	107.5	.0	4990.7	337.7
T175	121.2	.0	4979.6	337.0
200+ F	451.4	.0	14947.3	3684.6
TOTAL	42833.3	11139.0	164076.7	5543.0
FLOW, MM SCF/HR	4.010	.128	2.190	
TEMPERATURE, F	100.0	250.0	111.0	100.0
PRESSURE, PSIA	3290.0	14.7	25.0	50.0
H2 FLOW, MM SCF/HR	3.610		.423	
MOLE % HYDROGEN	90.017		19.327	

- CONTINUED ON NEXT PAGE -

PLANT 6.2 - SUMMARY REPORT (CONTINUED)
HYDROGEN PURIFICATION BY PRESSURE SWING ABSORPTION

PLANT UTILITIES CONSUMPTIONS	
POWER, KW	19804.
900 PSIG/750 F STEAM, MLBS/HR	.0
900 PSIG SATD STEAM, MLBS/HR	.0
600 PSIG/720 F STEAM, MLBS/HR	.0
600 PSIG SATD STEAM, MLBS/HR	.0
150 PSIG SATD STEAM, MLBS/HR	.0
50 PSIG SATD STEAM, MLBS/HR	55.3
PLANT FUEL, MM BTUS/HR	.00
COOLING WATER, MGAL/HR	315.13
PROCESS WATER, MGAL/HR	1.92
NITROGEN, MM SCF/HR OF N2	.00
TOTAL PLANT OPERATORS/DAY	.0

PLANT COSTING INFORMATION

TOTAL NUMBER OF DUPLICATE TRAINS	1
MAXIMUM SIZE, MM SCF/HR OF H2	5.000
MINIMUM SIZE, MM SCF/HR OF H2	.500
CAPACITY, MM SCF/HR OF H2	3.610
PLANT ISBL FIELD COST, MM$	.000

PLANT 8.1 - ROSE-SR UNIT SUMMARY REPORT

COMPONENT FLOW RATES, LBS/HR

COMPONENT	INLET	DEASHED RESIDUUM	ASH CONCENTRATE
H2O	.0	.0	.0
C5-	.0	.0	.0
C6-350F	.0	.0	.0
350-450F	.0	.0	.0
450-650F	.0	.0	.0
650-850F	380.2	380.2	.0
850-900F	3366.1	588.5	2777.6
900-950F	3366.1	588.5	2777.6
950-1000F	3366.1	588.5	2777.6
1000+F	642820.9	536903.2	105917.7
URCOAL	254473.6	.0	254473.6
TOTAL	907773.2	539049.0	368724.1
TEMPERATURE, F	688.0	300.0	150.0
PRESSURE, PSIA	28.0	115.0	14.7

PLANT UTILITIES CONSUMPTIONS

POWER, KW	4366.
900 PSIG/750 F STEAM, MLBS/HR	.0
900 PSIG SATD STEAM, MLBS/HR	.0
600 PSIG/720 F STEAM, MLBS/HR	.0
600 PSIG SATD STEAM, MLBS/HR	.0
150 PSIG SATD STEAM, MLBS/HR	25.4
50 PSIG SATD STEAM, MLBS/HR	.0
PLANT FUEL, MM BTUS/HR	212.13
COOLING WATER, MGAL/HR	.00
PROCESS WATER, MGAL/HR	.00
NITROGEN, MM SCF/HR OF N2	.00
TOTAL PLANT OPERATORS/DAY	8.0

PLANT COSTING INFORMATION

TOTAL NUMBER OF DUPLICATE TRAINS	1
MAXIMUM SIZE, MLBS/HR	1500.000
MINIMUM SIZE, MLBS/HR	500.000
CAPACITY, MLBS/HR	907.773
PLANT ISBL FIELD COST, MM$	42.213

PLANT 9 - SUMMARY REPORT
HYDROGEN PRODUCTION BY COAL/CHAR GASIFICATION

GASIFICATION SECTION

INLET STREAMS	COAL*	WATER*	OXYGEN	TOTAL
FLOW, MLBS/HR	879.242	1011.321	746.864	2637.427
FLOW, MM SCF/HR			8.863	
TEMPERATURE, F	80.0	90.0	120.0	
PRESSURE, PSIA	14.7	150.0	180.0	

* COAL IS ON A DRY BASIS. THE WATER INCLUDES THAT IN THE COAL.

OUTLET STREAMS	GAS	SLAG	TOTAL
FLOW, MLBS/HR	2403.093	234.335	2637.427
FLOW, MM SCF/HR	44.833		

SHIFT REACTOR SECTION

STREAM	SHIFT REACTOR INPUT GAS	SHIFT REACTOR INPUT STEAM	REACTOR OUTLET
FLOW, MLBS/HR	2403.093	167.543	2570.636
FLOW, MM SCF/HR	44.833		48.362
H2, MLBS/HR	49.162		109.429
H2, MM SCF/HR	9.255		20.601
CO, MLBS/HR	871.335		33.895
CO, MM SCF/HR	11.805		.459
FRACTION OF CO SHIFTED	.9611		

RECTISOL PRODUCT RECOVERY SECTION

OUTLET STREAMS	H2	ACID GAS	VENT GAS	SOUR H2O
FLOW, MLBS/HR	92.601	117.886	1859.005	501.144
FLOW, MM SCF/HR	17.207	1.135	19.469	
FLOW, MGAL/HR				60.175
H2, MLBS/HR	91.308	.168	17.953	
H2, MM SCF/HR	17.190	.032	3.380	
COMPOSITION, WT%				
H2	98.60	.14	.97	
CO	.00	1.57	1.72	
CO2	.00	72.40	96.70	
CH4	.00	.00	.00	
N2	1.40	1.09	.61	
H2S	.00	24.71	.00	.06
COS		.09		.00
H2O				99.74
HCL				.06
NH3				.14
TOTAL	100.00	100.00	100.00	100.00

- CONTINUED ON NEXT PAGE -

PLANT 9 - SUMMARY REPORT (CONTINUED)
HYDROGEN PRODUCTION BY COAL/CHAR GASIFICATION

OVERALL PLANT MATERIAL BALANCE

INLET STREAMS	MLBS/HR	PRODUCT STREAMS	MLBS/HR
TOTAL COAL/URCOAL	923.024	SLAG FROM GASIFIER	234.335
WATER/STEAM TO GASIFIER	967.539	H2 PRODUCT STREAM	92.601
OXYGEN STREAM	746.864	ACID GAS STREAM	117.886
STEAM TO SHIFT REACTORS	167.543	VENT GAS STREAM	1859.005
		SOUR WATER STREAM	501.144
TOTAL INPUT	2804.970	TOTAL OUTPUT	2804.970

HYDROGEN PRODUCTION RATE, MM SCF/HR OF H2 17.190

PLANT UTILITIES CONSUMPTIONS

POWER, KW	63243.
900 PSIG/750 F STEAM, MLBS/HR	.0
900 PSIG SATD STEAM, MLBS/HR	.0
600 PSIG/720 F STEAM, MLBS/HR	.0
600 PSIG SATD STEAM, MLBS/HR	-292.0
150 PSIG SATD STEAM, MLBS/HR	-763.3
50 PSIG SATD STEAM, MLBS/HR	-781.7
PLANT FUEL, MM BTUS/HR	-981.51
COOLING WATER, MGAL/HR	3157.65
PROCESS WATER, MGAL/HR	71.80
NITROGEN, MM SCF/HR OF N2	1.42
TOTAL PLANT OPERATORS/DAY	120.0

PLANT COSTING INFORMATION

TOTAL NUMBER OF DUPLICATE TRAINS	5
MAXIMUM SIZE, MM SCF/HR OF H2	3.500
MINIMUM SIZE, MM SCF/HR OF H2	1.000

	TOTAL	FIRST	SUBSEQUENT
CAPACITY, MM SCF/HR OF H2	17.190	3.438	3.438
PLANT ISBL FIELD COST, MM$	263.613	52.723	52.723

PLANT 10 - SUMMARY REPORT
AIR SEPARATION PLANT

SIMPLIFIED BLOCK MODEL

OXYGEN PRODUCTION RATE, MM SCF/HR OF O2 8.819

TOTAL INPUT, MLBS/HR	3207.420
TOTAL OUTPUT, MLBS/HR	3207.420

STREAM SUMMARY	INLET	OUTLET	
	AIR	OXYGEN	NITROGEN
FLOW, LB MOLES/HR	111189.9	23354.9	87835.0
FLOW, MM SCF/HR	42.196	8.863	33.333
FLOW, MLBS/HR	3207.420	746.864	2460.556
TEMPERATURE, F	70.0	80.0	-275.0
PRESSURE, PSIA	14.7	350.0	164.7
COMPOSITION, WT%			
OXYGEN	23.18	99.56	.00
NITROGEN	76.82	.44	100.00
COMPOSITION, MOL% OR VOL%			
OXYGEN	20.90	99.50	.00
NITROGEN	79.10	.50	100.00

PLANT UTILITIES CONSUMPTIONS	
POWER, KW	160008.
900 PSIG/750 F STEAM, MLBS/HR	.0
900 PSIG SATD STEAM, MLBS/HR	.0
600 PSIG/720 F STEAM, MLBS/HR	.0
600 PSIG SATD STEAM, MLBS/HR	.0
150 PSIG SATD STEAM, MLBS/HR	.0
50 PSIG SATD STEAM, MLBS/HR	.0
PLANT FUEL, MM BTUS/HR	.00
COOLING WATER, MGAL/HR	.00
PROCESS WATER, MGAL/HR	.00
NITROGEN, MM SCF/HR OF N2	.00
TOTAL PLANT OPERATORS/DAY	4.0

PLANT COSTING INFORMATION

TOTAL NUMBER OF DUPLICATE TRAINS	5
MAXIMUM SIZE, MM SCF/HR OF O2	1.875
MINIMUM SIZE, MM SCF/HR OF O2	1.000

	TOTAL	FIRST	SUBSEQUENT
CAPACITY, MM SCF/HR OF O2	8.819	1.764	1.764
PLANT ISBL FIELD COST, MM$	191.012	38.202	38.202

PLANT 11 - SUMMARY REPORT
SULFUR PLANT

	FEED GAS	FLUE GAS	SULFUR
FLOW, MLBS/HR	175.548	113.786	61.762
FLOW, MM SCF/HR	1.736	1.736	
TEMPERATURE, F	110.0	80.0	80.0
PRESSURE, PSIA	14.7	14.7	14.7

NOTE: THE FLOW RATE OF THE FLUE GAS STREAM IS SIGNIFICANTLY UNDER PREDICTED BECAUSE THE INLET AIR STREAM IS NOT CONSIDERED.

FRACTIONAL LIQUID SULFUR RECOVERY = .9984820

DEPENDING UPON THE IMPURITIES IN THE FEED, THIS SULFUR PLANT WILL REQUIRE AT LEAST 1751.641 M SCF/HR OF AIR.

PLANT UTILITIES CONSUMPTIONS

POWER, KW	3064.
900 PSIG/750 F STEAM, MLBS/HR	.0
900 PSIG SATD STEAM, MLBS/HR	.0
600 PSIG/720 F STEAM, MLBS/HR	.0
600 PSIG SATD STEAM, MLBS/HR	60.0
150 PSIG SATD STEAM, MLBS/HR	-186.7
50 PSIG SATD STEAM, MLBS/HR	54.5
PLANT FUEL, MM BTUS/HR	69.04
COOLING WATER, MGAL/HR	487.87
PROCESS WATER, MGAL/HR	.00
NITROGEN, MM SCF/HR OF N2	.00
TOTAL PLANT OPERATORS/DAY	20.0

PLANT COSTING INFORMATION

TOTAL NUMBER OF DUPLICATE TRAINS	4
MAXIMUM SIZE, MLBS/HR	16.500
MINIMUM SIZE, MLBS/HR	5.000

	TOTAL	FIRST	SUBSEQUENT
CAPACITY, MLBS/HR	61.762	15.440	15.440
PLANT ISBL FIELD COST, MM$	46.723	11.681	11.681

PLANT 31 - SUMMARY REPORT
UTILITIES PLANT

ENERGY SOURCE	AMOUNT*	MMBTU/HR	NET PRODUCTION ELECTRIC POWER, MW	NET PRODUCTION STEAM, MLBS/HR
COMBUSTION TURBINES SECTION				
PLANT FUEL		361.005	34.399	
STEAM GENERATION SECTION				
EXCESS STEAM	305.740	233.452	27.367	-305.740
POWER PLANT SECTION				
NATURAL GAS	3510.992	3510.992	334.555	
		---	---	---
UTILITIES PLANT TOTAL		4105.449	396.322	-305.740
PURCHASED MATERIALS				
NATURAL GAS	3510.992	3510.992		

*SOLID FUEL AMOUNTS ARE IN MLBS/HR, AND NATURAL GAS IS IN MSCF/HR.
NEGATIVE NET PRODUCTION VALUES INDICATE CONSUMPTION.

PLANT 31 - SUMMARY REPORT
UTILITIES PLANT

UTILITIES SUMMARY

PLANT NO.	POWER KW	FUEL MMBTUS/HR	COOLING WATER MGAL/HR	PROCESS WATER MGAL/HR	NITROGEN MMSCF/HR
1. -00	8289.	.000	.00	47.10	.000
2	58990.	1089.993	485.70	154.20	.042
3	913.	-1472.796	1317.12	.00	.000
4	1073.	74.028	153.90	2.28	.000
5	2181.	162.114	494.03	.00	.000
6.1	24108.	.000	84.02	1.68	.000
6.2	19804.	.000	315.13	1.92	.000
8.1	4366.	212.130	.00	.00	.000
9	63243.	-981.513	3157.65	71.80	1.417
10	160008.	.000	.00	.00	.000
11	3064.	69.044	487.87	.00	.000
38	1533.	.000	4616.05	.00	.000
39	817.	.000	269.11	.00	.000
1.4	12114.	485.996	14.40	.00	4503.740
31	-396322.	3871.997	.00	.00	.000
OTHERS	35821.	.000	.00	.00	.000
TOTAL	0.	3510.992	11394.97	278.97	4505.199

	STEAM, MLBS/HR					
PLANT NO.	900 PSIG 750 F	900 PSIG SATD	600 PSIG 720 F	600 PSIG SATD	150 PSIG SATD	50 PSIG SATD
1. -00	.0	.0	.0	.0	.0	.0
2	.0	.0	5.6	-149.1	-90.1	56.1
3	.0	.0	.0	396.6	.0	17.2
4	.0	.0	.0	26.6	.0	.0
5	.0	.0	.0	65.1	-33.9	.0
6.1	.0	.0	.0	.0	.0	4.0
6.2	.0	.0	.0	.0	.0	55.3
8.1	.0	.0	.0	.0	25.4	.0
9	.0	.0	.0	-292.0	-763.3	-781.7
10	.0	.0	.0	.0	.0	.0
11	.0	.0	.0	60.0	-186.7	54.5
38	.0	.0	.0	326.5	582.1	.0
39	.0	.0	.0	.0	22.8	61.8
1.4	.0	.0	.0	.0	.0	.0
31	.0	.0	-512.3	.0	381.6	436.5
OTHERS	.0	.0	73.0	.0	62.0	96.3
TOTAL	.0	.0	-433.8	433.8	.0	.0

POSITIVE VALUES DESIGNATE NET CONSUMPTION, AND NEGATIVE VALUES DESIGNATE NET PRODUCTION.
600 PSIG STEAM AT 720 F IS USED TO SATISFY THE 600 PSIG SATURATED STEAM DEMAND.

PLANT 38 - SUMMARY REPORT
AMMONIA RECOVERY PLANT

STREAM FLOW RATES, MLBS/HR

COMPONENT	FEED	NH3 PRODUCT	SOUR H2O
NH3	20.434	20.251	.183
H2O	1774.729	.091	1774.638
OTHERS	33.483	.000	33.483
TOTAL	1828.646	20.342	1808.304
TEMPERATURE, F	94.6	80.0	80.0
PRESSURE, PSIA	14.7	14.7	14.7

PLANT UTILITIES CONSUMPTIONS

POWER, KW	1533.
900 PSIG/750 F STEAM, MLBS/HR	.0
900 PSIG SATD STEAM, MLBS/HR	.0
600 PSIG/720 F STEAM, MLBS/HR	.0
600 PSIG SATD STEAM, MLBS/HR	326.5
150 PSIG SATD STEAM, MLBS/HR	582.1
50 PSIG SATD STEAM, MLBS/HR	.0
PLANT FUEL, MM BTUS/HR	.00
COOLING WATER, MGAL/HR	4616.05
PROCESS WATER, MGAL/HR	.00
NITROGEN, MM SCF/HR OF N2	.00
TOTAL PLANT OPERATORS/DAY	20.0

PLANT COSTING INFORMATION

TOTAL NUMBER OF DUPLICATE TRAINS	1
MAXIMUM SIZE, MLBS/HR OF NH3	100.000
MINIMUM SIZE, MLBS/HR OF NH3	5.000
CAPACITY, MLBS/HR OF NH3	20.251
PLANT ISBL FIELD COST, MM$	40.146

PLANT 39 - SUMMARY REPORT
PHENOL RECOVERY PLANT

STREAM FLOW RATES, MLBS/HR

COMPONENT	FEED	PHENOL PRODUCT	WASTE H2O
PHENOLS	2.482	2.408	.074
H2O	1263.689	.279	1263.410
OTHERS	.633	.000	.633
TOTAL	1266.804	2.686	1264.118
TEMPERATURE, F	90.0	80.0	80.0
PRESSURE, PSIA	25.0	14.7	14.7

PLANT UTILITIES CONSUMPTIONS

POWER, KW	817.
900 PSIG/750 F STEAM, MLBS/HR	.0
900 PSIG SATD STEAM, MLBS/HR	.0
600 PSIG/720 F STEAM, MLBS/HR	.0
600 PSIG SATD STEAM, MLBS/HR	.0
150 PSIG SATD STEAM, MLBS/HR	22.8
50 PSIG SATD STEAM, MLBS/HR	61.8
PLANT FUEL, MM BTUS/HR	.00
COOLING WATER, MGAL/HR	269.11
PROCESS WATER, MGAL/HR	.00
NITROGEN, MM SCF/HR OF N2	.00
TOTAL PLANT OPERATORS/DAY	.0

PLANT COSTING INFORMATION

TOTAL NUMBER OF DUPLICATE TRAINS	1
MAXIMUM SIZE, MLBS/HR OF PHENOL	20.000
MINIMUM SIZE, MLBS/HR OF PHENOL	1.000
CAPACITY, MLBS/HR OF PHENOL	2.408
PLANT ISBL FIELD COST, MM$	13.334

APPENDIX F

APPENDIX F

ASPEN/SP PROCESS SIMULATION MODEL

INPUT FILE FOR OPTION 1 --

LIQUEFACTION FEED COAL CLEANING BY HEAVY MEDIUM SEPARATION

ASPEN/SP PROCESS SIMULATION MODEL

INPUT FILE FOR OPTION 1 --

LIQUEFACTION FEED COAL CLEANING BY HEAVY MEDIUM SEPARATION

```
NEW
;
;   File: OPT1.INP
;
TITLE 'OPT1 - DIRECT COAL LIQUEFACTION - OPTION 1 - NTH PLANT'
;
DESCRIPTION &
  "ASPEN/SP INPUT FILE FOR SIMULATING OPTION 1, ONE OF THE TWO COAL
   CLEANING OPTIONS FOR THE DOE DIRECT COAL LIQUEFACTION BASELINE
   DESIGN AND SYSTEMS ANALYSIS PROJECT.  THIS FILE DOES THE NTH PLANT
   COST CALCULATIONS.  THIS INPUT FILE ALSO CAN BE USED TO RUN OPTION
   7 (NAPHTHA REFORMING), AND A MODIFIED VERSION OF OPTION 6 (STEAM
   REFORMING OF NATURAL GAS FOR HYDROGEN PRODUCTION WITH AN FBC
   UNIT)."
;
;  NOTES:
;  1.  The dry clean coal feed rate to the Plant 2 coal liquefaction
;      reactors is set in the design specification DES-SPEC COALFLO.
;  2.  The switches LOSBL and LPLANT contained in Fortran block SUMMARY
;      control the costing logic for OSBL and first or Nth plant.
;  3.  Option 1, coal cleaning for liquefaction by heavy medium
;      separation is activated by setting the fraction going to
;      stream 1S11 to 1.0 in the S1 Splitter block.  All other stream
;      fractions must be zero.
;  4.  Option 2, coal cleaning for liquefaction by spherical
;      agglomeration is activated by setting the fraction going to
;      stream 1S21 to 1.0 in the S1 Splitter block.  All other stream
;      fraction must be zero.
;  5.  Option 7 (naphtha reforming) is activated in Block S7 by
;      sending all the hydrotreated naphtha to Plant 7 rather than
;      to the product PNAHTHA.
;  6.  Modified Option 6 (hydrogen production by steam reforming of
;      natural gas with an FBC unit) is activated by variable N9 in
;      Fortran block OPTION6.  When N9 = 1, the modified Option 6 is
;      invoked.  This is a modified version in that cost parameters
;      for the coal cleaning plant, Plant 1, are based on sending
;      some jig cleaned coal to gasification for hydrogen production.
;      Thus, since no coal is being sent for gasification, the Plant 1
;      costs will be over-estimated.
;  7.  The costing logic is controlled by switches in Fortran block
;      SUMMARY.
;
;   Last revision - July 17, 1992.
;
;   Prepared under DOE contract no. DE-AC22 90PC89857.
;
IN-UNITS  ENG
```

```
OUT-UNITS ENG
HISTORY-UNITS ENG
RUN-CONTROL MAX-ERRORS=100
;
;  The following two lines are used with V8.0 to produce the overall
;  and block elemental balances.
;REPORT ATOMBAL
;BLOCK-REPORT ATOMBAL
;
HISTORY  MSG-LEVEL  PROPERTIES=2
  MAX-PRINT  PROPERTIES=100  SIMULATION=2000
;
PROPERTIES SYSOP2 GLOBAL
;
PSEUDO-COMPS
  METHOD METCCOAL -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 &
                  -1 -1 -1 -1 -1 -1 -1
;  The following APIs and MWs are revised from the ASPEN/SP predictions.
;  Component T1000+ is the 1000+ F material leaving the second coal
;    liquefaction reactor in Plant 2.
;  Component I1000+ is the 1000+ F intermediate material leaving the
;    first coal liquefaction reactor in Plant 2.
   COMPONENT T125    TBP=324.82 <K>  API=67.91  MW= 82.27
   COMPONENT T175    TBP=352.59 <K>  API=61.99  MW= 92.77
   COMPONENT T225    TBP=380.37 <K>  API=56.21  MW=102.84
   COMPONENT T275    TBP=408.15 <K>  API=50.60  MW=112.50
   COMPONENT T325    TBP=435.93 <K>  API=45.18  MW=121.82
   COMPONENT T375    TBP=463.71 <K>  API=39.96  MW=130.86
   COMPONENT T425    TBP=491.48 <K>  API=34.96  MW=139.75
   COMPONENT T475    TBP=519.26 <K>  API=30.19  MW=148.60
   COMPONENT T525    TBP=547.04 <K>  API=25.66  MW=157.54
   COMPONENT T575    TBP=574.82 <K>  API=21.39  MW=166.69
   COMPONENT T625    TBP=602.59 <K>  API=17.38  MW=176.16
   COMPONENT T675    TBP=630.37 <K>  API=13.66  MW=186.05
   COMPONENT T725    TBP=658.15 <K>  API=10.23  MW=196.44
   COMPONENT T775    TBP=685.93 <K>  API= 7.09  MW=207.37
   COMPONENT T825    TBP=713.71 <K>  API= 4.27  MW=218.85
   COMPONENT T875    TBP=741.48 <K>  API= 1.78  MW=230.87
   COMPONENT T925    TBP=769.26 <K>  API=-0.39  MW=243.37
   COMPONENT T975    TBP=797.04 <K>  API=-2.22  MW=256.24
   COMPONENT T1000+  TBP=824.82 <K>  API=-3.69  MW=269.33
   COMPONENT P125    TBP=324.82 <K>  API=67.91  MW= 82.27
   COMPONENT P175    TBP=352.59 <K>  API=61.99  MW= 92.77
   COMPONENT P225    TBP=380.37 <K>  API=56.21  MW=102.84
   COMPONENT P275    TBP=408.15 <K>  API=50.60  MW=112.50
   COMPONENT P325    TBP=435.93 <K>  API=45.18  MW=121.82
   COMPONENT P375    TBP=463.71 <K>  API=39.96  MW=130.86
   COMPONENT P425    TBP=491.48 <K>  API=34.96  MW=139.75
   COMPONENT P475    TBP=519.26 <K>  API=30.19  MW=148.60
   COMPONENT P525    TBP=547.04 <K>  API=25.66  MW=157.54
   COMPONENT P575    TBP=574.82 <K>  API=21.39  MW=166.69
   COMPONENT P625    TBP=602.59 <K>  API=17.38  MW=176.16
   COMPONENT P675    TBP=630.37 <K>  API=13.66  MW=186.05
   COMPONENT P725    TBP=658.15 <K>  API=10.23  MW=196.44
   COMPONENT P775    TBP=685.93 <K>  API= 7.09  MW=207.37
```

```
   COMPONENT P825    TBP=713.71 <K>  API= 4.27  MW=218.85
   COMPONENT P875    TBP=741.48 <K>  API= 1.78  MW=230.87
   COMPONENT P925    TBP=769.26 <K>  API=-0.39  MW=243.37
   COMPONENT P975    TBP=797.04 <K>  API=-2.22  MW=256.24
   COMPONENT P1000+ TBP=824.82 <K>  API=-3.69  MW=269.33
   COMPONENT I1000+ TBP=825.00 <K>  API=-4.00  MW=275.00
   COMPONENT REFORMAT TBP=390.00 <K>  API=38.25  MW=100.00
;
COMPONENTS H2 H2 / N2 N2 / O2 O2 / H2S H2S / CO CO / CO2 CO2 / NH3 H3N /
           L-SULFUR SULFUR / H2O H2O / HCL HCL / COS COS / CH4 CH4 /
           C2H6 C2H6 / C3H8 C3H8 / IC4H10 C4H10-2 / NC4H10 C4H10-1 /
           IC5H12 C5H12-2 / NC5H12 C5H12-1 /
;  Pseudocomponents
           T125 / T175 / T225 / T275 / T325 / T375 / T425 / T475 /
           T525 / T575 / T625 / T675 / T725 / T775 / T825 / T875 /
           T925 / T975 / T1000+ /
           P125 / P175 / P225 / P275 / P325 / P375 / P425 / P475 /
           P525 / P575 / P625 / P675 / P725 / P775 / P825 / P875 /
           P925 / P975 / P1000+ / I1000+ / REFORMAT /
;  Non-conventional components
            COAL / URCOAL / SLAG
;
FORMULA    H2 H2 / N2 N2 / O2 O2 / H2S H2S / CO CO / CO2 CO2 / NH3 H3N /
           L-SULFUR S / H2O H2O / HCL HCL / COS COS / CH4 CH4 /
           C2H6 C2H6 / C3H8 C3H8 / NC4H10 C4H10 / IC4H10 C4H10 /
           NC5H12 C5H12 / IC5H12 C5H12
;
;  Load the liquid sulfur (L-SULFUR) physical properties as taken from
;  DIPPR - MW adjusted to be consistent with ASPEN.
PROP-DATA  IN-UNITS SI
  PROP-LIST        MW     /   TC    /     PC     /    VC    /   ZC
  PVAL L-SULFUR   32.06  / 1313.0 / 1.8208E+7 / 0.15800 / 0.2640
  PROP-LIST       MUP    /  OMEGA /    TB     /   RGYR
  PVAL L-SULFUR   0.0    / 0.2624 /  717.82   /   0.0
  PROP-LIST         DELTA   /  DGFORM   /  DHFORM
  PVAL L-SULFUR   2.0245E+4 / 2.3825E+8 / 2.7880E+8
  PROP-LIST       CPIG
  PVAL L-SULFUR   2.5639E+4  -7.9870  4.7860E-3  -9.5700E-7  0.0  0.0  &
                  273.15  1500.0  0.0  87.113  1.0
;
; Load the solubility parameter for COS from the API Tech Data Book.
  PROP-LIST       DELTA
  PVAL COS        18179.0
;
;  Reset some component molecular weights to be consisitent with the
;  following elemental atomic weights, where needed.
;  H=1.0079, C=12.011, O=15.9994, N=14.0067, S=32.06 & Cl=35.453
  PROP-LIST       MW
  PVAL H2          2.0158
  PVAL N2         28.0134
  PVAL O2         31.9988
  PVAL H2S        34.0758
  PVAL CO         28.0104
  PVAL CO2        44.0098
  PVAL NH3        17.0304
```

```
   PVAL H2O        18.0152
   PVAL HCl        36.4609
   PVAL COS        60.0704
   PVAL CH4        16.0426
   PVAL C2H6       30.0694
   PVAL C3H8       44.0962
   PVAL IC4H10     58.1230
   PVAL NC4H10     58.1230
   PVAL IC5H12     72.1498
   PVAL NC5H12     72.1498
 ;
 ;  Set the specific gravities of H2, CO, CO2, NH3, H2S, N2 and COS to
 ;  the values given in the API Technical Data Book - Petroleum Refining.
   PROP-LIST        SPGR
   PVAL H2         0.3000
   PVAL CO         0.3000
   PVAL CO2        0.8180
   PVAL NH3        0.6162
   PVAL H2S        0.8014
   PVAL N2         0.8094
   PVAL COS        1.0200
 ;
ATTR-COMPS COAL   PROXANAL ULTANAL SULFANAL AOXANAL
ATTR-COMPS URCOAL PROXANAL ULTANAL SULFANAL AOXANAL
ATTR-COMPS SLAG   PROXANAL ULTANAL SULFANAL AOXANAL
;
NC-PROPS    COAL ENTHALPY  HCOALGEN /
                 DENSITY   DCOALIGT
NC-PROPS  URCOAL ENTHALPY  HCOALGEN /
                 DENSITY   DCHARIGT
NC-PROPS    SLAG ENTHALPY  HCOALGEN /
                 DENSITY   DCHARIGT
;
DEF-STREAMS MIXNC ALL
;
;  Set an initial GUESS for the ROM COAL stream to Plant 1.
STREAM ROMCOAL
   SUBSTREAM MIXED TEMP = 71.0  PRES = 14.7
     MASS-FLOW  H2O 24798.0
   SUBSTREAM NC TEMP = 71.0  PRES = 14.7
     MASS-FLOW  COAL 285035.0 / URCOAL 0.0 / SLAG 0.0
     COMP-ATTR COAL   PROXANAL (0.0 42.06 36.24 21.70) /
                      ULTANAL (21.7 61.1 4.2 1.2 0.1 5.1 6.6) /
                      SULFANAL (3.0 0.3 1.8) /
                      AOXANAL (43.8 17.1 24.1 0.8 0.1 5.6 1.0 0.6 2.1 4.1)
;  Fake the URCOAL properties.
     COMP-ATTR URCOAL PROXANAL (0.0 19.197 16.549 64.254) /
                      ULTANAL (64.254 29.914 0.185 1.304 0.0 4.267 0.076) /
                      SULFANAL (2.507 0.253 1.507) /
                      AOXANAL (43.8 17.1 24.1 0.8 0.1 5.6 1.0 0.6 2.1 4.1)
;  Fake the SLAG properties.
     COMP-ATTR SLAG   PROXANAL (0.0 10.0 0.0 90.0) /
                      ULTANAL (90.0 10.0 0.0 0.0 0.0 0.0 0.0 ) /
                      SULFANAL (0.0 0.0 0.0) /
                      AOXANAL (42.0 17.0 23.0 1.0 1.0 6.0 2.0 1.0 3.0 4.0)
```

```
;
;  Set an initial GUESS for the fresh make-up H2 stream to Plant 2.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 2-H2IN
   SUBSTREAM MIXED TEMP = 100.0  PRES = 3440.0
     MASS-FLOW  H2 70300.0 / N2 980.0
;
;  Set an initial GUESS for the total water feed streams (both steam
;  and wash water) to Plant 2.
STREAM 2-H2OIN
   SUBSTREAM MIXED TEMP = 126.0  PRES = 3200.0
     MASS-FLOW  H2O 1073000.0
;
;  Set an initial GUESS for the ROSE EXTRACT stream to Plant 2.
STREAM ROSE-XTR
   SUBSTREAM MIXED TEMP = 300.0  PRES = 3215.0
     MASS-FLOW  T675 95.0 / T725 95.0 / T775 95.0 /
       T825 95.0 / T875 588.335 / T925 588.335 /
       T975 588.355 /  T1000+ 536585.0
;
;  Set an initial GUESS for the SOLVENT stream to Plant 2.  The user
;  Fortran block model for Plant 2 does not require any solvent, but
;  the input stream is required.  Thus, set a small H2O flow to avoid
;  ASPEN warnings.
STREAM SOLVENT
   SUBSTREAM MIXED TEMP = 500.0  PRES = 500.0
     MASS-FLOW  H2O 1.0
;
;  Set an initial GUESS for the 2S-BOTTS stream leaving Plant 2.
STREAM 2S-BOTTS
   SUBSTREAM MIXED TEMP = 688.0  PRES = 28.0
     MASS-FLOW  H2O 0.0 /
       T825 380.0 / T875 3365.0 /
       T925 3365.0 / T975 3365.0 / T1000+ 642440.0
   SUBSTREAM NC TEMP = 688.0  PRES = 28.0
     MASS-FLOW  COAL 0.0 / URCOAL 254475.0
;
;  Set an initial GUESS for the H2 stream to Plant 4.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 4-H2IN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 500.0
     MASS-FLOW  H2 1400.0 / N2 19.0
;
;  Set an initial GUESS for the H2O stream to Plant 4.
STREAM 4-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 50.0
     MASS-FLOW  H2O 18770.
;
;  Set an initial GUESS for the H2 stream to Plant 5.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 5-H2IN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 500.0
     MASS-FLOW  H2 17000.0 / N2 279.0
;
;  Set an initial GUESS for the H2O stream to Plant 5.
```

```
STREAM 5-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 50.0
     MASS-FLOW  H2O 36382.0
;
;  Set an initial GUESS for the pseudo sour H2O from Plant 6.
STREAM 6S-SH2O
   SUBSTREAM MIXED TEMP = 60.0  PRES = 14.7
     MASS-FLOW  NH3 2830.0
;
;  Set an initial GUESS for the H2O stream to Plant 9.0.
STREAM 9-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 14.7
     MASS-FLOW  H2O 967545.0
;
;  Set an initial GUESS for the STEAM stream to Plant 9.0.
STREAM 9-STEMIN
   SUBSTREAM MIXED TEMP = 450.0  PRES = 500.0
     MASS-FLOW  H2O 167545.0
;
;  Set an initial GUESS for the OXYGEN stream to Plant 9.0.
STREAM 9-O2IN
   SUBSTREAM MIXED TEMP = 80.0  PRES = 300.0
     MASS-FLOW  O2 743531.0 / N2 3269.0
;
;  Set an initial GUESS for the AIR stream to Plant 10.
STREAM 10-AIRIN   TEMP = 70.0  PRES = 14.7
     MASS-FLOW  O2 743531.0 / N2 2463614.0
;
;  Set an initial GUESS for the natural-gas stream to Plant 9.1.
STREAM NAT-GAS
   SUBSTREAM MIXED TEMP = 70.0  PRES = 100.0
     MASS-FLOW  CH4 307352
;
;  Set an initial GUESS for the STEAM stream to Plant 9.1.
STREAM STEAM
   SUBSTREAM MIXED TEMP = 620.0  PRES = 500.0
     MASS-FLOW  H2O 864428.
;
; Model Connectivity
; ------------------
;
FLOWSHEET COAL
; Plant M1 is the clean coal outlet streams mixer.
;   Stream 1S-CCOAL is the cleaned coal product stream going to
;     liquefaction after drying in Plant 1.4
; Plant M2 is the middling coal outlet streams mixer.
;   Stream 1S-XMID  is the combined outlet middling coal product stream.
; Plant M-2HYD is the mixer to combine H2 streams for Plant 2.
;   Stream 2-H2MIX  is the combined H2 stream from 6.1, 6.2, & source.
; Plant M3 is the refuse outlet streams mixer.
;   Stream 1S-REFSE is the combined outlet refuse product stream.
; Plant M38 is the sour water mixer.
;   Stream 38-FEED  is the combined sour water streams to Plant 38.
; Plant M4 is the waste water outlet streams mixer.
;   Stream 1S-WATER is the combined outlet waste water product stream.
```

```
; Plant M-462 is the mixer to combine H2 streams for Plant 6.2.
;   Stream 62-HYD   is the combined H2 stream from Plants 2 & 4.
; Plant M-561 is the mixer to combine H2 streams for Plant 6.1.
;   Stream 61-HYD   is the combined H2 stream from Plants 2 & 5.
; Plant M-6GAS is the heater to combine sour gas streams for Plant 11.
;   Stream 6-SGAS   is the combined sour gas stream from Plants 6.1 & 6.2.
; Plant M-73 is the mixer to combine H2 gas streams for Plant 3.
;   Stream 3-GAS    is the combined H2 gas stream from Plant 3.
; Plant M-HYD is the mixer (flash2) to combine H2 streams for M-2HYD.
;   Stream H2MIX    is the combined H2 stream from Plants 6.1 & 6.2.
;   Stream DUMMY    is the dummy vapor stream that contains no flow.
; Plant M-NAP is the mixer to combine naphtha streams for Plant 4.
;   Stream 4-FEED   is the combined naphtha stream from Plants 2 & 6.2.
; Plant M-PNAP is the mixer to combine product naphtha streams.
;   Stream PS-NAPH is the combined naphtha stream from Plants 4 & 5.
; Plant P1-ALT1 is the Coal Cleaning and Preparation Plant - ALT CASE 1.
;   Stream 1S12     is the outlet clean coal product stream.
;   Stream 1S13     is the outlet middling coal product stream.
;   Stream 1S14     is the outlet refuse product stream.
;   Stream 1S15     is the outlet waste water product stream.
; Plant P1-ALT2 is the Coal Cleaning and Preparation Plant - ALT CASE 2.
;   Stream 1S22     is the outlet clean coal product stream.
;   Stream 1S23     is the outlet middling coal product stream.
;   Stream 1S24     is the outlet refuse product stream.
;   Stream 1S25     is the outlet waste water product stream.
; Plant P1-BASE is the Coal Cleaning and Preparation Plant - BASE CASE.
;   Stream 1S02     is the outlet clean coal product stream.
;   Stream 1S03     is the outlet middling coal product stream.
;   Stream 1S04     is the outlet refuse product stream.
;   Stream 1S05     is the outlet waste water product stream.
; Plant P1-JIGS is part of the Coal Cleaning and Preparation Plant
;   that only cleans the coal going to gasification for H2 production.
;   Stream COALTO9  is the outlet clean coal product stream.
;   Stream 1S33     is the outlet middling coal product stream.
;   Stream 1S34     is the outlet refuse product stream.
;   Stream 1S35     is the outlet waste water product stream.
; Plant P14 is the Coal Grinding and Drying Plant.
;   Stream COALTO2  is the outlet clean coal product stream.
;   Stream 14S-XMID is the outlet middling coal product stream.
;   Stream 14S-REF  is the outlet refuse product stream.
;   Stream 14S-WAT  is the outlet waste water product stream.
; Plant P02 is the Coal Liquefaction Plant.
;   Stream 2-H2MIX  is the hydrogen feed stream.
;   Stream COALTO2  is the clean coal feed stream.
;   Stream SOLVENT  is the solvent feed stream.  This stream is used to
;     supply the steam required to Plant 2.
;   Stream ROSE-XTR is the deashed product stream.
;   Stream 2-H2OIN  is the water feed stream to the liquefaction unit.
;   Stream 2S-GAS   is the HP gas product stream going to Plant 6.1.
;   Stream GASES    is the LP gas product stream going to Plant 6.2.
;   Stream NAPHTHA  is the naphtha product stream.
;   Stream GAS-OIL  is the gas-oil product stream going to Plant 5.
;   Stream 2S-BOTTS is the bottoms stream going to Plant 8.1.
;   Stream 2S-SH2O  is the sour water product stream.
; Plant P03 is the Gas Plant.
```

```
;   Stream 3S-SGAS  is the sour off-gas product stream.
;   Stream 3S-FGAS  is the fuel gas product stream.
;   Stream 3S-PROP  is the C3 product stream.
;   Stream 3S-BUT   is the C4s product stream.
;   Stream 3S-OIL   is the lean-oil product stream to M-NAP.
;   Stream 3S-SH2O  is the product sour water stream.
; Plant P04 is the simplified model for plant 4, the naphtha hydrotreater.
;   Stream 4-H2IN   is the hydrogen feed stream.
;   Stream 4-H2OIN  is the water feed stream.
;   Stream 4S-GAS   is the hydrotreater off-gas product stream.
;   Stream 4S-NAPH  is the hydrotreated naphtha product stream.
;   Stream 4S-SH2O  is the hydrotreater sour water stream.
; Plant P05 is the simplified model for plant 5, the gas-oil hydrotreater.
;   Stream 5-H2IN   is the hydrogen feed stream.
;   Stream 5-H2OIN  is the water feed stream.
;   Stream 5S-HPGAS is the hydrotreater hi-pressure purge gas stream.
;   Stream 5S-LPGAS is the hydrotreater other gases stream.
;   Stream 5S-NAPH  is the hydrotreated C6-350 F naphtha product stream.
;   Stream P350-450 is the hydrotreated 350 - 450 F product stream.
;   Stream P450-650 is the hydrotreated 450 - 650 F product stream.
;   Stream P650-850 is the hydrotreated 650 - 850 F product stream.
;   Stream 5S-SH2O  is the hydrotreater sour water stream.
; Plant P61 is the model for the Hydrogen purification by Membrane
;     Separation Plant, Plant 6.1.
;   Stream 61-HYD   is the feed stream to the H2 purification plant.
;   Stream H2-RICH  is the purified H2-rich product gas stream.
;   Stream SOUR-GAS is the sour gas product stream.
;   Stream P61-GAS  is the reject (non-permeate) product gas stream.
; Plant P62 is the model for the Hydrogen purification by Pressure
;     Swing absorption Plant, Plant 6.2.
;   Stream 62-HYD   is the mixed gas feed stream to the PSA hydrogen
;     purification plant.
;   Stream P61-GAS  is the reject gas stream from Plant 6.1, the high
;     pressure section of Plant 6, the hydrogen purification by
;     membrane permeation section.
;   Stream H2-2RICH is the purified h2-rich product gas stream.
;   Stream SOUR-2GS is the sour gas product stream.
;   Stream GAS-OUT  is the reject product gas stream.
;   Stream NAPHTHA2 is the liquid raw naphtha product stream.
; Plant P07 is the simplified model for Plant 7, the naphtha reformer.
;   Stream 7-NAPH   is the naphtha feed stream.
;   Stream 7S-H2    is the hydrogen rich product gas stream.
;   Stream 7S-GAS   is the light hydrocarbon product gas stream.
;   Stream REFORMED is the reformate product stream.
; Plant P81 is the model for the ROSE-SR Critical Solvent Deashing unit.
;   Stream ROSE-XTR is the deashed product stream.
;   Stream ASH-CONC is the ash concentrate stream.
; Plant P11 is the Sulfur plant.
;   Stream 11S-LIQS is the sulfur product stream.
;   Stream 11S-FGAS contains all the other material in the feed that
;     does not leave in the product SULFUR STREAM.
; Plant P31 is the simplified model for the utility plant.
;   Stream 31S-01   is the dummy product stream.
; Plant P314 is the model for the Fluidized Bed Combustor and the
;  Steam Turbine Generator unit.
```

```
;   Stream FBC-FEED is the feed stream to Plant P314.
;   Stream SA6-01   is the combined product stream out of Plant P314.
; Plant P38 is the NH3 recovery plant.
;   Stream NH3-PROD is the product NH3.
;   Stream 38S-OUT  is the reject stream.
; Plant P38A is the reject stream component splitter from plant 38.
;   Stream 38AS-VAP is the vapor stream going to Plant 11.
;   Stream 38AS-LIQ is the liquid stream going to Plant 38B.
; Plant P38B is the liquid reject stream splitter from Plant 38A.
;   Stream WASTE    is the reject portion of the inlet stream which
;     in this model is rejected, but actually goes to the coal
;     gasification plant, if present.
;   Stream 39FEED   is the stream going on to Plant 39.
; Plant P39 is the phenol recovery plant.
;   Stream PHENOL   is the phenol product stream.
;   Stream WASTEH2O is the waste water stream.
; Plant SA6 is the product stream separator from Plant P314.
;   Stream FBC-GAS  is the gas product stream from Plant SA6.
;   Stream FBC-SOL  is the solids product stream from Plant SA6.
; Block S1 is the inlet coal splitter.
;   Stream ROMCOAL  is the inlet ROM coal stream.
;   Stream 1S01     is the splitter outlet to the base case plant.
;   Stream 1S11     is the splitter outlet to the alternate case 1 plant.
;   Stream 1S21     is the splitter outlet to the alternate case 2 plant.
; Block S6-SH2O is a component splitter to generate a pseudo sour-water
;   stream from Plant 6 to get the NH3 to Plant 38, the Ammonia Recovery
;   Plant.
;   Stream 6S-SH2O  is the pseudo sour-water stream.
;   Stream 11-FEED  is the Plant 11 feed stream.
; Block S7 is the product naphtha splitter.
;   Stream PS-NAPH  is the inlet product naphtha stream.
;   Stream 7-NAPH   is the splitter outlet to the naphtha reformer plant.
;   Stream PNAPHTHA is the splitter outlet as product naphtha.
; Block S8 is the ash-concentrate splitter.
;   Stream ASH-CONC is the inlet ash-concentrate stream from the ROSE.
;   Stream FBC-FEED is the splitter outlet to the FBC plant.
;   Stream S8-ASHC  is the splitter outlet to the M9C coal mixer.
;
 M1        IN = 1S02 1S12 1S22        OUT = 1S-CCOAL
 M2        IN = 1S03 1S13 1S23 1S33   OUT = 1S-XMID
 M-2HYD    IN = H2MIX 2-H2IN          OUT = 2-H2MIX
 M3        IN = 1S04 1S14 1S24 1S34   OUT = 1S-REFSE
 M38       IN = 2S-SH2O 3S-SH2O 4S-SH2O 5S-SH2O 6S-SH2O 9S-SH2O     &
             OUT = 38-FEED
 M4        IN = 1S05 1S15 1S25 1S35   OUT = 1S-WATER
 M-462     IN = 4S-GAS GASES 5S-LPGAS 3S-SGAS 7S-H2     OUT = 62-HYD
 M-561     IN = 5S-HPGAS 2S-GAS  OUT = 61-HYD
 M-6GAS    IN = SOUR-GAS SOUR-2GS H2S-GAS 38AS-VAP      OUT = 6-SGAS
 M-73      IN = GAS-OUT 7S-GAS   OUT = 3-GAS
 M-HYD     IN = H2-RICH H2-2RICH OUT = H2MIX DUMMY
 M-NAP     IN = NAPHTHA2 3S-OIL  OUT = 4-FEED
 M-PNAP    IN = 4S-NAPH 5S-NAPH  OUT = PS-NAPH
 P1-ALT1   IN = 1S11             OUT = 1S12 1S13 1S14 1S15
 P1-ALT2   IN = 1S21             OUT = 1S22 1S23 1S24 1S25
 P1-BASE   IN = 1S01             OUT = 1S02 1S03 1S04 1S05
```

```
  P1-JIGS  IN = ROMCOAL2          OUT = COALTO9 1S33 1S34 1S35
  P14      IN = 1S-CCOAL          OUT = COALTO2 14S-XMID 14S-REF 14S-WAT
  P02      IN = 2-H2MIX COALTO2 SOLVENT ROSE-XTR 2-H2OIN                &
              OUT = 2S-GAS GASES NAPHTHA GAS-OIL 2S-BOTTS 2S-SH2O
  P03      IN = NAPHTHA 3-GAS                                           &
              OUT = 3S-SGAS 3S-FGAS 3S-PROP 3S-BUT 3S-OIL 3S-SH2O
  P04      IN = 4-H2IN 4-FEED 4-H2OIN                                   &
              OUT = 4S-GAS 4S-NAPH 4S-SH2O
  P05      IN = 5-H2IN GAS-OIL 5-H2OIN                                  &
              OUT = 5S-HPGAS 5S-LPGAS 5S-NAPH P350-450 P450-650        &
                    P650-850 5S-SH2O
  P61      IN = 61-HYD            OUT = H2-RICH SOUR-GAS P61-GAS
  P62      IN = 62-HYD P61-GAS                                          &
              OUT = H2-2RICH SOUR-2GS GAS-OUT NAPHTHA2
  P07      IN = 7-NAPH            OUT = 7S-H2 7S-GAS REFORMED
  P81      IN = 2S-BOTTS          OUT = ROSE-XTR ASH-CONC
  P11      IN = 11-FEED           OUT = 11S-FGAS 11S-LIQS
  P31      IN = 3S-FGAS           OUT = 31S-01
  P314     IN = FBC-FEED          OUT = SA6-01
  P38      IN = 38-FEED           OUT = NH3-PROD 38S-OUT
  P38A     IN = 38S-OUT           OUT = 38AS-VAP 38AS-LIQ
  P38B     IN = 38AS-LIQ          OUT = WASTE 39FEED
  P39      IN = 39FEED            OUT = PHENOL WASTEH2O
  SA6      IN = SA6-01            OUT = FBC-SOL FBC-GAS
  S1       IN = ROMCOAL           OUT = 1S01 1S11 1S21
  S6-SH2O  IN = 6-SGAS            OUT = 6S-SH2O 11-FEED
  S7       IN = PS-NAPH           OUT = 7-NAPH PNAPHTHA
  S8       IN = ASH-CONC          OUT = FBC-FEED S8-ASHC
;
FLOWSHEET HYDROGEN
; Plant M9 is the hydrogen stream mixer.
;   Stream M9H2     is the dummy H2 stream to the liquefaction unit.
;   Stream M9H4     is the dummy H2 stream to the naphtha hydrotreater.
;   Stream M9H5     is the dummy H2 stream to the gas-oil hydrotreater.
;   Stream HHNEED   is the dummy H2 stream from the mixer.
; Plant M9C is the coal stream mixer.
;   Stream COALTO9  is the clean coal stream to the mixer.
;   Stream S8-ASHC  is the ash concentrate stream from the ROSE unit.
;   Stream 9-FEED   is the mixed coal stream to the gasifier.
; Plant P09 is the plant for producing hydrogen by coal gasification.
;   Stream 9-H2OIN  is the water feed stream to the gasifier section.
;   Stream 9-O2IN   is the purified O2 stream from the air sep. plant.
;   Stream 9-STEMIN is the steam that goes to the shift reactors.
;   Stream H2-GAS   is the product hydrogen stream.
;   Stream H2S-GAS  is the product hydrogen sulfide stream.
;   Stream VENT-GAS is the product vent gas stream.
;   Stream 9S-SH2O  is the product sour water stream.
;   Stream SLAG     is the product slag stream.
; Plant P91 is the Steam Reforming of Natural Gas Plant.
;   Stream NAT-GAS  is the inlet natural gas stream.
;   Stream STEAM    is the inlet process water stream.
;   Stream H2-PROD  is the product hydrogen stream.
;   Stream FLUE-GAS is the product flue gas stream.
; Plant P10 is the Air Separation Plant.
;   Stream 10-AIRIN is the air input stream.
```

```
;   Stream 10S01    is the product oxygen stream.
;   Stream 10S02    is the product nitrogen stream.
; Plant S9 is the hydrogen stream splitter.
;   Stream H9NEED   is the dummy H2 stream for the gasifier.
;   Stream H91NEED  is the dummy H2 stream for the steam reformer.
;
  M9H       IN = M9H2 M9H4 M9H5    OUT = MHNEED
  M9C       IN = S8-ASHC COALT09   OUT = 9-FEED
  P09       IN = 9-FEED 9-H2OIN 9-O2IN 9-STEMIN        &
              OUT = H2-GAS H2S-GAS VENT-GAS 9S-SH2O SLAG
  P91       IN = NAT-GAS STEAM     OUT = H2-PROD FLUE-GAS
  P10       IN = 10-AIRIN          OUT = 10S01  10S02
  S9        IN = MHNEED            OUT = H9NEED H91NEED
;
; Design Specifications
; ---------------------
;
;  Design spec to set the hydrogen flow rate to Plant 2 (2-H2MIX)
;  to a specified weight percent (HPCT2) of the MAF coal input stream.
DES-SPEC 2H2FLO
   DEFINE CHP2   MASS-FLOW  STREAM=2-H2MIX  COMPONENT=H2
   DEFINE CCOAL  MASS-FLOW  STREAM=COALTO2  SUBSTREAM=NC COMPONENT=COAL
   DEFINE CCASH  COMP-ATTR-VAR STREAM=COALTO2  SUBSTREAM=NC &
                   COMPONENT=COAL ATTRIBUTE=ULTANAL ELEMENT=1
C     Set the specified H2 rate to Plant 2 in wt% in the following line.
F     HPCT2 = 7.9205D0
C     DAFCOAL is the dry ash-free coal (MAF coal).
F     DAFCOAL = CCOAL * (100.0D0 - CCASH) * 0.01D0
F     H2P2 = 0.01D0 * HPCT2 * DAFCOAL
   SPEC CHP2 TO H2P2
   TOL-SPEC 0.1
   VARY STREAM-VAR  STREAM=2-H2IN  VARIABLE=MASS-FLOW
   LIMITS 100 1000000
;
;  Design spec to set the correct ROM coal flow to the splitter to
;  obtain the desired 17,102 TPSD of MF coal flow rate to the coal
;  liquefaction plant, Plant 2.
DES-SPEC COALFLO
   DEFINE CTARG  MASS-FLOW  STREAM=COALTO2   SUBSTREAM=NC  COMPONENT=COAL
;  Set TPD to the target coal rate to Plant 2 in TPSD of MF coal.
;  ==============================================================
;
F     TPD = 16565.0D0
F     WTPHR = (TPD * 2000.0D0) / 24.0D0
   SPEC CTARG TO WTPHR
   TOL-SPEC 0.1
   VARY MASS-FLOW  STREAM=ROMCOAL  SUBSTREAM=NC  COMPONENT=COAL
   LIMITS 100 10000000
;
;  Design spec to set the correct dry ROMCOAL2 flow rate to the P1-JIGS
;  and Plant 9, the coal cleaning for gasification plant and the coal
;  coal gasifier, to obtain the desired hydrogen production rate.
DES-SPEC H2FLO
   DEFINE HOUT   MASS-FLOW   STREAM=H2-GAS   COMPONENT=H2
   DEFINE HTOT   MASS-FLOW   STREAM=H9NEED   COMPONENT=H2
```

```
    SPEC HOUT TO HTOT
    TOL-SPEC 1.0
    VARY STREAM-VAR STREAM=ROMCOAL2  SUBSTREAM=NC  VAR=MASS-FLOW
    LIMITS 0.1 10000000
;
;  Design spec to set the heat duty to block M-HYD to zero by
;  varying the temperature. This corrects a temperature calculating
;  error in the ASPEN mixer block algorithm.
DES-SPEC HD-HYD
    DEFINE HDTY BLOCK-VAR BLOCK=M-HYD SENTENCE=RETENTION VARIABLE=HEAT-DUTY
    SPEC HDTY TO 0.0
    TOL-SPEC 1000
    VARY BLOCK-VAR BLOCK=M-HYD SENTENCE=PARAM VARIABLE=TEMPERATURE
    LIMITS 10 500
;
;  Design spec to set the 10-AIRIN stream flow to produce the required
;  amount of oxygen product required by Plant 9, coal gasification.
DES-SPEC O2FLO
 DEFINE FLO10S STREAM-VAR STREAM=10S01    VAR=MASS-FLOW
 DEFINE FLOOXY STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
    SPEC FLO10S TO FLOOXY
    TOL-SPEC 0.1
    VARY STREAM-VAR  STREAM=10-AIRIN  VARIABLE=MASS-FLOW
    LIMITS 0.1 10000000
;
;  Design spec to set the hydrogen flow rate for Plant 9.1.
DES-SPEC RFMRFLO
    DEFINE HOUT2  MASS-FLOW   STREAM=H2-PROD  COMPONENT=H2
    DEFINE HTOT2  MASS-FLOW   STREAM=H91NEED  COMPONENT=H2
    SPEC HOUT2 TO HTOT2
    TOL-SPEC 0.1
    VARY STREAM-VAR  STREAM=NAT-GAS  VARIABLE=MASS-FLOW
    LIMITS 1000 600000
;
; Transfer Blocks
; ---------------
;
;  Transfer block to set ROMCOAL2equal to the ROMCOAL stream (the wet
;  clean coal input).  This duplicates the full property set and
;  provides the initial guess flow rate for ROMCOAL2.
TRANSFER RCOAL
    SET STREAM ROMCOAL2
    EQUAL-TO STREAM ROMCOAL
;
;  Transfer block used to set the hydrogen flow rates of the input
;  streams to the calculated hydrogen flows to Plant 2 (2-H2IN),
;  Plant 4 (4-H2IN), and Plant 5 (5-H2IN).  M9's represent hydrogen
;  flows from Plant 9.0/10 and M91's are for the Plant 9.1 alternative.
TRANSFER HFLOW
    SET STREAM M9H2
    EQUAL-TO STREAM 2-H2IN
    SET STREAM M9H4
    EQUAL-TO STREAM 4-H2IN
    SET STREAM M9H5
    EQUAL-TO STREAM 5-H2IN
```

```
;
; Fortran Blocks
; --------------
;
;  This FORTRAN block will calculate the initial ratio of the MIXED
;  substream flow to the NC substream flow in the stream ROMCOAL.
;  It will store this result in RATIO, and use that value to adjust
;  the MIXED substream flow in proportion to the NC substream flow
;  that is varied by the COALFLO design-spec.  This is needed to set
;  the correct amount of water entering with the ROM coal.
FORTRAN MIXFLO
F     COMMON /RATIO/ RMIXNCP, RMIXN2
F     COMMON /RGLOB/ RDUM1, RMIN
 DEFINE FLONCP SUBSTREAM-VAR STREAM=ROMCOAL SUBSTREAM=NC VAR=MASSFLOW
 DEFINE FLOMIX SUBSTREAM-VAR STREAM=ROMCOAL SUBSTREAM=MIXED VAR=MASSFLOW
C  The following should only be true on the first pass.  This prevents
C  writing over the initial substream ratio on subsequent passes.
F     IF (RMIXNCP .LT. RMIN) THEN
F        RMIXNCP = FLONCP / FLOMIX
F     END IF
C  Adjust the other substream flow based on changes to the NC
C  substream.
F     FLOMIX = FLONCP / RMIXNCP
;
;  This FORTRAN block will calculate the initial ratio of the MIXED
;  substream flow to the NC substream flow in the stream ROMCOAL2.
;  It will store this result in RATIO2, and use that value to adjust
;  the MIXED substream flow in proportion to the NC substream flow
;  that is varied by the H2FLO design-spec.  This is needed to set
;  the correct amount of water entering with the ROM coal.
;  See Fortran block MIXFLO for the named common blocks /RATIO/ and
;  /RGLOB/ which contain the variables RMIN and RMIXN2.
FORTRAN MIXFL2
 DEFINE FLONC2 SUBSTREAM-VAR STREAM=ROMCOAL2 SUBSTREAM=NC VAR=MASSFLOW
 DEFINE FLOMI2 SUBSTREAM-VAR STREAM=ROMCOAL2 SUBSTREAM=MIXED VAR=MASSFLOW
C  The following should only be true on the first pass.  This prevents
C  writing over the initial substream ratio on subsequent passes.
F     IF (RMIXN2 .LT. RMIN) THEN
F        RMIXN2 = FLONC2 / FLOMI2
F     END IF
C  Adjust the other substream flow based on changes to the NC
C  substream.
F     FLOMI2 = FLONC2 / RMIXN2
;
;  Fortran block to dynamically set the URCOAL fraction in the
;  separation block, SA6, equal to the solids production parameter,
;  REAL(1), in block, P314.
FORTRAN SA6SET
   DEFINE FRAC1 BLOCK-VAR BLOCK=P314 SENTENCE=REAL VAR=REAL ELEMENT=1
   DEFINE FRAC2 BLOCK-VAR BLOCK=SA6  SENTENCE=FRAC VAR=FRAC ID1=NC    &
    ID2=FBC-SOL ELEMENT=1
F     FRAC2 = FRAC1
;
;  FORTRAN block to set the COMBINED steam and water flow rate to
;  Plant 2 as a specified weight percent of the dry coal feed.
```

```
FORTRAN SETUP2
   DEFINE FEED2 MASS-FLOW  STREAM=COALTO2  SUBSTREAM=NC  COMPONENT=COAL
   DEFINE H2O2  STREAM-VAR STREAM=2-H2OIN  VAR=MASSFLOW
F     H2O2 = 0.75315 * FEED2
;
;  FORTRAN block used to set the hydrogen flow rate to Plant 4 (4-H2IN)
;  to a specified weight percent (HPCT4) of the naphtha feed stream,
;  and the hydrogen flow rate to Plant 5 (5-H2IN) to a specified weight
;  percent (HPCT5) of the gas oil feed stream.  This block also sets
;  the inlet water flow rates for these plants to specified rates
;  as functions of the hydrocarbon feed rates.
FORTRAN SETUP45
   DEFINE CHP4   MASS-FLOW  STREAM=4-H2IN   COMPONENT=H2
   DEFINE CHP5   MASS-FLOW  STREAM=5-H2IN   COMPONENT=H2
   DEFINE FLP4   STREAM-VAR STREAM=4-H2IN   VAR=MASSFLOW
   DEFINE FLP5   STREAM-VAR STREAM=5-H2IN   VAR=MASSFLOW
   DEFINE XNAPH  STREAM-VAR STREAM=4-FEED   VAR=MASSFLOW
   DEFINE XGOIL  STREAM-VAR STREAM=GAS-OIL  VAR=MASSFLOW
   DEFINE H2O4   STREAM-VAR STREAM=4-H2OIN  VAR=MASSFLOW
   DEFINE H2O5   STREAM-VAR STREAM=5-H2OIN  VAR=MASSFLOW
C     Set the specified H2 rates in wt% in the following two lines.
F     HPCT4 = 1.1855
F     HPCT5 = 2.7554
F     H2P4 = 0.01D0 * HPCT4 * XNAPH
F     FLP4 = H2P4 * (FLP4 / CHP4)
F     H2P5 = 0.01D0 * HPCT5 * XGOIL
F     FLP5 = H2P5 * (FLP5 / CHP5)
C     Set the specified H2O rates in wt% in the following two lines.
F     H2O4 = 0.089017 * XNAPH
F     H2O5 = 0.054217 * XGOIL
;
;  FORTRAN block to set the steam, water and oxygen stream flow rates
;  to Plant 9 based on the inlet flow rate of hydrocarbons and NC
;  components (on a dry ash-free basis).
FORTRAN SETUP9
 DEFINE FL29MX SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=MIXED VAR=MASS-FLOW
 DEFINE ULCOAL COMP-ATTR-VAR STREAM=9-FEED  SUBSTREAM=NC &
        COMPONENT=COAL   ATTRIBUTE=ULTANAL ELEMENT=1
 DEFINE ULURC  COMP-ATTR-VAR STREAM=9-FEED  SUBSTREAM=NC &
        COMPONENT=URCOAL ATTRIBUTE=ULTANAL ELEMENT=1
 DEFINE FL29C   MASS-FLOW  STREAM=9-FEED  SUBSTREAM=NC COMPONENT=COAL
 DEFINE FL29UR  MASS-FLOW  STREAM=9-FEED  SUBSTREAM=NC COMPONENT=URCOAL
 DEFINE FL29W   MASS-FLOW  STREAM=9-FEED  COMPONENT=H2O
 DEFINE FL2STM  STREAM-VAR STREAM=9-STEMIN VAR=MASS-FLOW
 DEFINE FL2H2O  STREAM-VAR STREAM=9-H2OIN  VAR=MASS-FLOW
 DEFINE FL2O2   STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
C  Adjust the steam, water and oxygen stream flow rates based on the
C  inlet flow rate of hydrocarbons and NC components (on a dry basis).
F     X1 = 0.01*FL29C *(100.0-ULCOAL)
F     X2 = 0.01*FL29UR*(100.0-ULURC)
F     FL2STM = 0.25495 * (FL29MX + X1 + X2 - FL29W)
F     FL2H2O = 1.4723 * (FL29MX + X1 + X2 - FL29W)
F     FL2O2  = 1.1365 * (FL29MX + X1 + X2 - FL29W)
;
;  Fortran block to set up the common and OSBL utility consumptions.
```

```
FORTRAN SETUP31
F     COMMON /USRC01/ PLNTID(32), UTIL(32,15), CAPCST(32,5), OPCST(32,5)
F     CHARACTER * 6  PLNTID
 DEFINE DCOAL2 SUBSTREAM-VAR STREAM=COALTO2 SUBSTREAM=NC VAR=MASS-FLOW
C     COMMON /USRC03/ is ised to transfer vatiables FIN(5,4),
C       FOUT(20,4), PGAS, PPWR, OPTN6
C     See Subroutine USRSR1 for the definition of the items in named
C     common block /USRC03/.
C     Base all the offsite and OSBL utilities consumptions on the dry
C     coal feed rate to Plant 2, the Coal Liquefaction Plant. Ignore
C     cooling and process water consumptions and productions.
F     PLNTID (19) = 'OTHERS'
C     Electric Power.
F     UTIL(19,1) = 25.1346 * DCOAL2 * 0.001
F     IF ( OPTN6 .GE. 0.99D0 )  UTIL(19,1) = 29.5411 * DCOAL2 * 0.001
C     600 psig steam at 720F.
F     UTIL(19,4) = 0.05122207 * DCOAL2 * 0.001
C     150 psig saturated steam.
F     UTIL(19,6) = 0.04350367 * DCOAL2 * 0.001
C     50 psig saturated steam.
F     UTIL(19,7) = 0.06757103 * DCOAL2 * 0.001
;
;  Fortran statement to set the molar flow rate of the STEAM stream TO
;  be in balance with the feed stream to Plant 9.1.
FORTRAN SETUP91
   DEFINE GS     STREAM-VAR  STREAM=NAT-GAS  VARIABLE=MOLE-FLOW
   DEFINE ST     STREAM-VAR  STREAM=STEAM    VARIABLE=MOLE-FLOW
F     IF ( GS .GT. 0.0D0 )  THEN
F         ST = 2.504543D0 * GG
F       ELSE
F         ST = 0.0D0
F     ENDIF
;
;  Fortran block to switch between Plants 9.0 and 10 (Baseline Design
;  Case) or Plants 9.1, 31.1 and 31.4 (Option 6).
FORTRAN OPTION6
F     COMMON /USRC03/ FIN(5,4), FOUT(20,4), PGAS, PPWR, OPTN6
C     See Subroutine USRSR1 for the definition of the items in named
C     common block /USRC03/.
 DEFINE FSTM   STREAM-VAR STREAM=STEAM    VAR=MOLE-FLOW
 DEFINE FNG    STREAM-VAR STREAM=NAT-GAS  VAR=MOLE-FLOW
 DEFINE F10A   STREAM-VAR STREAM=10-AIRIN VAR=MASS-FLOW
 DEFINE F9H    STREAM-VAR STREAM=9-H2OIN  VAR=MASS-FLOW
 DEFINE F9S    STREAM-VAR STREAM=9-STEMIN VAR=MASS-FLOW
 DEFINE F9O    STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
 DEFINE FC9M   SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=MIXED VAR=MASS-FLOW
 DEFINE FC9NC  SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=NC    VAR=MASS-FLOW
 DEFINE FRAC8  BLOCK-VAR   BLOCK=S8  SENTENCE=FRAC  VAR=FRAC  &
  ID1=S8-ASHC  ELEMENT=1
 DEFINE FRAC9  BLOCK-VAR   BLOCK=S9  SENTENCE=FRAC  VAR=FRAC  &
  ID1=H9NEED   ELEMENT=1
 DEFINE FRAC38 BLOCK-VAR   BLOCK=P38B  SENTENCE=FRAC  VAR=FRAC  &
  ID1=WASTE    ELEMENT=1
C     Set N9 equal to 0 to run Plants 9.0 and 10 (Bseline), or
C     set N9 equal to 1 to run Plants 9.1, 31.1 and 31.4 (OPTION 6).
```

```
F     N9 = 0
F     IF (N9 .EQ. 0) THEN
F       OPTNM6 = 0.0D0
F       FSTM = 1.0D-6
F       FNG = 1.0D-6
F       FRAC8 = 1.0
F       FRAC9 = 1.0
F       FRAC38 = 0.28595
F     ENDIF
F     IF (N9 .EQ. 1) THEN
F       OPTNM6 =1.0D0
F       F10A = 1.0D-6
F       F9H = 1.0D-6
F       F9S = 1.0D-6
F       F9O = 1.0D-6
F       FC9M = 1.0D-6
F       FC9NC = 1.0D-6
F       FRAC8 = 0.0
F       FRAC9 = 0.0
F       FRAC38 = 0.0
F     ENDIF
;
FORTRAN SUMMARY
C     This Fortran block writes the summary report to the DCLSUM.REP
C     file, and also writes the DCL1.PRN file for transfering the
C     results to the Lotus spreadsheet economics model.
C     COMMON /USRC03/ is ised to transfer vatiables FIN(5,4),
C       FOUT(20,4), PGAS, PPWR, OPTN6
C     See Subroutine USRSR1 for the definition of the items in named
C     common block /USRC03/.
 DEFINE FIN1A  SUBSTREAM-VAR STREAM=ROMCOAL   SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FIN1B  SUBSTREAM-VAR STREAM=ROMCOAL2  SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FIN2   STREAM-VAR    STREAM=NAT-GAS   VAR=MASS-FLOW
 DEFINE FOUT1  STREAM-VAR    STREAM=3S-PROP   VAR=MASS-FLOW
 DEFINE FOUT2  STREAM-VAR    STREAM=3S-BUT    VAR=MASS-FLOW
 DEFINE FOUT3A STREAM-VAR    STREAM=PNAPHTHA  VAR=MASS-FLOW
 DEFINE FOUT3B STREAM-VAR    STREAM=REFORMED  VAR=MASS-FLOW
 DEFINE FOUT4  STREAM-VAR    STREAM=P350-450  VAR=MASS-FLOW
 DEFINE FOUT5  STREAM-VAR    STREAM=P450-650  VAR=MASS-FLOW
 DEFINE FOUT6  STREAM-VAR    STREAM=P650-850  VAR=MASS-FLOW
 DEFINE FOUT7  SUBSTREAM-VAR STREAM=1S-REFSE  SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT8  SUBSTREAM-VAR STREAM=SLAG      SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT8A SUBSTREAM-VAR STREAM=FBC-SOL   SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT10 STREAM-VAR    STREAM=NH3-PROD  VAR=MASS-FLOW
 DEFINE FOUT11 STREAM-VAR    STREAM=PHENOL    VAR=MASS-FLOW
 DEFINE FOUT12 STREAM-VAR    STREAM=11S-LIQS  VAR=MASS-FLOW
C     Load the stream flow rates in the FIN() and FOUT() arrays in
C     Mlbs/hr.  All solid stream flow rates are on a dry basis.
F     FIN(1,1)  = 0.001D0 * (FIN1A + FIN1B)
F     FIN(2,1)  = 0.001D0 * FIN2
F     FOUT(1,1) = 0.001D0 * FOUT1
F     FOUT(2,1) = 0.001D0 * FOUT2
F     FOUT(3,1) = 0.001D0 * (FOUT3A + FOUT3B)
F     FOUT(4,1) = 0.001D0 * FOUT4
F     FOUT(5,1) = 0.001D0 * FOUT5
```

```
F     FOUT(6,1) = 0.001D0 * FOUT6
F     FOUT(7,1) = 0.001D0 * FOUT7
F     FOUT(8,1) = 0.001D0 * (FOUT8 + FOUT8A)
F     FOUT(10,1) = 0.001D0 * FOUT10
F     FOUT(11,1) = 0.001D0 * FOUT11
F     FOUT(12,1) = 0.001D0 * FOUT12
C
C     Set XOF to the number of extra operators and OSBL operators
C     per dedicated plant operator.
C     ----------------------------
F     XOF = 0.343042
C
C     Set the LOSBL and LPLANT switches, as appropriate, to duplicate
C     the Bechtel OSBL and first vs. Nth plant costing logic.
C     LOSBL  = 0  - Use baseline case OSBL costing logic.
C     LOSBL  = 1  - Use option case OSBL costing logic.
C     LPLANT = 0  - Use first plant OSBL and engineering costing logic.
C     LPLANT = 1  - Use Nth plant OSBL and engineering costing logic.
C     ================================================================
F     LOSBL = 1
F     LPLANT = 1
C
C     Open the separate output file called DCLSUM.REP to contain the
C     summary report of the simulation results.
F     OPEN (UNIT=62, FILE='DCLSUM.REP', STATUS='UNKNOWN',
F    1  ACCESS='SEQUENTIAL', FORM='FORMATTED',
F    2  BUFFERED='BUFFERED')
C     Call Subroutines USRSR1 and USRSR2 to write the summary report.
F     CALL USRSR1 (62)
F     CALL USRSR2 (62, LOSBL, LPLANT, OPTN6, XOF)
F     CLOSE (UNIT=62, STATUS='KEEP')
C     Now write the LOTUS spreadsheet economics model input file.
F     OPEN (UNIT=62, FILE='DCL1.PRN', STATUS='UNKNOWN',
F    1  ACCESS='SEQUENTIAL', FORM='FORMATTED',
F    2  BUFFERED='BUFFERED')
C     Call Subroutines USRSR3 to write the model input file.
F     CALL USRSR3 (62, OPTN6, XOF)
F     CLOSE (UNIT=62, STATUS='KEEP')
;
; Convergence Blocks
; ------------------
;
CONVERGENCE CBLK1 WEGSTEIN
  TEAR H2MIX 1D-5
  PARAM WAIT=3
;
CONVERGENCE CBLK2 WEGSTEIN
  TEAR 2S-BOTTS 1D-5
;
CONVERGENCE CBLK3 WEGSTEIN
  TEAR 6S-SH2O 1D-5
;
CONVERGENCE COALF ONE-VAR
  SPEC COALFLO
;
```

```
CONVERGENCE HD-C1 ONE-VAR
  SPEC HD-HYD
;
CONVERGENCE HYDF BROYDEN-SPEC
  SPEC H2FLO
;
CONVERGENCE 2HYDF ONE-VAR
  SPEC 2H2FLO
;
CONVERGENCE OXYF ONE-VAR
  SPEC O2FLO
;
CONVERGENCE RFMRF ONE-VAR
  SPEC RFMRFLO
;
; Calculation Sequence
; --------------------
;
;  Define subsequence for coal cleaning complex.
SEQUENCE CLEAN COALF MIXFLO S1 P1-BASE P1-ALT1 P1-ALT2                  &
               M1 P14 (RETURN COALF)
;
;  Specify entire flowsheet sequence, including subsequence CLEAN.
SEQUENCE BASE  RCOAL (SEQUENCE CLEAN)                                   &
               CBLK1   2HYDF M-2HYD (RETURN 2HYDF)                      &
               CBLK2 SETUP2 P02 P81 (RETURN CBLK2)                      &
               P61 P62   HD-C1 M-HYD (RETURN HD-C1)                     &
               M-73 P03 M-NAP SETUP45 P04 M-462 P05 M-561               &
               M-PNAP S7 P07 (RETURN CBLK1)                             &
               HFLOW M9H OPTION6 S9  S8 P314 SA6SET SA6                 &
               HYDF MIXFL2 P1-JIGS M9C SETUP9 P09 (RETURN HYDF)         &
               OXYF P10 (RETURN OXYF)  M2 M3 M4                         &
               RFMRF SETUP91 P91 (RETURN RFMRF)                         &
               CBLK3 M38 P38 P38A P38B P39 M-6GAS S6-SH2O               &
               (RETURN CBLK3)                                           &
               P11 SETUP31 P31 SUMMARY
;
; Unit Operations Blocks
; ----------------------
;
;  Mix the clean coal product streams from the 3 different cases.
BLOCK M1 MIXER
  DESCRIPTION 'PLANT 1 OUTLET CLEAN COAL MIXER'
;
;  Mix the middling coal product streams from the 3 different cases.
BLOCK M2 MIXER
  DESCRIPTION 'PLANT 1 OUTLET MIDDLING COAL MIXER'
;
;  Mix the hydrogen streams going to Plant 2.
BLOCK M-2HYD MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL HYDROGEN STREAM TO PLANT 2'
  PARAM NPK=1  KPH=1
;
;  Mix the refuse product streams from the 3 different cases.
BLOCK M3 MIXER
```

```
  DESCRIPTION 'PLANT 1 OUTLET REFUSE MIXER'
;
;  Mix the sour water streams from Plants 2, 3, 4, 5, and 9.
BLOCK M38 MIXER
  DESCRIPTION 'SOUR WATER MIXER FOR PLANT 38 FEED'
;
;  Mix the waste water product streams from the 3 different cases.
BLOCK M4 MIXER
  DESCRIPTION 'PLANT 1 OUTLET WASTE WATER MIXER'
;
;  Mix the hydrogen streams from Plants 4 & 2 for Plant 6.2.
BLOCK M-462 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 6.2 FEED'
;
;  Mix the hydrogen streams from Plants 5 & 2 for Plant 6.1.
BLOCK M-561 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 6.1 FEED'
;
;  Mix the sour gas streams from Plants 6.1, 6.2, 9 and 38 for the
;  Plant 11 feed stream.
BLOCK M-6GAS HEATER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 11 FEED'
  PARAM  TEMP=110.0  PRES=14.7
;
;  Mix the H2 gas streams from Plants 7 & 6.2 for Plant 3.
BLOCK M-73 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 3 FEED'
;
;  Mixer M9C - The hydrogen plant feed mixer; used to mix the coal and
;  ROSE unit ASH-CONC stream that goes to Plant 9.0.
BLOCK M9C MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 9 FEED'
  BLOCK-OPTIONS HMB-RESULTS=2
;
;  Mixer M9 - The dummy hydrogen mixer; used to mix the three
;  streams that go to Plant 2 (M9H2), Plant 4 (M9H4), and
;  Plant 5 (M9H5) into one single output stream (MHNEED) for the
;  S9 splitter.
BLOCK M9H MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL AMOUNT OF HYDROGEN NEEDED'
  PARAM NPK=1  KPH=1
;
;  Mix the hydrogen streams from Plants 6.1 and 6.2. Use a flash2 block
;  to correct a temperature calculating error in the ASPEN mixer block
;  algorithm.
BLOCK M-HYD FLASH2
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL HYDROGEN FROM 6.1 AND 6.2'
  PARAM  TEMP=100.  PRES=3290.
;
;  Mix the naphtha streams from Plants 2 and 6.2.
BLOCK M-NAP MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL PLANT 4 NAPHTHA FEED'
;
;  Mix the product naphtha streams from Plants 4 and 5.
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL PRODUCT NAPHTHA STREAM'
```

```
BLOCK M-PNAP MIXER
;
;  Plant P1-ALT1, Coal Cleaning and Preparation Plant. Use User
;  Fortran Model, USR01, within the PLANTS file. ALTERNATE CASE 1 -
;  COAL CLEANING BY HEAVY MEDIUM SEPARATION.
BLOCK P1-ALT1 USER
   SUBROUTINE MODEL = USR01    REPORT = USR01
   DESCRIPTION 'PLANT 1 - ALTERNATE 1 - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following integer and real parameters are for production of
;   the coal cleaned by both jigs and heavy medium separation.  The coal
;   cleaned only by jigs for gasification is handled by a separate plant
;   that is modeled in BLOCK P1-JIGS.  The operators and cost for this
;   plant includes those associalted with the P1-JIGS portion of the coal
;   cleaning and preparation plant.  All parameters have the same meaning
;   as described below for Plant 1 in BLOCK P1-BASE.
;
    INT  0  1  0  1  1
;        FCP          FCM    FHP          FHM    FNP          FNM
     REAL 0.9120155    0.0    0.9050241    0.0    0.8869236    0.0  &
;        FC1P         FC1M   FSP          FSM    FOP          FOM
         0.7602203    0.0    0.4471884    0.0    0.9905900    0.0  &
;        FAP          FAM
         0.3012854    0.0  &
;        PCWP  PCWM  PCWR  Future Use (3 items)
         9.0   3.0   10.0    0.   0.   0.                    &
;        Power            900/750 F steam   900 satd steam
         0.0 7.400489       0.0 0.0           0.0 0.0        &
;        600/720 F steam    600 satd steam    150 satd steam
         0.0 0.0            0.0 0.0           0.0 0.0        &
;        50 satd steam      Plant fuel        Cooling  H2O
         0.0 0.0            0.0 0.0           0.0 0.0        &
;        Process H2O        Nitrogen
         0.0 0.042246       0.0 0.0         &
;        Future Use (6 items)
         0.0  0.0  0.0  0.0  0.0  0.0      &
;        Opers/day      (Opers/day)/train
         8.0            8.0                &
;        Ref Flow   Max Flow   Min Flow
         285.035    300.0      150.0       &
;        Plant cost equation constants.
;        A      B       E      F      Spares     Future Use (2 items)
         0.0    25.52   0.5942 1.0    0.0        0.0   0.0    &
;        Future Use (10 items)
         0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S12    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S13    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S14    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S15    KODE=2   TEMP = 70.0   PRES = 14.7
;
;  Plant P1-ALT2, Coal Cleaning and Preparation Plant. Use User Fortran
;  Model, USR01, within the PLANTS file. ALTERNATE CASE 2 - COAL CLEANING
```

```
;  BY HEAVY MEDIUM SEPARATION FOLLOWED BY SPHERICAL AGGLOMERATION.
BLOCK P1-ALT2 USER
   SUBROUTINE MODEL = USR01    REPORT = USR01
   DESCRIPTION 'PLANT 1 - ALTERNATE 2 - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following integer and real parameters are for production of
;   the coal cleaned by both jigs and heavy medium separation followed
;   by spherical agglomeration.  The coal cleaned only by jigs for
;   gasification is handled by a separate plant that is modeled in
;   BLOCK P1-JIGS.  The operators and cost for this plant includes
;   those associalted with the P1-JIGS portion of the coal cleaning
;   and preparation plant.  All parameters have the same meaning as
;   described below for Plant 1 in BLOCK P1-BASE.
;
    INT  0  1  0  1  2
;         FCP          FCM    FHP          FHM    FNP          FNM
     REAL 0.9435271    0.0    0.9338663    0.0    0.9250562    0.0  &
;         FC1P         FC1M   FSP          FSM    FOP          FOM
          0.7400450    0.0    0.3772778    0.0    0.9867266    0.0  &
;         FAP          FAM
          0.1295931    0.0  &
;         PCWP   PCWM  PCWR  Future Use (3 items)
          14.16  3.0   10.0  0.0   0.0   0.0                &
;         Power              900/750 F steam   900 satd steam
          0.0 51.68786       0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 0.0           0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 0.394967      0.0 0.0       &
;         Process H2O        Nitrogen
          0.0 0.103481       0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          8.0           8.0                 &
;         Ref Flow   Max Flow   Min Flow
          262.3      300.0      150.0      &
;         Plant cost equation constants.
;         A      B       E      F      Spares     Future Use (2 items)
          0.0    73.78   0.5942 1.0    0.0        0.0   0.0    &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S22    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S23    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S24    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S25    KODE=2   TEMP = 70.0   PRES = 14.7
;
;
; Plant 1 - Coal Cleaning, Preparation and Drying Plant, Use User Fortran
;           Model USR01
;           BASE CASE - COAL CLEANING BY JIGS For LIQUEFACTION.
BLOCK P1-BASE USER
```

```
   SUBROUTINE MODEL = USR01   REPORT = USR01
   DESCRIPTION 'PLANT 1 - BASE CASE - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;     The following 5 integer parameters are:
;     INT(1) = User block summary report control switch.
;              0 => Write the complete user block summary report.
;              1 => Skip the capital cost portion of the summary
;                   report.
;              2 => Skip the capital cost and utilities portions
;                   of the summary report.
;              3 => Skip writing the entire user block summary report.
;     INT(2) = User block summary report destination control switch.
;              0 => Write the user block summary report to the mormal
;                    ASPEN/SP output report file.
;              1 => Write the user block summary report to a separate
;                   user block output report file on logical unit 62
;                   called DCL01B.REP, DCL01A1.REP or DCL01A2.REP
;                   depending on the value of the coal cleaning option
;                   control switch, INT(5).
;     INT(3) = Number of operating duplicate trains, excluding spares.
;              If INT(3) = 0, the minimum number of duplicate
;                trains will be determined so that the capacity
;                of each train does not exceed the maximum train
;                capacity specified by variable REAL(52).
;              If INT(3) > 0, the number of duplicate trains.
;     INT(4) = History file additional output control switch.
;              0 => Write no additional output to the history file.
;              1 => Write the only the subroutine entry and exit
;                   messages to the history file.
;              2 => Write some additional output to the history file.
;            3-4 => Write some more additional output to the history
;                   file.  Larger values generate more intermediate
;                   output.
;     INT(5)  = Coal cleaning, drying and grinding option control
;               switch.  The name of the short plant report file
;               written for each option is option dependent.
;               0 => Base case - Coal cleaning by jigs for coal
;                    liquefaction in plant 2. (Report = DCL01B.REP)
;               1 => Alternate case 1 - Coal cleaning by heavy media
;                    separation.  (Report = DCL01A1.REP)
;               2 => Alternate case 2 - Coal cleaning by heavy media
;                    separation and spherical agglomeration.
;                    (Report = DCL01A2.REP)
;               3 => Coal cleaning by jigs for coal gasification in
;                    plant 9.  (Report = DCL01G.REP)
;               4 => Coal grinding and drying plant.
;                    (Report = DCL01D.REP)
;              NOTE: Values 0, 1 and 2 are used when this model
;                    cleans the coal going to the coal liquefaction
;                    plant, 3 is used only when this model cleans
;                    the coal going to the coal gasification plant,
;                    and 4 is for the grinding and drying plant.
   INT  0  1  0  1  0
;     The following 70 real parameters are:
;     REAL(1)   = Fraction of carbon in the inlet coal leaving
```

```
;                 in the clean coal product stream.
;     REAL(2)   = Fraction of carbon in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(3)   = Fraction of hydrogen in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(4)   = Fraction of hydrogen in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(5)   = Fraction of nitrogen in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(6)   = Fraction of nitrogen in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(7)   = Fraction of chlorine in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(8)   = Fraction of chlorine in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(9)   = Fraction of sulfur in the inlet coal leaving
;                 in the clean coal product stream.  OPTIONAL - See Note 1.
;     REAL(10)  = Fraction of sulfur in the inlet coal leaving
;                 in the middling coal stream.  OPTIONAL - See Note 1.
;     REAL(11)  = Fraction of oxygen in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(12)  = Fraction of oxygen in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(13)  = Fraction of ash in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(14)  = Fraction of ash in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(15)  = Moisture content of the clean product coal on a dry
;                 basis, wt%.
;     REAL(16)  = Moisture content of the middling coal on a dry
;                 basis, wt%.
;     REAL(17)  = Moisture content of the refuse on a dry basis, wt%.
;     REAL(18) -
;      REAL(20) = Future use.
;     REAL(21)  = Constant factor for the power consumption, kw.
;     REAL(22)  = Power consumption per Mlbs/hr of dry clean coal,
;                 kw/(Mlbs/hr).
;     REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                 consumption, Mlbs/hr.
;     REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                 dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;     REAL(25)  = Constant factor for the 900 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                 dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;     REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                 consumption, Mlbs/hr.
;     REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                 dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;     REAL(29)  = Constant factor for the 600 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                 dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;     REAL(31)  = Constant factor for the 150 psig saturated steam
;                 consumption, Mlbs/hr.
```

```
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of dry clean coal,
;                   (MM BTU/hr)/(Mlbs/hr).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of dry clean
;                   coal (Mgal/hr)/(Mlbs/hr).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of dry clean
;                   coal, (Mgal/hr)/(Mlbs/hr).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of dry clean coal,
;                   (MM SCF/hr of N2)/(Mlbs/hr).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference flow rate of the dry clean coal of a
;                   single train in Mlbs/hr for the calculation of
;                   the ISBL field cost of a single train as a function
;                   of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   flow rate of the dry clean coal in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   flow rate of the dry clean coal in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;     NOTES:
;       1. If both the sulfur distribution factors, REAL(9) and REAL(10),
;          are zero and a SULFANAL was supplied, the sulfur will be
;          distributed among the products as follows.
;          a. The ORGANIC sulfur will be distributed in the same
;             proportions as the carbon is distributed.
;          b. The PYRITIC and SULFATE sulfur will be distributed in the
;             same proportions as the ash is distributed.
;
;          FCP         FCM    FHP         FHM    FNP         FNM
      REAL 0.9302390   0.0    0.9142857   0.0    0.9533333   0.0  &
```

```
;         FC1P        FC1M   FSP          FSM    FOP          FOM
          0.40000     0.0    0.5019608    0.0    0.9696970    0.0  &
;         FAP         FAM
          0.4229677   0.0  &
;         PCWP   PCWM  PCWR  Future Use (3 items)
          8.576  3.0   10.0  0.0   0.0   0.0                  &
;         Power              900/750 F steam   900 satd steam
          0.0 4.281977       0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 0.0           0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 0.0           0.0 0.0       &
;         Process H2O        Nitrogen
          0.0 0.02433102     0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          8.0           8.0                 &
;         Ref Flow   Max Flow   Min Flow
          387.158    390.0      200.0      &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future use (2 items)
          0.0    31.56   0.5942 1.0    0.0      0.0   0.0       &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S02    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S03    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S04    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S05    KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 1-JIGS  - Coal Cleaning by Jigs for gasification - User Fortran
;                 Model USR01
;           COAL CLEANING BY JIGS For GASIFICATION.
BLOCK P1-JIGS USER
   SUBROUTINE MODEL = USR01   REPORT = USR01
   DESCRIPTION 'PLANT 1 - JIGS - COAL CLEANING FOR GASIFICATION'
;      The following integer and real parameters have the same meaning
;      as described above for Plant 1 in BLOCK P1-BASE.
   PARAM  NINT = 5   NREAL = 70
    INT  0  1  0  1  3
;
;         FCP         FCM    FHP          FHM    FNP          FNM
     REAL 0.9302390   0.0    0.9142857    0.0    0.9533333    0.0  &
;         FC1P        FC1M   FSP          FSM    FOP          FOM
          0.40000     0.0    0.5019608    0.0    0.9696970    0.0  &
;         FAP         FAM
          0.4229677   0.0  &
;         PCWP   PCWM  PCWR  Future Use (3 items)
          8.576  3.0   10.0  0.0   0.0   0.0                  &
;         Power              900/750 F steam   900 satd steam
          0.0 4.281977       0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
```

```
          0.0 0.0            0.0 0.0            0.0 0.0       &
;         50 satd steam      Plant fuel         Cooling  H2O
          0.0 0.0            0.0 0.0            0.0 0.0       &
;         Process H2O        Nitrogen
          0.0 0.02433102     0.0 0.0          &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0       &
;         Opers/day      (Opers/day)/train
          0.0            0.0                  &
;         Ref Flow   Max Flow   Min Flow
          387.158    390.0      200.0        &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future use (2 items)
          0.0    0.0     0.5942 1.0    0.0      0.0   0.0       &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = COALTO9 KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S33    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S34    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S35    KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 1.4 - Coal Grinding and Drying Plant - Fortran Model USR01
;             BASE CASE
BLOCK P14 USER
   SUBROUTINE MODEL = USR01   REPORT = USR01
   DESCRIPTION 'PLANT 1.4 - BASE CASE - COAL GRINDING AND DRYING PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following integer and real parameters have the same meaning
;      as described above for Plant 1 in BLOCK P1-BASE.
    INT  0  1  0  1  4
;         FCP         FCM    FHP          FHM    FNP         FNM
     REAL 1.0         0.0    1.0          0.0    1.0         0.0  &
;         FC1P        FC1M   FSP          FSM    FOP         FOM
          1.0         0.0    1.0          0.0    1.0         0.0  &
;         FAP         FAM
          1.0         0.0   &
;         PCWP   PCWM  PCWR  Future Use (3 items)
          2.0    3.0   10.0  0.0   0.0   0.0                  &
;         Power              900/750 F steam   900 satd steam
          0.0 8.499979       0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 0.0           0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 0.3410096     0.0 0.010104  &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 3.16015     &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day      (Opers/day)/train
          7.0            1.0                 &
;         Ref Flow   Max Flow   Min Flow
          142.518    145.0      50.0        &
```

```
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future use (2 items)
          0.0    8.75    0.8504 1.0    0.0      0.0   0.0       &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = COALTO2  KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-XMID KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-REF  KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-WAT  KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 2 - The coal liquefaction plant - user Fortran block USR02.
BLOCK P02 USER
   SUBROUTINE MODEL = USR02   REPORT = USR02
   DESCRIPTION 'PLANT 2 - COAL LIQUEFACTION PLANT'
   PARAM  NINT = 6   NREAL = 70
;      The following 6 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL02.REP.
;      INT(3) = Number of operating duplicate plants, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 plants will be determined so that the capacity
;                 of each plant does not exceed the maximum plant
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate plants.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
;      INT(5) = Switch to write the major equipment summary list and
;               cost summary report by plant section for the baseline
;               design to the separate block output summary report file
;               called DCL02.REP on logical unit 62.
;               0 => Do not write the major equipment summary list.
;               1 => Write the major equipment summary list to the
;                    separate block output file only when
;                    INT(1) <= 2, INT(2) = 1, and INT(6) = 0.
;               2 => Write the major equipment summary list and the
```

```
;                    cost summary report by plant section to the
;                    separate block output file only when
;                    INT(1) <= 2, INT(2) = 1, and INT(6) = 0.
;      INT(6) = Switch to select which coal liquefaction reactor yields
;               are calculated.
;               0 => Baseline design two-reactor model.
;               3 => Option 3 - Yields for Thermal/Catalytic two-
;                    reactor model.
;               4 => Option 4 - Two-reactor model with interstaage
;                    vent gas separation.
;               5 => Option 5 - Yields for two-reactor coker model.
;               8 => Improved Baseline (Option 8) - High space velocity
;                    two-reactor model.
   INT  0  1  0  1  2  0
;     The following 70 real parameters are:
;     REAL(1)    = Percent coal conversion based on fresh MAF coal
;                  entering the coal liquefaction reactors.
;     REAL(2)-
;      REAL(20) = Future use.
;     REAL(21)   = Constant factor for the power consumption, kw.
;     REAL(22)   = Power consumption per Mlbs/hr of dry coal feed,
;                  kw/(Mlbs/hr of dry coal).
;     REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;     REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(25)   = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;     REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(29)   = Constant factor for the 600 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(31)   = Constant factor for the 150 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(33)   = Constant factor for the 50 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(35)   = Constant factor for the plant fuel consumption,
;                  MM BTU/hr.
;     REAL(36)   = Plant fuel consumption per Mlbs/hr of dry coal feed,
;                  (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(37)   = Constant factor for the cooling water consumption,
;                  Mgal/hr.
;     REAL(38)   = Cooling water consumption per Mlbs/hr of dry coal
;                  feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;                  produced, (Mgal/hr)/(MM SCF/hr of H2).
```

```
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of dry coal
;                   feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of dry coal feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of dry coal).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference dry coal feed rate to a single train in
;                   Mlbs/hr for the calculation of the ISBL field cost of
;                   a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the dry
;                   coal feed rate in Mlbs/hr of dry coal.
;       REAL(53)  = Minimum size of a single train as defined by the dry
;                   coal feed rate in Mlbs/hr of dry coal.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Percent fresh MAF coal conversion
     REAL 92.7901  &
;          Future use (9 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0    &
;          Power              900/750 F steam    900 satd steam
           0.0 41.39141       0.0 0.0            0.0 0.0        &
;          600/720 F steam    600 satd steam     150 satd steam
           0.0 0.003904784    0.0 -0.1046117     0.0 -0.0632168 &
;          50 satd steam      Plant fuel         Cooling H2O
           0.0 0.0393741      0.0 0.764818       0.0 0.340800   &
;          Process H2O        Nitrogen
           0.0 0.1081972      0.0 0.000029236 &
;          Future Use (6 items)
           0.0  0.0  0.0 0.0  0.0  0.0       &
;          Opers/day     (Opers/day)/train
           0.0           8.0                 &
;          Ref Flow   Max Flow   Min Flow
           285.035    285.05     30.0        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future use (2 items)
           0.0    186.44  0.7142 1.0    0.0      0.0   0.0   &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
```

```
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR02.
   FLASH-SPECS STRM=2S-GAS KODE=2 TEMP=130.0 PRES=2985.0 NPK=1 KPH=1 /
               STRM = GASES     KODE=2   TEMP = 130.0  PRES = 65.0   /
               STRM = NAPHTHA   KODE=2   TEMP = 140.0  PRES = 16.0   /
               STRM = GAS-OIL   KODE=2   TEMP = 110.0  PRES = 30.0   /
               STRM = 2S-BOTTS  KODE=2   TEMP = 688.0  PRES = 28.0   /
               STRM = 2S-SH2O   KODE=2   TEMP = 100.0  PRES = 30.0
;
; Plant 3 - The gas plant - use user Fortran block USR03.
BLOCK P03 USER
   SUBROUTINE MODEL = USR03   REPORT = USR03
   DESCRIPTION 'PLANT 3 - THE GAS PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL03.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per MM SCF/hr of dry C4- gas,
;                  kw/(MM SCF/hr of dry C4- gas)
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr
;                  of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;      REAL(25)  = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
```

```
;       REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of dry C4- gas,
;                   (MM BTU/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of dry C4-
;                   gas, (Mgal/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of dry C4-
;                   gas, (Mgal/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of dry C4- gas,
;                   (MM SCF/hr of N2)/(MM SCF/hr of dry C4- gas).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference gas feed rate to a single train in
;                   MM SCF/hr of dry C4- gas for the calculation of
;                   the ISBL field cost of a single train as a function
;                   of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   gas feed rate in MM SCF/hr of dry C4- gas.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   gas feed rate in MM SCF/hr of dry C4- gas.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
```

```
;
;          Future use (10 items)
     REAL 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power                900/750 F steam   900 satd steam
           0.0 447.6001         0.0 0.0           0.0 0.0       &
;          600/720 F steam      600 satd steam    150 satd steam
           0.0 0.0              0.0 194.4388      0.0 0.0       &
;          50 satd steam        Plant fuel        Cooling  H2O
           0.0 8.425471         0.0 -722.141      0.0 645.8090  &
;          Process H2O          Nitrogen
           0.0 0.0              0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0         &
;          Opers/day      (Opers/day)/train
           0.0              8.0                 &
;          Ref Flow   Max Flow   Min Flow
           2.04       5.0        0.300          &
;          Plant cost equation constants.
;          A      B          E      F      Spares   Future Use (3 items)
           0.0    25.3       0.8013 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR03.
   FLASH-SPECS STRM = 3S-SGAS   KODE=2  TEMP = 137.0  PRES = 55.0   /
               STRM = 3S-FGAS   KODE=2  TEMP = 100.0  PRES = 215.0  /
               STRM = 3S-PROP   KODE=2  TEMP = 100.0  PRES = 280.0  /
               STRM = 3S-BUT    KODE=2  TEMP = 100.0  PRES = 280.0  /
               STRM = 3S-OIL    KODE=2  TEMP = 130.0  PRES = 263.0  &
                      NPK=1 KPH=2 /
               STRM = 3S-SH2O   KODE=2  TEMP = 137.0  PRES = 55.0
;
; Plant 4 - The naphtha hydrotreater - use user Fortran block USR04.
BLOCK P04 USER
   SUBROUTINE MODEL = USR04   REPORT = USR04
   DESCRIPTION 'PLANT 4 - THE NAPHTHA HYDROTREATER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL04.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
```

```
;                If INT(3) = 0, the minimum number of duplicate
;                  trains will be determined so that the capacity
;                  of each plant does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Percent desulfurization of the C5+ feed; i. e.,
;                  Percent of sulfur removed from the entering C5+ feed.
;      REAL(2)   = Percent denitrogenation of the C5+ feed; i. e.,
;                  Percent of nitrogen removed from the entering C5+ feed.
;      REAL(3)   = Percent deoxygenation of the C5+ feed.
;                  Percent of oxygen removed from the entering C5+ feed.
;      REAL(4)   = Chemical hydrogen consumption in SCF/bbl of C5+ feed.
;      REAL(5) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of C5+ feed,
;                  kw/(Mlbs/hr of C5+ feed).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                  C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(25)  = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                  C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;      REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                  C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(29)  = Constant factor for the 600 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                  C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(31)  = Constant factor for the 150 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                  C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(33)  = Constant factor for the 50 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                  C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(35)  = Constant factor for the plant fuel consumption,
;                  MM BTU/hr.
;      REAL(36)  = Plant fuel consumption per Mlbs/hr of C5+ feed,
;                  (MM BTU/hr)/(Mlbs/hr of C5+ feed).
```

```
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of C5+ feed,
;                   (Mgal/hr)/(Mlbs/hr of C5+ feed).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of C5+ feed,
;                   (Mgal/hr)/(Mlbs/hr of C5+ feed).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of C5+ feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of C5+ feed).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference C5+ feed rate to a single train in Mlbs/hr
;                   for the calculation of the ISBL field cost of a
;                   single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   C5+ feed rate in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   C5+ feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          % Desulfurization   % Denitrogenation
     REAL 99.99                99.988        &
;          % Deoxygenation   Chemical H2 consumption in SCF/bbl C5+ feed
           99.5              125.0           &
;          Future use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power             900/750 F steam   900 satd steam
           0.0 5.098308      0.0 0.0           0.0 0.0       &
;          600/720 F steam   600 satd steam    150 satd steam
           0.0 0.0           0.0 0.126493      0.0 0.0       &
;          50 satd steam     Plant fuel        Cooling  H2O
           0.0 0.0           0.0 0.351607      0.0 0.730963  &
;          Process H2O       Nitrogen
           0.0 0.010833      0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0            8.0               &
;          Ref Flow   Max Flow   Min Flow
           210.462    400.0      50.0       &
```

```
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future Use (3 items)
          0.0    15.6    0.7843 1.0    0.0      0.0   0.0   &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR04.
   FLASH-SPECS STRM = 4S-GAS   KODE=2  TEMP = 135.0  PRES = 915.0  /
               STRM = 4S-NAPH  KODE=2  TEMP = 100.0  PRES = 153.0  /
               STRM = 4S-SH2O  KODE=2  TEMP =  70.0  PRES = 14.7
;
; Plant 5 - The gas-oil hydrotreater - use user Fortran block USR05.
BLOCK P05 USER
   SUBROUTINE MODEL = USR05   REPORT = USR05
   DESCRIPTION 'PLANT 5 - THE GAS-OIL HYDROTREATER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL05.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Percent desulfurization of the C6+ feed; i. e.,
;                  Percent of sulfur removed from the entering C6+ feed.
;      REAL(2)   = Percent denitrogenation of the C6+ feed; i. e.,
;                  Percent of nitrogen removed from the entering C6+ feed.
;      REAL(3)   = Percent deoxygenation of the C6+ feed.
;                  Percent of oxygen removed from the entering C6+ feed.
;      REAL(4)   = Chemical hydrogen consumption in SCF/bbl of C6+ feed.
;      REAL(5) -
```

```
;        REAL(20) = Future use.
;        REAL(21) = Constant factor for the power consumption, kw.
;        REAL(22) = Power consumption per Mlbs/hr of C6+ feed,
;                   kw/(Mlbs/hr).
;        REAL(23) = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;        REAL(24) = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;        REAL(25) = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;        REAL(26) = 900 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;        REAL(27) = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;        REAL(28) = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;        REAL(29) = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;        REAL(30) = 600 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;        REAL(31) = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;        REAL(32) = 150 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;        REAL(33) = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;        REAL(34) = 50 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;        REAL(35) = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;        REAL(36) = Plant fuel consumption per Mlbs/hr of C6+ feed,
;                   (MM BTU/hr)/(Mlbs/hr).
;        REAL(37) = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;        REAL(38) = Cooling water consumption per Mlbs/hr of C6+ feed,
;                   (Mgal/hr)/(Mlbs/hr).
;        REAL(39) = Constant factor for the process water consumption,
;                   Mgal/hr.
;        REAL(40) = Process water consumption per Mlbs/hr of C6+ feed,
;                   (Mgal/hr)/(Mlbs/hr).
;        REAL(41) = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;        REAL(42) = Nitrogen consumption per Mlbs/hr of C6+ feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr).
;        REAL(43) -
;        REAL(48) = Future use.
;        REAL(49) = Constant factor for the number of operators per
;                   day, operators/day.
;        REAL(50) = Number of operators per day per train,
;                   (operators/day)/train.
;        REAL(51) = Reference C6+ feed rate to a single train in Mlbs/hr
;                   for the calculation of the ISBL field cost of a
;                   single train as a function of train capacity.
;        REAL(52) = Maximum size of a single train as defined by the
;                   C6+ feed rate in Mlbs/hr.
```

```
;       REAL(53)  = Minimum size of a single train as defined by the
;                   C6+ feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          % Desulfurization   % Denitrogenation
     REAL 92.5                 85.2       &
;          % Deoxygenation   Chemical H2 consumption in SCF/bbl C6+ feed
           97.6              947.00       &
;          Future use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0   &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power             900/750 F steam   900 satd steam
           0.0 3.247198      0.0 0.0           0.0 0.0       &
;          600/720 F steam   600 satd steam    150 satd steam
           0.0 0.0           0.0 0.096936      0.0 -0.050465 &
;          50 satd steam     Plant fuel        Cooling  H2O
           0.0 0.0           0.0 0.241416      0.0 0.735694 &
;          Process H2O       Nitrogen
           0.0 0.0           0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0            4.0               &
;          Ref Flow   Max Flow   Min Flow
           671.04     800.0      150.0      &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future Use (2 items)
           0.0    74.0    0.7467 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR05.
;  The 5S-LPGAS and 5S-NAPH temperature and pressure are those leaving
;  Plant 4 where this fractionation is actually performed.
   FLASH-SPECS STRM = 5S-HPGAS  KODE=2  TEMP = 135.0  PRES = 2690.0 /
               STRM = 5S-LPGAS  KODE=2  TEMP = 135.0  PRES = 915.0  /
               STRM = 5S-NAPH   KODE=2  TEMP = 100.0  PRES = 153.0  /
               STRM = P350-450  KODE=2  TEMP = 110.0  PRES = 80.0   /
               STRM = P450-650  KODE=2  TEMP = 135.0  PRES = 20.0   /
               STRM = P650-850  KODE=2  TEMP = 135.0  PRES = 20.0   /
               STRM = 5S-SH2O   KODE=2  TEMP = 135.0  PRES = 20.0
;
; Plant 6.1 - The Hydrogen purification by Membrane Separation Plant.
BLOCK P61 USER
   SUBROUTINE MODEL = USR61   REPORT = USR61
   DESCRIPTION 'PLANT 6.1 - THE MEMBRANE H2 PURIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
```

```
;       The following 4 integer parameters are:
;       INT(1) = User block summary report control switch.
;                0 => Write the complete user block summary report.
;                1 => Skip the capital cost portion of the summary
;                     report.
;                2 => Skip the capital cost and utilities portions
;                     of the summary report.
;                3 => Skip writing the entire user block summary report.
;       INT(2) = User block summary report destination control switch.
;                0 => Write the user block summary report to the normal
;                     ASPEN/SP output report file.
;                1 => Write the user block summary report to a separate
;                     user block output report file on logical unit 62
;                     called DCL61.REP.
;       INT(3) = Number of operating duplicate trains, excluding spares.
;                If INT(3) = 0, the minimum number of duplicate
;                  trains will be determined so that the capacity
;                  of each train does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate trains.
;       INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
    INT  0  1  0  1
;       The following 70 real parameters are:
;       REAL(1)    = Percent hydrogen recovery to the hydrogen-rich
;                    product gas stream from the inlet gas stream.
;       REAL(2)    = Concentration of hydrogen in the hydrogen-rich
;                    product gas stream, mole % or vol%.
;       REAL(3)-
;        REAL(20)  = Future use.
;       REAL(21)   = Constant factor for the power consumption, kw.
;       REAL(22)   = Power consumption per MM SCF/hr of H2 recovered,
;                    kw/(MM SCF/hr of H2 recovered).
;       REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                    consumption, Mlbs/hr.
;       REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                    H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(25)   = Constant factor for the 900 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr
;                    of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                    consumption, Mlbs/hr.
;       REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr of
;                    H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(29)   = Constant factor for the 600 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(30)   = 600 psig saturated steam consumption per MM SCF/hr of
;                    H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
```

```
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of H2 recovered,
;                   (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of H2 recovered,
;                   (MMM SCF/hr of N2)/(MM SCF/hr of H2 recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference hydrogen recovery rate for a single train
;                   in MM SCF/hr of H2 for the calculation of the
;                   ISBL field cost of a single train as a function of
;                   capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;           Percent H2 recovery    H2 purity in mole %
      REAL 43.83285               99.98677                    &
;           Future use (8 items)
            0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0            &
;           Future use (10 items)
            0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;           Power              900/750 F steam   900 satd steam
```

```
          0.0 12254.04      0.0 0.0           0.0 0.0       &
;         600/720 F steam   600 satd steam    150 satd steam
          0.0 0.0           0.0 0.0           0.0 0.0       &
;         50 satd steam     Plant fuel        Cooling H2O
          0.0 2.054966      0.0 0.0           0.0 42.705864 &
;         Process H2O       Nitrogen
          0.0 0.854117      0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.0            12.0               &
;         Ref Flow   Max Flow   Min Flow
          1.966943   2.5        0.5         &
;         Plant cost equation constants.
;         A      B          E      F      Spares   Future use (2 items)
          0.0    152.6      0.8478 1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR61.
   FLASH-SPECS STRM = H2-RICH   KODE=2   TEMP = 100.0  PRES = 3290.0 /
               STRM = SOUR-GAS  KODE=2   TEMP = 250.0  PRES = 14.7   /
               STRM = P61-GAS   KODE=2   TEMP = 111.0  PRES = 500.0
;
; Plant 6.2 - The Hydrogen purification by Pressure Swing Absorption
;             Plant.
BLOCK P62 USER
   SUBROUTINE MODEL = USR62   REPORT = USR62
   DESCRIPTION 'PLANT 6.2 - THE PSA H2 PURIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL62.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
```

```
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Percent hydrogen recovery to the hydrogen-rich
;                   product gas stream from the inlet gas stream.
;      REAL(2)    = Concentration of hydrogen in the hydrogen-rich
;                   product gas stream, mole % or vol%.
;      REAL(3)-
;       REAL(20)  = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per MM SCF/hr of H2 recovered,
;                   kw/(MM SCF/hr of H2 recovered).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr
;                   of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per MM SCF/hr of H2 recovered,
;                   (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(37)   = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;      REAL(38)   = Cooling water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(39)   = Constant factor for the process water consumption,
;                   Mgal/hr.
;      REAL(40)   = Process water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(41)   = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;      REAL(42)   = Nitrogen consumption per MM SCF/hr of H2 recovered,
;                   (MMM SCF/hr of N2)/(MM SCF/hr of H2 recovered).
```

```
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference hydrogen recovery rate for a single train
;                   in MM SCF/hr of H2 for the calculation of the
;                   ISBL field cost of a single train as a function of
;                   capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;        The cost of Plant 6.2 is included in Plant 6.1.
;          Percent H2 recovery    H2 purity in mole %
     REAL 89.5033                90.01665              &
;          Future use (8 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 5485.989       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.0           0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling H2O
           0.0 15.32654       0.0 0.0           0.0 87.29583  &
;          Process H2O        Nitrogen
           0.0 0.530875       0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0           0.0                 &
;          Ref Flow   Max Flow   Min Flow
           3.61667    5.0        0.5        &
;          Plant cost equation constants.
;          A      B      E      F      Spares   Future use (2 items)
           0.0    0.0    0.7    1.0    0.0      0.0   0.0    &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR62.
   FLASH-SPECS STRM = H2-2RICH  KODE=2   TEMP = 100.0  PRES = 3290.0 /
               STRM = SOUR-2GS  KODE=2   TEMP = 250.0  PRES = 14.7   /
```

```
                STRM = GAS-OUT   KODE=2   TEMP = 111.0  PRES = 25.0   /
                STRM = NAPHTHA2  KODE=2   TEMP = 100.0  PRES = 50.0
;
; Plant 7 - The naphtha reformer - use user Fortran block USR07.
BLOCK P07 USER
   SUBROUTINE MODEL = USR07   REPORT = USR07
   DESCRIPTION 'PLANT 7 - THE NAPHTHA REFORMER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL07.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of feed,
;                  kw/(Mlbs/hr of feed).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                  feed, (Mlbs/hr)/(Mlbs/hr of feed).
;      REAL(25)  = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                  feed, (Mlbs/hr)/(Mlbs/hr of feed).
;      REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;      REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                  feed, (Mlbs/hr)/(Mlbs/hr of feed).
```

```
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of feed,
;                   (MM BTU/hr)/(Mlbs/hr of feed).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of feed,
;                   (Mgal/hr)/(Mlbs/hr of feed).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of feed,
;                   (Mgal/hr)/(Mlbs/hr of feed).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of feed).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference feed rate to a single train in Mlbs/hr
;                   for the calculation of the ISBL field cost of a
;                   single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   feed rate in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Future use (10 items)
     REAL 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
          0.0 2.26494        0.0 0.0           0.0 0.0       &
```

```
;         600/720 F steam   600 satd steam    150 satd steam
          0.0 -0.314772     0.0 0.0           0.0 0.0       &
;         50 satd steam     Plant fuel        Cooling  H2O
          0.0 0.0           0.0 1.41781       0.0 0.123590  &
;         Process H2O       Nitrogen
          0.0 0.0           0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.            8.                  &
;         Ref Flow   Max Flow   Min Flow
          224.289    400.0      50.0       &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future Use (3 items)
          0.0    30.7    0.75   1.0    0.0      0.0   0.0   &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0

;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR07.
   FLASH-SPECS STRM = 7S-H2     KODE=2   TEMP = 80.0  PRES = 14.7  /
               STRM = 7S-GAS    KODE=2   TEMP = 80.0  PRES = 14.7  /
               STRM = REFORMED  KODE=2   TEMP = 80.0  PRES = 14.7
;
; Plant 8.1 - The ROSE-SR unit - user Fortran block USR81.
BLOCK P81 USER
   SUBROUTINE MODEL = USR81   REPORT = USR81
   DESCRIPTION 'PLANT 8.1 - THE ROSE-SR UNIT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL81.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate plants.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
```

```
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Hydrocarbon rejection factor.
;      REAL(2)-
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per Mlbs/hr of extract,
;                   kw/(Mlbs/hr of extract).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   extract, (Mlbs/hr)/(Mlbs/hr of extract).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                   extract, (Mlbs/hr)/(Mlbs/hr of extract).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   extract, (Mlbs/hr)/(Mlbs/hr of extract).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                   extract, (Mlbs/hr)/(Mlbs/hr of extract).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                   extract, (Mlbs/hr)/(Mlbs/hr of extract).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                   extract, (Mlbs/hr)/(Mlbs/hr of extract).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per Mlbs/hr of extract,
;                   (Mlbs/hr)/(Mlbs/hr of extract).
;      REAL(37)   = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;      REAL(38)   = Cooling water consumption per Mlbs/hr of extract,
;                   (Mlbs/hr)/(Mlbs/hr of extract).
;      REAL(39)   = Constant factor for the process water consumption,
;                   Mgal/hr.
;      REAL(40)   = Process water consumption per Mlbs/hr of extract,
;                   (Mlbs/hr)/(Mlbs/hr of extract).
;      REAL(41)   = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;      REAL(42)   = Nitrogen consumption per Mlbs/hr of extract,
;                   (MM SCF/hr of N2)/(Mlbs/hr of extract).
;      REAL(43) -
;       REAL(48) = Future use.
;      REAL(49)   = Constant factor for the number of operators per
;                   day, operators/day.
;      REAL(50)   = Number of operators per day per train,
```

```
;                    (operators/day)/train.
;       REAL(51)  = Reference feed rate to a single train in Mlbs/hr of
;                   unit feed for the calculation of the capital cost of
;                   a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   unit feed rate in Mlbs/hr of unit feed.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   unit feed rate in Mlbs/hr of unit feed.
;       REAL(54)  = Constant A in the plant costing equation.
;       REAL(55)  = Constant B in the plant costing equation.
;       REAL(56)  = Constant E in the plant costing equation.
;       REAL(57)  = Constant F in the plant costing equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;          Hydrocarbon rejection factor
    REAL  1.17   &
;         Future use (9 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam    900 satd steam
          0.0 8.098677       0.0 0.0            0.0 0.0       &
;         600/720 F steam    600 satd steam     150 satd steam
          0.0 0.0            0.0 0.0            0.0 0.0471832 &
;         50 satd steam      Plant fuel         Cooling H2O
          0.0 0.0            0.0 0.393518       0.0 0.0       &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0         &
;         Future Use (6 items)
          0.  0.  0.  0.  0.  0.             &
;         Opers/day     (Opers/day)/train
          0.0           8.0                  &
;         Ref Flow   Max Flow   Min Flow
          907.390   1500.0     500.0         &
;         Plant cost equation constants.
;         A      B        E      F      Spares   Future use (2 items)
          0.0    42.2     0.7215 1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR81.
   FLASH-SPECS STRM = ROSE-XTR  KODE=2   TEMP = 300.0  PRES = 115.0 /
               STRM = ASH-CONC  KODE=2   TEMP = 150.0  PRES = 14.7
;
; Plant 9 - H2 Production by coal gasification, Use the User Fortran
; Block USR09.
BLOCK P09 USER
   SUBROUTINE MODEL = USR09   REPORT = USR09
   DESCRIPTION 'PLANT 9 - H2 PRODUCTION BY COAL GASIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
```

```
;                1 => Skip the capital cost portion of the summary
;                     report.
;                2 => Skip the capital cost and utilities portions
;                     of the summary report.
;                3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;                0 => Write the user block summary report to the normal
;                     ASPEN/SP output report file called DCL09.REP.
;                1 => Write the user block summary report to a separate
;                      user block output report file on logical unit 62.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;                If INT(3) = 0, the minimum number of duplicate
;                  trains will be determined so that the capacity
;                  of each train does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Molar CO/CO2 ratio in the gasifier product gas.
;      REAL(2)   = Fraction of carbon entering the gasifier that goes
;                  to carbonyl sulfide (COS).
;      REAL(3)   = Fraction of carbon entering the gasifier that goes
;                  to methane (CH4).
;      REAL(4)   = Fraction of nitrogen entering the gasifier that goes
;                  to ammonia (NH3).
;      REAL(5)   = Carbon content of the slag produced by the gasifier,
;                  wt %.
;      REAL(6)   = Fraction of carbon monoxide (CO) entering the shift
;                  reactors that is shifted; i.e., converted to carbon
;                  dioxide (CO2) by the chemical reaction
;                      CO + H2O -----> CO2 + H2
;      REAL(7)   = Fraction of carbonyl sulfide (COS) entering the shift
;                  reactor section that is hydrolyzed; i.e., converted
;                  to carbon dioxide (CO2) and hydrogen sulfide (H2S)
;                  by the chemical reaction
;                      COS + H2O -----> CO2 + H2S
;      REAL(8)   = Future use.
;      REAL(9)-
;       REAL(20) = Rectisol section component distribution factors,
;                  where
;      REAL(9)   = Fraction of inlet H2 going to the hydrogen-rich
;                  gas stream.
;      REAL(10)  = Fraction of inlet H2 going to the acid gas stream.
;      REAL(11)  = Fraction of inlet CO going to the hydrogen-rich
;                  gas stream.
;      REAL(12)  = Fraction of inlet CO going to the acid gas stream.
;      REAL(13)  = Fraction of inlet CO2 going to the hydrogen-rich
```

```
;                 gas stream.
;     REAL(14)  = Fraction of inlet CO2 going to the acid gas stream.
;     REAL(15)  = Fraction of inlet CH4 going to the hydrogen-rich
;                 gas stream.
;     REAL(16)  = Fraction of inlet CH4 going to the acid gas stream.
;     REAL(17)  = Fraction of inlet N2 going to the hydrogen-rich
;                 gas stream.
;     REAL(18)  = Fraction of inlet N2 going to the acid gas stream.
;     REAL(19)  = Fraction of inlet H2S going to the hydrogen-rich
;                 gas stream.
;     REAL(20)  = Fraction of inlet H2S going to the acid gas stream.
;     REAL(21)  = Constant factor for the power consumption, kw.
;     REAL(22)  = Power consumption per MM SCF/hr of hydrogen
;                 produced, kw/(MM SCF/hr of H2).
;     REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                 consumption, Mlbs/hr.
;     REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr of
;                 hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;     REAL(25)  = Constant factor for the 900 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr of
;                 hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;     REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                 consumption, Mlbs/hr.
;     REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr of
;                 hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;     REAL(29)  = Constant factor for the 600 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr of
;                 hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;     REAL(31)  = Constant factor for the 150 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                 hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;     REAL(33)  = Constant factor for the 50 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                 hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;     REAL(35)  = Constant factor for the plant fuel consumption,
;                 MM BTU/hr.
;     REAL(36)  = Plant fuel consumption per MM SCF/hr of hydrogen
;                 produced, (MM BTU/hr)/(MM SCF/hr of H2).
;     REAL(37)  = Constant factor for the cooling water consumption,
;                 Mgal/hr.
;     REAL(38)  = Cooling water consumption per MM SCF/hr of hydrogen
;                 produced, (Mgal/hr)/(MM SCF/hr of H2).
;     REAL(39)  = Constant factor for the process water consumption,
;                 Mgal/hr.
;     REAL(40)  = Process water consumption per MM SCF/hr of hydrogen
;                 produced, (Mgal/hr)/(MM SCF/hr of H2).
;     REAL(41)  = Constant factor for the nitrogen consumption,
;                 MM SCF/hr of N2.
;     REAL(42)  = Nitrogen consumption per MM SCF/hr of hydrogen
;                 produced, (MM SCF/hr of N2)/(MM SCF/hr of H2).
;     REAL(43) -
```

```
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
;       REAL(51)  = Reference hydrogen production rate of a single train
;                   in MM SCF/hr of H2 for the calculation of the ISBL
;                   field cost of a single train as a function of train
;                   capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   hydrogen production rate in MM SCF/hr of H2.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   hydrogen production rate in MM SCF/hr of H2.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare plants.
;       REAL(59) -
;        REAL(70) = Future use.
;
;  NOTE:  MM SCF/hr of hydrogen produced means MM SCF/hr of hydrogen
;         in the hydrogen-rich product gas stream and NOT the total
;         flow rate of the hydrogen-rich product gas stream.
;
;                    Frac C       Frac C   Frac N   %C in
;         CO/CO2     to COS       to CH4   to NH3   slag
     REAL 2.419768  0.000804005  0.0      0.05212  5.229154  &
;         Frac CO shifted  Frac COS hydrolyzed  Future use
;         Adjust the fraction of CO shifted to get true H2 rate.
          0.9611           0.9516917            0.0          &
;         Component distribution factors for H2 to H2 and acid gas.
          0.8344      0.00153604                             &
;         Component distribution factors for CO to H2 and acid gas.
          0.0         0.0545937                              &
;         Component distribution factors for CO2 to H2 and acid gas.
          0.0         0.0453275                              &
;         Component distribution factors for CH4 to H2 and acid gas.
          0.0         0.0                                    &
;         Component distribution factors for N2 to H2 and acid gas.
          0.0932727   0.0923972                              &
;         Component distribution factors for H2S to H2 and acid gas.
          0.0         0.990203                               &
;         Power              900/750 F steam   900 satd steam
          0.0 3679.14335     0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 -16.98424     0.0 -44.40466 &
;         50 satd steam      Plant fuel        Cooling  H20
          0.0 -45.47563      0.0 -57.09919     0.0 183.6952  &
;         Process H20        Nitrogen
          0.0 4.176796       0.0 0.0824568   &
;         Future Use (6 items)
          0.  0.  0.  0.  0.  0.             &
;         Opers/day     (Opers/day)/train
          0.0           24.                  &
```

```
;         Ref Flow   Max Flow   Min Flow
          3.436      3.5        1.0        &
;         Plant cost equation constants.
;         A      B      E      F      Spares   Future use (3 items)
          0.0    52.7   0.7658 1.0    0.       0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR09.
   FLASH-SPECS STRM = H2-GAS    KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = H2S-GAS   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = VENT-GAS  KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = 9S-SH2O   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = SLAG      KODE=2   TEMP = 80.   PRES = 14.7
;
;  Plant 9.1 - Steam Reforming of Natural Gas Plant.
BLOCK P91 USER
   SUBROUTINE MODEL = USR91   REPORT = USR91
   DESCRIPTION 'PLANT 9.1 - STEAM REFORMING OF NATURAL GAS PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL91.REP.
;      INT(3) = Number of operating duplicate plants, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 plants will be determined so that the capacity
;                 of each plant does not exceed the maximum plant
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, this number of duplicate plants will
;                 be used.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Fraction of CH4 reacting to produce H2 and CO2.
;      REAL(2)   = Fraction of CH4 reacting to produce H2 and CO.
;      REAL(3)   = Fraction of hydrogen produced that leaves in the
```

```
;                 hydrogen-rich product gas stream.
;      REAL(4)    = Purity of the hydrogen-rich product gas. mole %.
;      REAL(5) -
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per MM SCF/hr of hydrogen produced,
;                   kw/(MM SCF/hr of H2).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per MM SCF/hr of hydrogen
;                   produced, (MM BTU/hr)/(MM SCF/hr of H2).
;      REAL(37)   = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;      REAL(38)   = Cooling water consumption per MM SCF/hr of hydrogen
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;      REAL(39)   = Constant factor for the process water consumption,
;                   Mgal/hr.
;      REAL(40)   = Process water consumption per MM SCF/hr of hydrogen
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;      REAL(41)   = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2..
;      REAL(42)   = Nitrogen consumption per MM SCF/hr of hydrogen
;                   produced, (MM SCF/hr of N2)/(MM SCF/hr of H2).
;      REAL(43) -
;       REAL(48) = Future use.
;      REAL(49)   = Constant factor for the number of operators per
;                   day, operators/day.
;      REAL(50)   = Number of operators per day per operating train,
;                   (operators/day)/train.
;      REAL(51)   = Reference hydrogen production rate of a single train
;                   in MM SCF/hr of H2 for the calculation of the ISBL
```

```
;                   field cost of a single train as a function of train
;                   capacity.
;      REAL(52)  = Maximum plant size as defined by the hydrogen
;                   production rate in MM SCF/hr of H2.
;      REAL(53)  = Minimum plant size as defined by the hydrogen
;                   production rate in MM SCF/hr of H2.
;      REAL(54)  = Constant A in the plant ISBL field cost equation.
;      REAL(55)  = Constant B in the plant ISBL field cost equation.
;      REAL(56)  = Constant E in the plant ISBL field cost equation.
;      REAL(57)  = Constant F in the plant ISBL field cost equation.
;      REAL(58)  = Number of spare plants.
;      REAL(59) -
;       REAL(70) = Future use.
;
;  NOTES: 1. MM SCF/hr of hydrogen produced means MM SCF/hr of hydrogen
;            in the hydrogen rich product gas stream and NOT the total
;            flow rate of the hydrogen rich product gas stream.
;         2. The number of operators in this plant and Plants 31.1 and
;            31.4 is set so as to maintain the same total number of
;            operators as used for the baseline design.
;
;         Frac CH4 to CO2  Frac CH4 to CO  Frac recovered  H2 Purity
     REAL 0.638648         0.04429         0.8862694       100.0 &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0                      &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 354.158        0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 -65.3773      0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 89.0448       0.0 32.6902   &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0           &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0         &
;         Opers/day      (Opers/day)/train
          0.0            8.0                   &
;         Ref Flow       Max Flow     Min Flow
          5.77237        6.25         2.0      &
;         Plant cost equation constants.
;         A      B      E      F      Spares   Future Use (2 items)
          0.0    68.1   0.75   1.0    0.0      0.0    0.0    &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR091.
   FLASH-SPECS STRM = H2-PROD    KODE=2  TEMP = 100.0  PRES = 500.0 /
               STRM = FLUE-GAS   KODE=2  TEMP = 250.0  PRES = 14.7
;
; Plant 10 - Air Separation Plant - Use the User Fortran Model USR10.
BLOCK P10 USER
   SUBROUTINE MODEL = USR10   REPORT = USR10
```

```
   DESCRIPTION 'PLANT 10 - AIR SEPARATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the complete user block summary report to
;                    the normal ASPEN/SP output report file.
;               1 => Write the complete user block summary report to
;                    a separate user block output report file on
;                    logical unit 62 CALLED DCL10.REP.
;      INT(3) = Number of operating duplicate trains, excluding
;               spares.
;               If INT(3) = 0, the minimun number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
     INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Purity of the product oxygen stream, mole %.
;      REAL(2)   = Purity of the product nitrogen stream, mole %.
;      REAL(3) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per MM SCF/hr of the oxygen stream
;                  flow rate, kw/(MM SCF/hr of O2).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr of
;                  the oxygen stream flow rate,
;                  (Mlbs/hr)/(MM SCF/hr of O2).
;      REAL(25)  = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr of
;                  the oxygen stream flow rate,
;                  (Mlbs/hr)/(MM SCF/hr of O2).
;      REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;      REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr of
;                  the oxygen stream flow rate,
;                  (Mlbs/hr)/(MM SCF/hr of O2).
```

```
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr of
;                   the oxygen stream flow rate,
;                   (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                   the oxygen stream flow rate,
;                   (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                   the oxygen stream flow rate,
;                   (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of the oxygen
;                   stream flow rate, (MM BTU/hr)/(MM SCF/hr of O2).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of the oxygen
;                   stream flow rate, (Mgal/hr)/(MM SCF/hr of O2).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of the oxygen
;                   stream flow rate, (Mgal/hr)/(MM SCF/hr of O2).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of the oxygen
;                   stream flow rate,
;                   (MM SCF/hr of N2)/(MM SCF/hr of O2).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference oxygen production rate for a single train
;                   in MM SCF/hr of O2 for the calculation of the
;                   ISBL field cost of a single train as a function of
;                   train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   oxygen production rate in MM SCF/hr of O2.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   oxygen production rate in MM SCF/hr of O2.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;     NOTES:
```

```
;       1.  This model does not consider Argon as a separate element.
;           Hence, argon is lumped with nitrogen.
;       2.  MM SCF/hr of O2 means the oxygen production rate in
;           MM SCF/hr of O2 in the product oxygen stream and NOT
;           the total flow rate of the product oxygen stream.
;
;         %O2 in O2    %N2 in N2   Future Use (8 items)
     REAL 99.5003      100.0       0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 18143.97       0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 0.0           0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 0.0           0.0 0.0       &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          4.0           0.0                 &
;         Ref Flow     Max Flow     Min Flow
          1.763605     1.875        1.0     &
;         Plant cost equation costants.
;         A       B        E       F      Spares   Future use (2 items)
          0.0     38.2     0.7028  1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR10.
   FLASH-SPECS STRM = 10S01   KODE=2   TEMP =   80.0   PRES = 350.0  /
               STRM = 10S02   KODE=2   TEMP = -275.0   PRES = 164.7
;
; Plant 11 - Sulfur Recovery Plant, Use the User Fortran Model USR11.
BLOCK P11 USER
   SUBROUTINE MODEL = USR11   REPORT = USR11
   DESCRIPTION 'PLANT 11 - THE SULFUR RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the
;                    normal ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL11.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
```

```
;                If INT(3) = 0, the minimun number of duplicate
;                  trains will be determined so that the capacity
;                  of each train does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Fractional sulfur recovery; fraction of sulfur in
;                   the entering H2S and COS that is recovered in the
;                   product liquid sulfur stream.  All entering liquid
;                   sulfur entering in the feed stream is assumed to
;                   be recovered in the liquid sulfur product stream.
;      REAL(2) -
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per Mlbs/hr of product sulfur,
;                   kw/(Mlbs/hr).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   product sulfur, (Mlbs/hr)/(Mlbs/hr).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                   product sulfur, (Mlbs/hr)/(Mlbs/hr).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   product sulfur, (Mlbs/hr)/(Mlbs/hr).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                   product sulfur, (Mlbs/hr)/(Mlbs/hr).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                   product sulfur, (Mlbs/hr)/(Mlbs/hr).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                   product sulfur, (Mlbs/hr)/(Mlbs/hr).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per Mlbs/hr of product sulfur,
;                   (MM BTU/hr)/(Mlbs/hr).
;      REAL(37)   = Constant factor for the cooling water consumption,
;                   Mgal/hr.
```

```
;       REAL(38)  = Cooling water consumption per Mlbs/hr of product
;                   sulfur (Mgal/hr)/(Mlbs/hr).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of product
;                   sulfur, (Mgal/hr)/(Mlbs/hr).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrigen consumption per Mlbs/hr of product sulfur,
;                   (MM SCF/hr of N2)/(Mlbs/hr).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference product sulfur flow rate of a single train
;                   in Mlbs/hr of S for the calculation of the ISBL field
;                   cost of a single train as a function of capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   product sulfur flow rate in Mlbs/hr of S.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   product sulfur flow rate in Mlbs/hr of S.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          S recovery
     REAL 0.998482    &
;          Future Use (19 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0       &
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 49.60954       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.971388      0.0 -3.022277 &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 0.882473       0.0 1.117916      0.0 7.89929   &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0           5.0                &
;          Ref Flow     Max Flow     Min Flow
           15.4305      16.5         5.0      &
;          Plant cost equation costants.
;          A       B        E      F      Spares   Future use (3 items)
           0.0     11.675   0.7823 1.0    0.0      0.0   0.0    &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
```

```
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 11S-FGAS  KODE=2   TEMP = 80.0   PRES = 14.7  /
               STRM = 11S-LIQS  KODE=2   TEMP = 80.0   PRES = 14.7
;
; Plant 31 - The Utilities plant - user Fortran block USR31.
BLOCK P31 USER
   SUBROUTINE MODEL = USR31   REPORT = USR31
   DESCRIPTION 'PLANTS 31 - THE UTILITIES PLANT'
   PARAM  NINT = 20   NREAL = 20
;      The following 20 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Not used.
;               2 => Not used.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL02.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(2).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
;      INT(5) = Future use.
;      INT(6) -  Switches to select which fuels are burned in the steam
;       INT(10)  boiler to produce steam and/or electric power to
;                satisfy the steam demand.  The fuel specified in
;                INT(6) is used until it is all consumed, the steam
;                demand is satisfied, or the capacity to use this fuel
;                is reached.  Then the INT(7) fuel is used, etc.
;                The fuel codes are
;                  1 = Coal
;                  2 = ROSE-SR unit bottoms
;                  3 = Coke
;                  4 = Natural gas
;                  5 = Plant fuel
;      INT(11) - Switches to select which fuels are burned to satisfy
;       INT(16)  the electric power demand.  The fuel specified in
;                INT(11) is used until it is all consumed, the power
;                demand is satisfied, or the capacity to use this fuel
;                is reached.  Then the INT(12) fuel is used, etc.
```

```
;                 The fuel codes are
;                   1 = Coal
;                   2 = ROSE-SR unit bottoms
;                   3 = Coke
;                   4 = Natural gas
;                   5 = Plant fuel
;                   6 = Purchased electric power
;       INT(17) -
;        INT(20)  Future use.
    INT  0  1  0  1  0  4  1  2  3  5    &
         4  1  2  3  5  6  0  0  0  0
;
;       The following 20 real parameters are:
;       REAL(1)  = Reference electric power generation rate of a single
;                  train in MW.
;       REAL(2)  = Maximum size of a single train as defined by the
;                  electric power generation rate in MW.
;       REAL(3)  = Minimum size of a single train as defined by the
;                  electric power generation rate in MW.
;       REAL(4)  = Constant A in the plant costing equation.
;       REAL(5)  = Constant B in the plant costing equation.
;       REAL(6)  = Constant E in the plant costing equation.
;       REAL(7)  = Constant F in the plant costing equation.
;       REAL(8)  = Number of spare trains.
;       REAL(9)  = Future use
;       REAL(10) = Future use
;       REAL(11) = Constant factor for the number of operators per
;                  day, operators/day.
;       REAL(12) = Number of operators per day per train,
;                  (operators/day)/train.
;       REAL(13) -
;        REAL(20) = Future use.
;
;          Ref MW    Max size   Min size
     REAL 79.259    84.0       1.0        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future use (2 items)
           0.0    87.466  0.7    1.0    0.0      0.0   0.0   &
;          Opers/day     (Opers/day)/train
           6.0           2.0                 &
;          Future use (8 items)
           0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
;
; Plants 31.1 and 31.4 - The Fluidized Bed Combustor and Steam Turbine
; Generator unit - user Fortran block USRA6.
BLOCK P314 USER
   SUBROUTINE MODEL = USRA6   REPORT = USRA6
   DESCRIPTION 'PLANTS 31.1 AND 31.4 - THE FLUIDIZED BED COMBUSTOR AND
   STEAM TURBINE GENERATOR UNIT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
```

```
;                2 => Skip the capital cost and utilities portions
;                     of the summary report.
;                3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;                0 => Write the user block summary report to the normal
;                     ASPEN/SP output report file.
;                1 => Write the user block summary report to a separate
;                     user block output report file on logical unit 62
;                     called DCLA6.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;                If INT(3) = 0, the minimum number of duplicate
;                  trains will be determined so that the capacity
;                  of each train does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate plants.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Solids production expressed as fraction of URCOAL
;                   in feed ending up in solids.
;      REAL(2)-
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per Mlbs/hr of unit feed,
;                   kw/(Mlbs/hr of unit feed).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
```

```
;                 unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(35)  = Constant factor for the plant fuel consumption,
;                  MM BTU/hr.
;      REAL(36)  = Plant fuel consumption per Mlbs/hr of unit feed,
;                  (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(37)  = Constant factor for the cooling water consumption,
;                  Mgal/hr.
;      REAL(38)  = Cooling water consumption per Mlbs/hr of unit feed,
;                  (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(39)  = Constant factor for the process water consumption,
;                  Mgal/hr.
;      REAL(40)  = Process water consumption per Mlbs/hr of unit feed,
;                  (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(41)  = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2
;      REAL(42)  = Nitrogen consumption per Mlbs/hr of unit feed,
;                  (MM SCF/hr of N2)/(Mlbs/hr of unit feed).
;      REAL(43) -
;       REAL(48) = Future use.
;      REAL(49)  = Constant factor for the number of operators per
;                  day, operators/day.
;      REAL(50)  = Number of operators per day per train,
;                  (operators/day)/train.
;      REAL(51)  = Reference feed rate to a single train in Mlbs/hr of
;                  unit feed for the calculation of the ISBL field cost
;                  of a single train as a function of train capacity.
;      REAL(52)  = Maximum size of a single train as defined by the
;                  unit feed rate in Mlbs/hr of unit feed.
;      REAL(53)  = Minimum size of a single train as defined by the
;                  unit feed rate in Mlbs/hr of unit feed.
;      REAL(54)  = Constant A in the plant ISBL field cost equation.
;      REAL(55)  = Constant B in the plant ISBL field cost equation.
;      REAL(56)  = Constant E in the plant ISBL field cost equation.
;      REAL(57)  = Constant F in the plant ISBL field cost equation.
;      REAL(58)  = Number of spare trains.
;      REAL(59) -
;       REAL(70) = Future use.
;
;  NOTE: The number of operators in this plant and Plant 9lis set so
;            as to maintain the same total number of operators as used
;            for the baseline design.
;
;         Fraction of URCOAL in feed ending up in solids
   REAL   0.8500914  &
;         Future use (9 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0        &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   &
;         Power              900/750 F steam    900 satd steam
          0.0 -552.6474      0.0 0.0            0.0 0.0       &
;         600/720 F steam    600 satd steam     150 satd steam
          0.0 0.0            0.0 0.0            0.0 0.0       &
;         50 satd steam      Plant fuel         Cooling H2O
          0.0 0.0            0.0 0.0            0.0 27.99327  &
;         Process H2O        Nitrogen
```

```
          0.0 0.06900667    0.0 0.0          &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0       &
;         Opers/day    (Opers/day)/train
          0.0          30.0                  &
;         Ref Flow     Max Flow   Min Flow
          368.660      400.0      30.0       &
;         Plant cost equation constants.
;         A      B      E      F      Spares   Future use (2 items)
          0.0    0.0    0.75   1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet stream.  These
;  values will override the default values in subroutine USRA6.
   FLASH-SPECS STRM = SA6-01    KODE=2   TEMP = 130.0  PRES = 14.7
;
; Plant 38 - The Ammonia Recovery Plant - use user Fortran block USR38.
BLOCK P38 USER
   SUBROUTINE MODEL = USR38   REPORT = USR38
   DESCRIPTION 'PLANT 38 - THE AMMONIA RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL38.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Ammonia recovery, percent.
;      REAL(2)   = Purity of ammonia product, wt %.
;      REAL(3) -
```

```
;        REAL(20) = Future use.
;       REAL(21)  = Constant factor for the power consumption, kw.
;       REAL(22)  = Power consumption per Mlbs/hr of NH3 recovered,
;                   kw/(Mlbs/hr of NH3 recovered).
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of NH3 recovered,
;                   (MM BTU/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of NH3
;                   recovered, (Mgal/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of NH3
;                   recovered, (Mgal/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of NH3 recovered,
;                   (MM SCF/hr of N2)/(Mlbs/hr of NH3 recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
;       REAL(51)  = Reference NH3 recovery rate of a single train in
;                   Mlbs/hr for the calculation of the ISBL field cost
;                   of a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   NH3 recovery rate in Mlbs/hr of NH3 recovered.
```

```
;       REAL(53)  = Minimum size of a single train as defined by the
;                   NH3 recovery rate in Mlbs/hr of NH3 recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          NH3 recovery, %     NH3 purity, wt%
     REAL 99.103              99.552              &
;          Future use (8 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 75.713367      0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0  0.0           0.0 16.124425     0.0 28.745809 &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 0.0            0.0 0.0           0.0 227.9442  &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0            &
;          Opers/day     (Opers/day)/train
           0.0           20.0                  &
;          Ref Flow   Max Flow   Min Flow
           20.221     100.0      5.0         &
;          Plant cost equation constants.
;          A      B      E      F      Spares   Future Use (3 items)
           0.0    40.1   0.7807 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR38.
   FLASH-SPECS STRM = NH3-PROD  KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = 38S-OUT   KODE=2   TEMP = 80.   PRES = 14.7
;
;  Component splitter to generate the vapor and liquid streams
;  leaving Plant 38, the ammonia recovery plant.
BLOCK P38A SEP
   FRAC  SUBS = MIXED  STRM = 38AS-VAP                  &
   COMP = H2  N2  O2  H2S  CO  CO2  NH3                 &
          L-SULFUR H2O HCL COS CH4                      &
          C2H6 C3H8 IC4H10 NC4H10 IC5H12 NC5H12         &
          T125  T175  T225  T275  T325                  &
          T375  T425                                    &
          T475  T525  T575  T625  T675                  &
          P125  P175  P225  P275  P325  P375            &
          P425  P475  P525  P575  P625  P675            &
   FRAC = 1.0  1.0  1.0  0.9956  1.0  0.9985  0.07104   &
          0.0  0.002755  1.0  1.0  0.8888889            &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492     &
```

```
          0.9492 0.9492 0.9492 0.9492 0.9492          &
          0.9492 0.9492                               &
          0.08481 0.08481 0.08481 0.08481 0.9492      &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492   &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492
   FLASH-SPECS STRM = 38AS-VAP  TEMP=90.0  PRES=25.0  NPK=1  KPH=1 /
               STRM = 38AS-LIQ  TEMP=90.0  PRES=25.0  NPK=1  KPH=2
;
;  Flow splitter to generate the waste water stream going to the
;  gasifier, Plant 9, and the stream going to the phenol recovery
;  plant, Plant 39.
BLOCK P38B FSPLIT
   FRAC  WASTE  0.28595
   PARAM NPK=1  KPH=2
;
; Plant 39 - The PHENOL RECOVERY PLANT - Use user Fortran block USR39.
BLOCK P39 USER
   SUBROUTINE MODEL = USR39   REPORT = USR39
   DESCRIPTION 'PLANT 39 - THE PHENOL RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL39.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Phenol recovery, percent.
;      REAL(2)   = Purity of phenol product, wt %.
;      REAL(3) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
```

```
;       REAL(22)  = Power consumption per Mlbs/hr of phenol recovered,
;                   kw/(Mlbs/hr of phenol recovered).
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of phenol
;                   recovered,
;                   (MM BTU/hr)/(Mlbs/hr of phenol recovered).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(39)  = Cooling water consumption per Mlbs/hr of phenol
;                   recovered, (Mgal/hr)/(Mlbs/hr of phenol recovered).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of phenol
;                   recovered, (Mgal/hr)/(Mlbs/hr of phenol recovered).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of phenol recovered,
;                   (MM SCF/hr of N2)/(Mlbs/hr of phenol recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
```

```
;       REAL(51)  = Reference phenol recovery rate of a single train in
;                   Mlbs/hr for the calculation of the IKSBL field cost
;                   of a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   phenol recovery rate in Mlbs/hr of phenol recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   phenol recovery rate in Mlbs/hr of phenol recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;    NOTE: In the above, phenol recovered means pure phenol recovered.
;
;          Phenol recovery, %     Phenol purity, wt%
     REAL 97.0089             89.62                &
;          Future use (8 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 339.16667      0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0  0.0           0.0 0.0           0.0 9.465     &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 25.652917      0.0 0.0           0.0 111.775   &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0           0.0                 &
;          Ref Flow   Max Flow   Min Flow
           2.4        20.0       1.0        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future Use (3 items)
           0.0    13.3    0.8056 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR39.
   FLASH-SPECS STRM = PHENOL   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = WASTEH2O KODE=2   TEMP = 80.   PRES = 14.7
;
;  Plant SA6 separates the combined product stream from Plants 31.1
;  and 31.4 into two streams, one for flue gas and another for solids.
;  The separation is set to the URCOAL fraction in the solids stream.
BLOCK SA6 SEP
  FRAC  SUBS=NC    STREAM=FBC-SOL  COMP=URCOAL  FRAC=0.8500914   /
        SUBS=MIXED STREAM=FBC-SOL  COMP=T1000+  FRAC=1.0D-10
;
;  Splitter S1 - The Inlet Coal Splitter.  Used as a switch to divert
```

```
;  flow between the three different coal cleaning options, as represented
;  by the three different Coal Cleaning and Preparation Plants:
;  Base Case (1S01), Alternate Case 1 (1S11), and Alternate Case 2 (1S21).
BLOCK S1 FSPLIT
  DESCRIPTION 'INLET ROM COAL SPLITTER - COAL CLEANING SWITCH'
  FRAC  1S01 0.0 / 1S11 1.0 / 1S21 0.0
;
;  Splitter S6-SH2O is a component splitter to generate a pseudo
;   sour-water stream from Plant 6 to get the NH3 to Plant 38, the
;   Ammonia Recovery Plant.
BLOCK S6-SH2O SEP
  DESCRIPTION 'SPLITTER TO GENERATE PSEUDO SOUR WATER FROM PLANT 6'
  FRAC  SUBS=MIXED  STREAM=6S-SH2O  COMP=NH3  FRAC=1.0
;
;  Splitter S7 - The Product Naphtha Splitter.  Used as a switch to
;  divert flow between the naphtha reformer, Plant 7 and output to
;  naphtha product.
BLOCK S7 FSPLIT
  DESCRIPTION 'HYDROTREATED NAPHTHA SPLITTER - REFORMER OPTION SWITCH'
;  ==================================================================
;  Use the following line to direct total flow to the reformer, or....
;   FRAC  7-NAPH 1.0
;  Use the following line to direct total flow to the product stream.
  FRAC PNAPHTHA 1.0
;
;  Splitter S8 - The Ash-Concentrate Splitter.  Used as a switch to
;  divert flow between the fluidized bed combustor, Plant 314 and the
;  coal gasification train; Plants M9C, P09, & P10.
BLOCK S8 FSPLIT
  DESCRIPTION 'ASH-CONCENTRATE SPLITTER - FBC OPTION 6 SWITCH'
;  Direct the ash-concentrate flow to coal gasification.
  FRAC  S8-ASHC 1.0
;
;  Splitter S9 - The dummy hydrogen splitter used to switch between
;  the two hydorgen production alternatives, Plant 9.0/10 - coal
;  gasification, or Plant 9.1 - steam reforming of methane.
BLOCK S9 FSPLIT
  DESCRIPTION 'DUMMY H2 SPLITTER - H2 GENERATION OPTION SWITCH'
;  Set an H2 target flow for Plant 9.0/10 - coal gasification.
  FRAC  H9NEED 1.0
  PARAM   NPK=1  KPH=1
;
; Stream Report Section
; ---------------------
;
STREAM-REPORT P1A
   STREAMS STRM = ROMCOAL ROMCOAL2 1S-CCOAL COALTO9 COALTO2     &
                  14S-XMID 14S-REF 1S-XMID 1S-REFSE             &
                  ASH-CONC S8-ASHC 9-FEED SLAG SOLVENT          &
                  2S-BOTTS FBC-FEED SA6-01 FBC-SOL FBC-GAS
   FLOW-FRAC SUBS=MIXED BASES=MASS / SUBS=NC BASES=MASS
   INTENSIVE-PROPS SUBS=MIXED BASES=MASS &
                   PROPS=TEMP PRES MW ENTH ENTR DENS HCAP /
                   SUBS=NC BASES=MASS &
                   PROPS=TEMP PRES MW ENTH DENS
```

```
   ATTRIBUTES SUBS=NC COMPONENT
;
STREAM-REPORT P1B
   STREAMS STRM = 1S-WATER 14S-WAT 2-H2OIN 2-H2IN H2MIX 2-H2MIX      &
                  SOLVENT ROSE-XTR 2S-GAS GASES 2S-SH2O              &
                  NAPHTHA GAS-OIL H2-RICH SOUR-GAS P61-GAS           &
                  H2-2RICH SOUR-2GS GAS-OUT NAPHTHA2 3-GAS           &
                  3S-SGAS 3S-FGAS 3S-PROP 3S-BUT 3S-OIL 3S-SH2O      &
                  4-FEED 4-H2IN 4-H2OIN 4S-GAS 4S-NAPH 4S-SH2O       &
                  5S-HPGAS 5S-LPGAS 5-H2IN 5-H2OIN                   &
                  5S-NAPH P350-450 P450-650 P650-850 5S-SH2O         &
                  PS-NAPH PNAPHTHA 7-NAPH 7S-H2 7S-GAS REFORMED      &
                  61-HYD 62-HYD M9H2 M9H4 M9H5 MHNEED                &
                  H9NEED H91NEED                                     &
                  10-AIRIN 10S01 10S02 9-O2IN 9-H2OIN 9-STEMIN       &
                  H2-GAS H2S-GAS VENT-GAS 9S-SH2O                    &
                  NAT-GAS STEAM H2-PROD FLUE-GAS                     &
                  6-SGAS 6S-SH2O 11-FEED 11S-FGAS 11S-LIQS 31S-01    &
                  38-FEED NH3-PROD 38S-OUT 38AS-VAP 38AS-LIQ         &
                  WASTE 39FEED PHENOL WASTEH2O
   FLOW-FRAC SUBS=MIXED BASES=MASS
   INTENSIVE-PROPS SUBS=MIXED BASES=MASS &
                   PROPS=TEMP PRES MW ENTH ENTR DENS HCAP
;
;  End of input file OPT1.INP
```

APPENDIX G

APPENDIX G

ASPEN/SP PROCESS SIMULATION MODEL

INPUT FILE FOR OPTION 2 --

LIQUEFACTION FEED COAL CLEANING BY SPHERICAL AGGLOMERATION

ASPEN/SP PROCESS SIMULATION MODEL

INPUT FILE FOR OPTION 2 --

LIQUEFACTION FEED COAL CLEANING BY SPHERICAL AGGLOMERATION

```
NEW
;
;   File: OPT2.INP
;
TITLE 'OPT2 - DIRECT COAL LIQUEFACTION - OPTION 2 - NTH PLANT'
;
DESCRIPTION &
  "ASPEN/SP INPUT FILE FOR SIMULATING OPTION 2, ONE OF THE TWO COAL
   CLEANING OPTIONS FOR THE DOE DIRECT COAL LIQUEFACTION BASELINE
   DESIGN AND SYSTEMS ANALYSIS PROJECT.  THIS FILE DOES THE NTH PLANT
   COST CALCULATIONS.  THIS INPUT FILE ALSO CAN BE USED TO RUN OPTION
   7 (NAPHTHA REFORMING), AND A MODIFIED VERSION OF OPTION 6 (STEAM
   REFORMING OF NATURAL GAS FOR HYDROGEN PRODUCTION WITH AN FBC
   UNIT)."
;
;  NOTES:
;  1.  The dry clean coal feed rate to the Plant 2 coal liquefaction
;      reactors is set in the design specification DES-SPEC COALFLO.
;  2.  The switches LOSBL and LPLANT contained in Fortran block SUMMARY
;      control the costing logic for OSBL and first or Nth plant.
;  3.  Option 1, coal cleaning for liquefaction by heavy mediium
;      separation is activated by setting the fraction going to
;      stream 1S11 to 1.0 in the S1 Splitter block.  All other stream
;      fractions must be zero.
;  4.  Option 2, coal cleaning for liquefaction by spherical
;      agglomeration is activated by setting the fraction going to
;      stream 1S21 to 1.0 in the S1 Splitter block.  All other stream
;      fraction must be zero.
;  5.  Option 7 (naphtha reforming) is activated in Block S7 by
;      sending all the hydrotreated naphtha to Plant 7 rather than
;      to the product PNAHTHA.
;  6.  Modified Option 6 (hydrogen production by steam reforming of
;      natural gas with an FBC unit) is activated by variable N9 in
;      Fortran block OPTION6.  When N9 = 1, the modified Option 6 is
;      invoked.  This is a modified version in that cost parameters
;      for the coal cleaning plant, Plant 1, are based on sending
;      some jig cleaned coal to gasification for hydrogen production.
;      Thus. since no coal is being sent for gasification, the Plant 1
;      costs will be over-estimated.
;  7.  The costing logic is controlled by switches in Fortran block
;      SUMMARY.
;
;   Last revision - July 17, 1992.
;
;   Prepared under DOE contract no. DE-AC22 90PC89857.
;
IN-UNITS  ENG
```

```
OUT-UNITS ENG
HISTORY-UNITS ENG
RUN-CONTROL MAX-ERRORS=100
;
;  The following two lines are used with V8.0 to produce the overall
;  and block elemental balances.
;REPORT ATOMBAL
;BLOCK-REPORT ATOMBAL
;
HISTORY  MSG-LEVEL  PROPERTIES=2
  MAX-PRINT  PROPERTIES=100  SIMULATION=2000
;
PROPERTIES SYSOP2 GLOBAL
;
PSEUDO-COMPS
  METHOD METCCOAL -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 &
                  -1 -1 -1 -1 -1 -1 -1
;  The following APIs and MWs are revised from the ASPEN/SP predictions.
;  Component T1000+ is the 1000+ F material leaving the second coal
;    liquefaction reactor in Plant 2.
;  Component I1000+ is the 1000+ F intermediate material leaving the
;    first coal liquefaction reactor in Plant 2.
   COMPONENT T125   TBP=324.82 <K>  API=67.91  MW= 82.27
   COMPONENT T175   TBP=352.59 <K>  API=61.99  MW= 92.77
   COMPONENT T225   TBP=380.37 <K>  API=56.21  MW=102.84
   COMPONENT T275   TBP=408.15 <K>  API=50.60  MW=112.50
   COMPONENT T325   TBP=435.93 <K>  API=45.18  MW=121.82
   COMPONENT T375   TBP=463.71 <K>  API=39.96  MW=130.86
   COMPONENT T425   TBP=491.48 <K>  API=34.96  MW=139.75
   COMPONENT T475   TBP=519.26 <K>  API=30.19  MW=148.60
   COMPONENT T525   TBP=547.04 <K>  API=25.66  MW=157.54
   COMPONENT T575   TBP=574.82 <K>  API=21.39  MW=166.69
   COMPONENT T625   TBP=602.59 <K>  API=17.38  MW=176.16
   COMPONENT T675   TBP=630.37 <K>  API=13.66  MW=186.05
   COMPONENT T725   TBP=658.15 <K>  API=10.23  MW=196.44
   COMPONENT T775   TBP=685.93 <K>  API= 7.09  MW=207.37
   COMPONENT T825   TBP=713.71 <K>  API= 4.27  MW=218.85
   COMPONENT T875   TBP=741.48 <K>  API= 1.78  MW=230.87
   COMPONENT T925   TBP=769.26 <K>  API=-0.39  MW=243.37
   COMPONENT T975   TBP=797.04 <K>  API=-2.22  MW=256.24
   COMPONENT T1000+ TBP=824.82 <K>  API=-3.69  MW=269.33
   COMPONENT P125   TBP=324.82 <K>  API=67.91  MW= 82.27
   COMPONENT P175   TBP=352.59 <K>  API=61.99  MW= 92.77
   COMPONENT P225   TBP=380.37 <K>  API=56.21  MW=102.84
   COMPONENT P275   TBP=408.15 <K>  API=50.60  MW=112.50
   COMPONENT P325   TBP=435.93 <K>  API=45.18  MW=121.82
   COMPONENT P375   TBP=463.71 <K>  API=39.96  MW=130.86
   COMPONENT P425   TBP=491.48 <K>  API=34.96  MW=139.75
   COMPONENT P475   TBP=519.26 <K>  API=30.19  MW=148.60
   COMPONENT P525   TBP=547.04 <K>  API=25.66  MW=157.54
   COMPONENT P575   TBP=574.82 <K>  API=21.39  MW=166.69
   COMPONENT P625   TBP=602.59 <K>  API=17.38  MW=176.16
   COMPONENT P675   TBP=630.37 <K>  API=13.66  MW=186.05
   COMPONENT P725   TBP=658.15 <K>  API=10.23  MW=196.44
   COMPONENT P775   TBP=685.93 <K>  API= 7.09  MW=207.37
```

```
   COMPONENT P825   TBP=713.71 <K>  API= 4.27  MW=218.85
   COMPONENT P875   TBP=741.48 <K>  API= 1.78  MW=230.87
   COMPONENT P925   TBP=769.26 <K>  API=-0.39  MW=243.37
   COMPONENT P975   TBP=797.04 <K>  API=-2.22  MW=256.24
   COMPONENT P1000+ TBP=824.82 <K>  API=-3.69  MW=269.33
   COMPONENT I1000+ TBP=825.00 <K>  API=-4.00  MW=275.00
   COMPONENT REFORMAT TBP=390.00 <K>  API=38.25  MW=100.00
;
COMPONENTS H2 H2 / N2 N2 / O2 O2 / H2S H2S / CO CO / CO2 CO2 / NH3 H3N /
           L-SULFUR SULFUR / H2O H2O / HCL HCL / COS COS / CH4 CH4 /
           C2H6 C2H6 / C3H8 C3H8 / IC4H10 C4H10-2 / NC4H10 C4H10-1 /
           IC5H12 C5H12-2 / NC5H12 C5H12-1 /
;  Pseudocomponents
           T125 / T175 / T225 / T275 / T325 / T375 / T425 / T475 /
           T525 / T575 / T625 / T675 / T725 / T775 / T825 / T875 /
           T925 / T975 / T1000+ /
           P125 / P175 / P225 / P275 / P325 / P375 / P425 / P475 /
           P525 / P575 / P625 / P675 / P725 / P775 / P825 / P875 /
           P925 / P975 / P1000+ / I1000+ / REFORMAT /
;  Non-conventional components
            COAL / URCOAL / SLAG
;
FORMULA    H2 H2 / N2 N2 / O2 O2 / H2S H2S / CO CO / CO2 CO2 / NH3 H3N /
           L-SULFUR S / H2O H2O / HCL HCL / COS COS / CH4 CH4 /
           C2H6 C2H6 / C3H8 C3H8 / NC4H10 C4H10 / IC4H10 C4H10 /
           NC5H12 C5H12 / IC5H12 C5H12
;
;  Load the liquid sulfur (L-SULFUR) physical properties as taken from
;  DIPPR - MW adjusted to be consistent with ASPEN.
PROP-DATA  IN-UNITS SI
  PROP-LIST        MW    /   TC    /     PC     /    VC    /   ZC
  PVAL L-SULFUR   32.06  / 1313.0 / 1.8208E+7 / 0.15800 / 0.2640
  PROP-LIST       MUP    /  OMEGA /    TB     /   RGYR
  PVAL L-SULFUR   0.0    / 0.2624 /  717.82   /   0.0
  PROP-LIST         DELTA   /  DGFORM   /  DHFORM
  PVAL L-SULFUR   2.0245E+4 / 2.3825E+8 / 2.7880E+8
  PROP-LIST       CPIG
  PVAL L-SULFUR   2.5639E+4  -7.9870  4.7860E-3  -9.5700E-7  0.0  0.0  &
                  273.15  1500.0  0.0  87.113  1.0
;
; Load the solubility parameter for COS from the API Tech Data Book.
  PROP-LIST       DELTA
  PVAL COS        18179.0
;
;  Reset some component molecular weights to be consisitent with the
;  following elemental atomic weights, where needed.
;  H=1.0079, C=12.011, O=15.9994, N=14.0067, S=32.06 & Cl=35.453
  PROP-LIST       MW
  PVAL H2          2.0158
  PVAL N2         28.0134
  PVAL O2         31.9988
  PVAL H2S        34.0758
  PVAL CO         28.0104
  PVAL CO2        44.0098
  PVAL NH3        17.0304
```

```
  PVAL H2O        18.0152
  PVAL HCl        36.4609
  PVAL COS        60.0704
  PVAL CH4        16.0426
  PVAL C2H6       30.0694
  PVAL C3H8       44.0962
  PVAL IC4H10     58.1230
  PVAL NC4H10     58.1230
  PVAL IC5H12     72.1498
  PVAL NC5H12     72.1498
;
;  Set the specific gravities of H2, CO, CO2, NH3, H2S, N2 and COS to
;  the values given in the API Technical Data Book - Petroleum Refining.
  PROP-LIST        SPGR
  PVAL H2         0.3000
  PVAL CO         0.3000
  PVAL CO2        0.8180
  PVAL NH3        0.6162
  PVAL H2S        0.8014
  PVAL N2         0.8094
  PVAL COS        1.0200
;
ATTR-COMPS COAL   PROXANAL ULTANAL SULFANAL AOXANAL
ATTR-COMPS URCOAL PROXANAL ULTANAL SULFANAL AOXANAL
ATTR-COMPS SLAG   PROXANAL ULTANAL SULFANAL AOXANAL
;
NC-PROPS    COAL ENTHALPY  HCOALGEN /
                 DENSITY   DCOALIGT
NC-PROPS  URCOAL ENTHALPY  HCOALGEN /
                 DENSITY   DCHARIGT
NC-PROPS    SLAG ENTHALPY  HCOALGEN /
                 DENSITY   DCHARIGT
;
DEF-STREAMS MIXNC ALL
;
;  Set an initial GUESS for the ROM COAL stream to Plant 1.
STREAM ROMCOAL
   SUBSTREAM MIXED TEMP = 71.0  PRES = 14.7
     MASS-FLOW  H2O 24798.0
   SUBSTREAM NC TEMP = 71.0  PRES = 14.7
     MASS-FLOW  COAL 285035.0 / URCOAL 0.0 / SLAG 0.0
     COMP-ATTR COAL   PROXANAL (0.0 42.06 36.24 21.70) /
                      ULTANAL (21.7 61.1 4.2 1.2 0.1 5.1 6.6) /
                      SULFANAL (3.0 0.3 1.8) /
                      AOXANAL (43.8 17.1 24.1 0.8 0.1 5.6 1.0 0.6 2.1 4.1)
;  Fake the URCOAL properties.
     COMP-ATTR URCOAL PROXANAL (0.0 19.197 16.549 64.254) /
                      ULTANAL (64.254 29.914 0.185 1.304 0.0 4.267 0.076) /
                      SULFANAL (2.507 0.253 1.507) /
                      AOXANAL (43.8 17.1 24.1 0.8 0.1 5.6 1.0 0.6 2.1 4.1)
;  Fake the SLAG properties.
     COMP-ATTR SLAG   PROXANAL (0.0 10.0 0.0 90.0) /
                      ULTANAL (90.0 10.0 0.0 0.0 0.0 0.0 0.0 ) /
                      SULFANAL (0.0 0.0 0.0) /
                      AOXANAL (42.0 17.0 23.0 1.0 1.0 6.0 2.0 1.0 3.0 4.0)
```

```
;
;  Set an initial GUESS for the fresh make-up H2 stream to Plant 2.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 2-H2IN
   SUBSTREAM MIXED TEMP = 100.0  PRES = 3440.0
     MASS-FLOW  H2 70300.0 / N2 980.0
;
;  Set an initial GUESS for the total water feed streams (both steam
;  and wash water) to Plant 2.
STREAM 2-H2OIN
   SUBSTREAM MIXED TEMP = 126.0  PRES = 3200.0
     MASS-FLOW  H2O 1073000.0
;
;  Set an initial GUESS for the ROSE EXTRACT stream to Plant 2.
STREAM ROSE-XTR
   SUBSTREAM MIXED TEMP = 300.0  PRES = 3215.0
     MASS-FLOW  T675 95.0 / T725 95.0 / T775 95.0 /
       T825 95.0 / T875 588.335 / T925 588.335 /
       T975 588.355 /  T1000+ 536585.0
;
;  Set an initial GUESS for the SOLVENT stream to Plant 2.  The user
;  Fortran block model for Plant 2 does not require any solvent, but
;  the input stream is required.  Thus, set a small H2O flow to avoid
;  ASPEN warnings.
STREAM SOLVENT
   SUBSTREAM MIXED TEMP = 500.0  PRES = 500.0
     MASS-FLOW  H2O 1.0
;
;  Set an initial GUESS for the 2S-BOTTS stream leaving Plant 2.
STREAM 2S-BOTTS
   SUBSTREAM MIXED TEMP = 688.0  PRES = 28.0
     MASS-FLOW  H2O 0.0 /
       T825 380.0 / T875 3365.0 /
       T925 3365.0 / T975 3365.0 / T1000+ 642440.0
   SUBSTREAM NC TEMP = 688.0  PRES = 28.0
     MASS-FLOW  COAL 0.0 / URCOAL 254475.0
;
;  Set an initial GUESS for the H2 stream to Plant 4.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 4-H2IN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 500.0
     MASS-FLOW  H2 1400.0 / N2 19.0
;
;  Set an initial GUESS for the H2O stream to Plant 4.
STREAM 4-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 50.0
     MASS-FLOW  H2O 18770.
;
;  Set an initial GUESS for the H2 stream to Plant 5.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 5-H2IN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 500.0
     MASS-FLOW  H2 17000.0 / N2 279.0
;
;  Set an initial GUESS for the H2O stream to Plant 5.
```

```
STREAM 5-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 50.0
     MASS-FLOW  H2O 36382.0
;
;  Set an initial GUESS for the pseudo sour H2O from Plant 6.
STREAM 6S-SH2O
   SUBSTREAM MIXED TEMP = 60.0  PRES = 14.7
     MASS-FLOW  NH3 2830.0
;
;  Set an initial GUESS for the H2O stream to Plant 9.0.
STREAM 9-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 14.7
     MASS-FLOW  H2O 967545.0
;
;  Set an initial GUESS for the STEAM stream to Plant 9.0.
STREAM 9-STEMIN
   SUBSTREAM MIXED TEMP = 450.0  PRES = 500.0
     MASS-FLOW  H2O 167545.0
;
;  Set an initial GUESS for the OXYGEN stream to Plant 9.0.
STREAM 9-O2IN
   SUBSTREAM MIXED TEMP = 80.0  PRES = 300.0
     MASS-FLOW  O2 743531.0 / N2 3269.0
;
;  Set an initial GUESS for the AIR stream to Plant 10.
STREAM 10-AIRIN   TEMP = 70.0  PRES = 14.7
     MASS-FLOW  O2 743531.0 / N2 2463614.0
;
;  Set an initial GUESS for the natural-gas stream to Plant 9.1.
STREAM NAT-GAS
   SUBSTREAM MIXED TEMP = 70.0  PRES = 100.0
     MASS-FLOW  CH4 307352
;
;  Set an initial GUESS for the STEAM stream to Plant 9.1.
STREAM STEAM
   SUBSTREAM MIXED TEMP = 620.0  PRES = 500.0
     MASS-FLOW  H2O 864428.
;
; Model Connectivity
; ------------------
;
FLOWSHEET COAL
; Plant M1 is the clean coal outlet streams mixer.
;   Stream 1S-CCOAL is the cleaned coal product stream going to     .
;     liquefaction after drying in Plant 1.4
; Plant M2 is the middling coal outlet streams mixer.
;   Stream 1S-XMID  is the combined outlet middling coal product stream.
; Plant M-2HYD is the mixer to combine H2 streams for Plant 2.
;   Stream 2-H2MIX  is the combined H2 stream from 6.1, 6.2, & source.
; Plant M3 is the refuse outlet streams mixer.
;   Stream 1S-REFSE is the combined outlet refuse product stream.
; Plant M38 is the sour water mixer.
;   Stream 38-FEED  is the combined sour water streams to Plant 38.
; Plant M4 is the waste water outlet streams mixer.
;   Stream 1S-WATER is the combined outlet waste water product stream.
```

```
; Plant M-462 is the mixer to combine H2 streams for Plant 6.2.
;   Stream 62-HYD   is the combined H2 stream from Plants 2 & 4.
; Plant M-561 is the mixer to combine H2 streams for Plant 6.1.
;   Stream 61-HYD   is the combined H2 stream from Plants 2 & 5.
; Plant M-6GAS is the heater to combine sour gas streams for Plant 11.
;   Stream 6-SGAS   is the combined sour gas stream from Plants 6.1 & 6.2.
; Plant M-73 is the mixer to combine H2 gas streams for Plant 3.
;   Stream 3-GAS    is the combined H2 gas stream from Plant 3.
; Plant M-HYD is the mixer (flash2) to combine H2 streams for M-2HYD.
;   Stream H2MIX    is the combined H2 stream from Plants 6.1 & 6.2.
;   Stream DUMMY    is the dummy vapor stream that contains no flow.
; Plant M-NAP is the mixer to combine naphtha streams for Plant 4.
;   Stream 4-FEED   is the combined naphtha stream from Plants 2 & 6.2.
; Plant M-PNAP is the mixer to combine product naphtha streams.
;   Stream PS-NAPH is the combined naphtha stream from Plants 4 & 5.
; Plant P1-ALT1 is the Coal Cleaning and Preparation Plant - ALT CASE 1.
;   Stream 1S12     is the outlet clean coal product stream.
;   Stream 1S13     is the outlet middling coal product stream.
;   Stream 1S14     is the outlet refuse product stream.
;   Stream 1S15     is the outlet waste water product stream.
; Plant P1-ALT2 is the Coal Cleaning and Preparation Plant - ALT CASE 2.
;   Stream 1S22     is the outlet clean coal product stream.
;   Stream 1S23     is the outlet middling coal product stream.
;   Stream 1S24     is the outlet refuse product stream.
;   Stream 1S25     is the outlet waste water product stream.
; Plant P1-BASE is the Coal Cleaning and Preparation Plant - BASE CASE.
;   Stream 1S02     is the outlet clean coal product stream.
;   Stream 1S03     is the outlet middling coal product stream.
;   Stream 1S04     is the outlet refuse product stream.
;   Stream 1S05     is the outlet waste water product stream.
; Plant P1-JIGS is part of the Coal Cleaning and Preparation Plant
;   that only cleans the coal going to gasification for H2 production.
;   Stream COALTO9  is the outlet clean coal product stream.
;   Stream 1S33     is the outlet middling coal product stream.
;   Stream 1S34     is the outlet refuse product stream.
;   Stream 1S35     is the outlet waste water product stream.
; Plant P14 is the Coal Grinding and Drying Plant.
;   Stream COALTO2  is the outlet clean coal product stream.
;   Stream 14S-XMID is the outlet middling coal product stream.
;   Stream 14S-REF  is the outlet refuse product stream.
;   Stream 14S-WAT  is the outlet waste water product stream.
; Plant P02 is the Coal Liquefaction Plant.
;   Stream 2-H2MIX  is the hydrogen feed stream.
;   Stream COALTO2  is the clean coal feed stream.
;   Stream SOLVENT  is the solvent feed stream.  This stream is used to
;     supply the steam required to Plant 2.
;   Stream ROSE-XTR is the deashed product stream.
;   Stream 2-H2OIN  is the water feed stream to the liquefaction unit.
;   Stream 2S-GAS   is the HP gas product stream going to Plant 6.1.
;   Stream GASES    is the LP gas product stream going to Plant 6.2.
;   Stream NAPHTHA  is the naphtha product stream.
;   Stream GAS-OIL  is the gas-oil product stream going to Plant 5.
;   Stream 2S-BOTTS is the bottoms stream going to Plant 8.1.
;   Stream 2S-SH2O  is the sour water product stream.
; Plant P03 is the Gas Plant.
```

```
;   Stream 3S-SGAS  is the sour off-gas product stream.
;   Stream 3S-FGAS  is the fuel gas product stream.
;   Stream 3S-PROP  is the C3 product stream.
;   Stream 3S-BUT   is the C4s product stream.
;   Stream 3S-OIL   is the lean-oil product stream to M-NAP.
;   Stream 3S-SH2O  is the product sour water stream.
; Plant P04 is the simplified model for plant 4, the naphtha hydrotreater.
;   Stream 4-H2IN   is the hydrogen feed stream.
;   Stream 4-H2OIN  is the water feed stream.
;   Stream 4S-GAS   is the hydrotreater off-gas product stream.
;   Stream 4S-NAPH  is the hydrotreated naphtha product stream.
;   Stream 4S-SH2O  is the hydrotreater sour water stream.
; Plant P05 is the simplified model for plant 5, the gas-oil hydrotreater.
;   Stream 5-H2IN   is the hydrogen feed stream.
;   Stream 5-H2OIN  is the water feed stream.
;   Stream 5S-HPGAS is the hydrotreater hi-pressure purge gas stream.
;   Stream 5S-LPGAS is the hydrotreater other gases stream.
;   Stream 5S-NAPH  is the hydrotreated C6-350 F naphtha product stream.
;   Stream P350-450 is the hydrotreated 350 - 450 F product stream.
;   Stream P450-650 is the hydrotreated 450 - 650 F product stream.
;   Stream P650-850 is the hydrotreated 650 - 850 F product stream.
;   Stream 5S-SH2O  is the hydrotreater sour water stream.
; Plant P61 is the model for the Hydrogen purification by Membrane
;     Separation Plant, Plant 6.1.
;   Stream 61-HYD   is the feed stream to the H2 purification plant.
;   Stream H2-RICH  is the purified H2-rich product gas stream.
;   Stream SOUR-GAS is the sour gas product stream.
;   Stream P61-GAS  is the reject (non-permeate) product gas stream.
; Plant P62 is the model for the Hydrogen purification by Pressure
;     Swing absorption Plant, Plant 6.2.
;   Stream 62-HYD   is the mixed gas feed stream to the PSA hydrogen
;     purification plant.
;   Stream P61-GAS  is the reject gas stream from Plant 6.1, the high
;     pressure section of Plant 6, the hydrogen purification by
;     membrane permeation section.
;   Stream H2-2RICH is the purified h2-rich product gas stream.
;   Stream SOUR-2GS is the sour gas product stream.
;   Stream GAS-OUT  is the reject product gas stream.
;   Stream NAPHTHA2 is the liquid raw naphtha product stream.
; Plant P07 is the simplified model for Plant 7, the naphtha reformer.
;   Stream 7-NAPH   is the naphtha feed stream.
;   Stream 7S-H2    is the hydrogen rich product gas stream.
;   Stream 7S-GAS   is the light hydrocarbon product gas stream.
;   Stream REFORMED is the reformate product stream.
; Plant P81 is the model for the ROSE-SR Critical Solvent Deashing unit.
;   Stream ROSE-XTR is the deashed product stream.
;   Stream ASH-CONC is the ash concentrate stream.
; Plant P11 is the Sulfur plant.
;   Stream 11S-LIQS is the sulfur product stream.
;   Stream 11S-FGAS contains all the other material in the feed that
;     does not leave in the product SULFUR STREAM.
; Plant P31 is the simplified model for the utility plant.
;   Stream 31S-01   is the dummy product stream.
; Plant P314 is the model for the Fluidized Bed Combustor and the
;  Steam Turbine Generator unit.
```

```
;   Stream FBC-FEED is the feed stream to Plant P314.
;   Stream SA6-01   is the combined product stream out of Plant P314.
; Plant P38 is the NH3 recovery plant.
;   Stream NH3-PROD is the product NH3.
;   Stream 38S-OUT  is the reject stream.
; Plant P38A is the reject stream component splitter from plant 38.
;   Stream 38AS-VAP is the vapor stream going to Plant 11.
;   Stream 38AS-LIQ is the liquid stream going to Plant 38B.
; Plant P38B is the liquid reject stream splitter from Plant 38A.
;   Stream WASTE    is the reject portion of the inlet stream which
;     in this model is rejected, but actually goes to the coal
;     gasification plant, if present.
;   Stream 39FEED   is the stream going on to Plant 39.
; Plant P39 is the phenol recovery plant.
;   Stream PHENOL   is the phenol product stream.
;   Stream WASTEH2O is the waste water stream.
; Plant SA6 is the product stream separator from Plant P314.
;   Stream FBC-GAS  is the gas product stream from Plant SA6.
;   Stream FBC-SOL  is the solids product stream from Plant SA6.
; Block S1 is the inlet coal splitter.
;   Stream ROMCOAL  is the inlet ROM coal stream.
;   Stream 1S01     is the splitter outlet to the base case plant.
;   Stream 1S11     is the splitter outlet to the alternate case 1 plant.
;   Stream 1S21     is the splitter outlet to the alternate case 2 plant.
; Block S6-SH2O is a component splitter to generate a pseudo sour-water
;   stream from Plant 6 to get the NH3 to Plant 38, the Ammonia Recovery
;   Plant.
;   Stream 6S-SH2O  is the pseudo sour-water stream.
;   Stream 11-FEED  is the Plant 11 feed stream.
; Block S7 is the product naphtha splitter.
;   Stream PS-NAPH  is the inlet product naphtha stream.
;   Stream 7-NAPH   is the splitter outlet to the naphtha reformer plant.
;   Stream PNAPHTHA is the splitter outlet as product naphtha.
; Block S8 is the ash-concentrate splitter.
;   Stream ASH-CONC is the inlet ash-concentrate stream from the ROSE.
;   Stream FBC-FEED is the splitter outlet to the FBC plant.
;   Stream S8-ASHC  is the splitter outlet to the M9C coal mixer.
;
 M1        IN = 1S02 1S12 1S22        OUT = 1S-CCOAL
 M2        IN = 1S03 1S13 1S23 1S33   OUT = 1S-XMID
 M-2HYD    IN = H2MIX 2-H2IN          OUT = 2-H2MIX
 M3        IN = 1S04 1S14 1S24 1S34   OUT = 1S-REFSE
 M38       IN = 2S-SH2O 3S-SH2O 4S-SH2O 5S-SH2O 6S-SH2O 9S-SH2O     &
             OUT = 38-FEED
 M4        IN = 1S05 1S15 1S25 1S35   OUT = 1S-WATER
 M-462     IN = 4S-GAS GASES 5S-LPGAS 3S-SGAS 7S-H2     OUT = 62-HYD
 M-561     IN = 5S-HPGAS 2S-GAS  OUT = 61-HYD
 M-6GAS    IN = SOUR-GAS SOUR-2GS H2S-GAS 38AS-VAP      OUT = 6-SGAS
 M-73      IN = GAS-OUT 7S-GAS   OUT = 3-GAS
 M-HYD     IN = H2-RICH H2-2RICH OUT = H2MIX DUMMY
 M-NAP     IN = NAPHTHA2 3S-OIL  OUT = 4-FEED
 M-PNAP    IN = 4S-NAPH 5S-NAPH  OUT = PS-NAPH
 P1-ALT1   IN = 1S11             OUT = 1S12 1S13 1S14 1S15
 P1-ALT2   IN = 1S21             OUT = 1S22 1S23 1S24 1S25
 P1-BASE   IN = 1S01             OUT = 1S02 1S03 1S04 1S05
```

```
  P1-JIGS  IN = ROMCOAL2          OUT = COALTO9 1S33 1S34 1S35
  P14      IN = 1S-CCOAL          OUT = COALTO2 14S-XMID 14S-REF 14S-WAT
  P02      IN = 2-H2MIX COALTO2 SOLVENT ROSE-XTR 2-H2OIN                &
              OUT = 2S-GAS GASES NAPHTHA GAS-OIL 2S-BOTTS 2S-SH2O
  P03      IN = NAPHTHA 3-GAS                                           &
              OUT = 3S-SGAS 3S-FGAS 3S-PROP 3S-BUT 3S-OIL 3S-SH2O
  P04      IN = 4-H2IN 4-FEED 4-H2OIN                                   &
              OUT = 4S-GAS 4S-NAPH 4S-SH2O
  P05      IN = 5-H2IN GAS-OIL 5-H2OIN                                  &
              OUT = 5S-HPGAS 5S-LPGAS 5S-NAPH P350-450 P450-650        &
                    P650-850 5S-SH2O
  P61      IN = 61-HYD            OUT = H2-RICH SOUR-GAS P61-GAS
  P62      IN = 62-HYD P61-GAS                                          &
              OUT = H2-2RICH SOUR-2GS GAS-OUT NAPHTHA2
  P07      IN = 7-NAPH            OUT = 7S-H2 7S-GAS REFORMED
  P81      IN = 2S-BOTTS          OUT = ROSE-XTR ASH-CONC
  P11      IN = 11-FEED           OUT = 11S-FGAS 11S-LIQS
  P31      IN = 3S-FGAS           OUT = 31S-01
  P314     IN = FBC-FEED          OUT = SA6-01
  P38      IN = 38-FEED           OUT = NH3-PROD 38S-OUT
  P38A     IN = 38S-OUT           OUT = 38AS-VAP 38AS-LIQ
  P38B     IN = 38AS-LIQ          OUT = WASTE 39FEED
  P39      IN = 39FEED            OUT = PHENOL WASTEH2O
  SA6      IN = SA6-01            OUT = FBC-SOL FBC-GAS
  S1       IN = ROMCOAL           OUT = 1S01 1S11 1S21
  S6-SH2O  IN = 6-SGAS            OUT = 6S-SH2O 11-FEED
  S7       IN = PS-NAPH           OUT = 7-NAPH PNAPHTHA
  S8       IN = ASH-CONC          OUT = FBC-FEED S8-ASHC
;
FLOWSHEET HYDROGEN
; Plant M9 is the hydrogen stream mixer.
;   Stream M9H2     is the dummy H2 stream to the liquefaction unit.
;   Stream M9H4     is the dummy H2 stream to the naphtha hydrotreater.
;   Stream M9H5     is the dummy H2 stream to the gas-oil hydrotreater.
;   Stream HHNEED   is the dummy H2 stream from the mixer.
; Plant M9C is the coal stream mixer.
;   Stream COALTO9  is the clean coal stream to the mixer.
;   Stream S8-ASHC  is the ash concentrate stream from the ROSE unit.
;   Stream 9-FEED   is the mixed coal stream to the gasifier.
; Plant P09 is the plant for producing hydrogen by coal gasification.
;   Stream 9-H2OIN  is the water feed stream to the gasifier section.
;   Stream 9-O2IN   is the purified O2 stream from the air sep. plant.
;   Stream 9-STEMIN is the steam that goes to the shift reactors.
;   Stream H2-GAS   is the product hydrogen stream.
;   Stream H2S-GAS  is the product hydrogen sulfide stream.
;   Stream VENT-GAS is the product vent gas stream.
;   Stream 9S-SH2O  is the product sour water stream.
;   Stream SLAG     is the product slag stream.
; Plant P91 is the Steam Reforming of Natural Gas Plant.
;   Stream NAT-GAS  is the inlet natural gas stream.
;   Stream STEAM    is the inlet process water stream.
;   Stream H2-PROD  is the product hydrogen stream.
;   Stream FLUE-GAS is the product flue gas stream.
; Plant P10 is the Air Separation Plant.
;   Stream 10-AIRIN is the air input stream.
```

```
;   Stream 10S01    is the product oxygen stream.
;   Stream 10S02    is the product nitrogen stream.
; Plant S9 is the hydrogen stream splitter.
;   Stream H9NEED   is the dummy H2 stream for the gasifier.
;   Stream H91NEED  is the dummy H2 stream for the steam reformer.
;
  M9H       IN = M9H2 M9H4 M9H5    OUT = MHNEED
  M9C       IN = S8-ASHC COALTO9   OUT = 9-FEED
  P09       IN = 9-FEED 9-H2OIN 9-O2IN 9-STEMIN        &
              OUT = H2-GAS H2S-GAS VENT-GAS 9S-SH2O SLAG
  P91       IN = NAT-GAS STEAM     OUT = H2-PROD FLUE-GAS
  P10       IN = 10-AIRIN          OUT = 10S01  10S02
  S9        IN = MHNEED            OUT = H9NEED H91NEED
;
; Design Specifications
; ---------------------
;
;  Design spec to set the hydrogen flow rate to Plant 2 (2-H2MIX)
;  to a specified weight percent (HPCT2) of the MAF coal input stream.
DES-SPEC 2H2FLO
   DEFINE CHP2   MASS-FLOW  STREAM=2-H2MIX  COMPONENT=H2
   DEFINE CCOAL  MASS-FLOW  STREAM=COALTO2  SUBSTREAM=NC COMPONENT=COAL
   DEFINE CCASH  COMP-ATTR-VAR STREAM=COALTO2  SUBSTREAM=NC &
                   COMPONENT=COAL ATTRIBUTE=ULTANAL ELEMENT=1
C     Set the specified H2 rate to Plant 2 in wt% in the following line.
F     HPCT2 = 7.9205D0
C     DAFCOAL is the dry ash-free coal (MAF coal).
F     DAFCOAL = CCOAL * (100.0D0 - CCASH) * 0.01D0
F     H2P2 = 0.01D0 * HPCT2 * DAFCOAL
   SPEC CHP2 TO H2P2
   TOL-SPEC 0.1
   VARY STREAM-VAR  STREAM=2-H2IN  VARIABLE=MASS-FLOW
   LIMITS 100 1000000
;
;  Design spec to set the correct ROM coal flow to the splitter to
;  obtain the desired 17,102 TPSD of MF coal flow rate to the coal
;  liquefaction plant, Plant 2.
DES-SPEC COALFLO
   DEFINE CTARG  MASS-FLOW  STREAM=COALTO2   SUBSTREAM=NC  COMPONENT=COAL
;  Set TPD to the target coal rate to Plant 2 in TPSD of MF coal.
;  ==============================================================
;
F     TPD = 15738.0D0
F     WTPHR = (TPD * 2000.0D0) / 24.0D0
   SPEC CTARG TO WTPHR
   TOL-SPEC 0.1
   VARY MASS-FLOW  STREAM=ROMCOAL  SUBSTREAM=NC  COMPONENT=COAL
   LIMITS 100 10000000
;
;  Design spec to set the correct dry ROMCOAL2 flow rate to the P1-JIGS
;  and Plant 9, the coal cleaning for gasification plant and the coal
;  coal gasifier, to obtain the desired hydrogen production rate.
DES-SPEC H2FLO
   DEFINE HOUT   MASS-FLOW   STREAM=H2-GAS   COMPONENT=H2
   DEFINE HTOT   MASS-FLOW   STREAM=H9NEED   COMPONENT=H2
```

```
   SPEC HOUT TO HTOT
   TOL-SPEC 1.0
   VARY STREAM-VAR STREAM=ROMCOAL2  SUBSTREAM=NC  VAR=MASS-FLOW
   LIMITS 0.1 10000000
;
;  Design spec to set the heat duty to block M-HYD to zero by
;  varying the temperature. This corrects a temperature calculating
;  error in the ASPEN mixer block algorithm.
DES-SPEC HD-HYD
   DEFINE HDTY BLOCK-VAR BLOCK=M-HYD SENTENCE=RETENTION VARIABLE=HEAT-DUTY
   SPEC HDTY TO 0.0
   TOL-SPEC 1000
   VARY BLOCK-VAR BLOCK=M-HYD SENTENCE=PARAM VARIABLE=TEMPERATURE
   LIMITS 10 500
;
;  Design spec to set the 10-AIRIN stream flow to produce the required
;  amount of oxygen product required by Plant 9, coal gasification.
DES-SPEC O2FLO
 DEFINE FLO10S STREAM-VAR STREAM=10S01    VAR=MASS-FLOW
 DEFINE FLOOXY STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
   SPEC FLO10S TO FLOOXY
   TOL-SPEC 0.1
   VARY STREAM-VAR  STREAM=10-AIRIN  VARIABLE=MASS-FLOW
   LIMITS 0.1 10000000
;
;  Design spec to set the hydrogen flow rate for Plant 9.1.
DES-SPEC RFMRFLO
   DEFINE HOUT2  MASS-FLOW   STREAM=H2-PROD  COMPONENT=H2
   DEFINE HTOT2  MASS-FLOW   STREAM=H91NEED  COMPONENT=H2
   SPEC HOUT2 TO HTOT2
   TOL-SPEC 0.1
   VARY STREAM-VAR  STREAM=NAT-GAS  VARIABLE=MASS-FLOW
   LIMITS 1000 600000
;
; Transfer Blocks
; ---------------
;
;  Transfer block to set ROMCOAL2equal to the ROMCOAL stream (the wet
;  clean coal input).  This duplicates the full property set and
;  provides the initial guess flow rate for ROMCOAL2.
TRANSFER RCOAL
   SET STREAM ROMCOAL2
   EQUAL-TO STREAM ROMCOAL
;
;  Transfer block used to set the hydrogen flow rates of the input
;  streams to the calculated hydrogen flows to Plant 2 (2-H2IN),
;  Plant 4 (4-H2IN), and Plant 5 (5-H2IN).  M9's represent hydrogen
;  flows from Plant 9.0/10 and M91's are for the Plant 9.1 alternative.
TRANSFER HFLOW
   SET STREAM M9H2
   EQUAL-TO STREAM 2-H2IN
   SET STREAM M9H4
   EQUAL-TO STREAM 4-H2IN
   SET STREAM M9H5
   EQUAL-TO STREAM 5-H2IN
```

```
;
; Fortran Blocks
; --------------
;
;  This FORTRAN block will calculate the initial ratio of the MIXED
;  substream flow to the NC substream flow in the stream ROMCOAL.
;  It will store this result in RATIO, and use that value to adjust
;  the MIXED substream flow in proportion to the NC substream flow
;  that is varied by the COALFLO design-spec.  This is needed to set
;  the correct amount of water entering with the ROM coal.
FORTRAN MIXFLO
F     COMMON /RATIO/ RMIXNCP, RMIXN2
F     COMMON /RGLOB/ RDUM1, RMIN
 DEFINE FLONCP SUBSTREAM-VAR STREAM=ROMCOAL SUBSTREAM=NC VAR=MASSFLOW
 DEFINE FLOMIX SUBSTREAM-VAR STREAM=ROMCOAL SUBSTREAM=MIXED VAR=MASSFLOW
C  The following should only be true on the first pass.  This prevents
C  writing over the initial substream ratio on subsequent passes.
F     IF (RMIXNCP .LT. RMIN) THEN
F        RMIXNCP = FLONCP / FLOMIX
F     END IF
C  Adjust the other substream flow based on changes to the NC
C  substream.
F     FLOMIX = FLONCP / RMIXNCP
;
;  This FORTRAN block will calculate the initial ratio of the MIXED
;  substream flow to the NC substream flow in the stream ROMCOAL2.
;  It will store this result in RATIO2, and use that value to adjust
;  the MIXED substream flow in proportion to the NC substream flow
;  that is varied by the H2FLO design-spec.  This is needed to set
;  the correct amount of water entering with the ROM coal.
;  See Fortran block MIXFLO for the named common blocks /RATIO/ and
;  /RGLOB/ which contain the variables RMIN and RMIXN2.
FORTRAN MIXFL2
 DEFINE FLONC2 SUBSTREAM-VAR STREAM=ROMCOAL2 SUBSTREAM=NC VAR=MASSFLOW
 DEFINE FLOMI2 SUBSTREAM-VAR STREAM=ROMCOAL2 SUBSTREAM=MIXED VAR=MASSFLOW
C  The following should only be true on the first pass.  This prevents
C  writing over the initial substream ratio on subsequent passes.
F     IF (RMIXN2 .LT. RMIN) THEN
F        RMIXN2 = FLONC2 / FLOMI2
F     END IF
C  Adjust the other substream flow based on changes to the NC
C  substream.
F     FLOMI2 = FLONC2 / RMIXN2
;
;  Fortran block to dynamically set the URCOAL fraction in the
;  separation block, SA6, equal to the solids production parameter,
;  REAL(1), in block P314, the fluidized bed combustor.  This block
;  only has significance when Option 6 is in effect.
FORTRAN SA6SET
   DEFINE FRAC1 BLOCK-VAR BLOCK=P314 SENTENCE=REAL VAR=REAL ELEMENT=1
   DEFINE FRAC2 BLOCK-VAR BLOCK=SA6  SENTENCE=FRAC VAR=FRAC ID1=NC    &
    ID2=FBC-SOL ELEMENT=1
F     FRAC2 = FRAC1
;
;  FORTRAN block to set the COMBINED steam and water flow rate to
```

```
;  Plant 2 as a specified weight percent of the dry coal feed.
FORTRAN SETUP2
   DEFINE FEED2 MASS-FLOW  STREAM=COALTO2  SUBSTREAM=NC  COMPONENT=COAL
   DEFINE H2O2  STREAM-VAR STREAM=2-H2OIN  VAR=MASSFLOW
F     H2O2 = 0.75315 * FEED2
;
;  FORTRAN block used to set the hydrogen flow rate to Plant 4 (4-H2IN)
;  to a specified weight percent (HPCT4) of the naphtha feed stream,
;  and the hydrogen flow rate to Plant 5 (5-H2IN) to a specified weight
;  percent (HPCT5) of the gas oil feed stream.  This block also sets
;  the inlet water flow rates for these plants to specified rates
;  as functions of the hydrocarbon feed rates.
FORTRAN SETUP45
   DEFINE CHP4   MASS-FLOW  STREAM=4-H2IN   COMPONENT=H2
   DEFINE CHP5   MASS-FLOW  STREAM=5-H2IN   COMPONENT=H2
   DEFINE FLP4   STREAM-VAR STREAM=4-H2IN   VAR=MASSFLOW
   DEFINE FLP5   STREAM-VAR STREAM=5-H2IN   VAR=MASSFLOW
   DEFINE XNAPH  STREAM-VAR STREAM=4-FEED   VAR=MASSFLOW
   DEFINE XGOIL  STREAM-VAR STREAM=GAS-OIL  VAR=MASSFLOW
   DEFINE H2O4   STREAM-VAR STREAM=4-H2OIN  VAR=MASSFLOW
   DEFINE H2O5   STREAM-VAR STREAM=5-H2OIN  VAR=MASSFLOW
C     Set the specified H2 rates in wt% in the following two lines.
F     HPCT4 = 1.1855
F     HPCT5 = 2.7554
F     H2P4 = 0.01D0 * HPCT4 * XNAPH
F     FLP4 = H2P4 * (FLP4 / CHP4)
F     H2P5 = 0.01D0 * HPCT5 * XGOIL
F     FLP5 = H2P5 * (FLP5 / CHP5)
C     Set the specified H2O rates in wt% in the following two lines.
F     H2O4 = 0.089017 * XNAPH
F     H2O5 = 0.054217 * XGOIL
;
;  FORTRAN block to set the steam, water and oxygen stream flow rates
;  to Plant 9 based on the inlet flow rate of hydrocarbons and NC
;  components (on a dry ash-free basis).
FORTRAN SETUP9
 DEFINE FL29MX SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=MIXED VAR=MASS-FLOW
 DEFINE ULCOAL COMP-ATTR-VAR STREAM=9-FEED  SUBSTREAM=NC &
        COMPONENT=COAL   ATTRIBUTE=ULTANAL ELEMENT=1
 DEFINE ULURC  COMP-ATTR-VAR STREAM=9-FEED  SUBSTREAM=NC &
        COMPONENT=URCOAL ATTRIBUTE=ULTANAL ELEMENT=1
 DEFINE FL29C   MASS-FLOW  STREAM=9-FEED  SUBSTREAM=NC COMPONENT=COAL
 DEFINE FL29UR  MASS-FLOW  STREAM=9-FEED  SUBSTREAM=NC COMPONENT=URCOAL
 DEFINE FL29W   MASS-FLOW  STREAM=9-FEED  COMPONENT=H2O
 DEFINE FL2STM  STREAM-VAR STREAM=9-STEMIN VAR=MASS-FLOW
 DEFINE FL2H2O  STREAM-VAR STREAM=9-H2OIN  VAR=MASS-FLOW
 DEFINE FL2O2   STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
C  Adjust the steam, water and oxygen stream flow rates based on the
C  inlet flow rate of hydrocarbons and NC components (on a dry basis).
F     X1 = 0.01*FL29C *(100.0-ULCOAL)
F     X2 = 0.01*FL29UR*(100.0-ULURC)
F     FL2STM = 0.25495 * (FL29MX + X1 + X2 - FL29W)
F     FL2H2O = 1.4723 * (FL29MX + X1 + X2 - FL29W)
F     FL2O2  = 1.1365 * (FL29MX + X1 + X2 - FL29W)
;
```

```
;  Fortran block to set up the common and OSBL utility consumptions.
FORTRAN SETUP31
F      COMMON /USRC01/ PLNTID(32), UTIL(32,15), CAPCST(32,5), OPCST(32,5)
F      CHARACTER * 6  PLNTID
 DEFINE DCOAL2 SUBSTREAM-VAR STREAM=COALT02 SUBSTREAM=NC VAR=MASS-FLOW
C      COMMON /USRC03/ is ised to transfer vatiables FIN(5,4),
C        FOUT(20,4), PGAS, PPWR, OPTN6
C      See Subroutine USRSR1 for the definition of the items in named
C      common block /USRC03/.
C      Base all the offsite and OSBL utilities consumptions on the dry
C      coal feed rate to Plant 2, the Coal Liquefaction Plant. Ignore
C      cooling and process water consumptions and productions.
F      PLNTID (19) = 'OTHERS'
C      Electric Power.
F      UTIL(19,1) = 25.1346 * DCOAL2 * 0.001
F      IF ( OPTN6 .GE. 0.99D0 )  UTIL(19,1) = 29.5411 * DCOAL2 * 0.001
C      600 psig steam at 720F.
F      UTIL(19,4) = 0.05122207 * DCOAL2 * 0.001
C      150 psig saturated steam.
F      UTIL(19,6) = 0.04350367 * DCOAL2 * 0.001
C      50 psig saturated steam.
F      UTIL(19,7) = 0.06757103 * DCOAL2 * 0.001
;
;  Fortran statement to set the molar flow rate of the STEAM stream TO
;  be in balance with the feed stream to Plant 9.1.
FORTRAN SETUP91
   DEFINE GS      STREAM-VAR  STREAM=NAT-GAS  VARIABLE=MOLE-FLOW
   DEFINE ST      STREAM-VAR  STREAM=STEAM    VARIABLE=MOLE-FLOW
F      IF ( GS .GT. 0.0D0 )  THEN
F          ST = 2.504543D0 * GG
F        ELSE
F          ST = 0.0D0
F      ENDIF
;
;  Fortran block to switch between Plants 9.0 and 10 (Baseline Design
;  Case) or Plants 9.1, 31.1 and 31.4 (Option 6).
FORTRAN OPTION6
F      COMMON /USRC03/ FIN(5,4), FOUT(20,4), PGAS, PPWR, OPTN6
C      See Subroutine USRSR1 for the definition of the items in named
C      common block /USRC03/.
 DEFINE FSTM    STREAM-VAR STREAM=STEAM    VAR=MOLE-FLOW
 DEFINE FNG     STREAM-VAR STREAM=NAT-GAS  VAR=MOLE-FLOW
 DEFINE F10A    STREAM-VAR STREAM=10-AIRIN VAR=MASS-FLOW
 DEFINE F9H     STREAM-VAR STREAM=9-H2OIN  VAR=MASS-FLOW
 DEFINE F9S     STREAM-VAR STREAM=9-STEMIN VAR=MASS-FLOW
 DEFINE F9O     STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
 DEFINE FC9M    SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=MIXED VAR=MASS-FLOW
 DEFINE FC9NC   SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=NC    VAR=MASS-FLOW
 DEFINE FRAC8   BLOCK-VAR   BLOCK=S8  SENTENCE=FRAC  VAR=FRAC  &
  ID1=S8-ASHC   ELEMENT=1
 DEFINE FRAC9   BLOCK-VAR   BLOCK=S9  SENTENCE=FRAC  VAR=FRAC  &
  ID1=H9NEED    ELEMENT=1
 DEFINE FRAC38  BLOCK-VAR   BLOCK=P38B  SENTENCE=FRAC  VAR=FRAC  &
  ID1=WASTE     ELEMENT=1
C      Set N9 equal to 0 to run Plants 9.0 and 10 (Bseline), or
```

```
C     set N9 equal to 1 to run Plants 9.1, 31.1 and 31.4 (OPTION 6).
F     N9 = 0
F     IF (N9 .EQ. 0) THEN
F       OPTNM6 = 0.0D0
F       FSTM = 1.0D-6
F       FNG = 1.0D-6
F       FRAC8 = 1.0
F       FRAC9 = 1.0
F       FRAC38 = 0.28595
F     ENDIF
F     IF (N9 .EQ. 1) THEN
F       OPTNM6 =1.0D0
F       F10A = 1.0D-6
F       F9H = 1.0D-6
F       F9S = 1.0D-6
F       F9O = 1.0D-6
F       FC9M = 1.0D-6
F       FC9NC = 1.0D-6
F       FRAC8 = 0.0
F       FRAC9 = 0.0
F       FRAC38 = 0.0
F     ENDIF
;
FORTRAN SUMMARY
C     This Fortran block writes the summary report to the DCLSUM.REP
C     file, and also writes the DCL1.PRN file for transfering the
C     results to the Lotus spreadsheet economics model.
C     COMMON /USRC03/ is ised to transfer vatiables FIN(5,4),
C       FOUT(20,4), PGAS, PPWR, OPTN6
C     See Subroutine USRSR1 for the definition of the items in named
C     common block /USRC03/.
 DEFINE FIN1A  SUBSTREAM-VAR STREAM=ROMCOAL   SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FIN1B  SUBSTREAM-VAR STREAM=ROMCOAL2  SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FIN2   STREAM-VAR    STREAM=NAT-GAS   VAR=MASS-FLOW
 DEFINE FOUT1  STREAM-VAR    STREAM=3S-PROP   VAR=MASS-FLOW
 DEFINE FOUT2  STREAM-VAR    STREAM=3S-BUT    VAR=MASS-FLOW
 DEFINE FOUT3A STREAM-VAR    STREAM=PNAPHTHA  VAR=MASS-FLOW
 DEFINE FOUT3B STREAM-VAR    STREAM=REFORMED  VAR=MASS-FLOW
 DEFINE FOUT4  STREAM-VAR    STREAM=P350-450  VAR=MASS-FLOW
 DEFINE FOUT5  STREAM-VAR    STREAM=P450-650  VAR=MASS-FLOW
 DEFINE FOUT6  STREAM-VAR    STREAM=P650-850  VAR=MASS-FLOW
 DEFINE FOUT7  SUBSTREAM-VAR STREAM=1S-REFSE  SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT8  SUBSTREAM-VAR STREAM=SLAG      SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT8A SUBSTREAM-VAR STREAM=FBC-SOL   SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT10 STREAM-VAR    STREAM=NH3-PROD  VAR=MASS-FLOW
 DEFINE FOUT11 STREAM-VAR    STREAM=PHENOL    VAR=MASS-FLOW
 DEFINE FOUT12 STREAM-VAR    STREAM=11S-LIQS  VAR=MASS-FLOW
C     Load the stream flow rates in the FIN() and FOUT() arrays in
C     Mlbs/hr.  All solid stream flow rates are on a dry basis.
F     FIN(1,1)  = 0.001D0 * (FIN1A + FIN1B)
F     FIN(2,1)  = 0.001D0 * FIN2
F     FOUT(1,1) = 0.001D0 * FOUT1
F     FOUT(2,1) = 0.001D0 * FOUT2
F     FOUT(3,1) = 0.001D0 * (FOUT3A + FOUT3B)
F     FOUT(4,1) = 0.001D0 * FOUT4
```

```
F     FOUT(5,1) = 0.001D0 * FOUT5
F     FOUT(6,1) = 0.001D0 * FOUT6
F     FOUT(7,1) = 0.001D0 * FOUT7
F     FOUT(8,1) = 0.001D0 * (FOUT8 + FOUT8A)
F     FOUT(10,1) = 0.001D0 * FOUT10
F     FOUT(11,1) = 0.001D0 * FOUT11
F     FOUT(12,1) = 0.001D0 * FOUT12
C
C     Set XOF to the number of extra operators and OSBL operators
C     per dedicated plant operator.
C     ----------------------------
F     XOF = 0.343042
C
C     Set the LOSBL and LPLANT switches, as appropriate, to duplicate
C     the Bechtel OSBL and first vs. Nth plant costing logic.
C     LOSBL  = 0  - Use baseline case OSBL costing logic.
C     LOSBL  = 1  - Use option case OSBL costing logic.
C     LPLANT = 0  - Use first plant OSBL and engineering costing logic.
C     LPLANT = 1  - Use Nth plant OSBL and engineering costing logic.
C     ================================================================
F     LOSBL = 1
F     LPLANT = 1
C
C     Open the separate output file called DCLSUM.REP to contain the
C     summary report of the simulation results.
F     OPEN (UNIT=62, FILE='DCLSUM.REP', STATUS='UNKNOWN',
F    1  ACCESS='SEQUENTIAL', FORM='FORMATTED',
F    2  BUFFERED='BUFFERED')
C     Call Subroutines USRSR1 and USRSR2 to write the summary report.
F     CALL USRSR1 (62)
F     CALL USRSR2 (62, LOSBL, LPLANT, OPTN6, XOF)
F     CLOSE (UNIT=62, STATUS='KEEP')
C     Now write the LOTUS spreadsheet economics model input file.
F     OPEN (UNIT=62, FILE='DCL1.PRN', STATUS='UNKNOWN',
F    1  ACCESS='SEQUENTIAL', FORM='FORMATTED',
F    2  BUFFERED='BUFFERED')
C     Call Subroutines USRSR3 to write the model input file.
F     CALL USRSR3 (62, OPTN6, XOF)
F     CLOSE (UNIT=62, STATUS='KEEP')
;
; Convergence Blocks
; ------------------
;
CONVERGENCE CBLK1 WEGSTEIN
  TEAR H2MIX 1D-5
  PARAM WAIT=3
;
CONVERGENCE CBLK2 WEGSTEIN
  TEAR 2S-BOTTS 1D-5
;
CONVERGENCE CBLK3 WEGSTEIN
  TEAR 6S-SH2O 1D-5
;
CONVERGENCE COALF ONE-VAR
  SPEC COALFLO
```

```
;
CONVERGENCE HD-C1 ONE-VAR
  SPEC HD-HYD
;
CONVERGENCE HYDF BROYDEN-SPEC
  SPEC H2FLO
;
CONVERGENCE 2HYDF ONE-VAR
  SPEC 2H2FLO
;
CONVERGENCE OXYF ONE-VAR
  SPEC O2FLO
;
CONVERGENCE RFMRF ONE-VAR
  SPEC RFMRFLO
;
; Calculation Sequence
; --------------------
;
;  Define subsequence for coal cleaning complex.
SEQUENCE CLEAN COALF MIXFLO S1 P1-BASE P1-ALT1 P1-ALT2                  &
               M1 P14 (RETURN COALF)
;
;  Specify entire flowsheet sequence, including subsequence CLEAN.
SEQUENCE BASE  RCOAL (SEQUENCE CLEAN)                                   &
               CBLK1   2HYDF M-2HYD (RETURN 2HYDF)                      &
               CBLK2 SETUP2 P02 P81 (RETURN CBLK2)                      &
               P61 P62   HD-C1 M-HYD (RETURN HD-C1)                     &
               M-73 P03 M-NAP SETUP45 P04 M-462 P05 M-561               &
               M-PNAP S7 P07 (RETURN CBLK1)                             &
               HFLOW M9H OPTION6 S9  S8 P314 SA6SET SA6                 &
               HYDF MIXFL2 P1-JIGS M9C SETUP9 P09 (RETURN HYDF)         &
               OXYF P10 (RETURN OXYF)  M2 M3 M4                         &
               RFMRF SETUP91 P91 (RETURN RFMRF)                         &
               CBLK3 M38 P38 P38A P38B P39 M-6GAS S6-SH2O               &
               (RETURN CBLK3)                                           &
               P11 SETUP31 P31 SUMMARY
;
; Unit Operations Blocks
; ----------------------
;
;  Mix the clean coal product streams from the 3 different cases.
BLOCK M1 MIXER
  DESCRIPTION 'PLANT 1 OUTLET CLEAN COAL MIXER'
;
;  Mix the middling coal product streams from the 3 different cases.
BLOCK M2 MIXER
  DESCRIPTION 'PLANT 1 OUTLET MIDDLING COAL MIXER'
;
;  Mix the hydrogen streams going to Plant 2.
BLOCK M-2HYD MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL HYDROGEN STREAM TO PLANT 2'
  PARAM NPK=1  KPH=1
;
;  Mix the refuse product streams from the 3 different cases.
```

```
BLOCK M3 MIXER
  DESCRIPTION 'PLANT 1 OUTLET REFUSE MIXER'
;
;  Mix the sour water streams from Plants 2, 3, 4, 5, and 9.
BLOCK M38 MIXER
  DESCRIPTION 'SOUR WATER MIXER FOR PLANT 38 FEED'
;
;  Mix the waste water product streams from the 3 different cases.
BLOCK M4 MIXER
  DESCRIPTION 'PLANT 1 OUTLET WASTE WATER MIXER'
;
;  Mix the hydrogen streams from Plants 4 & 2 for Plant 6.2.
BLOCK M-462 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 6.2 FEED'
;
;  Mix the hydrogen streams from Plants 5 & 2 for Plant 6.1.
BLOCK M-561 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 6.1 FEED'
;
;  Mix the sour gas streams from Plants 6.1, 6.2, 9 and 38 for the
;  Plant 11 feed stream.
BLOCK M-6GAS HEATER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 11 FEED'
  PARAM  TEMP=110.0  PRES=14.7
;
;  Mix the H2 gas streams from Plants 7 & 6.2 for Plant 3.
BLOCK M-73 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 3 FEED'
;
;  Mixer M9C - The hydrogen plant feed mixer; used to mix the coal and
;  ROSE unit ASH-CONC stream that goes to Plant 9.0.
BLOCK M9C MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 9 FEED'
  BLOCK-OPTIONS HMB-RESULTS=2
;
;  Mixer M9 - The dummy hydrogen mixer; used to mix the three
;  streams that go to Plant 2 (M9H2), Plant 4 (M9H4), and
;  Plant 5 (M9H5) into one single output stream (MHNEED) for the
;  S9 splitter.
BLOCK M9H MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL AMOUNT OF HYDROGEN NEEDED'
  PARAM NPK=1  KPH=1
;
;  Mix the hydrogen streams from Plants 6.1 and 6.2. Use a flash2 block
;  to correct a temperature calculating error in the ASPEN mixer block
;  algorithm.
BLOCK M-HYD FLASH2
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL HYDROGEN FROM 6.1 AND 6.2'
  PARAM  TEMP=100.  PRES=3290.
;
;  Mix the naphtha streams from Plants 2 and 6.2.
BLOCK M-NAP MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL PLANT 4 NAPHTHA FEED'
;
;  Mix the product naphtha streams from Plants 4 and 5.
```

```
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL PRODUCT NAPHTHA STREAM'
BLOCK M-PNAP MIXER
;
;  Plant P1-ALT1, Coal Cleaning and Preparation Plant. Use User
;  Fortran Model, USR01, within the PLANTS file. ALTERNATE CASE 1 -
;  COAL CLEANING BY HEAVY MEDIUM SEPARATION.
BLOCK P1-ALT1 USER
   SUBROUTINE MODEL = USR01    REPORT = USR01
   DESCRIPTION 'PLANT 1 - ALTERNATE 1 - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following integer and real parameters are for production of
;   the coal cleaned by both jigs and heavy medium separation.  The coal
;   cleaned only by jigs for gasification is handled by a separate plant
;   that is modeled in BLOCK P1-JIGS.  The operators and cost for this
;   plant includes those associalted with the P1-JIGS portion of the coal
;   cleaning and preparation plant.  All parameters have the same meaning
;   as described below for Plant 1 in BLOCK P1-BASE.
;
    INT  0  1  0  1  1
;         FCP          FCM    FHP          FHM    FNP          FNM
     REAL 0.9120155    0.0    0.9050241    0.0    0.8869236    0.0  &
;         FC1P         FC1M   FSP          FSM    FOP          FOM
          0.7602203    0.0    0.4471884    0.0    0.9905900    0.0  &
;         FAP          FAM
          0.3012854    0.0  &
;         PCWP  PCWM  PCWR  Future Use (3 items)
          9.0   3.0   10.0    0.   0.   0.                    &
;         Power            900/750 F steam   900 satd steam
          0.0 7.400489      0.0 0.0           0.0 0.0         &
;         600/720 F steam   600 satd steam    150 satd steam
          0.0 0.0           0.0 0.0           0.0 0.0         &
;         50 satd steam     Plant fuel        Cooling  H2O
          0.0 0.0           0.0 0.0           0.0 0.0         &
;         Process H2O       Nitrogen
          0.0 0.042246      0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          8.0           8.0                 &
;         Ref Flow   Max Flow   Min Flow
          285.035    300.0      150.0      &
;         Plant cost equation constants.
;         A      B       E      F      Spares     Future Use (2 items)
          0.0    25.52   0.5942 1.0    0.0        0.0   0.0    &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S12    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S13    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S14    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S15    KODE=2   TEMP = 70.0   PRES = 14.7
;
;  Plant P1-ALT2, Coal Cleaning and Preparation Plant. Use User Fortran
```

```
;  Model, USR01, within the PLANTS file. ALTERNATE CASE 2 - COAL CLEANING
;  BY HEAVY MEDIUM SEPARATION FOLLOWED BY SPHERICAL AGGLOMERATION.
BLOCK P1-ALT2 USER
   SUBROUTINE MODEL = USR01    REPORT = USR01
   DESCRIPTION 'PLANT 1 - ALTERNATE 2 - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following integer and real parameters are for production of
;   the coal cleaned by both jigs and heavy medium separation followed
;   by spherical agglomeration.  The coal cleaned only by jigs for
;   gasification is handled by a separate plant that is modeled in
;   BLOCK P1-JIGS.  The operators and cost for this plant includes
;   those associalted with the P1-JIGS portion of the coal cleaning
;   and preparation plant.  All parameters have the same meaning as
;   described below for Plant 1 in BLOCK P1-BASE.
;
    INT  0  1  0  1  2
;         FCP          FCM    FHP          FHM    FNP          FNM
     REAL 0.9435271    0.0    0.9338663    0.0    0.9250562    0.0  &
;         FC1P         FC1M   FSP          FSM    FOP          FOM
          0.7400450    0.0    0.3772778    0.0    0.9867266    0.0  &
;         FAP          FAM
          0.1295931    0.0  &
;         PCWP   PCWM  PCWR  Future Use (3 items)
          14.16  3.0   10.0  0.0   0.0   0.0                  &
;         Power                900/750 F steam   900 satd steam
          0.0 51.68786         0.0 0.0           0.0 0.0      &
;         600/720 F steam      600 satd steam    150 satd steam
          0.0 0.0              0.0 0.0           0.0 0.0      &
;         50 satd steam        Plant fuel        Cooling  H2O
          0.0 0.0              0.0 0.394967      0.0 0.0      &
;         Process H2O          Nitrogen
          0.0 0.103481         0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          8.0           8.0                 &
;         Ref Flow   Max Flow   Min Flow
          262.3      300.0      150.0      &
;         Plant cost equation constants.
;         A      B       E      F      Spares     Future Use (2 items)
          0.0    73.78   0.5942 1.0    0.0        0.0   0.0    &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S22    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S23    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S24    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S25    KODE=2   TEMP = 70.0   PRES = 14.7
;
;
; Plant 1 - Coal Cleaning, Preparation and Drying Plant, Use User Fortran
;           Model USR01
;           BASE CASE - COAL CLEANING BY JIGS For LIQUEFACTION.
```

```
BLOCK P1-BASE USER
   SUBROUTINE MODEL = USR01   REPORT = USR01
   DESCRIPTION 'PLANT 1 - BASE CASE - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following 5 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL01B.REP, DCL01A1.REP or DCL01A2.REP
;                    depending on the value of the coal cleaning option
;                    control switch, INT(5).
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-4 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
;      INT(5)  = Coal cleaning, drying and grinding option control
;                switch.  The name of the short plant report file
;                written for each option is option dependent.
;                0 => Base case - Coal cleaning by jigs for coal
;                     liquefaction in plant 2. (Report = DCL01B.REP)
;                1 => Alternate case 1 - Coal cleaning by heavy media
;                     separation.  (Report = DCL01A1.REP)
;                2 => Alternate case 2 - Coal cleaning by heavy media
;                     separation and spherical agglomeration.
;                     (Report = DCL01A2.REP)
;                3 => Coal cleaning by jigs for coal gasification in
;                     plant 9.  (Report = DCL01G.REP)
;                4 => Coal grinding and drying plant.
;                     (Report = DCL01D.REP)
;               NOTE: Values 0, 1 and 2 are used when this model
;                     cleans the coal going to the coal liquefaction
;                     plant, 3 is used only when this model cleans
;                     the coal going to the coal gasification plant,
;                     and 4 is for the grinding and drying plant.
   INT  0  1  0  1  0
;      The following 70 real parameters are:
```

```
;       REAL(1)   = Fraction of carbon in the inlet coal leaving
;                   in the clean coal product stream.
;       REAL(2)   = Fraction of carbon in the inlet coal leaving
;                   in the middling coal stream.
;       REAL(3)   = Fraction of hydrogen in the inlet coal leaving
;                   in the clean coal product stream.
;       REAL(4)   = Fraction of hydrogen in the inlet coal leaving
;                   in the middling coal stream.
;       REAL(5)   = Fraction of nitrogen in the inlet coal leaving
;                   in the clean coal product stream.
;       REAL(6)   = Fraction of nitrogen in the inlet coal leaving
;                   in the middling coal stream.
;       REAL(7)   = Fraction of chlorine in the inlet coal leaving
;                   in the clean coal product stream.
;       REAL(8)   = Fraction of chlorine in the inlet coal leaving
;                   in the middling coal stream.
;       REAL(9)   = Fraction of sulfur in the inlet coal leaving
;                   in the clean coal product stream.  OPTIONAL - See Note 1.
;       REAL(10)  = Fraction of sulfur in the inlet coal leaving
;                   in the middling coal stream.  OPTIONAL - See Note 1.
;       REAL(11)  = Fraction of oxygen in the inlet coal leaving
;                   in the clean coal product stream.
;       REAL(12)  = Fraction of oxygen in the inlet coal leaving
;                   in the middling coal stream.
;       REAL(13)  = Fraction of ash in the inlet coal leaving
;                   in the clean coal product stream.
;       REAL(14)  = Fraction of ash in the inlet coal leaving
;                   in the middling coal stream.
;       REAL(15)  = Moisture content of the clean product coal on a dry
;                   basis, wt%.
;       REAL(16)  = Moisture content of the middling coal on a dry
;                   basis, wt%.
;       REAL(17)  = Moisture content of the refuse on a dry basis, wt%.
;       REAL(18) -
;        REAL(20) = Future use.
;       REAL(21)  = Constant factor for the power consumption, kw.
;       REAL(22)  = Power consumption per Mlbs/hr of dry clean coal,
;                   kw/(Mlbs/hr).
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
```

```
;                    consumption, Mlbs/hr.
;      REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                  dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;      REAL(33)  = Constant factor for the 50 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                  dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;      REAL(35)  = Constant factor for the plant fuel consumption,
;                  MM BTU/hr.
;      REAL(36)  = Plant fuel consumption per Mlbs/hr of dry clean coal,
;                  (MM BTU/hr)/(Mlbs/hr).
;      REAL(37)  = Constant factor for the cooling water consumption,
;                  Mgal/hr.
;      REAL(38)  = Cooling water consumption per Mlbs/hr of dry clean
;                  coal (Mgal/hr)/(Mlbs/hr).
;      REAL(39)  = Constant factor for the process water consumption,
;                  Mgal/hr.
;      REAL(40)  = Process water consumption per Mlbs/hr of dry clean
;                  coal, (Mgal/hr)/(Mlbs/hr).
;      REAL(41)  = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2.
;      REAL(42)  = Nitrogen consumption per Mlbs/hr of dry clean coal,
;                  (MM SCF/hr of N2)/(Mlbs/hr).
;      REAL(43) -
;       REAL(48) = Future use.
;      REAL(49)  = Constant factor for the number of operators per
;                  day, operators/day.
;      REAL(50)  = Number of operators per day per train,
;                  (operators/day)/train.
;      REAL(51)  = Reference flow rate of the dry clean coal of a
;                  single train in Mlbs/hr for the calculation of
;                  the ISBL field cost of a single train as a function
;                  of train capacity.
;      REAL(52)  = Maximum size of a single train as defined by the
;                  flow rate of the dry clean coal in Mlbs/hr.
;      REAL(53)  = Minimum size of a single train as defined by the
;                  flow rate of the dry clean coal in Mlbs/hr.
;      REAL(54)  = Constant A in the plant ISBL field cost equation.
;      REAL(55)  = Constant B in the plant ISBL field cost equation.
;      REAL(56)  = Constant E in the plant ISBL field cost equation.
;      REAL(57)  = Constant F in the plant ISBL field cost equation.
;      REAL(58)  = Number of spare trains.
;      REAL(59) -
;       REAL(70) = Future use.
;
;    NOTES:
;      1. If both the sulfur distribution factors, REAL(9) and REAL(10),
;         are zero and a SULFANAL was supplied, the sulfur will be
;         distributed among the products as follows.
;         a. The ORGANIC sulfur will be distributed in the same
;            proportions as the carbon is distributed.
;         b. The PYRITIC and SULFATE sulfur will be distributed in the
;            same proportions as the ash is distributed.
;
;         FCP         FCM    FHP         FHM    FNP         FNM
```

```
     REAL 0.9302390   0.0    0.9142857    0.0    0.9533333   0.0  &
;         FC1P        FC1M   FSP          FSM    FOP         FOM
          0.40000     0.0    0.5019608    0.0    0.9696970   0.0  &
;         FAP         FAM
          0.4229677   0.0  &
;         PCWP   PCWM  PCWR  Future Use (3 items)
          8.576  3.0   10.0  0.0   0.0   0.0                &
;         Power              900/750 F steam   900 satd steam
          0.0 4.281977       0.0 0.0           0.0 0.0      &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 0.0           0.0 0.0      &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 0.0           0.0 0.0      &
;         Process H2O        Nitrogen
          0.0 0.02433102     0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          8.0           8.0                 &
;         Ref Flow   Max Flow   Min Flow
          387.158    390.0      200.0      &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future use (2 items)
          0.0    31.56   0.5942 1.0    0.0      0.0   0.0       &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S02    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S03    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S04    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S05    KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 1-JIGS  - Coal Cleaning by Jigs for gasification - User Fortran
;                 Model USR01
;            COAL CLEANING BY JIGS For GASIFICATION.
BLOCK P1-JIGS USER
   SUBROUTINE MODEL = USR01   REPORT = USR01
   DESCRIPTION 'PLANT 1 - JIGS - COAL CLEANING FOR GASIFICATION'
;      The following integer and real parameters have the same meaning
;      as described above for Plant 1 in BLOCK P1-BASE.
   PARAM  NINT = 5   NREAL = 70
    INT  0  1  0  1  3
;
;         FCP         FCM    FHP          FHM    FNP         FNM
     REAL 0.9302390   0.0    0.9142857    0.0    0.9533333   0.0  &
;         FC1P        FC1M   FSP          FSM    FOP         FOM
          0.40000     0.0    0.5019608    0.0    0.9696970   0.0  &
;         FAP         FAM
          0.4229677   0.0  &
;         PCWP   PCWM  PCWR  Future Use (3 items)
          8.576  3.0   10.0  0.0   0.0   0.0                &
;         Power              900/750 F steam   900 satd steam
          0.0 4.281977       0.0 0.0           0.0 0.0      &
```

```
;         600/720 F steam   600 satd steam    150 satd steam
          0.0 0.0           0.0 0.0           0.0 0.0       &
;         50 satd steam     Plant fuel        Cooling  H2O
          0.0 0.0           0.0 0.0           0.0 0.0       &
;         Process H2O       Nitrogen
          0.0 0.02433102    0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.0           0.0                 &
;         Ref Flow   Max Flow   Min Flow
          387.158    390.0      200.0       &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future use (2 items)
          0.0    0.0     0.5942 1.0    0.0      0.0   0.0       &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = COALTO9 KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S33    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S34    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S35    KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 1.4 - Coal Grinding and Drying Plant - Fortran Model USR01
;             BASE CASE
BLOCK P14 USER
   SUBROUTINE MODEL = USR01   REPORT = USR01
   DESCRIPTION 'PLANT 1.4 - BASE CASE - COAL GRINDING AND DRYING PLANT'
   PARAM  NINT = 5   NREAL = 70
;     The following integer and real parameters have the same meaning
;     as described above for Plant 1 in BLOCK P1-BASE.
    INT  0  1  0  1  4
;         FCP         FCM    FHP          FHM    FNP         FNM
     REAL 1.0         0.0    1.0          0.0    1.0         0.0  &
;         FC1P        FC1M   FSP          FSM    FOP         FOM
          1.0         0.0    1.0          0.0    1.0         0.0  &
;         FAP         FAM
          1.0         0.0   &
;         PCWP   PCWM  PCWR  Future Use (3 items)
          2.0    3.0   10.0  0.0   0.0   0.0                 &
;         Power             900/750 F steam   900 satd steam
          0.0 8.499979      0.0 0.0           0.0 0.0       &
;         600/720 F steam   600 satd steam    150 satd steam
          0.0 0.0           0.0 0.0           0.0 0.0       &
;         50 satd steam     Plant fuel        Cooling  H2O
          0.0 0.0           0.0 0.3410096     0.0 0.010104  &
;         Process H2O       Nitrogen
          0.0 0.0           0.0 3.16015     &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          7.0           1.0                 &
;         Ref Flow   Max Flow   Min Flow
```

```
          142.518    145.0      50.0        &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future use (2 items)
          0.0    8.75    0.8504 1.0    0.0      0.0   0.0       &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = COALTO2  KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-XMID KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-REF  KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-WAT  KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 2 - The coal liquefaction plant - user Fortran block USR02.
BLOCK P02 USER
   SUBROUTINE MODEL = USR02   REPORT = USR02
   DESCRIPTION 'PLANT 2 - COAL LIQUEFACTION PLANT'
   PARAM  NINT = 6   NREAL = 70
;      The following 6 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL02.REP.
;      INT(3) = Number of operating duplicate plants, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 plants will be determined so that the capacity
;                 of each plant does not exceed the maximum plant
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate plants.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
;      INT(5) = Switch to write the major equipment summary list and
;               cost summary report by plant section for the baseline
;               design to the separate block output summary report file
;               called DCL02.REP on logical unit 62.
;               0 => Do not write the major equipment summary list.
;               1 => Write the major equipment summary list to the
;                    separate block output file only when
;                    INT(1) <= 2, INT(2) = 1, and INT(6) = 0.
```

```
;                2 => Write the major equipment summary list and the
;                     cost summary report by plant section to the
;                     separate block output file only when
;                     INT(1) <= 2, INT(2) = 1, and INT(6) = 0.
;      INT(6) = Switch to select which coal liquefaction reactor yields
;               are calculated.
;               0 => Baseline design two-reactor model.
;               3 => Option 3 - Yields for Thermal/Catalytic two-
;                     reactor model.
;               4 => Option 4 - Two-reactor model with interstaage
;                     vent gas separation.
;               5 => Option 5 - Yields for two-reactor coker model.
;               8 => Improved Baseline (Option 8) - High space velocity
;                     two-reactor model.
   INT  0  1  0  1  2  0
;      The following 70 real parameters are:
;      REAL(1)    = Percent coal conversion based on fresh MAF coal
;                   entering the coal liquefaction reactors.
;      REAL(2)-
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per Mlbs/hr of dry coal feed,
;                   kw/(Mlbs/hr of dry coal).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                   dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                   dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                   dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                   dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per Mlbs/hr of dry coal feed,
;                   (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(37)   = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;      REAL(38)   = Cooling water consumption per Mlbs/hr of dry coal
;                   feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
```

```
;                    produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(39)  = Constant factor for the process water consumption,
;                    Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of dry coal
;                    feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                    MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of dry coal feed,
;                    (MM SCF/hr of N2)/(Mlbs/hr of dry coal).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                    day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                    (operators/day)/train.
;       REAL(51)  = Reference dry coal feed rate to a single train in
;                    Mlbs/hr for the calculation of the ISBL field cost of
;                    a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the dry
;                    coal feed rate in Mlbs/hr of dry coal.
;       REAL(53)  = Minimum size of a single train as defined by the dry
;                    coal feed rate in Mlbs/hr of dry coal.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Percent fresh MAF coal conversion
     REAL 92.7901  &
;          Future use (9 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0    &
;          Power              900/750 F steam    900 satd steam
           0.0 41.39141       0.0 0.0            0.0 0.0        &
;          600/720 F steam    600 satd steam     150 satd steam
           0.0 0.003904784    0.0 -0.1046117     0.0 -0.0632168 &
;          50 satd steam      Plant fuel         Cooling H2O
           0.0 0.0393741      0.0 0.764818       0.0 0.340800   &
;          Process H2O        Nitrogen
           0.0 0.1081972      0.0 0.000029236 &
;          Future Use (6 items)
           0.0  0.0  0.0 0.0  0.0  0.0       &
;          Opers/day     (Opers/day)/train
           0.0           8.0                 &
;          Ref Flow   Max Flow   Min Flow
           285.035    285.05     30.0        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future use (2 items)
           0.0    186.44  0.7142 1.0    0.0      0.0   0.0   &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
```

```
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR02.
   FLASH-SPECS STRM=2S-GAS KODE=2 TEMP=130.0 PRES=2985.0 NPK=1 KPH=1 /
               STRM = GASES     KODE=2   TEMP = 130.0  PRES = 65.0   /
               STRM = NAPHTHA   KODE=2   TEMP = 140.0  PRES = 16.0   /
               STRM = GAS-OIL   KODE=2   TEMP = 110.0  PRES = 30.0   /
               STRM = 2S-BOTTS  KODE=2   TEMP = 688.0  PRES = 28.0   /
               STRM = 2S-SH2O   KODE=2   TEMP = 100.0  PRES = 30.0
;
; Plant 3 - The gas plant - use user Fortran block USR03.
BLOCK P03 USER
   SUBROUTINE MODEL = USR03   REPORT = USR03
   DESCRIPTION 'PLANT 3 - THE GAS PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL03.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per MM SCF/hr of dry C4- gas,
;                  kw/(MM SCF/hr of dry C4- gas)
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr
;                  of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;      REAL(25)  = Constant factor for the 900 psig saturated steam
```

```
;                 consumption, Mlbs/hr.
;     REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr
;                 of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;     REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                 consumption, Mlbs/hr.
;     REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr
;                 of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;     REAL(29)  = Constant factor for the 600 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr
;                 of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;     REAL(31)  = Constant factor for the 150 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr
;                 of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;     REAL(33)  = Constant factor for the 50 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr
;                 of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;     REAL(35)  = Constant factor for the plant fuel consumption,
;                 MM BTU/hr.
;     REAL(36)  = Plant fuel consumption per MM SCF/hr of dry C4- gas,
;                 (MM BTU/hr)/(MM SCF/hr of dry C4- gas).
;     REAL(37)  = Constant factor for the cooling water consumption,
;                 Mgal/hr.
;     REAL(38)  = Cooling water consumption per MM SCF/hr of dry C4-
;                 gas, (Mgal/hr)/(MM SCF/hr of dry C4- gas).
;     REAL(39)  = Constant factor for the process water consumption,
;                 Mgal/hr.
;     REAL(40)  = Process water consumption per MM SCF/hr of dry C4-
;                 gas, (Mgal/hr)/(MM SCF/hr of dry C4- gas).
;     REAL(41)  = Constant factor for the nitrogen consumption,
;                 MM SCF/hr of N2.
;     REAL(42)  = Nitrogen consumption per MM SCF/hr of dry C4- gas,
;                 (MM SCF/hr of N2)/(MM SCF/hr of dry C4- gas).
;     REAL(43) -
;      REAL(48) = Future use.
;     REAL(49)  = Constant factor for the number of operators per
;                 day, operators/day.
;     REAL(50)  = Number of operators per day per train,
;                 (operators/day)/train.
;     REAL(51)  = Reference gas feed rate to a single train in
;                 MM SCF/hr of dry C4- gas for the calculation of
;                 the ISBL field cost of a single train as a function
;                 of train capacity.
;     REAL(52)  = Maximum size of a single train as defined by the
;                 gas feed rate in MM SCF/hr of dry C4- gas.
;     REAL(53)  = Minimum size of a single train as defined by the
;                 gas feed rate in MM SCF/hr of dry C4- gas.
;     REAL(54)  = Constant A in the plant ISBL field cost equation.
;     REAL(55)  = Constant B in the plant ISBL field cost equation.
;     REAL(56)  = Constant E in the plant ISBL field cost equation.
;     REAL(57)  = Constant F in the plant ISBL field cost equation.
;     REAL(58)  = Number of spare trains.
;     REAL(59) -
```

```
;       REAL(70) = Future use.
;
;         Future use (10 items)
     REAL 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 447.6001       0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 194.4388      0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 8.425471       0.0 -722.141      0.0 645.8090  &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.0            8.0                &
;         Ref Flow   Max Flow   Min Flow
          2.04       5.0        0.300      &
;         Plant cost equation constants.
;         A      B          E      F      Spares   Future Use (3 items)
          0.0    25.3       0.8013 1.0    0.0      0.0   0.0   &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR03.
   FLASH-SPECS STRM = 3S-SGAS   KODE=2  TEMP = 137.0  PRES = 55.0   /
               STRM = 3S-FGAS   KODE=2  TEMP = 100.0  PRES = 215.0  /
               STRM = 3S-PROP   KODE=2  TEMP = 100.0  PRES = 280.0  /
               STRM = 3S-BUT    KODE=2  TEMP = 100.0  PRES = 280.0  /
               STRM = 3S-OIL    KODE=2  TEMP = 130.0  PRES = 263.0  &
                      NPK=1 KPH=2 /
               STRM = 3S-SH2O   KODE=2  TEMP = 137.0  PRES = 55.0
;
; Plant 4 - The naphtha hydrotreater - use user Fortran block USR04.
BLOCK P04 USER
   SUBROUTINE MODEL = USR04   REPORT = USR04
   DESCRIPTION 'PLANT 4 - THE NAPHTHA HYDROTREATER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL04.REP.
```

```
;       INT(3) = Number of operating duplicate trains, excluding spares.
;                If INT(3) = 0, the minimum number of duplicate
;                  trains will be determined so that the capacity
;                  of each plant does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate trains.
;       INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
    INT  0  1  0  1
;       The following 70 real parameters are:
;       REAL(1)    = Percent desulfurization of the C5+ feed; i. e.,
;                    Percent of sulfur removed from the entering C5+ feed.
;       REAL(2)    = Percent denitrogenation of the C5+ feed; i. e.,
;                    Percent of nitrogen removed from the entering C5+ feed.
;       REAL(3)    = Percent deoxygenation of the C5+ feed.
;                    Percent of oxygen removed from the entering C5+ feed.
;       REAL(4)    = Chemical hydrogen consumption in SCF/bbl of C5+ feed.
;       REAL(5) -
;        REAL(20)  = Future use.
;       REAL(21)   = Constant factor for the power consumption, kw.
;       REAL(22)   = Power consumption per Mlbs/hr of C5+ feed,
;                    kw/(Mlbs/hr of C5+ feed).
;       REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                    consumption, Mlbs/hr.
;       REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                    C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;       REAL(25)   = Constant factor for the 900 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                    C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;       REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                    consumption, Mlbs/hr.
;       REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                    C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;       REAL(29)   = Constant factor for the 600 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                    C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;       REAL(31)   = Constant factor for the 150 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                    C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;       REAL(33)   = Constant factor for the 50 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                    C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;       REAL(35)   = Constant factor for the plant fuel consumption,
;                    MM BTU/hr.
;       REAL(36)   = Plant fuel consumption per Mlbs/hr of C5+ feed,
```

```
;                    (MM BTU/hr)/(Mlbs/hr of C5+ feed).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                    Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of C5+ feed,
;                    (Mgal/hr)/(Mlbs/hr of C5+ feed).
;       REAL(39)  = Constant factor for the process water consumption,
;                    Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of C5+ feed,
;                    (Mgal/hr)/(Mlbs/hr of C5+ feed).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                    MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of C5+ feed,
;                    (MM SCF/hr of N2)/(Mlbs/hr of C5+ feed).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                    day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                    (operators/day)/train.
;       REAL(51)  = Reference C5+ feed rate to a single train in Mlbs/hr
;                    for the calculation of the ISBL field cost of a
;                    single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                    C5+ feed rate in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                    C5+ feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          % Desulfurization   % Denitrogenation
     REAL 99.99                99.988        &
;          % Deoxygenation   Chemical H2 consumption in SCF/bbl C5+ feed
           99.5              125.0           &
;          Future use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power             900/750 F steam   900 satd steam
           0.0 5.098308      0.0 0.0           0.0 0.0       &
;          600/720 F steam   600 satd steam    150 satd steam
           0.0 0.0           0.0 0.126493      0.0 0.0       &
;          50 satd steam     Plant fuel        Cooling  H2O
           0.0 0.0           0.0 0.351607      0.0 0.730963  &
;          Process H2O       Nitrogen
           0.0 0.010833      0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0            8.0                &
;          Ref Flow   Max Flow   Min Flow
```

```
          210.462    400.0      50.0        &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future Use (3 items)
          0.0    15.6    0.7843 1.0    0.0      0.0   0.0   &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR04.
   FLASH-SPECS STRM = 4S-GAS   KODE=2  TEMP = 135.0  PRES = 915.0  /
               STRM = 4S-NAPH  KODE=2  TEMP = 100.0  PRES = 153.0  /
               STRM = 4S-SH2O  KODE=2  TEMP =  70.0  PRES = 14.7
;
; Plant 5 - The gas-oil hydrotreater - use user Fortran block USR05.
BLOCK P05 USER
   SUBROUTINE MODEL = USR05   REPORT = USR05
   DESCRIPTION 'PLANT 5 - THE GAS-OIL HYDROTREATER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL05.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Percent desulfurization of the C6+ feed; i. e.,
;                  Percent of sulfur removed from the entering C6+ feed.
;      REAL(2)   = Percent denitrogenation of the C6+ feed; i. e.,
;                  Percent of nitrogen removed from the entering C6+ feed.
;      REAL(3)   = Percent deoxygenation of the C6+ feed.
;                  Percent of oxygen removed from the entering C6+ feed.
;      REAL(4)   = Chemical hydrogen consumption in SCF/bbl of C6+ feed.
```

```
;       REAL(5) -
;        REAL(20) = Future use.
;       REAL(21)  = Constant factor for the power consumption, kw.
;       REAL(22)  = Power consumption per Mlbs/hr of C6+ feed,
;                   kw/(Mlbs/hr).
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of C6+ feed,
;                   (MM BTU/hr)/(Mlbs/hr).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of C6+ feed,
;                   (Mgal/hr)/(Mlbs/hr).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of C6+ feed,
;                   (Mgal/hr)/(Mlbs/hr).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of C6+ feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference C6+ feed rate to a single train in Mlbs/hr
;                   for the calculation of the ISBL field cost of a
;                   single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
```

```
;                   C6+ feed rate in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   C6+ feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          % Desulfurization   % Denitrogenation
     REAL 92.5                 85.2       &
;          % Deoxygenation   Chemical H2 consumption in SCF/bbl C6+ feed
           97.6             947.00       &
;          Future use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0   &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power            900/750 F steam   900 satd steam
           0.0 3.247198     0.0 0.0           0.0 0.0       &
;          600/720 F steam  600 satd steam    150 satd steam
           0.0 0.0          0.0 0.096936      0.0 -0.050465 &
;          50 satd steam    Plant fuel        Cooling  H2O
           0.0 0.0          0.0 0.241416      0.0 0.735694 &
;          Process H2O      Nitrogen
           0.0 0.0          0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0           4.0                 &
;          Ref Flow   Max Flow   Min Flow
           671.04     800.0      150.0       &
;          Plant cost equation constants.
;          A      B      E      F      Spares   Future Use (2 items)
           0.0    74.0   0.7467 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR05.
;  The 5S-LPGAS and 5S-NAPH temperature and pressure are those leaving
;  Plant 4 where this fractionation is actually performed.
   FLASH-SPECS STRM = 5S-HPGAS  KODE=2  TEMP = 135.0  PRES = 2690.0 /
               STRM = 5S-LPGAS  KODE=2  TEMP = 135.0  PRES = 915.0  /
               STRM = 5S-NAPH   KODE=2  TEMP = 100.0  PRES = 153.0  /
               STRM = P350-450  KODE=2  TEMP = 110.0  PRES = 80.0   /
               STRM = P450-650  KODE=2  TEMP = 135.0  PRES = 20.0   /
               STRM = P650-850  KODE=2  TEMP = 135.0  PRES = 20.0   /
               STRM = 5S-SH2O   KODE=2  TEMP = 135.0  PRES = 20.0
;
; Plant 6.1 - The Hydrogen purification by Membrane Separation Plant.
BLOCK P61 USER
   SUBROUTINE MODEL = USR61   REPORT = USR61
   DESCRIPTION 'PLANT 6.1 - THE MEMBRANE H2 PURIFICATION PLANT'
```

```
PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL61.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Percent hydrogen recovery to the hydrogen-rich
;                   product gas stream from the inlet gas stream.
;      REAL(2)    = Concentration of hydrogen in the hydrogen-rich
;                   product gas stream, mole % or vol%.
;      REAL(3)-
;       REAL(20)  = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per MM SCF/hr of H2 recovered,
;                   kw/(MM SCF/hr of H2 recovered).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr
;                   of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per MM SCF/hr of
```

```
;                 H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;     REAL(31)  = Constant factor for the 150 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                 H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;     REAL(33)  = Constant factor for the 50 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                 H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;     REAL(35)  = Constant factor for the plant fuel consumption,
;                 MM BTU/hr.
;     REAL(36)  = Plant fuel consumption per MM SCF/hr of H2 recovered,
;                 (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;     REAL(37)  = Constant factor for the cooling water consumption,
;                 Mgal/hr.
;     REAL(38)  = Cooling water consumption per MM SCF/hr of H2
;                 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;     REAL(39)  = Constant factor for the process water consumption,
;                 Mgal/hr.
;     REAL(40)  = Process water consumption per MM SCF/hr of H2
;                 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;     REAL(41)  = Constant factor for the nitrogen consumption,
;                 MM SCF/hr of N2
;     REAL(42)  = Nitrogen consumption per MM SCF/hr of H2 recovered,
;                 (MMM SCF/hr of N2)/(MM SCF/hr of H2 recovered).
;     REAL(43) -
;      REAL(48) = Future use.
;     REAL(49)  = Constant factor for the number of operators per
;                 day, operators/day.
;     REAL(50)  = Number of operators per day per train,
;                 (operators/day)/train.
;     REAL(51)  = Reference hydrogen recovery rate for a single train
;                 in MM SCF/hr of H2 for the calculation of the
;                 ISBL field cost of a single train as a function of
;                 capacity.
;     REAL(52)  = Maximum size of a single train as defined by the
;                 hydrogen recovery rate in MM SCF/hr of H2
;                 recovered.
;     REAL(53)  = Minimum size of a single train as defined by the
;                 hydrogen recovery rate in MM SCF/hr of H2
;                 recovered.
;     REAL(54)  = Constant A in the plant ISBL field cost equation.
;     REAL(55)  = Constant B in the plant ISBL field cost equation.
;     REAL(56)  = Constant E in the plant ISBL field cost equation.
;     REAL(57)  = Constant F in the plant ISBL field cost equation.
;     REAL(58)  = Number of spare trains.
;     REAL(59) -
;      REAL(70) = Future use.
;
;        Percent H2 recovery    H2 purity in mole %
   REAL 43.83285               99.98677                    &
;        Future use (8 items)
         0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0             &
;        Future use (10 items)
         0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   &
```

```
;         Power                900/750 F steam   900 satd steam
          0.0 12254.04         0.0 0.0           0.0 0.0       &
;         600/720 F steam      600 satd steam    150 satd steam
          0.0 0.0              0.0 0.0           0.0 0.0       &
;         50 satd steam        Plant fuel        Cooling H2O
          0.0 2.054966         0.0 0.0           0.0 42.705864 &
;         Process H2O          Nitrogen
          0.0 0.854117         0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0         &
;         Opers/day      (Opers/day)/train
          0.0              12.0                &
;         Ref Flow   Max Flow   Min Flow
          1.966943   2.5        0.5            &
;         Plant cost equation constants.
;         A      B          E      F      Spares   Future use (2 items)
          0.0    152.6      0.8478 1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR61.
   FLASH-SPECS STRM = H2-RICH   KODE=2   TEMP = 100.0  PRES = 3290.0 /
               STRM = SOUR-GAS  KODE=2   TEMP = 250.0  PRES = 14.7   /
               STRM = P61-GAS   KODE=2   TEMP = 111.0  PRES = 500.0
;
; Plant 6.2 - The Hydrogen purification by Pressure Swing Absorption
;             Plant.
BLOCK P62 USER
   SUBROUTINE MODEL = USR62   REPORT = USR62
   DESCRIPTION 'PLANT 6.2 - THE PSA H2 PURIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL62.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
```

```
;                    messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Percent hydrogen recovery to the hydrogen-rich
;                   product gas stream from the inlet gas stream.
;      REAL(2)    = Concentration of hydrogen in the hydrogen-rich
;                   product gas stream, mole % or vol%.
;      REAL(3)-
;       REAL(20)  = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per MM SCF/hr of H2 recovered,
;                   kw/(MM SCF/hr of H2 recovered).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr
;                   of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per MM SCF/hr of H2 recovered,
;                   (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(37)   = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;      REAL(38)   = Cooling water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(39)   = Constant factor for the process water consumption,
;                   Mgal/hr.
;      REAL(40)   = Process water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(41)   = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;      REAL(42)   = Nitrogen consumption per MM SCF/hr of H2 recovered,
```

```
;                    (MMM SCF/hr of N2)/(MM SCF/hr of H2 recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference hydrogen recovery rate for a single train
;                   in MM SCF/hr of H2 for the calculation of the
;                   ISBL field cost of a single train as a function of
;                   capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;       The cost of Plant 6.2 is included in Plant 6.1.
;         Percent H2 recovery    H2 purity in mole %
    REAL 89.5033                90.01665              &
;         Future use (8 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 5485.989       0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 0.0           0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling H2O
          0.0 15.32654       0.0 0.0           0.0 87.29583  &
;         Process H2O        Nitrogen
          0.0 0.530875       0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.0           0.0                 &
;         Ref Flow   Max Flow   Min Flow
          3.61667    5.0        0.5        &
;         Plant cost equation constants.
;         A      B      E      F      Spares   Future use (2 items)
          0.0    0.0    0.7    1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR62.
   FLASH-SPECS STRM = H2-2RICH  KODE=2   TEMP = 100.0  PRES = 3290.0 /
```

```
              STRM = SOUR-2GS  KODE=2   TEMP = 250.0  PRES = 14.7   /
              STRM = GAS-OUT   KODE=2   TEMP = 111.0  PRES = 25.0   /
              STRM = NAPHTHA2  KODE=2   TEMP = 100.0  PRES = 50.0
;
; Plant 7 - The naphtha reformer - use user Fortran block USR07.
BLOCK P07 USER
   SUBROUTINE MODEL = USR07   REPORT = USR07
   DESCRIPTION 'PLANT 7 - THE NAPHTHA REFORMER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL07.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of feed,
;                  kw/(Mlbs/hr of feed).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                  feed, (Mlbs/hr)/(Mlbs/hr of feed).
;      REAL(25)  = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                  feed, (Mlbs/hr)/(Mlbs/hr of feed).
;      REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;      REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
```

```
;                 feed, (Mlbs/hr)/(Mlbs/hr of feed).
;      REAL(29)  = Constant factor for the 600 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                  feed, (Mlbs/hr)/(Mlbs/hr of feed).
;      REAL(31)  = Constant factor for the 150 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                  feed, (Mlbs/hr)/(Mlbs/hr of feed).
;      REAL(33)  = Constant factor for the 50 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                  feed, (Mlbs/hr)/(Mlbs/hr of feed).
;      REAL(35)  = Constant factor for the plant fuel consumption,
;                  MM BTU/hr.
;      REAL(36)  = Plant fuel consumption per Mlbs/hr of feed,
;                  (MM BTU/hr)/(Mlbs/hr of feed).
;      REAL(37)  = Constant factor for the cooling water consumption,
;                  Mgal/hr.
;      REAL(38)  = Cooling water consumption per Mlbs/hr of feed,
;                  (Mgal/hr)/(Mlbs/hr of feed).
;      REAL(39)  = Constant factor for the process water consumption,
;                  Mgal/hr.
;      REAL(40)  = Process water consumption per Mlbs/hr of feed,
;                  (Mgal/hr)/(Mlbs/hr of feed).
;      REAL(41)  = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2.
;      REAL(42)  = Nitrogen consumption per Mlbs/hr of feed,
;                  (MM SCF/hr of N2)/(Mlbs/hr of feed).
;      REAL(43) -
;       REAL(48) = Future use.
;      REAL(49)  = Constant factor for the number of operators per
;                  day, operators/day.
;      REAL(50)  = Number of operators per day per train,
;                  (operators/day)/train.
;      REAL(51)  = Reference feed rate to a single train in Mlbs/hr
;                  for the calculation of the ISBL field cost of a
;                  single train as a function of train capacity.
;      REAL(52)  = Maximum size of a single train as defined by the
;                  feed rate in Mlbs/hr.
;      REAL(53)  = Minimum size of a single train as defined by the
;                  feed rate in Mlbs/hr.
;      REAL(54)  = Constant A in the plant ISBL field cost equation.
;      REAL(55)  = Constant B in the plant ISBL field cost equation.
;      REAL(56)  = Constant E in the plant ISBL field cost equation.
;      REAL(57)  = Constant F in the plant ISBL field cost equation.
;      REAL(58)  = Number of spare trains.
;      REAL(59) -
;       REAL(70) = Future use.
;
;         Future use (10 items)
    REAL 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Future use (10 items)
         0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power            900/750 F steam   900 satd steam
```

```
          0.0 2.26494       0.0 0.0           0.0 0.0       &
;         600/720 F steam   600 satd steam    150 satd steam
          0.0 -0.314772     0.0 0.0           0.0 0.0       &
;         50 satd steam     Plant fuel        Cooling  H2O
          0.0 0.0           0.0 1.41781       0.0 0.123590  &
;         Process H2O       Nitrogen
          0.0 0.0           0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.            8.                  &
;         Ref Flow   Max Flow   Min Flow
          224.289    400.0      50.0       &
;         Plant cost equation constants.
;         A      B      E      F      Spares   Future Use (3 items)
          0.0    30.7   0.75   1.0    0.0      0.0   0.0   &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0

;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR07.
   FLASH-SPECS STRM = 7S-H2     KODE=2   TEMP = 80.0  PRES = 14.7  /
               STRM = 7S-GAS    KODE=2   TEMP = 80.0  PRES = 14.7  /
               STRM = REFORMED  KODE=2   TEMP = 80.0  PRES = 14.7
;
; Plant 8.1 - The ROSE-SR unit - user Fortran block USR81.
BLOCK P81 USER
   SUBROUTINE MODEL = USR81   REPORT = USR81
   DESCRIPTION 'PLANT 8.1 - THE ROSE-SR UNIT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL81.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate plants.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
```

```
;            3-5 => Write some more additional output to the history
;                   file.  Larger values generate more intermediate
;                   output.
   INT  0  1  0  1
;     The following 70 real parameters are:
;     REAL(1)    = Hydrocarbon rejection factor.
;     REAL(2)-
;      REAL(20) = Future use.
;     REAL(21)   = Constant factor for the power consumption, kw.
;     REAL(22)   = Power consumption per Mlbs/hr of extract,
;                  kw/(Mlbs/hr of extract).
;     REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;     REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                  extract, (Mlbs/hr)/(Mlbs/hr of extract).
;     REAL(25)   = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                  extract, (Mlbs/hr)/(Mlbs/hr of extract).
;     REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;     REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                  extract, (Mlbs/hr)/(Mlbs/hr of extract).
;     REAL(29)   = Constant factor for the 600 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                  extract, (Mlbs/hr)/(Mlbs/hr of extract).
;     REAL(31)   = Constant factor for the 150 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                  extract, (Mlbs/hr)/(Mlbs/hr of extract).
;     REAL(33)   = Constant factor for the 50 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                  extract, (Mlbs/hr)/(Mlbs/hr of extract).
;     REAL(35)   = Constant factor for the plant fuel consumption,
;                  MM BTU/hr.
;     REAL(36)   = Plant fuel consumption per Mlbs/hr of extract,
;                  (Mlbs/hr)/(Mlbs/hr of extract).
;     REAL(37)   = Constant factor for the cooling water consumption,
;                  Mgal/hr.
;     REAL(38)   = Cooling water consumption per Mlbs/hr of extract,
;                  (Mlbs/hr)/(Mlbs/hr of extract).
;     REAL(39)   = Constant factor for the process water consumption,
;                  Mgal/hr.
;     REAL(40)   = Process water consumption per Mlbs/hr of extract,
;                  (Mlbs/hr)/(Mlbs/hr of extract).
;     REAL(41)   = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2
;     REAL(42)   = Nitrogen consumption per Mlbs/hr of extract,
;                  (MM SCF/hr of N2)/(Mlbs/hr of extract).
;     REAL(43) -
;      REAL(48) = Future use.
;     REAL(49)   = Constant factor for the number of operators per
;                  day, operators/day.
```

```
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference feed rate to a single train in Mlbs/hr of
;                   unit feed for the calculation of the capital cost of
;                   a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   unit feed rate in Mlbs/hr of unit feed.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   unit feed rate in Mlbs/hr of unit feed.
;       REAL(54)  = Constant A in the plant costing equation.
;       REAL(55)  = Constant B in the plant costing equation.
;       REAL(56)  = Constant E in the plant costing equation.
;       REAL(57)  = Constant F in the plant costing equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;          Hydrocarbon rejection factor
    REAL  1.6  &
;         Future use (9 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam    900 satd steam
          0.0 8.098677       0.0 0.0            0.0 0.0       &
;         600/720 F steam    600 satd steam     150 satd steam
          0.0 0.0            0.0 0.0            0.0 0.0471832 &
;         50 satd steam      Plant fuel         Cooling H2O
          0.0 0.0            0.0 0.393518       0.0 0.0       &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0         &
;         Future Use (6 items)
          0.  0.  0.  0.  0.  0.             &
;         Opers/day     (Opers/day)/train
          0.0           8.0                  &
;         Ref Flow   Max Flow   Min Flow
          907.390   1500.0     500.0         &
;         Plant cost equation constants.
;         A      B        E      F      Spares   Future use (2 items)
          0.0    42.2     0.7215 1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR81.
   FLASH-SPECS STRM = ROSE-XTR  KODE=2   TEMP = 300.0  PRES = 115.0 /
               STRM = ASH-CONC  KODE=2   TEMP = 150.0  PRES = 14.7
;
; Plant 9 - H2 Production by coal gasification, Use the User Fortran
; Block USR09.
BLOCK P09 USER
   SUBROUTINE MODEL = USR09   REPORT = USR09
   DESCRIPTION 'PLANT 9 - H2 PRODUCTION BY COAL GASIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
```

```
;                0 => Write the complete user block summary report.
;                1 => Skip the capital cost portion of the summary
;                     report.
;                2 => Skip the capital cost and utilities portions
;                     of the summary report.
;                3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;                0 => Write the user block summary report to the normal
;                     ASPEN/SP output report file called DCL09.REP.
;                1 => Write the user block summary report to a separate
;                      user block output report file on logical unit 62.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;                If INT(3) = 0, the minimum number of duplicate
;                  trains will be determined so that the capacity
;                  of each train does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Molar CO/CO2 ratio in the gasifier product gas.
;      REAL(2)   = Fraction of carbon entering the gasifier that goes
;                  to carbonyl sulfide (COS).
;      REAL(3)   = Fraction of carbon entering the gasifier that goes
;                  to methane (CH4).
;      REAL(4)   = Fraction of nitrogen entering the gasifier that goes
;                  to ammonia (NH3).
;      REAL(5)   = Carbon content of the slag produced by the gasifier,
;                  wt %.
;      REAL(6)   = Fraction of carbon monoxide (CO) entering the shift
;                  reactors that is shifted; i.e., converted to carbon
;                  dioxide (CO2) by the chemical reaction
;                      CO + H2O -----> CO2 + H2
;      REAL(7)   = Fraction of carbonyl sulfide (COS) entering the shift
;                  reactor section that is hydrolyzed; i.e., converted
;                  to carbon dioxide (CO2) and hydrogen sulfide (H2S)
;                  by the chemical reaction
;                      COS + H2O -----> CO2 + H2S
;      REAL(8)   = Future use.
;      REAL(9)-
;       REAL(20) = Rectisol section component distribution factors,
;                  where
;      REAL(9)   = Fraction of inlet H2 going to the hydrogen-rich
;                  gas stream.
;      REAL(10)  = Fraction of inlet H2 going to the acid gas stream.
;      REAL(11)  = Fraction of inlet CO going to the hydrogen-rich
;                  gas stream.
;      REAL(12)  = Fraction of inlet CO going to the acid gas stream.
```

```
;       REAL(13)  = Fraction of inlet CO2 going to the hydrogen-rich
;                   gas stream.
;       REAL(14)  = Fraction of inlet CO2 going to the acid gas stream.
;       REAL(15)  = Fraction of inlet CH4 going to the hydrogen-rich
;                   gas stream.
;       REAL(16)  = Fraction of inlet CH4 going to the acid gas stream.
;       REAL(17)  = Fraction of inlet N2 going to the hydrogen-rich
;                   gas stream.
;       REAL(18)  = Fraction of inlet N2 going to the acid gas stream.
;       REAL(19)  = Fraction of inlet H2S going to the hydrogen-rich
;                   gas stream.
;       REAL(20)  = Fraction of inlet H2S going to the acid gas stream.
;       REAL(21)  = Constant factor for the power consumption, kw.
;       REAL(22)  = Power consumption per MM SCF/hr of hydrogen
;                   produced, kw/(MM SCF/hr of H2).
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of hydrogen
;                   produced, (MM BTU/hr)/(MM SCF/hr of H2).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of hydrogen
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of hydrogen
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of hydrogen
;                   produced, (MM SCF/hr of N2)/(MM SCF/hr of H2).
```

```
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
;       REAL(51)  = Reference hydrogen production rate of a single train
;                   in MM SCF/hr of H2 for the calculation of the ISBL
;                   field cost of a single train as a function of train
;                   capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   hydrogen production rate in MM SCF/hr of H2.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   hydrogen production rate in MM SCF/hr of H2.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare plants.
;       REAL(59) -
;        REAL(70) = Future use.
;
;  NOTE:  MM SCF/hr of hydrogen produced means MM SCF/hr of hydrogen
;         in the hydrogen-rich product gas stream and NOT the total
;         flow rate of the hydrogen-rich product gas stream.
;
;                    Frac C       Frac C   Frac N   %C in
;         CO/CO2     to COS       to CH4   to NH3   slag
     REAL 2.419768  0.000804005  0.0      0.05212  5.229154  &
;         Frac CO shifted  Frac COS hydrolyzed  Future use
;         Adjust the fraction of CO shifted to get true H2 rate.
          0.9611           0.9516917            0.0          &
;         Component distribution factors for H2 to H2 and acid gas.
          0.8344      0.00153604                             &
;         Component distribution factors for CO to H2 and acid gas.
          0.0         0.0545937                              &
;         Component distribution factors for CO2 to H2 and acid gas.
          0.0         0.0453275                              &
;         Component distribution factors for CH4 to H2 and acid gas.
          0.0         0.0                                    &
;         Component distribution factors for N2 to H2 and acid gas.
          0.0932727   0.0923972                              &
;         Component distribution factors for H2S to H2 and acid gas.
          0.0         0.990203                               &
;         Power              900/750 F steam   900 satd steam
          0.0 3679.14335     0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 -16.98424     0.0 -44.40466 &
;         50 satd steam      Plant fuel        Cooling  H20
          0.0 -45.47563      0.0 -57.09919     0.0 183.6952  &
;         Process H20        Nitrogen
          0.0 4.176796       0.0 0.0824568   &
;         Future Use (6 items)
          0.  0.  0.  0.  0.  0.            &
;         Opers/day     (Opers/day)/train
```

```
          0.0          24.                  &
;         Ref Flow   Max Flow   Min Flow
          3.436      3.5        1.0         &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future use (3 items)
          0.0    52.7    0.7658 1.0    0.       0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR09.
   FLASH-SPECS STRM = H2-GAS    KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = H2S-GAS   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = VENT-GAS  KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = 9S-SH2O   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = SLAG      KODE=2   TEMP = 80.   PRES = 14.7
;
;  Plant 9.1 - Steam Reforming of Natural Gas Plant.
BLOCK P91 USER
   SUBROUTINE MODEL = USR91   REPORT = USR91
   DESCRIPTION 'PLANT 9.1 - STEAM REFORMING OF NATURAL GAS PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL91.REP.
;      INT(3) = Number of operating duplicate plants, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 plants will be determined so that the capacity
;                 of each plant does not exceed the maximum plant
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, this number of duplicate plants will
;                 be used.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
     INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Fraction of CH4 reacting to produce H2 and CO2.
;      REAL(2)   = Fraction of CH4 reacting to produce H2 and CO.
```

```
;       REAL(3)    = Fraction of hydrogen produced that leaves in the
;                    hydrogen-rich product gas stream.
;       REAL(4)    = Purity of the hydrogen-rich product gas. mole %.
;       REAL(5) -
;        REAL(20)  = Future use.
;       REAL(21)   = Constant factor for the power consumption, kw.
;       REAL(22)   = Power consumption per MM SCF/hr of hydrogen produced,
;                    kw/(MM SCF/hr of H2).
;       REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                    consumption, Mlbs/hr.
;       REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                    hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(25)   = Constant factor for the 900 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr of
;                    hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                    consumption, Mlbs/hr.
;       REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr of
;                    hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(29)   = Constant factor for the 600 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(30)   = 600 psig saturated steam consumption per MM SCF/hr of
;                    hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(31)   = Constant factor for the 150 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(32)   = 150 psig saturated steam consumption per MM SCF/hr of
;                    hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(33)   = Constant factor for the 50 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(34)   = 50 psig saturated steam consumption per MM SCF/hr of
;                    hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(35)   = Constant factor for the plant fuel consumption,
;                    MM BTU/hr.
;       REAL(36)   = Plant fuel consumption per MM SCF/hr of hydrogen
;                    produced, (MM BTU/hr)/(MM SCF/hr of H2).
;       REAL(37)   = Constant factor for the cooling water consumption,
;                    Mgal/hr.
;       REAL(38)   = Cooling water consumption per MM SCF/hr of hydrogen
;                    produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(39)   = Constant factor for the process water consumption,
;                    Mgal/hr.
;       REAL(40)   = Process water consumption per MM SCF/hr of hydrogen
;                    produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(41)   = Constant factor for the nitrogen consumption,
;                    MM SCF/hr of N2..
;       REAL(42)   = Nitrogen consumption per MM SCF/hr of hydrogen
;                    produced, (MM SCF/hr of N2)/(MM SCF/hr of H2).
;       REAL(43) -
;        REAL(48)  = Future use.
;       REAL(49)   = Constant factor for the number of operators per
;                    day, operators/day.
;       REAL(50)   = Number of operators per day per operating train,
;                    (operators/day)/train.
;       REAL(51)   = Reference hydrogen production rate of a single train
```

```
;                 in MM SCF/hr of H2 for the calculation of the ISBL
;                 field cost of a single train as a function of train
;                 capacity.
;     REAL(52)  = Maximum plant size as defined by the hydrogen
;                 production rate in MM SCF/hr of H2.
;     REAL(53)  = Minimum plant size as defined by the hydrogen
;                 production rate in MM SCF/hr of H2.
;     REAL(54)  = Constant A in the plant ISBL field cost equation.
;     REAL(55)  = Constant B in the plant ISBL field cost equation.
;     REAL(56)  = Constant E in the plant ISBL field cost equation.
;     REAL(57)  = Constant F in the plant ISBL field cost equation.
;     REAL(58)  = Number of spare plants.
;     REAL(59) -
;      REAL(70) = Future use.
;
;  NOTES: 1. MM SCF/hr of hydrogen produced means MM SCF/hr of hydrogen
;            in the hydrogen rich product gas stream and NOT the total
;            flow rate of the hydrogen rich product gas stream.
;         2. The number of operators in this plant and Plants 31.1 and
;            31.4 is set so as to maintain the same total number of
;            operators as used for the baseline design.
;
;         Frac CH4 to CO2  Frac CH4 to CO  Frac recovered  H2 Purity
     REAL 0.638648         0.04429         0.8862694       100.0 &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0                      &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 354.158        0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 -65.3773      0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 89.0448       0.0 32.6902   &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0           &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0         &
;         Opers/day      (Opers/day)/train
          0.0            8.0                   &
;         Ref Flow       Max Flow     Min Flow
          5.77237        6.25         2.0      &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future Use (2 items)
          0.0    68.1    0.75   1.0    0.0      0.0    0.0    &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR091.
   FLASH-SPECS STRM = H2-PROD    KODE=2  TEMP = 100.0  PRES = 500.0 /
               STRM = FLUE-GAS   KODE=2  TEMP = 250.0  PRES = 14.7
;
; Plant 10 - Air Separation Plant - Use the User Fortran Model USR10.
BLOCK P10 USER
```

```
      SUBROUTINE MODEL = USR10   REPORT = USR10
      DESCRIPTION 'PLANT 10 - AIR SEPARATION PLANT'
      PARAM  NINT = 4   NREAL = 70
;        The following 4 integer parameters are:
;        INT(1) = User block summary report control switch.
;                 0 => Write the complete user block summary report.
;                 1 => Skip the capital cost portion of the summary
;                      report.
;                 2 => Skip the capital cost and utilities portions
;                      of the summary report.
;                 3 => Skip writing the entire user block summary report.
;        INT(2) = User block summary report destination control switch.
;                 0 => Write the complete user block summary report to
;                      the normal ASPEN/SP output report file.
;                 1 => Write the complete user block summary report to
;                      a separate user block output report file on
;                      logical unit 62 CALLED DCL10.REP.
;        INT(3) = Number of operating duplicate trains, excluding
;                 spares.
;                 If INT(3) = 0, the minimun number of duplicate
;                   trains will be determined so that the capacity
;                   of each train does not exceed the maximum train
;                   capacity specified by variable REAL(52).
;                 If INT(3) > 0, the number of duplicate trains.
;        INT(4) = History file additional output control switch.
;                 0 => Write no additional output to the history file.
;                 1 => Write the only the subroutine entry and exit
;                      messages to the history file.
;                 2 => Write some additional output to the history file.
;               3-5 => Write some more additional output to the history
;                      file.  Larger values generate more intermediate
;                      output.
      INT  0  1  0  1
;        The following 70 real parameters are:
;        REAL(1)   = Purity of the product oxygen stream, mole %.
;        REAL(2)   = Purity of the product nitrogen stream, mole %.
;        REAL(3) -
;         REAL(20) = Future use.
;        REAL(21)  = Constant factor for the power consumption, kw.
;        REAL(22)  = Power consumption per MM SCF/hr of the oxygen stream
;                    flow rate, kw/(MM SCF/hr of O2).
;        REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                    consumption, Mlbs/hr.
;        REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr of
;                    the oxygen stream flow rate,
;                    (Mlbs/hr)/(MM SCF/hr of O2).
;        REAL(25)  = Constant factor for the 900 psig saturated steam
;                    consumption, Mlbs/hr.
;        REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr of
;                    the oxygen stream flow rate,
;                    (Mlbs/hr)/(MM SCF/hr of O2).
;        REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                    consumption, Mlbs/hr.
;        REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr of
;                    the oxygen stream flow rate,
```

```
;                (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(29) = Constant factor for the 600 psig saturated steam
;                  consumption, Mlbs/hr.
;       REAL(30) = 600 psig saturated steam consumption per MM SCF/hr of
;                  the oxygen stream flow rate,
;                  (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(31) = Constant factor for the 150 psig saturated steam
;                  consumption, Mlbs/hr.
;       REAL(32) = 150 psig saturated steam consumption per MM SCF/hr of
;                  the oxygen stream flow rate,
;                  (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(33) = Constant factor for the 50 psig saturated steam
;                  consumption, Mlbs/hr.
;       REAL(34) = 50 psig saturated steam consumption per MM SCF/hr of
;                  the oxygen stream flow rate,
;                  (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(35) = Constant factor for the plant fuel consumption,
;                  MM BTU/hr.
;       REAL(36) = Plant fuel consumption per MM SCF/hr of the oxygen
;                  stream flow rate, (MM BTU/hr)/(MM SCF/hr of O2).
;       REAL(37) = Constant factor for the cooling water consumption,
;                  Mgal/hr.
;       REAL(38) = Cooling water consumption per MM SCF/hr of the oxygen
;                  stream flow rate, (Mgal/hr)/(MM SCF/hr of O2).
;       REAL(39) = Constant factor for the process water consumption,
;                  Mgal/hr.
;       REAL(40) = Process water consumption per MM SCF/hr of the oxygen
;                  stream flow rate, (Mgal/hr)/(MM SCF/hr of O2).
;       REAL(41) = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2.
;       REAL(42) = Nitrogen consumption per MM SCF/hr of the oxygen
;                  stream flow rate,
;                  (MM SCF/hr of N2)/(MM SCF/hr of O2).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49) = Constant factor for the number of operators per
;                  day, operators/day.
;       REAL(50) = Number of operators per day per train,
;                  (operators/day)/train.
;       REAL(51) = Reference oxygen production rate for a single train
;                  in MM SCF/hr of O2 for the calculation of the
;                  ISBL field cost of a single train as a function of
;                  train capacity.
;       REAL(52) = Maximum size of a single train as defined by the
;                  oxygen production rate in MM SCF/hr of O2.
;       REAL(53) = Minimum size of a single train as defined by the
;                  oxygen production rate in MM SCF/hr of O2.
;       REAL(54) = Constant A in the plant ISBL field cost equation.
;       REAL(55) = Constant B in the plant ISBL field cost equation.
;       REAL(56) = Constant E in the plant ISBL field cost equation.
;       REAL(57) = Constant F in the plant ISBL field cost equation.
;       REAL(58) = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
```

```
;      NOTES:
;        1.  This model does not consider Argon as a separate element.
;            Hence, argon is lumped with nitrogen.
;        2.  MM SCF/hr of O2 means the oxygen production rate in
;            MM SCF/hr of O2 in the product oxygen stream and NOT
;            the total flow rate of the product oxygen stream.
;
;          %O2 in O2    %N2 in N2   Future Use (8 items)
      REAL 99.5003      100.0       0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 18143.97       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.0           0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 0.0            0.0 0.0           0.0 0.0       &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day      (Opers/day)/train
           4.0            0.0                &
;          Ref Flow      Max Flow      Min Flow
           1.763605      1.875         1.0     &
;          Plant cost equation costants.
;          A        B        E        F      Spares   Future use (2 items)
           0.0      38.2     0.7028   1.0    0.0      0.0   0.0    &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR10.
   FLASH-SPECS STRM = 10S01   KODE=2   TEMP =   80.0   PRES = 350.0  /
               STRM = 10S02   KODE=2   TEMP = -275.0   PRES = 164.7
;
; Plant 11 - Sulfur Recovery Plant, Use the User Fortran Model USR11.
BLOCK P11 USER
   SUBROUTINE MODEL = USR11   REPORT = USR11
   DESCRIPTION 'PLANT 11 - THE SULFUR RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the
;                    normal ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL11.REP.
```

```
;       INT(3) = Number of operating duplicate trains, excluding spares.
;                If INT(3) = 0, the minimun number of duplicate
;                  trains will be determined so that the capacity
;                  of each train does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate trains.
;       INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
    INT  0  1  0  1
;       The following 70 real parameters are:
;       REAL(1)    = Fractional sulfur recovery; fraction of sulfur in
;                    the entering H2S and COS that is recovered in the
;                    product liquid sulfur stream.  All entering liquid
;                    sulfur entering in the feed stream is assumed to
;                    be recovered in the liquid sulfur product stream.
;       REAL(2) -
;        REAL(20) = Future use.
;       REAL(21)   = Constant factor for the power consumption, kw.
;       REAL(22)   = Power consumption per Mlbs/hr of product sulfur,
;                    kw/(Mlbs/hr).
;       REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                    consumption, Mlbs/hr.
;       REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                    product sulfur, (Mlbs/hr)/(Mlbs/hr).
;       REAL(25)   = Constant factor for the 900 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                    product sulfur, (Mlbs/hr)/(Mlbs/hr).
;       REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                    consumption, Mlbs/hr.
;       REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                    product sulfur, (Mlbs/hr)/(Mlbs/hr).
;       REAL(29)   = Constant factor for the 600 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                    product sulfur, (Mlbs/hr)/(Mlbs/hr).
;       REAL(31)   = Constant factor for the 150 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                    product sulfur, (Mlbs/hr)/(Mlbs/hr).
;       REAL(33)   = Constant factor for the 50 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                    product sulfur, (Mlbs/hr)/(Mlbs/hr).
;       REAL(35)   = Constant factor for the plant fuel consumption,
;                    MM BTU/hr.
;       REAL(36)   = Plant fuel consumption per Mlbs/hr of product sulfur,
;                    (MM BTU/hr)/(Mlbs/hr).
;       REAL(37)   = Constant factor for the cooling water consumption,
```

```
;                   Mgal/hr.
;      REAL(38)  = Cooling water consumption per Mlbs/hr of product
;                  sulfur (Mgal/hr)/(Mlbs/hr).
;      REAL(39)  = Constant factor for the process water consumption,
;                  Mgal/hr.
;      REAL(40)  = Process water consumption per Mlbs/hr of product
;                  sulfur, (Mgal/hr)/(Mlbs/hr).
;      REAL(41)  = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2.
;      REAL(42)  = Nitrigen consumption per Mlbs/hr of product sulfur,
;                  (MM SCF/hr of N2)/(Mlbs/hr).
;      REAL(43) -
;       REAL(48) = Future use.
;      REAL(49)  = Constant factor for the number of operators per
;                  day, operators/day.
;      REAL(50)  = Number of operators per day per train,
;                  (operators/day)/train.
;      REAL(51)  = Reference product sulfur flow rate of a single train
;                  in Mlbs/hr of S for the calculation of the ISBL field
;                  cost of a single train as a function of capacity.
;      REAL(52)  = Maximum size of a single train as defined by the
;                  product sulfur flow rate in Mlbs/hr of S.
;      REAL(53)  = Minimum size of a single train as defined by the
;                  product sulfur flow rate in Mlbs/hr of S.
;      REAL(54)  = Constant A in the plant ISBL field cost equation.
;      REAL(55)  = Constant B in the plant ISBL field cost equation.
;      REAL(56)  = Constant E in the plant ISBL field cost equation.
;      REAL(57)  = Constant F in the plant ISBL field cost equation.
;      REAL(58)  = Number of spare trains.
;      REAL(59) -
;       REAL(70) = Future use.
;
;         S recovery
     REAL 0.998482    &
;         Future Use (19 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0       &
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 49.60954       0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 0.971388      0.0 -3.022277 &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.882473       0.0 1.117916      0.0 7.89929   &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.0           5.0                 &
;         Ref Flow     Max Flow     Min Flow
          15.4305      16.5         5.0      &
;         Plant cost equation costants.
;         A       B        E      F      Spares   Future use (3 items)
          0.0     11.675   0.7823 1.0    0.0      0.0   0.0    &
;         Future use (10 items)
```

```
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 11S-FGAS  KODE=2   TEMP = 80.0   PRES = 14.7  /
               STRM = 11S-LIQS  KODE=2   TEMP = 80.0   PRES = 14.7
;
; Plant 31 - The Utilities plant - user Fortran block USR31.
BLOCK P31 USER
   SUBROUTINE MODEL = USR31   REPORT = USR31
   DESCRIPTION 'PLANTS 31 - THE UTILITIES PLANT'
   PARAM  NINT = 20   NREAL = 20
;      The following 20 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Not used.
;               2 => Not used.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL02.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(2).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
;      INT(5) = Future use.
;      INT(6) -  Switches to select which fuels are burned in the steam
;       INT(10)  boiler to produce steam and/or electric power to
;                satisfy the steam demand.  The fuel specified in
;                INT(6) is used until it is all consumed, the steam
;                demand is satisfied, or the capacity to use this fuel
;                is reached.  Then the INT(7) fuel is used, etc.
;                The fuel codes are
;                  1 = Coal
;                  2 = ROSE-SR unit bottoms
;                  3 = Coke
;                  4 = Natural gas
;                  5 = Plant fuel
;      INT(11) - Switches to select which fuels are burned to satisfy
;       INT(16)  the electric power demand.  The fuel specified in
;                INT(11) is used until it is all consumed, the power
;                demand is satisfied, or the capacity to use this fuel
```

```
;                 is reached.  Then the INT(12) fuel is used, etc.
;                 The fuel codes are
;                   1 = Coal
;                   2 = ROSE-SR unit bottoms
;                   3 = Coke
;                   4 = Natural gas
;                   5 = Plant fuel
;                   6 = Purchased electric power
;       INT(17) -
;        INT(20)  Future use.
    INT  0  1  0  1  0  4  1  2  3  5    &
         4  1  2  3  5  6  0  0  0  0
;
;       The following 20 real parameters are:
;       REAL(1)  = Reference electric power generation rate of a single
;                  train in MW.
;       REAL(2)  = Maximum size of a single train as defined by the
;                  electric power generation rate in MW.
;       REAL(3)  = Minimum size of a single train as defined by the
;                  electric power generation rate in MW.
;       REAL(4)  = Constant A in the plant costing equation.
;       REAL(5)  = Constant B in the plant costing equation.
;       REAL(6)  = Constant E in the plant costing equation.
;       REAL(7)  = Constant F in the plant costing equation.
;       REAL(8)  = Number of spare trains.
;       REAL(9)  = Future use
;       REAL(10) = Future use
;       REAL(11) = Constant factor for the number of operators per
;                  day, operators/day.
;       REAL(12) = Number of operators per day per train,
;                  (operators/day)/train.
;       REAL(13) -
;        REAL(20) = Future use.
;
;          Ref MW    Max size   Min size
    REAL 79.259    84.0       1.0        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future use (2 items)
           0.0    87.466  0.7    1.0    0.0      0.0   0.0   &
;          Opers/day     (Opers/day)/train
           6.0           2.0                 &
;          Future use (8 items)
           0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
;
; Plants 31.1 and 31.4 - The Fluidized Bed Combustor and Steam Turbine
; Generator unit - user Fortran block USRA6.
BLOCK P314 USER
   SUBROUTINE MODEL = USRA6   REPORT = USRA6
   DESCRIPTION 'PLANTS 31.1 AND 31.4 - THE FLUIDIZED BED COMBUSTOR AND
   STEAM TURBINE GENERATOR UNIT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
```

```
;                    report.
;                2 => Skip the capital cost and utilities portions
;                     of the summary report.
;                3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;                0 => Write the user block summary report to the normal
;                     ASPEN/SP output report file.
;                1 => Write the user block summary report to a separate
;                     user block output report file on logical unit 62
;                     called DCLA6.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;                If INT(3) = 0, the minimum number of duplicate
;                  trains will be determined so that the capacity
;                  of each train does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate plants.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Solids production expressed as fraction of URCOAL
;                   in feed ending up in solids.
;      REAL(2)-
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per Mlbs/hr of unit feed,
;                   kw/(Mlbs/hr of unit feed).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
```

```
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of unit feed,
;                   (Mlbs/hr)/(Mlbs/hr of unit feed).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of unit feed,
;                   (Mlbs/hr)/(Mlbs/hr of unit feed).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of unit feed,
;                   (Mlbs/hr)/(Mlbs/hr of unit feed).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of unit feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of unit feed).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference feed rate to a single train in Mlbs/hr of
;                   unit feed for the calculation of the ISBL field cost
;                   of a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   unit feed rate in Mlbs/hr of unit feed.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   unit feed rate in Mlbs/hr of unit feed.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;  NOTE: The number of operators in this plant and Plant 91is set so
;            as to maintain the same total number of operators as used
;            for the baseline design.
;
;         Fraction of URCOAL in feed ending up in solids
   REAL   0.8500914  &
;         Future use (9 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0        &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   &
;         Power              900/750 F steam    900 satd steam
          0.0 -552.6474      0.0 0.0            0.0 0.0       &
;         600/720 F steam    600 satd steam     150 satd steam
          0.0 0.0            0.0 0.0            0.0 0.0       &
;         50 satd steam      Plant fuel         Cooling H2O
          0.0 0.0            0.0 0.0            0.0 27.99327  &
```

```
;         Process H2O       Nitrogen
          0.0 0.06900667    0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day    (Opers/day)/train
          0.0          30.0                 &
;         Ref Flow     Max Flow   Min Flow
          368.660      400.0      30.0      &
;         Plant cost equation constants.
;         A      B      E      F      Spares   Future use (2 items)
          0.0    0.0    0.75   1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet stream.  These
;  values will override the default values in subroutine USRA6.
   FLASH-SPECS STRM = SA6-01    KODE=2   TEMP = 130.0  PRES = 14.7
;
; Plant 38 - The Ammonia Recovery Plant - use user Fortran block USR38.
BLOCK P38 USER
   SUBROUTINE MODEL = USR38   REPORT = USR38
   DESCRIPTION 'PLANT 38 - THE AMMONIA RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL38.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Ammonia recovery, percent.
;      REAL(2)   = Purity of ammonia product, wt %.
```

```
;       REAL(3) -
;        REAL(20) = Future use.
;       REAL(21)  = Constant factor for the power consumption, kw.
;       REAL(22)  = Power consumption per Mlbs/hr of NH3 recovered,
;                   kw/(Mlbs/hr of NH3 recovered).
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of NH3 recovered,
;                   (MM BTU/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of NH3
;                   recovered, (Mgal/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of NH3
;                   recovered, (Mgal/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of NH3 recovered,
;                   (MM SCF/hr of N2)/(Mlbs/hr of NH3 recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
;       REAL(51)  = Reference NH3 recovery rate of a single train in
;                   Mlbs/hr for the calculation of the ISBL field cost
;                   of a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
```

```
;                    NH3 recovery rate in Mlbs/hr of NH3 recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                    NH3 recovery rate in Mlbs/hr of NH3 recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          NH3 recovery, %     NH3 purity, wt%
     REAL 99.103              99.552              &
;          Future use (8 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 75.713367      0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0  0.0           0.0 16.124425     0.0 28.745809 &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 0.0            0.0 0.0           0.0 227.9442  &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0            &
;          Opers/day      (Opers/day)/train
           0.0            20.0                 &
;          Ref Flow   Max Flow   Min Flow
           20.221     100.0      5.0          &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future Use (3 items)
           0.0    40.1    0.7807 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR38.
   FLASH-SPECS STRM = NH3-PROD  KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = 38S-OUT   KODE=2   TEMP = 80.   PRES = 14.7
;
;  Component splitter to generate the vapor and liquid streams
;  leaving Plant 38, the ammonia recovery plant.
BLOCK P38A SEP
   FRAC  SUBS = MIXED  STRM = 38AS-VAP                  &
   COMP = H2  N2  O2  H2S  CO  CO2  NH3                 &
          L-SULFUR H2O HCL COS CH4                      &
          C2H6 C3H8 IC4H10 NC4H10 IC5H12 NC5H12         &
          T125  T175  T225  T275  T325                  &
          T375  T425                                    &
          T475  T525  T575  T625  T675                  &
          P125  P175  P225  P275  P325  P375            &
          P425  P475  P525  P575  P625  P675            &
   FRAC = 1.0  1.0  1.0  0.9956  1.0  0.9985  0.07104   &
          0.0  0.002755  1.0  1.0  0.8888889            &
```

```
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492     &
          0.9492 0.9492 0.9492 0.9492 0.9492            &
          0.9492 0.9492                                 &
          0.08481 0.08481 0.08481 0.08481 0.9492        &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492     &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492
   FLASH-SPECS STRM = 38AS-VAP  TEMP=90.0  PRES=25.0  NPK=1  KPH=1 /
               STRM = 38AS-LIQ  TEMP=90.0  PRES=25.0  NPK=1  KPH=2
;
;  Flow splitter to generate the waste water stream going to the
;  gasifier, Plant 9, and the stream going to the phenol recovery
;  plant, Plant 39.
BLOCK P38B FSPLIT
   FRAC  WASTE  0.28595
   PARAM NPK=1  KPH=2
;
; Plant 39 - The PHENOL RECOVERY PLANT - Use user Fortran block USR39.
BLOCK P39 USER
   SUBROUTINE MODEL = USR39   REPORT = USR39
   DESCRIPTION 'PLANT 39 - THE PHENOL RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL39.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Phenol recovery, percent.
;      REAL(2)   = Purity of phenol product, wt %.
;      REAL(3) -
;       REAL(20) = Future use.
```

```
;       REAL(21)  = Constant factor for the power consumption, kw.
;       REAL(22)  = Power consumption per Mlbs/hr of phenol recovered,
;                   kw/(Mlbs/hr of phenol recovered).
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of phenol
;                   recovered,
;                   (MM BTU/hr)/(Mlbs/hr of phenol recovered).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(39)  = Cooling water consumption per Mlbs/hr of phenol
;                   recovered, (Mgal/hr)/(Mlbs/hr of phenol recovered).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of phenol
;                   recovered, (Mgal/hr)/(Mlbs/hr of phenol recovered).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of phenol recovered,
;                   (MM SCF/hr of N2)/(Mlbs/hr of phenol recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
```

```
;                    (operators/day)/train.
;       REAL(51)  = Reference phenol recovery rate of a single train in
;                   Mlbs/hr for the calculation of the IKSBL field cost
;                   of a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   phenol recovery rate in Mlbs/hr of phenol recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   phenol recovery rate in Mlbs/hr of phenol recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;    NOTE: In the above, phenol recovered means pure phenol recovered.
;
;          Phenol recovery, %     Phenol purity, wt%
     REAL 97.0089              89.62                &
;          Future use (8 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 339.16667      0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0  0.0           0.0 0.0           0.0 9.465     &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 25.652917      0.0 0.0           0.0 111.775   &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0           0.0                 &
;          Ref Flow   Max Flow   Min Flow
           2.4        20.0       1.0        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future Use (3 items)
           0.0    13.3    0.8056 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR39.
   FLASH-SPECS STRM = PHENOL   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = WASTEH2O KODE=2   TEMP = 80.   PRES = 14.7
;
;  Plant SA6 separates the combined product stream from Plants 31.1
;  and 31.4 into two streams, one for flue gas and another for solids.
;  The separation is set to the URCOAL fraction in the solids stream.
BLOCK SA6 SEP
  FRAC  SUBS=NC    STREAM=FBC-SOL  COMP=URCOAL  FRAC=0.8500914   /
        SUBS=MIXED STREAM=FBC-SOL  COMP=T1000+  FRAC=1.0D-10
;
```

```
;  Splitter S1 - The Inlet Coal Splitter.  Used as a switch to divert
;  flow between the three different coal cleaning options, as represented
;  by the three different Coal Cleaning and Preparation Plants:
;  Base Case (1S01), Alternate Case 1 (1S11), and Alternate Case 2 (1S21).
BLOCK S1 FSPLIT
  DESCRIPTION 'INLET ROM COAL SPLITTER - COAL CLEANING SWITCH'
  FRAC  1S01 0.0 / 1S11 0.0 / 1S21 1.0
;
;  Splitter S6-SH20 is a component splitter to generate a pseudo
;   sour-water stream from Plant 6 to get the NH3 to Plant 38, the
;   Ammonia Recovery Plant.
BLOCK S6-SH20 SEP
  DESCRIPTION 'SPLITTER TO GENERATE PSEUDO SOUR WATER FROM PLANT 6'
  FRAC  SUBS=MIXED  STREAM=6S-SH20  COMP=NH3  FRAC=1.0
;
;  Splitter S7 - The Product Naphtha Splitter.  Used as a switch to
;  divert flow between the naphtha reformer, Plant 7 and output to
;  naphtha product.
BLOCK S7 FSPLIT
  DESCRIPTION 'HYDROTREATED NAPHTHA SPLITTER - REFORMER OPTION SWITCH'
;  ==================================================================
;  Use the following line to direct total flow to the reformer, or....
;   FRAC  7-NAPH 1.0
;  Use the following line to direct total flow to the product stream.
  FRAC PNAPHTHA 1.0
;
;  Splitter S8 - The Ash-Concentrate Splitter.  Used as a switch to
;  divert flow between the fluidized bed combustor, Plant 314 and the
;  coal gasification train; Plants M9C, P09, & P10.
BLOCK S8 FSPLIT
  DESCRIPTION 'ASH-CONCENTRATE SPLITTER - FBC OPTION 6 SWITCH'
;  Direct the ash-concentrate flow to coal gasification.
  FRAC  S8-ASHC 1.0
;
;  Splitter S9 - The dummy hydrogen splitter used to switch between
;  the two hydorgen production alternatives, Plant 9.0/10 - coal
;  gasification, or Plant 9.1 - steam reforming of methane.
BLOCK S9 FSPLIT
  DESCRIPTION 'DUMMY H2 SPLITTER - H2 GENERATION OPTION SWITCH'
;  Set an H2 target flow for Plant 9.0/10 - coal gasification.
  FRAC  H9NEED 1.0
  PARAM   NPK=1  KPH=1
;
; Stream Report Section
; ---------------------
;
STREAM-REPORT P1A
   STREAMS STRM = ROMCOAL ROMCOAL2 1S-CCOAL COALTO9 COALTO2     &
                  14S-XMID 14S-REF 1S-XMID 1S-REFSE             &
                  ASH-CONC S8-ASHC 9-FEED SLAG SOLVENT          &
                  2S-BOTTS FBC-FEED SA6-01 FBC-SOL FBC-GAS
   FLOW-FRAC SUBS=MIXED BASES=MASS / SUBS=NC BASES=MASS
   INTENSIVE-PROPS SUBS=MIXED BASES=MASS &
                   PROPS=TEMP PRES MW ENTH ENTR DENS HCAP /
                   SUBS=NC BASES=MASS &
```

```
                    PROPS=TEMP PRES MW ENTH DENS
   ATTRIBUTES SUBS=NC COMPONENT
;
STREAM-REPORT P1B
   STREAMS STRM = 1S-WATER 14S-WAT 2-H2OIN 2-H2IN H2MIX 2-H2MIX      &
                  SOLVENT ROSE-XTR 2S-GAS GASES 2S-SH2O              &
                  NAPHTHA GAS-OIL H2-RICH SOUR-GAS P61-GAS           &
                  H2-2RICH SOUR-2GS GAS-OUT NAPHTHA2 3-GAS           &
                  3S-SGAS 3S-FGAS 3S-PROP 3S-BUT 3S-OIL 3S-SH2O      &
                  4-FEED 4-H2IN 4-H2OIN 4S-GAS 4S-NAPH 4S-SH2O       &
                  5S-HPGAS 5S-LPGAS 5-H2IN 5-H2OIN                   &
                  5S-NAPH P350-450 P450-650 P650-850 5S-SH2O         &
                  PS-NAPH PNAPHTHA 7-NAPH 7S-H2 7S-GAS REFORMED      &
                  61-HYD 62-HYD M9H2 M9H4 M9H5 MHNEED                &
                  H9NEED H91NEED                                     &
                  10-AIRIN 10S01 10S02 9-O2IN 9-H2OIN 9-STEMIN       &
                  H2-GAS H2S-GAS VENT-GAS 9S-SH2O                    &
                  NAT-GAS STEAM H2-PROD FLUE-GAS                     &
                  6-SGAS 6S-SH2O 11-FEED 11S-FGAS 11S-LIQS 31S-01    &
                  38-FEED NH3-PROD 38S-OUT 38AS-VAP 38AS-LIQ         &
                  WASTE 39FEED PHENOL WASTEH2O
   FLOW-FRAC SUBS=MIXED BASES=MASS
   INTENSIVE-PROPS SUBS=MIXED BASES=MASS &
                   PROPS=TEMP PRES MW ENTH ENTR DENS HCAP
;
;  End of input file OPT2.INP
```

APPENDIX H

APPENDIX H

ASPEN/SP PROCESS SIMULATION MODEL

INPUT FILE FOR OPTION 3 --

THERMAL-CATALYTIC LIQUEFACTION REACTOR CONFIGURATION

ASPEN/SP PROCESS SIMULATION MODEL

INPUT FILE FOR OPTION 3 --

THERMAL-CATALYTIC LIQUEFACTION REACTOR CONFIGURATION

```
NEW
;
;   File: OPT3.INP
;
TITLE 'OPTION 3 - THERMAL/CATALYTIC OPTION - NTH PLANT SIMULATION'
;
DESCRIPTION &
  "ASPEN/SP INPUT FILE FOR SIMULATING OPTION 3, THE THERMAL/CATALYTIC
   COAL LIQUEFACTION REACTOR DESIGN, FOR THE NTH PLANT.  THIS INPUT FILE
   ALSO CAN BE USED TO RUN OPTION 6 (STEAM REFORMING OF NATURAL GAS FOR
   HYDROGEN PRODUCTION WITH AN FBC UNIT) AND OPTION 7 (NAPHTHA REFORMING)."
;
;  NOTES:
;  1.  The dry clean coal feed rate to the Plant 2 coal liquefaction
;      reactors is set in the design specification DES-SPEC COALFLO.
;  2.  The switches LOSBL and LPLANT contained in Fortran block SUMMARY
;      control the costing logic for OSBL and first or Nth plant.
;  3.  Option 6 (hydrogen production by steam reforming of natural
;      gas with an FBC unt) is activated by variable N9 in Fortran
;      block OPTION6.  When N9 = 1, Option 6 is invoked.
;  4.  Option 7 (naphtha reforming) is activated in Block S7 by
;      sending all the hydrotreated naphtha to Plant 7 rather than
;      to the product PNAHTHA.
;  5.  The costing logic is controlled by switches in Fortran block
;      SUMMARY.
;
;   Last revision - July 16, 1992.
;
;   Prepared under DOE contract no. DE-AC22 90PC89857.
;
IN-UNITS  ENG
OUT-UNITS ENG
HISTORY-UNITS ENG
RUN-CONTROL MAX-ERRORS=100
;
;  The following two lines are used with V8.0 to produce the overall
;  and block elemental balances.
;REPORT ATOMBAL
;BLOCK-REPORT ATOMBAL
;
HISTORY  MSG-LEVEL  PROPERTIES=2
  MAX-PRINT  PROPERTIES=100  SIMULATION=2000
;
PROPERTIES SYSOP2 GLOBAL
;
PSEUDO-COMPS
  METHOD METCCOAL -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 &
```

```
                    -1 -1 -1 -1 -1 -1 -1
;  The following APIs and MWs are revised from the ASPEN/SP predictions.
;  Component T1000+ is the 1000+ F material leaving the second coal
;    liquefaction reactor in Plant 2.
;  Component I1000+ is the 1000+ F intermediate material leaving the
;    first coal liquefaction reactor in Plant 2.
   COMPONENT T125    TBP=324.82 <K>  API=67.91  MW= 82.27
   COMPONENT T175    TBP=352.59 <K>  API=61.99  MW= 92.77
   COMPONENT T225    TBP=380.37 <K>  API=56.21  MW=102.84
   COMPONENT T275    TBP=408.15 <K>  API=50.60  MW=112.50
   COMPONENT T325    TBP=435.93 <K>  API=45.18  MW=121.82
   COMPONENT T375    TBP=463.71 <K>  API=39.96  MW=130.86
   COMPONENT T425    TBP=491.48 <K>  API=34.96  MW=139.75
   COMPONENT T475    TBP=519.26 <K>  API=30.19  MW=148.60
   COMPONENT T525    TBP=547.04 <K>  API=25.66  MW=157.54
   COMPONENT T575    TBP=574.82 <K>  API=21.39  MW=166.69
   COMPONENT T625    TBP=602.59 <K>  API=17.38  MW=176.16
   COMPONENT T675    TBP=630.37 <K>  API=13.66  MW=186.05
   COMPONENT T725    TBP=658.15 <K>  API=10.23  MW=196.44
   COMPONENT T775    TBP=685.93 <K>  API= 7.09  MW=207.37
   COMPONENT T825    TBP=713.71 <K>  API= 4.27  MW=218.85
   COMPONENT T875    TBP=741.48 <K>  API= 1.78  MW=230.87
   COMPONENT T925    TBP=769.26 <K>  API=-0.39  MW=243.37
   COMPONENT T975    TBP=797.04 <K>  API=-2.22  MW=256.24
   COMPONENT T1000+  TBP=824.82 <K>  API=-3.69  MW=269.33
   COMPONENT P125    TBP=324.82 <K>  API=67.91  MW= 82.27
   COMPONENT P175    TBP=352.59 <K>  API=61.99  MW= 92.77
   COMPONENT P225    TBP=380.37 <K>  API=56.21  MW=102.84
   COMPONENT P275    TBP=408.15 <K>  API=50.60  MW=112.50
   COMPONENT P325    TBP=435.93 <K>  API=45.18  MW=121.82
   COMPONENT P375    TBP=463.71 <K>  API=39.96  MW=130.86
   COMPONENT P425    TBP=491.48 <K>  API=34.96  MW=139.75
   COMPONENT P475    TBP=519.26 <K>  API=30.19  MW=148.60
   COMPONENT P525    TBP=547.04 <K>  API=25.66  MW=157.54
   COMPONENT P575    TBP=574.82 <K>  API=21.39  MW=166.69
   COMPONENT P625    TBP=602.59 <K>  API=17.38  MW=176.16
   COMPONENT P675    TBP=630.37 <K>  API=13.66  MW=186.05
   COMPONENT P725    TBP=658.15 <K>  API=10.23  MW=196.44
   COMPONENT P775    TBP=685.93 <K>  API= 7.09  MW=207.37
   COMPONENT P825    TBP=713.71 <K>  API= 4.27  MW=218.85
   COMPONENT P875    TBP=741.48 <K>  API= 1.78  MW=230.87
   COMPONENT P925    TBP=769.26 <K>  API=-0.39  MW=243.37
   COMPONENT P975    TBP=797.04 <K>  API=-2.22  MW=256.24
   COMPONENT P1000+  TBP=824.82 <K>  API=-3.69  MW=269.33
   COMPONENT I1000+  TBP=825.00 <K>  API=-4.00  MW=275.00
   COMPONENT REFORMAT TBP=390.00 <K>  API=38.25  MW=100.00
;
COMPONENTS H2 H2 / N2 N2 / O2 O2 / H2S H2S / CO CO / CO2 CO2 / NH3 H3N /
           L-SULFUR SULFUR / H2O H2O / HCL HCL / COS COS / CH4 CH4 /
           C2H6 C2H6 / C3H8 C3H8 / IC4H10 C4H10-2 / NC4H10 C4H10-1 /
           IC5H12 C5H12-2 / NC5H12 C5H12-1 /
;  Pseudocomponents
           T125 / T175 / T225 / T275 / T325 / T375 / T425 / T475 /
           T525 / T575 / T625 / T675 / T725 / T775 / T825 / T875 /
           T925 / T975 / T1000+ /
```

```
          P125 / P175 / P225 / P275 / P325 / P375 / P425 / P475 /
          P525 / P575 / P625 / P675 / P725 / P775 / P825 / P875 /
          P925 / P975 / P1000+ / I1000+ / REFORMAT /
;  Non-conventional components
           COAL / URCOAL / SLAG
;
FORMULA    H2 H2 / N2 N2 / O2 O2 / H2S H2S / CO CO / CO2 CO2 / NH3 H3N /
           L-SULFUR S / H2O H2O / HCL HCL / COS COS / CH4 CH4 /
           C2H6 C2H6 / C3H8 C3H8 / NC4H10 C4H10 / IC4H10 C4H10 /
           NC5H12 C5H12 / IC5H12 C5H12
;
;  Load the liquid sulfur (L-SULFUR) physical properties as taken from
;  DIPPR - MW adjusted to be consistent with ASPEN.
PROP-DATA  IN-UNITS SI
  PROP-LIST        MW    /   TC    /     PC     /    VC    /   ZC
  PVAL L-SULFUR   32.06  / 1313.0 / 1.8208E+7 / 0.15800 / 0.2640
  PROP-LIST       MUP    /  OMEGA /    TB     /   RGYR
  PVAL L-SULFUR   0.0    / 0.2624 /  717.82   /   0.0
  PROP-LIST         DELTA   /  DGFORM   /  DHFORM
  PVAL L-SULFUR   2.0245E+4 / 2.3825E+8 / 2.7880E+8
  PROP-LIST       CPIG
  PVAL L-SULFUR   2.5639E+4  -7.9870  4.7860E-3  -9.5700E-7  0.0  0.0  &
                  273.15  1500.0  0.0  87.113  1.0
;
; Load the solubility parameter for COS from the API Tech Data Book.
  PROP-LIST       DELTA
  PVAL COS        18179.0
;
;  Reset some component molecular weights to be consisitent with the
;  following elemental atomic weights, where needed.
;  H=1.0079, C=12.011, O=15.9994, N=14.0067, S=32.06 & Cl=35.453
  PROP-LIST       MW
  PVAL H2          2.0158
  PVAL N2         28.0134
  PVAL O2         31.9988
  PVAL H2S        34.0758
  PVAL CO         28.0104
  PVAL CO2        44.0098
  PVAL NH3        17.0304
  PVAL H2O        18.0152
  PVAL HCl        36.4609
  PVAL COS        60.0704
  PVAL CH4        16.0426
  PVAL C2H6       30.0694
  PVAL C3H8       44.0962
  PVAL IC4H10     58.1230
  PVAL NC4H10     58.1230
  PVAL IC5H12     72.1498
  PVAL NC5H12     72.1498
;
;  Set the specific gravities of H2, CO, CO2, NH3, H2S, N2 and COS to
;  the values given in the API Technical Data Book - Petroleum Refining.
  PROP-LIST        SPGR
  PVAL H2         0.3000
  PVAL CO         0.3000
```

```
   PVAL CO2        0.8180
   PVAL NH3        0.6162
   PVAL H2S        0.8014
   PVAL N2         0.8094
   PVAL COS        1.0200
 ;
 ATTR-COMPS COAL   PROXANAL ULTANAL SULFANAL AOXANAL
 ATTR-COMPS URCOAL PROXANAL ULTANAL SULFANAL AOXANAL
 ATTR-COMPS SLAG   PROXANAL ULTANAL SULFANAL AOXANAL
 ;
 NC-PROPS    COAL ENTHALPY  HCOALGEN /
                  DENSITY   DCOALIGT
 NC-PROPS  URCOAL ENTHALPY  HCOALGEN /
                  DENSITY   DCHARIGT
 NC-PROPS    SLAG ENTHALPY  HCOALGEN /
                  DENSITY   DCHARIGT
 ;
 DEF-STREAMS MIXNC ALL
 ;
 ;  Set an initial GUESS for the ROM COAL stream to Plant 1.
 STREAM ROMCOAL
    SUBSTREAM MIXED TEMP = 71.0  PRES = 14.7
      MASS-FLOW  H2O 24798.0
    SUBSTREAM NC TEMP = 71.0  PRES = 14.7
      MASS-FLOW  COAL 285035.0 / URCOAL 0.0 / SLAG 0.0
      COMP-ATTR COAL   PROXANAL (0.0 42.06 36.24 21.70) /
                       ULTANAL (21.7 61.1 4.2 1.2 0.1 5.1 6.6) /
                       SULFANAL (3.0 0.3 1.8) /
                       AOXANAL (43.8 17.1 24.1 0.8 0.1 5.6 1.0 0.6 2.1 4.1)
 ;  Fake the URCOAL properties.
      COMP-ATTR URCOAL PROXANAL (0.0 19.197 16.549 64.254) /
                       ULTANAL (64.254 29.914 0.185 1.304 0.0 4.267 0.076) /
                       SULFANAL (2.507 0.253 1.507) /
                       AOXANAL (43.8 17.1 24.1 0.8 0.1 5.6 1.0 0.6 2.1 4.1)
 ;  Fake the SLAG properties.
      COMP-ATTR SLAG   PROXANAL (0.0 10.0 0.0 90.0) /
                       ULTANAL (90.0 10.0 0.0 0.0 0.0 0.0 0.0 ) /
                       SULFANAL (0.0 0.0 0.0) /
                       AOXANAL (42.0 17.0 23.0 1.0 1.0 6.0 2.0 1.0 3.0 4.0)
 ;
 ;  Set an initial GUESS for the fresh make-up H2 stream to Plant 2.
 ;  Assume the make-up H2 contains 1.396 wt% nitrogen.
 STREAM 2-H2IN
    SUBSTREAM MIXED TEMP = 100.0  PRES = 3440.0
      MASS-FLOW  H2 70300.0 / N2 980.0
 ;
 ;  Set an initial GUESS for the total water feed streams (both steam
 ;  and wash water) to Plant 2.
 STREAM 2-H2OIN
    SUBSTREAM MIXED TEMP = 126.0  PRES = 3200.0
      MASS-FLOW  H2O 1346856.0
 ;
 ;  Set an initial GUESS for the ROSE EXTRACT stream to Plant 2 (T/C opt).
 STREAM ROSE-XTR
    SUBSTREAM MIXED TEMP = 300.0  PRES = 3215.0
```

```
     MASS-FLOW  T675 147. / T725 147. / T775 147. / T825 147.0 /
       T875 911. / T925 911. / T975 911. /  T1000+ 831960.
;
;  Set an initial GUESS for the SOLVENT stream to Plant 2.  The user
;  Fortran block model for Plant 2 does not require any solvent, but
;  the input stream is required.  Thus, set a small H2O flow to avoid
;  ASPEN warnings.
STREAM SOLVENT
   SUBSTREAM MIXED TEMP = 500.0  PRES = 500.0
     MASS-FLOW  H2O 1.0
;
;  Set an initial GUESS for the 2S-BOTTS stream leaving Plant 2.
STREAM 2S-BOTTS
   SUBSTREAM MIXED TEMP = 688.0  PRES = 28.0
     MASS-FLOW  H2O 0.0 /
       T825 380.0 / T875 3365.0 /
       T925 3365.0 / T975 3365.0 / T1000+ 642440.0
   SUBSTREAM NC TEMP = 688.0  PRES = 28.0
     MASS-FLOW  COAL 0.0 / URCOAL 254475.0
;
;  Set an initial GUESS for the H2 stream to Plant 4.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 4-H2IN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 500.0
     MASS-FLOW  H2 1400.0 / N2 19.0
;
;  Set an initial GUESS for the H2O stream to Plant 4.
STREAM 4-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 50.0
     MASS-FLOW  H2O 18770.
;
;  Set an initial GUESS for the H2 stream to Plant 5.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 5-H2IN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 500.0
     MASS-FLOW  H2 17000.0 / N2 279.0
;
;  Set an initial GUESS for the H2O stream to Plant 5.
STREAM 5-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 50.0
     MASS-FLOW  H2O 36382.0
;
;  Set an initial GUESS for the pseudo sour H2O from Plant 6.
STREAM 6S-SH2O
   SUBSTREAM MIXED TEMP = 60.0  PRES = 14.7
     MASS-FLOW  NH3 2830.0
;
;  Set an initial GUESS for the H2O stream to Plant 9.0.
STREAM 9-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 14.7
     MASS-FLOW  H2O 967545.0
;
;  Set an initial GUESS for the STEAM stream to Plant 9.0.
STREAM 9-STEMIN
   SUBSTREAM MIXED TEMP = 450.0  PRES = 500.0
```

```
     MASS-FLOW  H2O 167545.0
;
;  Set an initial GUESS for the OXYGEN stream to Plant 9.0.
STREAM 9-O2IN
   SUBSTREAM MIXED TEMP = 80.0  PRES = 300.0
     MASS-FLOW  O2 743531.0 / N2 3269.0
;
;  Set an initial GUESS for the AIR stream to Plant 10.
STREAM 10-AIRIN   TEMP = 70.0  PRES = 14.7
     MASS-FLOW  O2 743531.0 / N2 2463614.0
;
;  Set an initial GUESS for the CH4 stream to Plant 9.1.
STREAM NAT-GAS
   SUBSTREAM MIXED TEMP = 70.0  PRES = 100.0
     MASS-FLOW  CH4 307352.
;
;  Set an initial GUESS for the STEAM stream to Plant 9.1.
STREAM STEAM
   SUBSTREAM MIXED TEMP = 620.0  PRES = 500.0
     MASS-FLOW  H2O 864428.
;
; Model Connectivity
; ------------------
;
FLOWSHEET COAL
; Plant M1 is the clean coal outlet streams mixer.
;   Stream 1S-CCOAL is the combined outlet clean coal product stream.
; Plant M2 is the middling coal outlet streams mixer.
;   Stream 1S-XMID  is the combined outlet middling coal product stream.
; Plant M-2HYD is the mixer to combine H2 streams for Plant 2.
;   Stream 2-H2MIX  is the combined H2 stream from 6.1, 6.2, & source.
; Plant M3 is the refuse outlet streams mixer.
;   Stream 1S-REFSE is the combined outlet refuse product stream.
; Plant M38 is the sour water mixer.
;   Stream 38-FEED  is the combined sour water streams to Plant 38.
; Plant M4 is the waste water outlet streams mixer.
;   Stream 1S-WATER is the combined outlet waste water product stream.
; Plant M-462 is the mixer to combine H2 streams for Plant 6.2.
;   Stream 62-HYD   is the combined H2 stream from Plants 2 & 4.
; Plant M-561 is the mixer to combine H2 streams for Plant 6.1.
;   Stream 61-HYD   is the combined H2 stream from Plants 2 & 5.
; Plant M-6GAS is the heater to combine sour gas streams for Plant 11.
;   Stream 6-SGAS   is the combined sour gas stream from Plants 6.1 & 6.2.
; Plant M-73 is the mixer to combine H2 gas streams for Plant 3.
;   Stream 3-GAS    is the combined H2 gas stream from Plant 3.
; Plant M-HYD is the mixer (flash2) to combine H2 streams for M-2HYD.
;   Stream H2MIX    is the combined H2 stream from Plants 6.1 & 6.2.
;   Stream DUMMY    is the dummy vapor stream that contains no flow.
; Plant M-NAP is the mixer to combine naphtha streams for Plant 4.
;   Stream 4-FEED   is the combined naphtha stream from Plants 2 & 6.2.
; Plant M-PNAP is the mixer to combine product naphtha streams.
;   Stream PS-NAPH is the combined naphtha stream from Plants 4 & 5.
; Plant P1-ALT1 is the Coal Cleaning and Preparation Plant - ALT CASE 1.
;   Stream 1S12     is the outlet clean coal product stream.
;   Stream 1S13     is the outlet middling coal product stream.
```

```
;   Stream 1S14     is the outlet refuse product stream.
;   Stream 1S15     is the outlet waste water product stream.
; Plant P1-ALT2 is the Coal Cleaning and Preparation Plant - ALT CASE 2.
;   Stream 1S22     is the outlet clean coal product stream.
;   Stream 1S23     is the outlet middling coal product stream.
;   Stream 1S24     is the outlet refuse product stream.
;   Stream 1S25     is the outlet waste water product stream.
; Plant P1-BASE is the Coal Cleaning and Preparation Plant - BASE CASE.
;   Stream 1S02     is the outlet clean coal product stream.
;   Stream 1S03     is the outlet middling coal product stream.
;   Stream 1S04     is the outlet refuse product stream.
;   Stream 1S05     is the outlet waste water product stream.
; Plant P14 is the Coal Grinding and Drying Plant.
;   Stream COALTO2  is the outlet clean coal product stream.
;   Stream 14S-XMID is the outlet middling coal product stream.
;   Stream 14S-REF  is the outlet refuse product stream.
;   Stream 14S-WAT  is the outlet waste water product stream.
; Plant PO2TC is the THEREMAL/CATALYTIC Coal Liquefaction Plant.
;   Stream 2-H2MIX  is the hydrogen feed stream.
;   Stream COALTO2  is the clean coal feed stream.
;   Stream SOLVENT  is the solvent feed stream.  This stream is used to
;     supply the steam required to Plant 2.
;   Stream ROSE-XTR is the deashed product stream.
;   Stream 2-H2OIN  is the water feed stream to the liquefaction unit.
;   Stream 2S-GAS   is the HP gas product stream going to Plant 6.1.
;   Stream GASES    is the LP gas product stream going to Plant 6.2.
;   Stream NAPHTHA  is the naphtha product stream.
;   Stream GAS-OIL  is the gas-oil product stream going to Plant 5.
;   Stream 2S-BOTTS is the bottoms stream going to Plant 8.1.
;   Stream 2S-SH2O  is the sour water product stream.
;  Plant PO2A simulates the fractionation of the bottoms stream leaving
;  Plant 2 into a 850-1000 F cut for gasifiaction and the ROSE-SR unit
;  feed stream
   PO2A   IN  = BOTTOMS    OUT = S2-GASIF  ROSE-FD
; Plant PO3 is the Gas Plant.
;   Stream 3S-SGAS  is the sour off-gas product stream.
;   Stream 3S-FGAS  is the fuel gas product stream.
;   Stream 3S-PROP  is the C3 product stream.
;   Stream 3S-BUT   is the C4s product stream.
;   Stream 3S-OIL   is the lean-oil product stream to M-NAP.
;   Stream 3S-SH2O  is the product sour water stream.
; Plant PO4 is the simplified model for plant 4, the naphtha hydrotreater.
;   Stream 4-H2IN   is the hydrogen feed stream.
;   Stream 4-H2OIN  is the water feed stream.
;   Stream 4S-GAS   is the hydrotreater off-gas product stream.
;   Stream 4S-NAPH  is the hydrotreated naphtha product stream.
;   Stream 4S-SH2O  is the hydrotreater sour water stream.
; Plant PO5 is the simplified model for plant 5, the gas-oil hydrotreater.
;   Stream 5-H2IN   is the hydrogen feed stream.
;   Stream 5-H2OIN  is the water feed stream.
;   Stream 5S-HPGAS is the hydrotreater hi-pressure purge gas stream.
;   Stream 5S-LPGAS is the hydrotreater other gases stream.
;   Stream 5S-NAPH  is the hydrotreated C6-350 F naphtha product stream.
;   Stream P350-450 is the hydrotreated 350 - 450 F product stream.
;   Stream P450-650 is the hydrotreated 450 - 650 F product stream.
```

```
;   Stream P650-850 is the hydrotreated 650 - 850 F product stream.
;   Stream 5S-SH2O  is the hydrotreater sour water stream.
; Plant P61 is the model for the Hydrogen purification by Membrane
;     Separation Plant, Plant 6.1.
;   Stream 61-HYD   is the feed stream to the H2 purification plant.
;   Stream H2-RICH  is the purified H2-rich product gas stream.
;   Stream SOUR-GAS is the sour gas product stream.
;   Stream P61-GAS  is the reject (non-permeate) product gas stream.
; Plant P62 is the model for the Hydrogen purification by Pressure
;     Swing absorption Plant, Plant 6.2.
;   Stream 62-HYD   is the mixed gas feed stream to the PSA hydrogen
;     purification plant.
;   Stream P61-GAS  is the reject gas stream from Plant 6.1, the high
;     pressure section of Plant 6, the hydrogen purification by
;     membrane permeation section.
;   Stream H2-2RICH is the purified h2-rich product gas stream.
;   Stream SOUR-2GS is the sour gas product stream.
;   Stream GAS-OUT  is the reject product gas stream.
;   Stream NAPHTHA2 is the liquid raw naphtha product stream.
; Plant P07 is the simplified model for Plant 7, the naphtha reformer.
;   Stream 7-NAPH   is the naphtha feed stream.
;   Stream 7S-H2    is the hydrogen rich product gas stream.
;   Stream 7S-GAS   is the light hydrocarbon product gas stream.
;   Stream REFORMED is the reformate product stream.
; Plant P81 is the model for the ROSE-SR Critical Solvent Deashing unit.
;   Stream ROSE-XTR is the deashed product stream.
;   Stream ASH-CONC is the ash concentrate stream.
; Plant P11 is the Sulfur plant.
;   Stream 11S-LIQS is the sulfur product stream.
;   Stream 11S-FGAS contains all the other material in the feed that
;     does not leave in the product SULFUR STREAM.
; Plant P31 is the simplified model for the utility plant.
;   Stream 31S-01   is the dummy product stream.
; Plant P314 is the model for the Fluidized Bed Combustor and the
;  Steam Turbine Generator unit.
;   Stream FBC-FEED is the feed stream to Plant P314.
;   Stream SA6-01   is the combined product stream out of Plant P314.
; Plant P38 is the NH3 recovery plant.
;   Stream NH3-PROD is the product NH3.
;   Stream 38S-OUT  is the reject stream.
; Plant P38A is the reject stream component splitter from plant 38.
;   Stream 38AS-VAP is the vapor stream going to Plant 11.
;   Stream 38AS-LIQ is the liquid stream going to Plant 38B.
; Plant P38B is the liquid reject stream splitter from Plant 38A.
;   Stream WASTE    is the reject portion of the inlet stream which
;     in this model is rejected, but actually goes to the coal
;     gasification plant, if present.
;   Stream 39FEED   is the stream going on to Plant 39.
; Plant P39 is the phenol recovery plant.
;   Stream PHENOL   is the phenol product stream.
;   Stream WASTEH2O is the waste water stream.
; Plant SA6 is the product stream separator from Plant P314.
;   Stream FBC-GAS  is the gas product stream from Plant SA6.
;   Stream FBC-SOL  is the solids product stream from Plant SA6.
; Block S1 is the inlet coal splitter.
```

```
;   Stream ROMCOAL  is the inlet ROM coal stream.
;   Stream 1S01     is the splitter outlet to the base case plant.
;   Stream 1S11     is the splitter outlet to the alternate case 1 plant.
;   Stream 1S21     is the splitter outlet to the alternate case 2 plant.
; Block S2 is the clean coal splitter.
;   Stream 1S-CCOAL is the inlet clean coal stream.
;   Stream COALTO14 is the splitter outlet to plant 2.
;   Stream 9-COAL   is the splitter outlet to plant 9.
; Block S6-SH2O is a component splitter to generate a pseudo sour-water
;   stream from Plant 6 to get the NH3 to Plant 38, the Ammonia Recovery
;   Plant.
;   Stream 6S-SH2O  is the pseudo sour-water stream.
;   Stream 11-FEED  is the Plant 11 feed stream.
; Block S7 is the product naphtha splitter.
;   Stream PS-NAPH  is the inlet product naphtha stream.
;   Stream 7-NAPH   is the splitter outlet to the naphtha reformer plant.
;   Stream PNAPHTHA is the splitter outlet as product naphtha.
; Block S8 is the ash-concentrate splitter.
;   Stream ASH-CONC is the inlet ash-concentrate stream from the ROSE.
;   Stream FBC-FEED is the splitter outlet to the FBC plant.
;   Stream S8-ASHC  is the splitter outlet to the M9C coal mixer.
;
  M1        IN = 1S02 1S12 1S22   OUT = 1S-CCOAL
  M2        IN = 1S03 1S13 1S23   OUT = 1S-XMID
  M-2HYD    IN = H2MIX 2-H2IN     OUT = 2-H2MIX
  M3        IN = 1S04 1S14 1S24   OUT = 1S-REFSE
  M38       IN = 2S-SH2O 3S-SH2O 4S-SH2O 5S-SH2O 6S-SH2O 9S-SH2O     &
              OUT = 38-FEED
  M4        IN = 1S05 1S15 1S25   OUT = 1S-WATER
  M-462     IN = 4S-GAS GASES 5S-LPGAS 3S-SGAS 7S-H2     OUT = 62-HYD
  M-561     IN = 5S-HPGAS 2S-GAS  OUT = 61-HYD
  M-6GAS    IN = SOUR-GAS SOUR-2GS H2S-GAS 38AS-VAP      OUT = 6-SGAS
  M-73      IN = GAS-OUT 7S-GAS   OUT = 3-GAS
  M-HYD     IN = H2-RICH H2-2RICH OUT = H2MIX DUMMY
  M-NAP     IN = NAPHTHA2 3S-OIL  OUT = 4-FEED
  M-PNAP    IN = 4S-NAPH 5S-NAPH  OUT = PS-NAPH
  P1-ALT1   IN = 1S11             OUT = 1S12 1S13 1S14 1S15
  P1-ALT2   IN = 1S21             OUT = 1S22 1S23 1S24 1S25
  P1-BASE   IN = 1S01             OUT = 1S02 1S03 1S04 1S05
  P14       IN = COALTO14         OUT = COALTO2 14S-XMID 14S-REF 14S-WAT
  P02TC     IN = 2-H2MIX COALTO2 SOLVENT ROSE-XTR 2-H2OIN            &
              OUT = 2S-GAS GASES NAPHTHA GAS-OIL 2S-BOTTS 2S-SH2O
  P02A      IN = 2S-BOTTS         OUT = S2-GASIF 81-FEED
  P03       IN = NAPHTHA 3-GAS                                       &
              OUT = 3S-SGAS 3S-FGAS 3S-PROP 3S-BUT 3S-OIL 3S-SH2O
  P04       IN = 4-H2IN 4-FEED 4-H2OIN                               &
              OUT = 4S-GAS 4S-NAPH 4S-SH2O
  P05       IN = 5-H2IN GAS-OIL 5-H2OIN                              &
              OUT = 5S-HPGAS 5S-LPGAS 5S-NAPH P350-450 P450-650      &
                    P650-850 5S-SH2O
  P61       IN = 61-HYD           OUT = H2-RICH SOUR-GAS P61-GAS
  P62       IN = 62-HYD P61-GAS                                      &
              OUT = H2-2RICH SOUR-2GS GAS-OUT NAPHTHA2
  P07       IN = 7-NAPH           OUT = 7S-H2 7S-GAS REFORMED
  P81       IN = 81-FEED          OUT = ROSE-XTR ASH-CONC
```

```
  P11       IN = 11-FEED          OUT = 11S-FGAS 11S-LIQS
  P31       IN = 3S-FGAS          OUT = 31S-01
  P314      IN = FBC-FEED         OUT = SA6-01
  P38       IN = 38-FEED          OUT = NH3-PROD 38S-OUT
  P38A      IN = 38S-OUT          OUT = 38AS-VAP 38AS-LIQ
  P38B      IN = 38AS-LIQ         OUT = WASTE 39FEED
  P39       IN = 39FEED           OUT = PHENOL WASTEH2O
  SA6       IN = SA6-01           OUT = FBC-SOL FBC-GAS
  S1        IN = ROMCOAL          OUT = 1S01 1S11 1S21
  S2        IN = 1S-CCOAL         OUT = COALTO14 9COAL
  S6-SH2O   IN = 6-SGAS           OUT = 6S-SH2O 11-FEED
  S7        IN = PS-NAPH          OUT = 7-NAPH PNAPHTHA
  S8        IN = ASH-CONC         OUT = FBC-FEED S8-ASHC
;
FLOWSHEET HYDROGEN
; Plant M9 is the hydrogen stream mixer.
;   Stream M9H2     is the dummy H2 stream to the liquefaction unit.
;   Stream M9H4     is the dummy H2 stream to the naphtha hydrotreater.
;   Stream M9H5     is the dummy H2 stream to the gas-oil hydrotreater.
;   Stream HHNEED   is the dummy H2 stream from the mixer.
; Plant M9C is the coal stream mixer.
;   Stream S2-GASIF is the 850-1000 F cut from the T/C option of Plant 2
;     that is gasified.
;   Stream COALTO9  is the clean coal stream to the mixer.
;   Stream S8-ASHC  is the ash concentrate stream from the ROSE unit.
;   Stream 9-FEED   is the mixed coal stream to the gasifier.
; Plant P09 is the plant for producing hydrogen by coal gasification.
;   Stream 9-H2OIN  is the water feed stream to the gasifier section.
;   Stream 9-O2IN   is the purified O2 stream from the air sep. plant.
;   Stream 9-STEMIN is the steam that goes to the shift reactors.
;   Stream H2-GAS   is the product hydrogen stream.
;   Stream H2S-GAS  is the product hydrogen sulfide stream.
;   Stream VENT-GAS is the product vent gas stream.
;   Stream 9S-SH2O  is the product sour water stream.
;   Stream SLAG     is the product slag stream.
; Plant P91 is the Steam Reforming of Natural Gas Plant.
;   Stream NAT-GAS  is the inlet natural gas stream.
;   Stream STEAM    is the inlet process water stream.
;   Stream H2-PROD  is the product hydrogen stream.
;   Stream FLUE-GAS is the product flue gas stream.
; Plant P10 is the Air Separation Plant.
;   Stream 10-AIRIN is the air input stream.
;   Stream 10S01    is the product oxygen stream.
;   Stream 10S02    is the product nitrogen stream.
; Plant S9 is the hydrogen stream splitter.
;   Stream H9NEED   is the dummy H2 stream for the gasifier.
;   Stream H91NEED  is the dummy H2 stream for the steam reformer.
;
  M9H       IN = M9H2 M9H4 M9H5             OUT = MHNEED
  M9C       IN = S2-GASIF S8-ASHC COALTO9   OUT = 9-FEED
  P09       IN = 9-FEED 9-H2OIN 9-O2IN 9-STEMIN         &
              OUT = H2-GAS H2S-GAS VENT-GAS 9S-SH2O SLAG
  P91       IN = NAT-GAS STEAM      OUT = H2-PROD FLUE-GAS
  P10       IN = 10-AIRIN           OUT = 10S01  10S02
  S9        IN = MHNEED             OUT = H9NEED H91NEED
```

```
;
; Design Specifications
; ---------------------
;
;  Design spec to set the hydrogen flow rate to Plant 2 (2-H2MIX)
;  to a specified weight percent (HPCT2) of the MAF coal input stream.
DES-SPEC 2H2FLO
   DEFINE CHP2   MASS-FLOW  STREAM=2-H2MIX  COMPONENT=H2
   DEFINE CCOAL  MASS-FLOW  STREAM=COALTO2  SUBSTREAM=NC COMPONENT=COAL
   DEFINE CCASH  COMP-ATTR-VAR STREAM=COALTO2  SUBSTREAM=NC &
                   COMPONENT=COAL ATTRIBUTE=ULTANAL ELEMENT=1
C     Set the specified H2 rate to Plant 2 in wt% in the following line.
F     HPCT2 = 7.9205D0
C     DAFCOAL is the dry ash-free coal (MAF coal).
F     DAFCOAL = CCOAL * (100.0D0 - CCASH) * 0.01D0
F     H2P2 = 0.01D0 * HPCT2 * DAFCOAL
   SPEC CHP2 TO H2P2
   TOL-SPEC 0.1
   VARY STREAM-VAR  STREAM=2-H2IN  VARIABLE=MASS-FLOW
   LIMITS 100 1000000
;
;  Design spec to set the correct ROM coal flow to the splitter to
;  obtain the desired 17,102 TPSD of MF coal flow rate to the coal
;  liquefaction plant, Plant 2.
DES-SPEC COALFLO
   DEFINE CTARG  MASS-FLOW  STREAM=COALTO2   SUBSTREAM=NC  COMPONENT=COAL
;  Set TPD to the target coal rate to Plant 2 in TPSD of MF coal.
;  ==============================================================
;
F     TPD = 17102.0D0
F     WTPHR = (TPD * 2000.0D0) / 24.0D0
   SPEC CTARG TO WTPHR
   TOL-SPEC 0.1
   VARY MASS-FLOW  STREAM=ROMCOAL  SUBSTREAM=NC  COMPONENT=COAL
   LIMITS 100 10000000
;
;  Design spec to set the correct 9-FEED flow rate to the Plant 9,
;  coal gasifier, to obtain the desired hydrogen production rate.
DES-SPEC H2FLO
   DEFINE HOUT   MASS-FLOW   STREAM=H2-GAS   COMPONENT=H2
   DEFINE HTOT   MASS-FLOW   STREAM=H9NEED   COMPONENT=H2
   SPEC HOUT TO HTOT
   TOL-SPEC 1.0
   VARY STREAM-VAR STREAM=COALTO9  SUBSTREAM=NC  VAR=MASS-FLOW
   LIMITS 0.1 10000000
;
;  Design spec to set the heat duty to block M-HYD to zero by
;  varying the temperature. This corrects a temperature calculating
;  error in the ASPEN mixer block algorithm.
DES-SPEC HD-HYD
   DEFINE HDTY BLOCK-VAR BLOCK=M-HYD SENTENCE=RETENTION VARIABLE=HEAT-DUTY
   SPEC HDTY TO 0.0
   TOL-SPEC 1000
   VARY BLOCK-VAR BLOCK=M-HYD SENTENCE=PARAM VARIABLE=TEMPERATURE
   LIMITS 10 500
```

```
;
;  Design spec to set the 10-AIRIN stream flow to produce the required
;  amount of oxygen product required by Plant 9, coal gasification.
DES-SPEC O2FLO
 DEFINE FLO10S STREAM-VAR STREAM=10S01    VAR=MASS-FLOW
 DEFINE FLOOXY STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
   SPEC FLO10S TO FLOOXY
   TOL-SPEC 0.1
   VARY STREAM-VAR  STREAM=10-AIRIN  VARIABLE=MASS-FLOW
   LIMITS 0.1 10000000
;
;  Design spec to set the hydrogen flow rate for Plant 9.1.
DES-SPEC RFMRFLO
   DEFINE HOUT2  MASS-FLOW   STREAM=H2-PROD  COMPONENT=H2
   DEFINE HTOT2  MASS-FLOW   STREAM=H91NEED  COMPONENT=H2
   SPEC HOUT2 TO HTOT2
   TOL-SPEC 0.1
   VARY STREAM-VAR  STREAM=NAT-GAS  VARIABLE=MASS-FLOW
   LIMITS 1000 600000
;
; Transfer Blocks
; ---------------
;
;  Transfer block to set COALTO9 equal to the 9COAL stream (the wet
;  clean coal input).  This duplicates the full property set and
;  provides the initial guess flow rate for COALTO9.
TRANSFER CCOAL
   SET STREAM COALTO9
   EQUAL-TO STREAM 9COAL
;
;  Transfer block used to set the hydrogen flow rates of the input
;  streams to the calculated hydrogen flows to Plant 2 (2-H2IN),
;  Plant 4 (4-H2IN), and Plant 5 (5-H2IN).  M9's represent hydrogen
;  flows from Plant 9.0/10 and M91's are for the Plant 9.1 alternative.
TRANSFER HFLOW
   SET STREAM M9H2
   EQUAL-TO STREAM 2-H2IN
   SET STREAM M9H4
   EQUAL-TO STREAM 4-H2IN
   SET STREAM M9H5
   EQUAL-TO STREAM 5-H2IN
;
; Fortran Blocks
; --------------
;
;  Fortran block to set the correct water flow rate in the clean
;  coal going to Plant 9.
FORTRAN 9COAL
   DEFINE W9COAL MASS-FLOW  STREAM=9COAL   COMPONENT=H2O
   DEFINE C9COAL MASS-FLOW  STREAM=9COAL   SUBSTREAM=NC COMPONENT=COAL
   DEFINE WCTO9  MASS-FLOW  STREAM=COALTO9 COMPONENT=H2O
   DEFINE CCTO9  MASS-FLOW  STREAM=COALTO9 SUBSTREAM=NC COMPONENT=COAL
F     WCTO9 = CCTO9 * (W9COAL / C9COAL)
;
;  This Fortran block resets the split fraction in S2 to provide the
```

```
;  flow rate of coal to Plant 9.0.
FORTRAN COALFLOW
   DEFINE C14    STREAM-VAR  STREAM=COALTO14  VAR=MASSFLOW
   DEFINE C9     STREAM-VAR  STREAM=COALTO9   VAR=MASSFLOW
   DEFINE RC     STREAM-VAR  STREAM=ROMCOAL   VAR=MASSFLOW
   DEFINE CC     STREAM-VAR  STREAM=1S-CCOAL  VAR=MASSFLOW
   DEFINE SFRAC  BLOCK-VAR   BLOCK=S2  SENTENCE=FRAC  VAR=FRAC  &
    ID1=COALTO14  ELEMENT=1
C     Calculate total clean coal.
F     TCC = C14 + C9
C     Reset the ROMCOAL feed rate to match the new value.
F     RC = RC * (TCC / CC)
C     Reset the split fraction in S2 to correct 9COAL flow rate.
F     SFRAC = C14 / (C9 + C14)
;
;  This FORTRAN block will calculate the initial ratio of the MIXED
;  substream flow to the NC substream flow in the stream ROMCOAL.
;  It will store this result in RATIO, and use that value to adjust
;  the MIXED substream flow in proportion to the NC substream flow
;  that is varied by the COALFLO design-spec.  This is needed to set
;  the correct amount of water entering with the ROM coal.
FORTRAN MIXFLO
F     COMMON /RATIO/ RMIXNCP
F     COMMON /RGLOB/ RDUM1, RMIN
 DEFINE FLONCP SUBSTREAM-VAR STREAM=ROMCOAL SUBSTREAM=NC VAR=MASSFLOW
 DEFINE FLOMIX SUBSTREAM-VAR STREAM=ROMCOAL SUBSTREAM=MIXED VAR=MASSFLOW
C  The following should only be true on the first pass.  This prevents
C  writing over the initial substream ratio on subsequent passes.
F     IF (RMIXNCP .LT. RMIN) THEN
F        RMIXNCP = FLONCP / FLOMIX
F     END IF
C  Adjust the other substream flow based on changes to the NC
C  substream.
F     FLOMIX = FLONCP / RMIXNCP
;
;  Fortran block to dynamically set the URCOAL fraction in the
;  separation block, SA6, equal to the solids production parameter,
;  REAL(1), in block P314, the fluidized bed combustor.  This block
;  only has significance when Option 6 is in effect.
FORTRAN SA6SET
   DEFINE FRAC1 BLOCK-VAR BLOCK=P314 SENTENCE=REAL VAR=REAL ELEMENT=1
   DEFINE FRAC2 BLOCK-VAR BLOCK=SA6  SENTENCE=FRAC VAR=FRAC ID1=NC    &
    ID2=FBC-SOL ELEMENT=1
F     FRAC2 = FRAC1
;
;  FORTRAN block to set the COMBINED steam and water flow rate to
;  Plant 2 as a specified weight percent of the dry coal feed.
FORTRAN SETUP2
   DEFINE FEED2 MASS-FLOW  STREAM=COALTO2  SUBSTREAM=NC  COMPONENT=COAL
   DEFINE H2O2  STREAM-VAR STREAM=2-H2OIN  VAR=MASSFLOW
C     The following value is for the T/C option (Option 3).
F     H2O2 = 0.9450434 * FEED2
;
;  FORTRAN block used to set the hydrogen flow rate to Plant 4 (4-H2IN)
;  to a specified weight percent (HPCT4) of the naphtha feed stream,
```

```
;  and the hydrogen flow rate to Plant 5 (5-H2IN) to a specified weight
;  percent (HPCT5) of the gas oil feed stream.  This block also sets
;  the inlet water flow rates for these plants to specified rates
;  as functions of the hydrocarbon feed rates.
FORTRAN SETUP45
   DEFINE CHP4   MASS-FLOW  STREAM=4-H2IN   COMPONENT=H2
   DEFINE CHP5   MASS-FLOW  STREAM=5-H2IN   COMPONENT=H2
   DEFINE FLP4   STREAM-VAR STREAM=4-H2IN   VAR=MASSFLOW
   DEFINE FLP5   STREAM-VAR STREAM=5-H2IN   VAR=MASSFLOW
   DEFINE XNAPH  STREAM-VAR STREAM=4-FEED   VAR=MASSFLOW
   DEFINE XGOIL  STREAM-VAR STREAM=GAS-OIL  VAR=MASSFLOW
   DEFINE H2O4   STREAM-VAR STREAM=4-H2OIN  VAR=MASSFLOW
   DEFINE H2O5   STREAM-VAR STREAM=5-H2OIN  VAR=MASSFLOW
C     Set the specified H2 rates in wt% in the following two lines.
F     HPCT4 = 1.1855
F     HPCT5 = 2.7554
F     H2P4 = 0.01D0 * HPCT4 * XNAPH
F     FLP4 = H2P4 * (FLP4 / CHP4)
F     H2P5 = 0.01D0 * HPCT5 * XGOIL
F     FLP5 = H2P5 * (FLP5 / CHP5)
C     Set the specified H2O rates in wt% in the following two lines.
F     H2O4 = 0.089017 * XNAPH
F     H2O5 = 0.054217 * XGOIL
;
;  FORTRAN block to set the steam, water and oxygen stream flow rates
;  to Plant 9 based on the inlet flow rate of hydrocarbons and NC
;  components (on a dry ash-free basis).  Note the T/C Option adjustment
;  on the oxygen plant.
FORTRAN SETUP9
 DEFINE FL29MX SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=MIXED VAR=MASS-FLOW
 DEFINE ULCOAL COMP-ATTR-VAR STREAM=9-FEED  SUBSTREAM=NC &
        COMPONENT=COAL   ATTRIBUTE=ULTANAL ELEMENT=1
 DEFINE ULURC  COMP-ATTR-VAR STREAM=9-FEED  SUBSTREAM=NC &
        COMPONENT=URCOAL ATTRIBUTE=ULTANAL ELEMENT=1
 DEFINE FL29C   MASS-FLOW  STREAM=9-FEED  SUBSTREAM=NC COMPONENT=COAL
 DEFINE FL29UR  MASS-FLOW  STREAM=9-FEED  SUBSTREAM=NC COMPONENT=URCOAL
 DEFINE FL29W   MASS-FLOW  STREAM=9-FEED  COMPONENT=H2O
 DEFINE FL2STM  STREAM-VAR STREAM=9-STEMIN VAR=MASS-FLOW
 DEFINE FL2H2O  STREAM-VAR STREAM=9-H2OIN  VAR=MASS-FLOW
 DEFINE FL2O2   STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
C  Adjust the steam, water and oxygen stream flow rates based on the
C  inlet flow rate of hydrocarbons and NC components (on a dry basis).
F     X1 = 0.01*FL29C *(100.0-ULCOAL)
F     X2 = 0.01*FL29UR*(100.0-ULURC)
F     FL2STM = 0.25495 * (FL29MX + X1 + X2 - FL29W)
F     FL2H2O = 1.4723 * (FL29MX + X1 + X2 - FL29W)
F     FL2O2  = 1.1365 * (FL29MX + X1 + X2 - FL29W) * 1.055
;
;  Fortran block to set up the common and OSBL utility consumptions.
FORTRAN SETUP31
F     COMMON /USRC01/ PLNTID(32), UTIL(32,15), CAPCST(32,5), OPCST(32,5)
F     CHARACTER * 6  PLNTID
 DEFINE DCOAL2 SUBSTREAM-VAR STREAM=COALTO2 SUBSTREAM=NC VAR=MASS-FLOW
C     COMMON /USRC03/ is used to transfer variables FIN(5,4),
C       FOUT(20,4), PGAS, PPWR, OPTN6
```

```
C     See Subroutine USRSR1 for the definition of the items in named
C     common block /USRC03/.
C     Base all the offsite and OSBL utilities consumptions on the dry
C     coal feed rate to Plant 2, the Coal Liquefaction Plant. Ignore
C     cooling and process water consumptions and productions.
F     PLNTID (19) = 'OTHERS'
C     Electric Power.
F     UTIL(19,1) = 25.1346 * DCOAL2 * 0.001
F     IF ( OPTN6 .GE. 0.99D0 )   UTIL(19,1) = 29.5411 * DCOAL2 * 0.001
C     600 psig steam at 720F.
F     UTIL(19,4) = 0.05122207 * DCOAL2 * 0.001
C     150 psig saturated steam.
F     UTIL(19,6) = 0.04350367 * DCOAL2 * 0.001
C     50 psig saturated steam.
F     UTIL(19,7) = 0.06757103 * DCOAL2 * 0.001
;
;  Fortran statement to set the molar flow rate of the STEAM stream to
;  be in balance with the feed stream to Plant 9.1.
FORTRAN SETUP91
   DEFINE GS     STREAM-VAR  STREAM=NAT-GAS  VARIABLE=MOLE-FLOW
   DEFINE ST     STREAM-VAR  STREAM=STEAM    VARIABLE=MOLE-FLOW
F     IF (GS .GT. 0.0D0 )   THEN
F         ST = 2.504543D0 * GS
F       ELSE
F         ST = 0.0D0
F     ENDIF
;
;  Fortran block to switch between Plants 9.0 and 10 (Baseline Design
;  Case) or Plants 9.1, 31.1 and 31.4 (Option 6).
FORTRAN OPTION6
F     COMMON /USRC03/ FIN(5,4), FOUT(20,4), PGAS, PPWR, OPTN6
C     See Subroutine USRSR1 for the definition of the items in named
C     common block /USRC03/.
 DEFINE FSTM   STREAM-VAR STREAM=STEAM    VAR=MOLE-FLOW
 DEFINE FNG    STREAM-VAR STREAM=NAT-GAS  VAR=MOLE-FLOW
 DEFINE F10A   STREAM-VAR STREAM=10-AIRIN VAR=MASS-FLOW
 DEFINE F9H    STREAM-VAR STREAM=9-H2OIN  VAR=MASS-FLOW
 DEFINE F9S    STREAM-VAR STREAM=9-STEMIN VAR=MASS-FLOW
 DEFINE F9O    STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
 DEFINE FC9M   SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=MIXED VAR=MASS-FLOW
 DEFINE FC9NC  SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=NC    VAR=MASS-FLOW
 DEFINE FRAC8  BLOCK-VAR   BLOCK=S8  SENTENCE=FRAC  VAR=FRAC  &
  ID1=S8-ASHC  ELEMENT=1
 DEFINE FRAC9  BLOCK-VAR   BLOCK=S9  SENTENCE=FRAC  VAR=FRAC  &
  ID1=H9NEED   ELEMENT=1
 DEFINE FRAC38 BLOCK-VAR   BLOCK=P38B  SENTENCE=FRAC  VAR=FRAC  &
  ID1=WASTE    ELEMENT=1
C     Set N9 equal to 0 to run Plants 9.0 and 10 (Baseline), or
C     set N9 equal to 1 to run Plants 9.1, 31.1 and 31.4 (OPTION 6).
F     N9 = 0
F     IF (N9 .EQ. 0) THEN
F       OPTN6 = 0.0D0
F       FSTM = 1.0D-6
F       FNG = 1.0D-6
F       FRAC8 = 1.0
```

```
F        FRAC9 = 1.0
F        FRAC38 = 0.28595
F      ENDIF
F      IF (N9 .EQ. 1) THEN
F        OPTN6 = 1.0D0
F        F10A = 1.0D-6
F        F9H = 1.0D-6
F        F9S = 1.0D-6
F        F9O = 1.0D-6
F        FC9M = 1.0D-6
F        FC9NC = 1.0D-6
F        FRAC8 = 0.0
F        FRAC9 = 0.0
F        FRAC38 = 0.0
F      ENDIF
;
FORTRAN SUMMARY
C      This Fortran block writes the summary report to the DCLSUM.REP
C      file, and also writes the DCL1.PRN file for transfering the
C      results to the Lotus spreadsheet economics model.
C      COMMON /USRC03/ is used to transfer variables FIN(5,4),
C        FOUT(20,4), PGAS, PPWR, OPTN6
C      See Subroutine USRSR1 for the definition of the items in named
C      common block /USRC03/.
 DEFINE FIN1   SUBSTREAM-VAR STREAM=ROMCOAL   SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FIN2   STREAM-VAR    STREAM=NAT-GAS   VAR=MASS-FLOW
 DEFINE FOUT1  STREAM-VAR    STREAM=3S-PROP   VAR=MASS-FLOW
 DEFINE FOUT2  STREAM-VAR    STREAM=3S-BUT    VAR=MASS-FLOW
 DEFINE FOUT3A STREAM-VAR    STREAM=PNAPHTHA  VAR=MASS-FLOW
 DEFINE FOUT3B STREAM-VAR    STREAM=REFORMED  VAR=MASS-FLOW
 DEFINE FOUT4  STREAM-VAR    STREAM=P350-450  VAR=MASS-FLOW
 DEFINE FOUT5  STREAM-VAR    STREAM=P450-650  VAR=MASS-FLOW
 DEFINE FOUT6  STREAM-VAR    STREAM=P650-850  VAR=MASS-FLOW
 DEFINE FOUT7  SUBSTREAM-VAR STREAM=1S-REFSE  SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT8  SUBSTREAM-VAR STREAM=SLAG      SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT8A SUBSTREAM-VAR STREAM=FBC-SOL   SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT10 STREAM-VAR    STREAM=NH3-PROD  VAR=MASS-FLOW
 DEFINE FOUT11 STREAM-VAR    STREAM=PHENOL    VAR=MASS-FLOW
 DEFINE FOUT12 STREAM-VAR    STREAM=11S-LIQS  VAR=MASS-FLOW
C      Load the stream flow rates in the FIN() and FOUT() arrays in
C      Mlbs/hr.  All solid stream flow rates are on a dry basis.
F      FIN(1,1)  = 0.001D0 * FIN1
F      FIN(2,1)  = 0.001D0 * FIN2
F      FOUT(1,1) = 0.001D0 * FOUT1
F      FOUT(2,1) = 0.001D0 * FOUT2
F      FOUT(3,1) = 0.001D0 * (FOUT3A + FOUT3B)
F      FOUT(4,1) = 0.001D0 * FOUT4
F      FOUT(5,1) = 0.001D0 * FOUT5
F      FOUT(6,1) = 0.001D0 * FOUT6
F      FOUT(7,1) = 0.001D0 * FOUT7
F      FOUT(8,1) = 0.001D0 * (FOUT8 + FOUT8A)
F      FOUT(10,1) = 0.001D0 * FOUT10
F      FOUT(11,1) = 0.001D0 * FOUT11
F      FOUT(12,1) = 0.001D0 * FOUT12
C
```

```
C     Set XOF to the number of extra operators and OSBL operators
C     per dedicated plant operator.
C     ----------------------------
F     XOF = 0.343042
C
C     Set the LOSBL and LPLANT switches, as appropriate, to duplicate
C     the Bechtel OSBL and first vs. Nth plant costing logic.
C     LOSBL  = 0  - Use baseline case OSBL costing logic.
C     LOSBL  = 1  - Use option case OSBL costing logic.
C     LPLANT = 0  - Use first plant OSBL and engineering costing logic.
C     LPLANT = 1  - Use Nth plant OSBL and engineering costing logic.
C     ==================================================================
F     LOSBL = 1
F     LPLANT = 1
C
C     Open the separate output file called DCLSUM.REP to contain the
C     summary report of the simulation results.
F     OPEN (UNIT=62, FILE='DCLSUM.REP', STATUS='UNKNOWN',
F    1  ACCESS='SEQUENTIAL', FORM='FORMATTED',
F    2  BUFFERED='BUFFERED')
C     Call Subroutines USRSR1 and USRSR2 to write the summary report.
F     CALL USRSR1 (62)
F     CALL USRSR2 (62, LOSBL, LPLANT, OPTN6, XOF)
F     CLOSE (UNIT=62, STATUS='KEEP')
C     Now write the LOTUS spreadsheet economics model input file.
F     OPEN (UNIT=62, FILE='DCL1.PRN', STATUS='UNKNOWN',
F    1  ACCESS='SEQUENTIAL', FORM='FORMATTED',
F    2  BUFFERED='BUFFERED')
C     Call Subroutines USRSR3 to write the model input file.
F     CALL USRSR3 (62, OPTN6, XOF)
F     CLOSE (UNIT=62, STATUS='KEEP')
;
; Convergence Blocks
; ------------------
;
CONVERGENCE CBLK1 WEGSTEIN
  TEAR H2MIX 1D-5
  PARAM WAIT=3
;
CONVERGENCE CBLK2 WEGSTEIN
  TEAR 2S-BOTTS 1D-5
;
CONVERGENCE CBLK3 WEGSTEIN
  TEAR 6S-SH2O 1D-5
;
CONVERGENCE COALF ONE-VAR
  SPEC COALFLO
;
CONVERGENCE HD-C1 ONE-VAR
  SPEC HD-HYD
;
CONVERGENCE HYDF BROYDEN-SPEC
  SPEC H2FLO
;
CONVERGENCE 2HYDF ONE-VAR
```

```
  SPEC 2H2FLO
;
CONVERGENCE OXYF ONE-VAR
  SPEC O2FLO
;
CONVERGENCE RFMRF ONE-VAR
  SPEC RFMRFLO
;
; Calculation Sequence
; --------------------
;
;  Define subsequence for coal cleaning complex.
SEQUENCE CLEAN COALF MIXFLO S1 P1-BASE P1-ALT1 P1-ALT2                  &
               M1 S2 P14 (RETURN COALF)                                  &
               M4 M3 M2
;
;  Specify entire flowsheet sequence, including subsequence CLEAN.
SEQUENCE BASE  (SEQUENCE CLEAN)  CCOAL                                  &
               CBLK1   2HYDF M-2HYD (RETURN 2HYDF)                       &
               CBLK2 SETUP2 P02TC P02A P81 (RETURN CBLK2)                &
               P61 P62   HD-C1 M-HYD (RETURN HD-C1)                      &
               M-73 P03 M-NAP SETUP45 P04 M-462 P05 M-561                &
               M-PNAP S7 P07 (RETURN CBLK1)                              &
               HFLOW M9H OPTION6 S9  S8 P314 SA6SET SA6                  &
               HYDF 9COAL M9C SETUP9 P09 (RETURN HYDF)                   &
               OXYF P10 (RETURN OXYF)  COALFLOW  (SEQUENCE CLEAN)        &
               RFMRF SETUP91 P91 (RETURN RFMRF)                          &
               CBLK3 M38 P38 P38A P38B P39 M-6GAS S6-SH2O                &
               (RETURN CBLK3)                                            &
               P11 SETUP31 P31 SUMMARY
;
; Unit Operations Blocks
; ----------------------
;
;  Mix the clean coal product streams from the 3 different cases.
BLOCK M1 MIXER
  DESCRIPTION 'PLANT 1 OUTLET CLEAN COAL MIXER'
;
;  Mix the middling coal product streams from the 3 different cases.
BLOCK M2 MIXER
  DESCRIPTION 'PLANT 1 OUTLET MIDDLING COAL MIXER'
;
;  Mix the hydrogen streams going to Plant 2.
BLOCK M-2HYD MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL HYDROGEN STREAM TO PLANT 2'
  PARAM NPK=1  KPH=1
;
;  Mix the refuse product streams from the 3 different cases.
BLOCK M3 MIXER
  DESCRIPTION 'PLANT 1 OUTLET REFUSE MIXER'
;
;  Mix the sour water streams from Plants 2, 3, 4, 5, and 9.
BLOCK M38 MIXER
  DESCRIPTION 'SOUR WATER MIXER FOR PLANT 38 FEED'
;
```

```
;  Mix the waste water product streams from the 3 different cases.
BLOCK M4 MIXER
  DESCRIPTION 'PLANT 1 OUTLET WASTE WATER MIXER'
;
;  Mix the hydrogen streams from Plants 4 & 2 for Plant 6.2.
BLOCK M-462 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 6.2 FEED'
;
;  Mix the hydrogen streams from Plants 5 & 2 for Plant 6.1.
BLOCK M-561 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 6.1 FEED'
;
;  Mix the sour gas streams from Plants 6.1, 6.2, 9 and 38 for the
;  Plant 11 feed stream.
BLOCK M-6GAS HEATER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 11 FEED'
  PARAM  TEMP=110.0  PRES=14.7
;
;  Mix the H2 gas streams from Plants 7 & 6.2 for Plant 3.
BLOCK M-73 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 3 FEED'
;
;  Mixer M9C - The hydrogen plant feed mixer; used to mix the coal and
;  ROSE unit ASH-CONC stream that goes to Plant 9.0.
BLOCK M9C MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 9 FEED'
  BLOCK-OPTIONS HMB-RESULTS=2
;
;  Mixer M9 - The dummy hydrogen mixer; used to mix the three
;  streams that go to Plant 2 (M9H2), Plant 4 (M9H4), and
;  Plant 5 (M9H5) into one single output stream (MHNEED) for the
;  S9 splitter.
BLOCK M9H MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL AMOUNT OF HYDROGEN NEEDED'
  PARAM NPK=1  KPH=1
;
;  Mix the hydrogen streams from Plants 6.1 and 6.2. Use a flash2 block
;  to correct a temperature calculating error in the ASPEN mixer block
;  algorithm.
BLOCK M-HYD FLASH2
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL HYDROGEN FROM 6.1 AND 6.2'
  PARAM  TEMP=100.  PRES=3290.
;
;  Mix the naphtha streams from Plants 2 and 6.2.
BLOCK M-NAP MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL PLANT 4 NAPHTHA FEED'
;
;  Mix the product naphtha streams from Plants 4 and 5.
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL PRODUCT NAPHTHA STREAM'
BLOCK M-PNAP MIXER
;
;  Plant P1-ALT1, Coal Cleaning and Preparation Plant. Use User
;  Fortran Model, USR01, within the PLANTS file. ALTERNATE CASE 1 -
;  COAL CLEANING BY HEAVY MEDIUM SEPARATION.
BLOCK P1-ALT1 USER
```

```
    SUBROUTINE MODEL = USR01    REPORT = USR01
    DESCRIPTION 'PLANT 1 - ALTERNATE 1 - COAL CLEANING AND PREPARATION PLANT'
    PARAM  NINT = 5   NREAL = 70
;       The following integer and real parameters are for production of
;   the coal cleaned by both jigs and heavy medium separation.  The coal
;   cleaned only by jigs for gasification is handled by a separate plant
;   that is modeled in BLOCK P1-JIGS.  The operators and cost for this
;   plant includes those associalted with the P1-JIGS portion of the coal
;   cleaning and preparation plant.  All parameters have the same meaning
;   as described below for Plant 1 in BLOCK P1-BASE.
;
    INT  0  1  0  1  1
;        FCP          FCM    FHP          FHM    FNP          FNM
     REAL 0.9120155    0.0    0.9050241    0.0    0.8869236    0.0  &
;        FC1P         FC1M   FSP          FSM    FOP          FOM
         0.7602203    0.0    0.4471884    0.0    0.9905900    0.0  &
;        FAP          FAM
         0.3012854    0.0  &
;        PCWP  PCWM  PCWR  Future Use (3 items)
         9.0   3.0   10.0    0.   0.   0.                    &
;        Power            900/750 F steam   900 satd steam
         0.0 7.400489       0.0 0.0           0.0 0.0        &
;        600/720 F steam    600 satd steam    150 satd steam
         0.0 0.0            0.0 0.0           0.0 0.0        &
;        50 satd steam      Plant fuel        Cooling  H2O
         0.0 0.0            0.0 0.0           0.0 0.0        &
;        Process H2O        Nitrogen
         0.0 0.042246       0.0 0.0         &
;        Future Use (6 items)
         0.0  0.0  0.0  0.0  0.0  0.0       &
;        Opers/day      (Opers/day)/train
         8.0            8.0                 &
;        Ref Flow   Max Flow   Min Flow
         285.035    300.0      150.0       &
;        Plant cost equation constants.
;        A      B       E      F      Spares     Future Use (2 items)
         0.0    25.52   0.5942 1.0    0.0        0.0   0.0    &
;        Future Use (10 items)
         0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S12    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S13    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S14    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S15    KODE=2   TEMP = 70.0   PRES = 14.7
;
;  Plant P1-ALT2, Coal Cleaning and Preparation Plant. Use User Fortran
;  Model, USR01, within the PLANTS file. ALTERNATE CASE 2 - COAL CLEANING
;  BY HEAVY MEDIUM SEPARATION FOLLOWED BY SPHERICAL AGGLOMERATION.
BLOCK P1-ALT2 USER
   SUBROUTINE MODEL = USR01    REPORT = USR01
   DESCRIPTION 'PLANT 1 - ALTERNATE 2 - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;       The following integer and real parameters are for production of
```

```
;   the coal cleaned by both jigs and heavy medium separation followed
;   by spherical agglomeration.  The coal cleaned only by jigs for
;   gasification is handled by a separate plant that is modeled in
;   BLOCK P1-JIGS.  The operators and cost for this plant includes
;   those associalted with the P1-JIGS portion of the coal cleaning
;   and preparation plant.  All parameters have the same meaning as
;   described below for Plant 1 in BLOCK P1-BASE.
;
    INT  0  1  0  1  2
;        FCP          FCM    FHP          FHM    FNP          FNM
     REAL 0.9435271   0.0    0.9338663    0.0    0.9250562    0.0  &
;        FC1P         FC1M   FSP          FSM    FOP          FOM
         0.7400450    0.0    0.3772778    0.0    0.9867266    0.0  &
;        FAP          FAM
         0.1295931    0.0  &
;        PCWP   PCWM  PCWR  Future Use (3 items)
         14.16  3.0   10.0  0.0   0.0   0.0                  &
;        Power              900/750 F steam   900 satd steam
         0.0 51.68786       0.0 0.0           0.0 0.0       &
;        600/720 F steam    600 satd steam    150 satd steam
         0.0 0.0            0.0 0.0           0.0 0.0       &
;        50 satd steam      Plant fuel        Cooling  H2O
         0.0 0.0            0.0 0.394967      0.0 0.0       &
;        Process H2O        Nitrogen
         0.0 0.103481       0.0 0.0         &
;        Future Use (6 items)
         0.0  0.0  0.0  0.0  0.0  0.0      &
;        Opers/day     (Opers/day)/train
         8.0           8.0                 &
;        Ref Flow   Max Flow   Min Flow
         262.3      300.0      150.0      &
;        Plant cost equation constants.
;        A      B      E      F      Spares     Future Use (2 items)
         0.0    73.78  0.5942 1.0    0.0        0.0   0.0    &
;        Future Use (10 items)
         0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S22    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S23    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S24    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S25    KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 1 - Coal Cleaning, Preparation and Drying Plant, Use User Fortran
;           Model USR01
;           BASE CASE - COAL CLEANING BY JIGS For LIQUEFACTION.
BLOCK P1-BASE USER
   SUBROUTINE MODEL = USR01   REPORT = USR01
   DESCRIPTION 'PLANT 1 - BASE CASE - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following 5 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
```

```
;                    report.
;                 2 => Skip the capital cost and utilities portions
;                      of the summary report.
;                 3 => Skip writing the entire user block summary report.
;       INT(2) = User block summary report destination control switch.
;                 0 => Write the user block summary report to the mormal
;                       ASPEN/SP output report file.
;                 1 => Write the user block summary report to a separate
;                      user block output report file on logical unit 62
;                      called DCL01B.REP, DCL01A1.REP or DCL01A2.REP
;                      depending on the value of the coal cleaning option
;                      control switch, INT(5).
;       INT(3) = Number of operating duplicate trains, excluding spares.
;                 If INT(3) = 0, the minimum number of duplicate
;                   trains will be determined so that the capacity
;                   of each train does not exceed the maximum train
;                   capacity specified by variable REAL(52).
;                 If INT(3) > 0, the number of duplicate trains.
;       INT(4) = History file additional output control switch.
;                 0 => Write no additional output to the history file.
;                 1 => Write the only the subroutine entry and exit
;                      messages to the history file.
;                 2 => Write some additional output to the history file.
;               3-4 => Write some more additional output to the history
;                      file.  Larger values generate more intermediate
;                      output.
;       INT(5)  = Coal cleaning, drying and grinding option control
;                 switch.  The name of the short plant report file
;                 written for each option is option dependent.
;                 0 => Base case - Coal cleaning by jigs for coal
;                      liquefaction in plant 2. (Report = DCL01B.REP)
;                 1 => Alternate case 1 - Coal cleaning by heavy media
;                      separation.  (Report = DCL01A1.REP)
;                 2 => Alternate case 2 - Coal cleaning by heavy media
;                      separation and spherical agglomeration.
;                      (Report = DCL01A2.REP)
;                 3 => Coal cleaning by jigs for coal gasification in
;                      plant 9.  (Report = DCL01G.REP)
;                 4 => Coal grinding and drying plant.
;                      (Report = DCL01D.REP)
;                NOTE: Values 0, 1 and 2 are used when this model
;                      cleans the coal going to the coal liquefaction
;                      plant, 3 is used only when this model cleans
;                      the coal going to the coal gasification plant,
;                      and 4 is for the grinding and drying plant.
   INT  0  1  0  1  0
;     The following 70 real parameters are:
;     REAL(1)   = Fraction of carbon in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(2)   = Fraction of carbon in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(3)   = Fraction of hydrogen in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(4)   = Fraction of hydrogen in the inlet coal leaving
;                 in the middling coal stream.
```

```
;       REAL(5)   = Fraction of nitrogen in the inlet coal leaving
;                   in the clean coal product stream.
;       REAL(6)   = Fraction of nitrogen in the inlet coal leaving
;                   in the middling coal stream.
;       REAL(7)   = Fraction of chlorine in the inlet coal leaving
;                   in the clean coal product stream.
;       REAL(8)   = Fraction of chlorine in the inlet coal leaving
;                   in the middling coal stream.
;       REAL(9)   = Fraction of sulfur in the inlet coal leaving
;                   in the clean coal product stream.  OPTIONAL - See Note 1.
;       REAL(10)  = Fraction of sulfur in the inlet coal leaving
;                   in the middling coal stream.  OPTIONAL - See Note 1.
;       REAL(11)  = Fraction of oxygen in the inlet coal leaving
;                   in the clean coal product stream.
;       REAL(12)  = Fraction of oxygen in the inlet coal leaving
;                   in the middling coal stream.
;       REAL(13)  = Fraction of ash in the inlet coal leaving
;                   in the clean coal product stream.
;       REAL(14)  = Fraction of ash in the inlet coal leaving
;                   in the middling coal stream.
;       REAL(15)  = Moisture content of the clean product coal on a dry
;                   basis, wt%.
;       REAL(16)  = Moisture content of the middling coal on a dry
;                   basis, wt%.
;       REAL(17)  = Moisture content of the refuse on a dry basis, wt%.
;       REAL(18) -
;        REAL(20) = Future use.
;       REAL(21)  = Constant factor for the power consumption, kw.
;       REAL(22)  = Power consumption per Mlbs/hr of dry clean coal,
;                   kw/(Mlbs/hr).
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(35)  = Constant factor for the plant fuel consumption,
```

```
;                    MM BTU/hr.
;      REAL(36)  = Plant fuel consumption per Mlbs/hr of dry clean coal,
;                  (MM BTU/hr)/(Mlbs/hr).
;      REAL(37)  = Constant factor for the cooling water consumption,
;                  Mgal/hr.
;      REAL(38)  = Cooling water consumption per Mlbs/hr of dry clean
;                  coal (Mgal/hr)/(Mlbs/hr).
;      REAL(39)  = Constant factor for the process water consumption,
;                  Mgal/hr.
;      REAL(40)  = Process water consumption per Mlbs/hr of dry clean
;                  coal, (Mgal/hr)/(Mlbs/hr).
;      REAL(41)  = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2.
;      REAL(42)  = Nitrogen consumption per Mlbs/hr of dry clean coal,
;                  (MM SCF/hr of N2)/(Mlbs/hr).
;      REAL(43) -
;       REAL(48) = Future use.
;      REAL(49)  = Constant factor for the number of operators per
;                  day, operators/day.
;      REAL(50)  = Number of operators per day per train,
;                  (operators/day)/train.
;      REAL(51)  = Reference flow rate of the dry clean coal of a
;                  single train in Mlbs/hr for the calculation of
;                  the ISBL field cost of a single train as a function
;                  of train capacity.
;      REAL(52)  = Maximum size of a single train as defined by the
;                  flow rate of the dry clean coal in Mlbs/hr.
;      REAL(53)  = Minimum size of a single train as defined by the
;                  flow rate of the dry clean coal in Mlbs/hr.
;      REAL(54)  = Constant A in the plant ISBL field cost equation.
;      REAL(55)  = Constant B in the plant ISBL field cost equation.
;      REAL(56)  = Constant E in the plant ISBL field cost equation.
;      REAL(57)  = Constant F in the plant ISBL field cost equation.
;      REAL(58)  = Number of spare trains.
;      REAL(59) -
;       REAL(70) = Future use.
;
;    NOTES:
;      1. If both the sulfur distribution factors, REAL(9) and REAL(10),
;         are zero and a SULFANAL was supplied, the sulfur will be
;         distributed among the products as follows.
;         a. The ORGANIC sulfur will be distributed in the same
;            proportions as the carbon is distributed.
;         b. The PYRITIC and SULFATE sulfur will be distributed in the
;            same proportions as the ash is distributed.
;
;         FCP          FCM    FHP          FHM    FNP          FNM
     REAL 0.9302390    0.0    0.9142857    0.0    0.9533333    0.0  &
;         FClP         FClM   FSP          FSM    FOP          FOM
          0.40000      0.0    0.5019608    0.0    0.9696970    0.0  &
;         FAP          FAM
          0.4229677    0.0  &
;         PCWP   PCWM  PCWR  Future Use (3 items)
          8.576  3.0   10.0  0.0   0.0   0.0                     &
;         Power              900/750 F steam   900 satd steam
```

```
          0.0 4.281977      0.0 0.0           0.0 0.0       &
;         600/720 F steam   600 satd steam    150 satd steam
          0.0 0.0           0.0 0.0           0.0 0.0       &
;         50 satd steam     Plant fuel        Cooling  H2O
          0.0 0.0           0.0 0.0           0.0 0.0       &
;         Process H2O       Nitrogen
          0.0 0.02433102    0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          8.0           8.0                 &
;         Ref Flow   Max Flow   Min Flow
          387.158    390.0      200.0      &
;         Plant cost equation constants.
;         A      B      E      F      Spares   Future use (2 items)
          0.0    18.2   0.5942 1.0    0.0      0.0   0.0       &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S02    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S03    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S04    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S05    KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 1.4 - Coal Grinding and Drying Plant - Fortran Model USR01
;             BASE CASE
BLOCK P14 USER
   SUBROUTINE MODEL = USR01   REPORT = USR01
   DESCRIPTION 'PLANT 1.4 - BASE CASE - COAL GRINDING AND DRYING PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following integer and real parameters have the same meaning
;      as described above for Plant 1 in BLOCK P1-BASE.
    INT  0  1  0  1  4
;         FCP          FCM    FHP          FHM    FNP          FNM
     REAL 1.0          0.0    1.0          0.0    1.0          0.0  &
;         FC1P         FC1M   FSP          FSM    FOP          FOM
          1.0          0.0    1.0          0.0    1.0          0.0  &
;         FAP          FAM
          1.0          0.0   &
;         PCWP   PCWM  PCWR  Future Use (3 items)
          2.0    3.0   10.0  0.0   0.0   0.0                     &
;         Power              900/750 F steam   900 satd steam
          0.0 8.499979       0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 0.0           0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 0.3410096     0.0 0.010104  &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 3.16015     &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          7.0           1.0                 &
```

```
;          Ref Flow   Max Flow   Min Flow
           142.518    145.0      50.0        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future use (2 items)
           0.0    8.75    0.8504 1.0    0.0      0.0   0.0       &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = COALTO2  KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-XMID KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-REF  KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-WAT  KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 2 - The coal liquefaction plant - T/C Option - Fortran USR02.
;   NOTE - This block has different parameters than the Baseline block.
BLOCK P02TC USER
   SUBROUTINE MODEL = USR02   REPORT = USR02
   DESCRIPTION 'PLANT 2 - T/C OPTION COAL LIQUEFACTION PLANT'
   PARAM  NINT = 6   NREAL = 70
;      The following 5 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL02.REP.
;      INT(3) = Number of operating duplicate plants, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 plants will be determined so that the capacity
;                 of each plant does not exceed the maximum plant
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate plants.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
;      INT(5) = Switch to write the major equipment summary list and
;               cost summary report by plant section for the baseline
;               design to the separate block output summary report file
;               called DCL02.REP on logical unit 62.
;               0 => Do not write the major equipment summary list.
;               1 => Write the major equipment summary list to the
```

```
;                    separate block output file only when
;                    INT(1) <= 2, INT(2) = 1, and INT(6) = 0.
;               2 => Write the major equipment summary list and the
;                    cost summary report by plant section to the
;                    separate block output file only when
;                    INT(1) <= 2, INT(2) = 1, and INT(6) = 0.
;     INT(6) = Switch to select which coal liquefaction reactor yields
;              are calculated.
;              0 => Baseline design two-reactor model.
;              3 => Option 3 - Yields for Thermal/Catalytic two-
;                   reactor model.
;              4 => Option 4 - Two-reactor model with interstaage
;                   vent gas separation.
;              5 => Option 5 - Yields for two-reactor coker model.
;              8 => Improved Baseline (Option 8) - High space velocity
;                   two-reactor model.
   INT  0  1  0  1  2  3
;     The following 70 real parameters are:
;     REAL(1)    = Percent coal conversion based on fresh MAF coal
;                  entering the coal liquefaction reactors.
;     REAL(2)-
;      REAL(20) = Future use.
;     REAL(21)   = Constant factor for the power consumption, kw.
;     REAL(22)   = Power consumption per Mlbs/hr of dry coal feed,
;                  kw/(Mlbs/hr of dry coal).
;     REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;     REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(25)   = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;     REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(29)   = Constant factor for the 600 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(31)   = Constant factor for the 150 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(33)   = Constant factor for the 50 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(35)   = Constant factor for the plant fuel consumption,
;                  MM BTU/hr.
;     REAL(36)   = Plant fuel consumption per Mlbs/hr of dry coal feed,
;                  (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(37)   = Constant factor for the cooling water consumption,
;                  Mgal/hr.
```

```
;       REAL(38)  = Cooling water consumption per Mlbs/hr of dry coal
;                   feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of dry coal
;                   feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of dry coal feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of dry coal).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference dry coal feed rate to a single plant in
;                   Mlbs/hr for the calculation of the capital cost of a
;                   single plant as a function of plant capacity.
;       REAL(52)  = Maximum size of a single plant as defined by the dry
;                   coal feed rate in Mlbs/hr of dry coal.
;       REAL(53)  = Minimum size of a single plant as defined by the dry
;                   coal feed rate in Mlbs/hr of dry coal.
;       REAL(54)  = Constant A in the plant costing equation.
;       REAL(55)  = Constant B in the plant costing equation.
;       REAL(56)  = Constant E in the plant costing equation.
;       REAL(57)  = Constant F in the plant costing equation.
;       REAL(58)  = Number of spare plants.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Percent fresh MAF coal conversion
     REAL 92.7901  &
;          Future use (9 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0    &
;          Power              900/750 F steam    900 satd steam
           0.0 47.6583        0.0 0.0            0.0 0.0        &
;          600/720 F steam    600 satd steam     150 satd steam
           0.0 0.0044963      0.0 -0.120468      0.0 -0.072790  &
;          50 satd steam      Plant fuel         Cooling H2O
           0.0 0.0453371      0.0 0.880599       0.0 0.3924172 &
;          Process H2O        Nitrogen
           0.0 0.1020512      0.0 0.000029236 &
;          Future Use (6 items)
           0.0  0.0  0.0 0.0  0.0  0.0       &
;          Opers/day     (Opers/day)/train
           0.0           8.0                 &
;          Ref Flow   Max Flow   Min Flow
           203.597    203.600    20.0        &
;          Plant cost equation constants.
;          A      B      E      F      Spares   Future use (2 items)
           0.0    142.4  0.7142 1.0    0.       0.0   0.0   &
```

```
;         Future use (10 items)
          0.  0.  0.  0.  0.  0.  0.  0.  0.  0.
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR02.
   FLASH-SPECS STRM=2S-GAS KODE=2 TEMP=130.0 PRES=2985.0 NPK=1 KPH=1 /
               STRM = GASES     KODE=2   TEMP = 130.0  PRES = 65.0   /
               STRM = NAPHTHA   KODE=2   TEMP = 140.0  PRES = 16.0   /
               STRM = GAS-OIL   KODE=2   TEMP = 110.0  PRES = 30.0   /
               STRM = 2S-BOTTS  KODE=2   TEMP = 688.0  PRES = 28.0   /
               STRM = 2S-SH2O   KODE=2   TEMP = 100.0  PRES = 30.0
;
BLOCK P02A SEP
  DESCRIPTION 'GENERATION OF 850-1000 F AND ROSE FEED STREAMS'
  FRAC  SUBS = MIXED  STREAM = S2-GASIF                    &
  COMP = T675 T725 T775 T825 T875 T925 T975 T1000+         &
  FRAC = .5625 .5625 .5625 .5625 .76271 .76271 .76271  .00100587
;
; Plant 3 - The gas plant - use user Fortran block USR03.
BLOCK P03 USER
   SUBROUTINE MODEL = USR03   REPORT = USR03
   DESCRIPTION 'PLANT 3 - THE GAS PLANT - WITH T/C OPTION CONSTANTS'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL03.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
```

```
;       REAL(22)  = Power consumption per MM SCF/hr of dry C4- gas,
;                   kw/(MM SCF/hr of dry C4- gas)
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of dry C4- gas,
;                   (MM BTU/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of dry C4-
;                   gas, (Mgal/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of dry C4-
;                   gas, (Mgal/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of dry C4- gas,
;                   (MM SCF/hr of N2)/(MM SCF/hr of dry C4- gas).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference gas feed rate to a single train in
;                   MM SCF/hr of dry C4- gas for the calculation of
;                   the ISBL field cost of a single train as a function
;                   of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   gas feed rate in MM SCF/hr of dry C4- gas.
;       REAL(53)  = Minimum size of a single train as defined by the
```

```
;                   gas feed rate in MM SCF/hr of dry C4- gas.
;      REAL(54)  = Constant A in the plant ISBL field cost equation.
;      REAL(55)  = Constant B in the plant ISBL field cost equation.
;      REAL(56)  = Constant E in the plant ISBL field cost equation.
;      REAL(57)  = Constant F in the plant ISBL field cost equation.
;      REAL(58)  = Number of spare trains.
;      REAL(59) -
;       REAL(70) = Future use.
;
;         Future use (10 items)
     REAL 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Future use (10 items)
         0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
         0.0 359.5931       0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
         0.0 0.0            0.0 156.141       0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling  H2O
         0.0 6.765          0.0 -778.06       0.0 518.602   &
;         Process H2O        Nitrogen
         0.0 0.0            0.0 0.0         &
;         Future Use (6 items)
         0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
         0.0            8.0               &
;         Ref Flow   Max Flow   Min Flow
         2.04       5.0        0.300      &
;         Plant cost equation constants.
;         A      B          E      F      Spares   Future Use (3 items)
         0.0    21.2       0.8013 1.0    0.0      0.0   0.0   &
;         Future Use (10 items)
         0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR03.
   FLASH-SPECS STRM = 3S-SGAS   KODE=2  TEMP = 137.0  PRES = 55.0   /
               STRM = 3S-FGAS   KODE=2  TEMP = 100.0  PRES = 215.0  /
               STRM = 3S-PROP   KODE=2  TEMP = 100.0  PRES = 280.0  /
               STRM = 3S-BUT    KODE=2  TEMP = 100.0  PRES = 280.0  /
               STRM = 3S-OIL    KODE=2  TEMP = 130.0  PRES = 263.0  &
                      NPK=1 KPH=2 /
               STRM = 3S-SH2O   KODE=2  TEMP = 137.0  PRES = 55.0
;
; Plant 4 - The naphtha hydrotreater - use user Fortran block USR04.
BLOCK P04 USER
   SUBROUTINE MODEL = USR04   REPORT = USR04
   DESCRIPTION 'PLANT 4 - THE NAPHTHA HYDROTREATER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
```

```
;                3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;                0 => Write the user block summary report to the mormal
;                      ASPEN/SP output report file.
;                1 => Write the user block summary report to a separate
;                     user block output report file on logical unit 62
;                     called DCL04.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;                If INT(3) = 0, the minimum number of duplicate
;                  trains will be determined so that the capacity
;                  of each plant does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Percent desulfurization of the C5+ feed; i. e.,
;                   Percent of sulfur removed from the entering C5+ feed.
;      REAL(2)    = Percent denitrogenation of the C5+ feed; i. e.,
;                   Percent of nitrogen removed from the entering C5+ feed.
;      REAL(3)    = Percent deoxygenation of the C5+ feed.
;                   Percent of oxygen removed from the entering C5+ feed.
;      REAL(4)    = Chemical hydrogen consumption in SCF/bbl of C5+ feed.
;      REAL(5) -
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per Mlbs/hr of C5+ feed,
;                   kw/(Mlbs/hr of C5+ feed).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
```

```
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of C5+ feed,
;                   (MM BTU/hr)/(Mlbs/hr of C5+ feed).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of C5+ feed,
;                   (Mgal/hr)/(Mlbs/hr of C5+ feed).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of C5+ feed,
;                   (Mgal/hr)/(Mlbs/hr of C5+ feed).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of C5+ feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of C5+ feed).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference C5+ feed rate to a single train in Mlbs/hr
;                   for the calculation of the ISBL field cost of a
;                   single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   C5+ feed rate in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   C5+ feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          % Desulfurization   % Denitrogenation
     REAL 99.99                99.988       &
;          % Deoxygenation    Chemical H2 consumption in SCF/bbl C5+ feed
           99.5               125.0        &
;          Future use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0     &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 5.098308       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.126493      0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 0.0            0.0 0.351607      0.0 0.730963  &
```

```
;          Process H2O       Nitrogen
           0.0 0.010833      0.0 0.0          &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0       &
;          Opers/day     (Opers/day)/train
           0.0            8.0                 &
;          Ref Flow   Max Flow   Min Flow
           210.462    400.0      50.0         &
;          Plant cost equation constants.
;          A      B      E      F      Spares   Future Use (3 items)
           0.0    15.6   0.7843 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR04.
   FLASH-SPECS STRM = 4S-GAS   KODE=2  TEMP = 135.0  PRES = 915.0  /
               STRM = 4S-NAPH  KODE=2  TEMP = 100.0  PRES = 153.0  /
               STRM = 4S-SH2O  KODE=2  TEMP =  70.0  PRES = 14.7
;
; Plant 5 - The gas-oil hydrotreater - use user Fortran block USR05.
BLOCK P05 USER
   SUBROUTINE MODEL = USR05   REPORT = USR05
   DESCRIPTION 'PLANT 5 - THE GAS-OIL HYDROTREATER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL05.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
```

```
;       REAL(1)   = Percent desulfurization of the C6+ feed; i. e.,
;                   Percent of sulfur removed from the entering C6+ feed.
;       REAL(2)   = Percent denitrogenation of the C6+ feed; i. e.,
;                   Percent of nitrogen removed from the entering C6+ feed.
;       REAL(3)   = Percent deoxygenation of the C6+ feed.
;                   Percent of oxygen removed from the entering C6+ feed.
;       REAL(4)   = Chemical hydrogen consumption in SCF/bbl of C6+ feed.
;       REAL(5) -
;        REAL(20) = Future use.
;       REAL(21)  = Constant factor for the power consumption, kw.
;       REAL(22)  = Power consumption per Mlbs/hr of C6+ feed,
;                   kw/(Mlbs/hr).
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of C6+ feed,
;                   (MM BTU/hr)/(Mlbs/hr).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of C6+ feed,
;                   (Mgal/hr)/(Mlbs/hr).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of C6+ feed,
;                   (Mgal/hr)/(Mlbs/hr).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of C6+ feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
```

```
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference C6+ feed rate to a single train in Mlbs/hr
;                   for the calculation of the ISBL field cost of a
;                   single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   C6+ feed rate in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   C6+ feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          % Desulfurization   % Denitrogenation
     REAL 92.5                 85.2        &
;          % Deoxygenation   Chemical H2 consumption in SCF/bbl C6+ feed
           97.6              947.00        &
;          Future use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0   &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power             900/750 F steam   900 satd steam
           0.0 3.247198      0.0 0.0           0.0 0.0       &
;          600/720 F steam   600 satd steam    150 satd steam
           0.0 0.0           0.0 0.096936      0.0 -0.050465 &
;          50 satd steam     Plant fuel        Cooling  H20
           0.0 0.0           0.0 0.241416      0.0 0.735694 &
;          Process H20       Nitrogen
           0.0 0.0           0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0            4.0               &
;          Ref Flow   Max Flow   Min Flow
           671.04     800.0      150.0      &
;          Plant cost equation constants.
;          A      B      E      F      Spares   Future Use (2 items)
           0.0    74.0   0.7467 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR05.
;  The 5S-LPGAS and 5S-NAPH temperature and pressure are those leaving
;  Plant 4 where this fractionation is actually performed.
   FLASH-SPECS STRM = 5S-HPGAS  KODE=2  TEMP = 135.0  PRES = 2690.0 /
               STRM = 5S-LPGAS  KODE=2  TEMP = 135.0  PRES = 915.0  /
               STRM = 5S-NAPH   KODE=2  TEMP = 100.0  PRES = 153.0  /
               STRM = P350-450  KODE=2  TEMP = 110.0  PRES = 80.0   /
               STRM = P450-650  KODE=2  TEMP = 135.0  PRES = 20.0   /
```

```
              STRM = P650-850  KODE=2  TEMP = 135.0  PRES = 20.0   /
              STRM = 5S-SH2O   KODE=2  TEMP = 135.0  PRES = 20.0
;
; Plant 6.1 - The Hydrogen purification by Membrane Separation Plant.
BLOCK P61 USER
   SUBROUTINE MODEL = USR61   REPORT = USR61
   DESCRIPTION 'PLANT 6.1 - THE MEMBRANE H2 PURIFICATION PLANT - T/C Cost'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL61.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Percent hydrogen recovery to the hydrogen-rich
;                  product gas stream from the inlet gas stream.
;      REAL(2)   = Concentration of hydrogen in the hydrogen-rich
;                  product gas stream, mole % or vol%.
;      REAL(3)-
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per MM SCF/hr of H2 recovered,
;                  kw/(MM SCF/hr of H2 recovered).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr of
;                  H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(25)  = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr
;                  of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
```

```
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of H2 recovered,
;                   (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of H2 recovered,
;                   (MMM SCF/hr of N2)/(MM SCF/hr of H2 recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference hydrogen recovery rate for a single train
;                   in MM SCF/hr of H2 for the calculation of the
;                   ISBL field cost of a single train as a function of
;                   capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
```

```
;
;         Percent H2 recovery    H2 purity in mole %
     REAL 43.83285               99.98677                    &
;         Future use (8 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0            &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 12254.04       0.0 0.0           0.0 0.0      &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 0.0           0.0 0.0      &
;         50 satd steam      Plant fuel        Cooling H2O
          0.0 2.054966       0.0 0.0           0.0 42.705864 &
;         Process H2O        Nitrogen
          0.0 0.854117       0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.0            12.0               &
;         Ref Flow   Max Flow   Min Flow
          1.966943   2.5        0.5        &
;         Plant cost equation constants.
;         A      B         E      F      Spares   Future use (2 items)
          0.0    174.3     0.8478 1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR61.
   FLASH-SPECS STRM = H2-RICH   KODE=2   TEMP = 100.0  PRES = 3290.0 /
               STRM = SOUR-GAS  KODE=2   TEMP = 250.0  PRES = 14.7   /
               STRM = P61-GAS   KODE=2   TEMP = 111.0  PRES = 500.0
;
; Plant 6.2 - The Hydrogen purification by Pressure Swing Absorption
;             Plant.
BLOCK P62 USER
   SUBROUTINE MODEL = USR62   REPORT = USR62
   DESCRIPTION 'PLANT 6.2 - THE PSA H2 PURIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL62.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
```

```
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;     The following 70 real parameters are:
;     REAL(1)    = Percent hydrogen recovery to the hydrogen-rich
;                  product gas stream from the inlet gas stream.
;     REAL(2)    = Concentration of hydrogen in the hydrogen-rich
;                  product gas stream, mole % or vol%.
;     REAL(3)-
;      REAL(20)  = Future use.
;     REAL(21)   = Constant factor for the power consumption, kw.
;     REAL(22)   = Power consumption per MM SCF/hr of H2 recovered,
;                  kw/(MM SCF/hr of H2 recovered).
;     REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;     REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                  H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;     REAL(25)   = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr
;                  of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;     REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;     REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr of
;                  H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;     REAL(29)   = Constant factor for the 600 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(30)   = 600 psig saturated steam consumption per MM SCF/hr of
;                  H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;     REAL(31)   = Constant factor for the 150 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(32)   = 150 psig saturated steam consumption per MM SCF/hr of
;                  H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;     REAL(33)   = Constant factor for the 50 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(34)   = 50 psig saturated steam consumption per MM SCF/hr of
;                  H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;     REAL(35)   = Constant factor for the plant fuel consumption,
;                  MM BTU/hr.
;     REAL(36)   = Plant fuel consumption per MM SCF/hr of H2 recovered,
;                  (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;     REAL(37)   = Constant factor for the cooling water consumption,
;                  Mgal/hr.
;     REAL(38)   = Cooling water consumption per MM SCF/hr of H2
;                  recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
```

```
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of H2 recovered,
;                   (MMM SCF/hr of N2)/(MM SCF/hr of H2 recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference hydrogen recovery rate for a single train
;                   in MM SCF/hr of H2 for the calculation of the
;                   ISBL field cost of a single train as a function of
;                   capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;        The cost of Plant 6.2 is included in Plant 6.1.
;          Percent H2 recovery    H2 purity in mole %
     REAL 89.5033                90.01665              &
;          Future use (8 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 5485.989       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.0           0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling H2O
           0.0 15.32654       0.0 0.0           0.0 87.29583  &
;          Process H2O        Nitrogen
           0.0 0.530875       0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0           0.0                 &
;          Ref Flow   Max Flow   Min Flow
           3.61667    5.0        0.5        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future use (2 items)
```

```
          0.0    0.0     0.7    1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR62.
   FLASH-SPECS STRM = H2-2RICH  KODE=2   TEMP = 100.0  PRES = 3290.0 /
               STRM = SOUR-2GS  KODE=2   TEMP = 250.0  PRES = 14.7   /
               STRM = GAS-OUT   KODE=2   TEMP = 111.0  PRES = 25.0   /
               STRM = NAPHTHA2  KODE=2   TEMP = 100.0  PRES = 50.0
;
; Plant 7 - The naphtha reformer - use user Fortran block USR07.
BLOCK P07 USER
   SUBROUTINE MODEL = USR07   REPORT = USR07
   DESCRIPTION 'PLANT 7 - THE NAPHTHA REFORMER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL07.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;     The following 70 real parameters are:
;     REAL(1) -
;      REAL(20) = Future use.
;     REAL(21)  = Constant factor for the power consumption, kw.
;     REAL(22)  = Power consumption per Mlbs/hr of feed,
;                 kw/(Mlbs/hr of feed).
;     REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                 consumption, Mlbs/hr.
;     REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                 feed, (Mlbs/hr)/(Mlbs/hr of feed).
```

```
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of feed,
;                   (MM BTU/hr)/(Mlbs/hr of feed).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of feed,
;                   (Mgal/hr)/(Mlbs/hr of feed).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of feed,
;                   (Mgal/hr)/(Mlbs/hr of feed).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of feed).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference feed rate to a single train in Mlbs/hr
;                   for the calculation of the ISBL field cost of a
;                   single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   feed rate in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
```

```
;       REAL(70) = Future use.
;
;          Future use (10 items)
     REAL 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
          0.0 2.26494        0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
          0.0 -0.314772      0.0 0.0           0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 1.41781       0.0 0.123590  &
;          Process H2O        Nitrogen
          0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0       &
;          Opers/day     (Opers/day)/train
          0.            8.                  &
;          Ref Flow   Max Flow   Min Flow
          224.289    400.0      50.0        &
;          Plant cost equation constants.
;          A      B      E      F      Spares   Future Use (3 items)
          0.0    30.7   0.75   1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0

;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR07.
   FLASH-SPECS STRM = 7S-H2     KODE=2   TEMP = 80.0  PRES = 14.7  /
               STRM = 7S-GAS    KODE=2   TEMP = 80.0  PRES = 14.7  /
               STRM = REFORMED  KODE=2   TEMP = 80.0  PRES = 14.7
;
; Plant 8.1 - The ROSE-SR unit - user Fortran block USR81.
BLOCK P81 USER
   SUBROUTINE MODEL = USR81   REPORT = USR81
   DESCRIPTION 'PLANT 8.1 - THE ROSE-SR UNIT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL81.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
```

```
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate plants.
;     INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;     The following 70 real parameters are:
;     REAL(1)   = Hydrocarbon rejection factor.
;     REAL(2)-
;      REAL(20) = Future use.
;     REAL(21)  = Constant factor for the power consumption, kw.
;     REAL(22)  = Power consumption per Mlbs/hr of extract,
;                 kw/(Mlbs/hr of extract).
;     REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                 consumption, Mlbs/hr.
;     REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                 extract, (Mlbs/hr)/(Mlbs/hr of extract).
;     REAL(25)  = Constant factor for the 900 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                 extract, (Mlbs/hr)/(Mlbs/hr of extract).
;     REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                 consumption, Mlbs/hr.
;     REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                 extract, (Mlbs/hr)/(Mlbs/hr of extract).
;     REAL(29)  = Constant factor for the 600 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                 extract, (Mlbs/hr)/(Mlbs/hr of extract).
;     REAL(31)  = Constant factor for the 150 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                 extract, (Mlbs/hr)/(Mlbs/hr of extract).
;     REAL(33)  = Constant factor for the 50 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                 extract, (Mlbs/hr)/(Mlbs/hr of extract).
;     REAL(35)  = Constant factor for the plant fuel consumption,
;                 MM BTU/hr.
;     REAL(36)  = Plant fuel consumption per Mlbs/hr of extract,
;                 (Mlbs/hr)/(Mlbs/hr of extract).
;     REAL(37)  = Constant factor for the cooling water consumption,
;                 Mgal/hr.
;     REAL(38)  = Cooling water consumption per Mlbs/hr of extract,
;                 (Mlbs/hr)/(Mlbs/hr of extract).
;     REAL(39)  = Constant factor for the process water consumption,
;                 Mgal/hr.
;     REAL(40)  = Process water consumption per Mlbs/hr of extract,
;                 (Mlbs/hr)/(Mlbs/hr of extract).
;     REAL(41)  = Constant factor for the nitrogen consumption,
```

```
;                    MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of extract,
;                   (MM SCF/hr of N2)/(Mlbs/hr of extract).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference feed rate to a single train in Mlbs/hr of
;                   unit feed for the calculation of the capital cost of
;                   a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   unit feed rate in Mlbs/hr of unit feed.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   unit feed rate in Mlbs/hr of unit feed.
;       REAL(54)  = Constant A in the plant costing equation.
;       REAL(55)  = Constant B in the plant costing equation.
;       REAL(56)  = Constant E in the plant costing equation.
;       REAL(57)  = Constant F in the plant costing equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;          Hydrocarbon rejection factor
    REAL  1.0  &
;          Future use (9 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam    900 satd steam
           0.0 8.098677       0.0 0.0            0.0 0.0       &
;          600/720 F steam    600 satd steam     150 satd steam
           0.0 0.0            0.0 0.0            0.0 0.0471832 &
;          50 satd steam      Plant fuel         Cooling H2O
           0.0 0.0            0.0 0.393518       0.0 0.0       &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.  0.  0.  0.  0.  0.             &
;          Opers/day     (Opers/day)/train
           0.0           8.0                  &
;          Ref Flow   Max Flow   Min Flow
           907.390   1500.0     500.0         &
;          Plant cost equation constants.
;          A      B        E      F      Spares   Future use (2 items)
           0.0    42.2     0.7215 1.0    0.0      0.0   0.0    &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR81.
   FLASH-SPECS STRM = ROSE-XTR  KODE=2   TEMP = 300.0  PRES = 115.0 /
               STRM = ASH-CONC  KODE=2   TEMP = 150.0  PRES = 14.7
;
; Plant 9 - H2 Production by coal gasification, Use the User Fortran
```

```
; Block USR09.
BLOCK P09 USER
   SUBROUTINE MODEL = USR09   REPORT = USR09
   DESCRIPTION 'PLANT 9 - H2 PRODUCTION BY COAL GASIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file called DCL09.REP.
;               1 => Write the user block summary report to a separate
;                     user block output report file on logical unit 62.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Molar CO/CO2 ratio in the gasifier product gas.
;      REAL(2)   = Fraction of carbon entering the gasifier that goes
;                  to carbonyl sulfide (COS).
;      REAL(3)   = Fraction of carbon entering the gasifier that goes
;                  to methane (CH4).
;      REAL(4)   = Fraction of nitrogen entering the gasifier that goes
;                  to ammonia (NH3).
;      REAL(5)   = Carbon content of the slag produced by the gasifier,
;                  wt %.
;      REAL(6)   = Fraction of carbon monoxide (CO) entering the shift
;                  reactors that is shifted; i.e., converted to carbon
;                  dioxide (CO2) by the chemical reaction
;                      CO + H2O -----> CO2 + H2
;      REAL(7)   = Fraction of carbonyl sulfide (COS) entering the shift
;                  reactor section that is hydrolyzed; i.e., converted
;                  to carbon dioxide (CO2) and hydrogen sulfide (H2S)
;                  by the chemical reaction
;                      COS + H2O -----> CO2 + H2S
;      REAL(8)   = Future use.
;      REAL(9)-
;       REAL(20) = Rectisol section component distribution factors,
```

```
;                    where
;      REAL(9)    = Fraction of inlet H2 going to the hydrogen-rich
;                   gas stream.
;      REAL(10)   = Fraction of inlet H2 going to the acid gas stream.
;      REAL(11)   = Fraction of inlet CO going to the hydrogen-rich
;                   gas stream.
;      REAL(12)   = Fraction of inlet CO going to the acid gas stream.
;      REAL(13)   = Fraction of inlet CO2 going to the hydrogen-rich
;                   gas stream.
;      REAL(14)   = Fraction of inlet CO2 going to the acid gas stream.
;      REAL(15)   = Fraction of inlet CH4 going to the hydrogen-rich
;                   gas stream.
;      REAL(16)   = Fraction of inlet CH4 going to the acid gas stream.
;      REAL(17)   = Fraction of inlet N2 going to the hydrogen-rich
;                   gas stream.
;      REAL(18)   = Fraction of inlet N2 going to the acid gas stream.
;      REAL(19)   = Fraction of inlet H2S going to the hydrogen-rich
;                   gas stream.
;      REAL(20)   = Fraction of inlet H2S going to the acid gas stream.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per MM SCF/hr of hydrogen
;                   produced, kw/(MM SCF/hr of H2).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per MM SCF/hr of hydrogen
;                   produced, (MM BTU/hr)/(MM SCF/hr of H2).
;      REAL(37)   = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;      REAL(38)   = Cooling water consumption per MM SCF/hr of hydrogen
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;      REAL(39)   = Constant factor for the process water consumption,
```

```
;                    Mgal/hr.
;      REAL(40)  = Process water consumption per MM SCF/hr of hydrogen
;                  produced, (Mgal/hr)/(MM SCF/hr of H2).
;      REAL(41)  = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2.
;      REAL(42)  = Nitrogen consumption per MM SCF/hr of hydrogen
;                  produced, (MM SCF/hr of N2)/(MM SCF/hr of H2).
;      REAL(43) -
;       REAL(48) = Future use.
;      REAL(49)  = Constant factor for the number of operators per
;                  day, operators/day.
;      REAL(50)  = Number of operators per day per operating train,
;                  (operators/day)/train.
;      REAL(51)  = Reference hydrogen production rate of a single train
;                  in MM SCF/hr of H2 for the calculation of the ISBL
;                  field cost of a single train as a function of train
;                  capacity.
;      REAL(52)  = Maximum size of a single train as defined by the
;                  hydrogen production rate in MM SCF/hr of H2.
;      REAL(53)  = Minimum size of a single train as defined by the
;                  hydrogen production rate in MM SCF/hr of H2.
;      REAL(54)  = Constant A in the plant ISBL field cost equation.
;      REAL(55)  = Constant B in the plant ISBL field cost equation.
;      REAL(56)  = Constant E in the plant ISBL field cost equation.
;      REAL(57)  = Constant F in the plant ISBL field cost equation.
;      REAL(58)  = Number of spare plants.
;      REAL(59) -
;       REAL(70) = Future use.
;
;  NOTE:  MM SCF/hr of hydrogen produced means MM SCF/hr of hydrogen
;         in the hydrogen-rich product gas stream and NOT the total
;         flow rate of the hydrogen-rich product gas stream.
;
;                    Frac C       Frac C   Frac N   %C in
;         CO/CO2     to COS       to CH4   to NH3   slag
     REAL 2.419768  0.000804005  0.0      0.05212  5.229154  &
;         Frac CO shifted  Frac COS hydrolyzed  Future use
;         Adjust the fraction of CO shifted to get Coal rate for the
;         Thermal/catalytic option
          0.855            0.9516917            0.0          &
;         Component distribution factors for H2 to H2 and acid gas.
          0.8344      0.00153604                             &
;         Component distribution factors for CO to H2 and acid gas.
          0.0         0.0545937                              &
;         Component distribution factors for CO2 to H2 and acid gas.
          0.0         0.0453275                              &
;         Component distribution factors for CH4 to H2 and acid gas.
          0.0         0.0                                    &
;         Component distribution factors for N2 to H2 and acid gas.
          0.0932727   0.0923972                              &
;         Component distribution factors for H2S to H2 and acid gas.
          0.0         0.990203                               &
;         Power              900/750 F steam   900 satd steam
          0.0 3679.14335     0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
```

```
          0.0 0.0            0.0 -16.98424     0.0 -44.40466  &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 -45.47563      0.0 -57.09919     0.0 183.6952   &
;         Process H2O        Nitrogen
          0.0 4.176796       0.0 0.0824568   &
;         Future Use (6 items)
          0.  0.  0.  0.  0.  0.             &
;         Opers/day      (Opers/day)/train
          0.0            24.                 &
;         Ref Flow   Max Flow   Min Flow
          3.436      3.5        1.0         &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future use (3 items)
          0.0    52.7    0.7658 1.0    0.       0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR09.
   FLASH-SPECS STRM = H2-GAS    KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = H2S-GAS   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = VENT-GAS  KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = 9S-SH2O   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = SLAG      KODE=2   TEMP = 80.   PRES = 14.7
;
;  Plant 9.1 - Steam Reforming of Natural Gas Plant.
BLOCK P91 USER
   SUBROUTINE MODEL = USR91   REPORT = USR91
   DESCRIPTION 'PLANT 9.1 - STEAM REFORMING OF NATURAL GAS PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL91.REP.
;      INT(3) = Number of operating duplicate plants, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 plants will be determined so that the capacity
;                 of each plant does not exceed the maximum plant
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, this number of duplicate plants will
;                 be used.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
```

```
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
     INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Fraction of CH4 reacting to produce H2 and CO2.
;      REAL(2)   = Fraction of CH4 reacting to produce H2 and CO.
;      REAL(3)   = Fraction of hydrogen produced that leaves in the
;                  hydrogen-rich product gas stream.
;      REAL(4)   = Purity of the hydrogen-rich product gas. mole %.
;      REAL(5) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per MM SCF/hr of hydrogen produced,
;                  kw/(MM SCF/hr of H2).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr of
;                  hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(25)  = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr of
;                  hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;      REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr of
;                  hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(29)  = Constant factor for the 600 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr of
;                  hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(31)  = Constant factor for the 150 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                  hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(33)  = Constant factor for the 50 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                  hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(35)  = Constant factor for the plant fuel consumption,
;                  MM BTU/hr.
;      REAL(36)  = Plant fuel consumption per MM SCF/hr of hydrogen
;                  produced, (MM BTU/hr)/(MM SCF/hr of H2).
;      REAL(37)  = Constant factor for the cooling water consumption,
;                  Mgal/hr.
;      REAL(38)  = Cooling water consumption per MM SCF/hr of hydrogen
;                  produced, (Mgal/hr)/(MM SCF/hr of H2).
;      REAL(39)  = Constant factor for the process water consumption,
;                  Mgal/hr.
;      REAL(40)  = Process water consumption per MM SCF/hr of hydrogen
;                  produced, (Mgal/hr)/(MM SCF/hr of H2).
;      REAL(41)  = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2..
;      REAL(42)  = Nitrogen consumption per MM SCF/hr of hydrogen
```

```
;                    produced, (MM SCF/hr of N2)/(MM SCF/hr of H2).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
;       REAL(51)  = Reference hydrogen production rate of a single train
;                   in MM SCF/hr of H2 for the calculation of the ISBL
;                   field cost of a single train as a function of train
;                   capacity.
;       REAL(52)  = Maximum plant size as defined by the hydrogen
;                   production rate in MM SCF/hr of H2.
;       REAL(53)  = Minimum plant size as defined by the hydrogen
;                   production rate in MM SCF/hr of H2.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare plants.
;       REAL(59) -
;        REAL(70) = Future use.
;
;  NOTES: 1. MM SCF/hr of hydrogen produced means MM SCF/hr of hydrogen
;            in the hydrogen rich product gas stream and NOT the total
;            flow rate of the hydrogen rich product gas stream.
;         2. The number of operators in this plant and Plants 31.1 and
;            31.4 is set so as to maintain the same total number of
;            operators as used for the baseline design.
;
;         Frac CH4 to CO2  Frac CH4 to CO  Frac recovered  H2 Purity
     REAL 0.638648         0.04429         0.8862694       100.0 &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0                      &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 354.158        0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 -65.3773      0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling  H20
          0.0 0.0            0.0 89.0448       0.0 32.6902   &
;         Process H20        Nitrogen
          0.0 0.0            0.0 0.0           &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0         &
;         Opers/day      (Opers/day)/train
          0.0            8.0                   &
;         Ref Flow       Max Flow     Min Flow
          5.77237        6.25         2.0      &
;         Plant cost equation constants.
;         A      B      E      F      Spares   Future Use (2 items)
          0.0    68.1   0.75   1.0    0.0      0.0    0.0    &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0
```

```
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR091.
   FLASH-SPECS STRM = H2-PROD    KODE=2  TEMP = 100.0  PRES = 500.0 /
               STRM = FLUE-GAS   KODE=2  TEMP = 250.0  PRES = 14.7
;
; Plant 10 - Air Separation Plant - Use the User Fortran Model USR10.
BLOCK P10 USER
   SUBROUTINE MODEL = USR10   REPORT = USR10
   DESCRIPTION 'PLANT 10 - AIR SEPARATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the complete user block summary report to
;                    the normal ASPEN/SP output report file.
;               1 => Write the complete user block summary report to
;                    a separate user block output report file on
;                    logical unit 62 CALLED DCL10.REP.
;      INT(3) = Number of operating duplicate trains, excluding
;               spares.
;               If INT(3) = 0, the minimun number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
     INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Purity of the product oxygen stream, mole %.
;      REAL(2)   = Purity of the product nitrogen stream, mole %.
;      REAL(3) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per MM SCF/hr of the oxygen stream
;                  flow rate, kw/(MM SCF/hr of O2).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr of
;                  the oxygen stream flow rate,
;                  (Mlbs/hr)/(MM SCF/hr of O2).
;      REAL(25)  = Constant factor for the 900 psig saturated steam
```

```
;                 consumption, Mlbs/hr.
;      REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr of
;                  the oxygen stream flow rate,
;                  (Mlbs/hr)/(MM SCF/hr of O2).
;      REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;      REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr of
;                  the oxygen stream flow rate,
;                  (Mlbs/hr)/(MM SCF/hr of O2).
;      REAL(29)  = Constant factor for the 600 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr of
;                  the oxygen stream flow rate,
;                  (Mlbs/hr)/(MM SCF/hr of O2).
;      REAL(31)  = Constant factor for the 150 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                  the oxygen stream flow rate,
;                  (Mlbs/hr)/(MM SCF/hr of O2).
;      REAL(33)  = Constant factor for the 50 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                  the oxygen stream flow rate,
;                  (Mlbs/hr)/(MM SCF/hr of O2).
;      REAL(35)  = Constant factor for the plant fuel consumption,
;                  MM BTU/hr.
;      REAL(36)  = Plant fuel consumption per MM SCF/hr of the oxygen
;                  stream flow rate, (MM BTU/hr)/(MM SCF/hr of O2).
;      REAL(37)  = Constant factor for the cooling water consumption,
;                  Mgal/hr.
;      REAL(38)  = Cooling water consumption per MM SCF/hr of the oxygen
;                  stream flow rate, (Mgal/hr)/(MM SCF/hr of O2).
;      REAL(39)  = Constant factor for the process water consumption,
;                  Mgal/hr.
;      REAL(40)  = Process water consumption per MM SCF/hr of the oxygen
;                  stream flow rate, (Mgal/hr)/(MM SCF/hr of O2).
;      REAL(41)  = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2.
;      REAL(42)  = Nitrogen consumption per MM SCF/hr of the oxygen
;                  stream flow rate,
;                  (MM SCF/hr of N2)/(MM SCF/hr of O2).
;      REAL(43) -
;       REAL(48) = Future use.
;      REAL(49)  = Constant factor for the number of operators per
;                  day, operators/day.
;      REAL(50)  = Number of operators per day per train,
;                  (operators/day)/train.
;      REAL(51)  = Reference oxygen production rate for a single train
;                  in MM SCF/hr of O2 for the calculation of the
;                  ISBL field cost of a single train as a function of
;                  train capacity.
;      REAL(52)  = Maximum size of a single train as defined by the
;                  oxygen production rate in MM SCF/hr of O2.
;      REAL(53)  = Minimum size of a single train as defined by the
;                  oxygen production rate in MM SCF/hr of O2.
```

```
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;      NOTES:
;        1.  This model does not consider Argon as a separate element.
;            Hence, argon is lumped with nitrogen.
;        2.  MM SCF/hr of O2 means the oxygen production rate in
;            MM SCF/hr of O2 in the product oxygen stream and NOT
;            the total flow rate of the product oxygen stream.
;
;          %O2 in O2    %N2 in N2   Future Use (8 items)
     REAL 99.5003      100.0       0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 18143.97       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.0           0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 0.0            0.0 0.0           0.0 0.0       &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0       &
;          Opers/day      (Opers/day)/train
           4.0            0.0                 &
;          Ref Flow      Max Flow     Min Flow
           1.763605      1.875        1.0     &
;          Plant cost equation costants.
;          A       B        E       F      Spares   Future use (2 items)
           0.0     38.2     0.7028  1.0    0.0      0.0   0.0    &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR10.
   FLASH-SPECS STRM = 10S01   KODE=2   TEMP =   80.0   PRES = 350.0  /
               STRM = 10S02   KODE=2   TEMP = -275.0   PRES = 164.7
;
; Plant 11 - Sulfur Recovery Plant, Use the User Fortran Model USR11.
BLOCK P11 USER
   SUBROUTINE MODEL = USR11   REPORT = USR11
   DESCRIPTION 'PLANT 11 - THE SULFUR RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
```

```
;                    of the summary report.
;                 3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;                 0 => Write the user block summary report to the
;                      normal ASPEN/SP output report file.
;                 1 => Write the user block summary report to a separate
;                      user block output report file on logical unit 62
;                      called DCL11.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;                 If INT(3) = 0, the minimun number of duplicate
;                   trains will be determined so that the capacity
;                   of each train does not exceed the maximum train
;                   capacity specified by variable REAL(52).
;                 If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;                 0 => Write no additional output to the history file.
;                 1 => Write the only the subroutine entry and exit
;                      messages to the history file.
;                 2 => Write some additional output to the history file.
;               3-5 => Write some more additional output to the history
;                      file.  Larger values generate more intermediate
;                      output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Fractional sulfur recovery; fraction of sulfur in
;                   the entering H2S and COS that is recovered in the
;                   product liquid sulfur stream.  All entering liquid
;                   sulfur entering in the feed stream is assumed to
;                   be recovered in the liquid sulfur product stream.
;      REAL(2) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of product sulfur,
;                  kw/(Mlbs/hr).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                  product sulfur, (Mlbs/hr)/(Mlbs/hr).
;      REAL(25)  = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                  product sulfur, (Mlbs/hr)/(Mlbs/hr).
;      REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;      REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                  product sulfur, (Mlbs/hr)/(Mlbs/hr).
;      REAL(29)  = Constant factor for the 600 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                  product sulfur, (Mlbs/hr)/(Mlbs/hr).
;      REAL(31)  = Constant factor for the 150 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                  product sulfur, (Mlbs/hr)/(Mlbs/hr).
;      REAL(33)  = Constant factor for the 50 psig saturated steam
```

```
;                    consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                    product sulfur, (Mlbs/hr)/(Mlbs/hr).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                    MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of product sulfur,
;                    (MM BTU/hr)/(Mlbs/hr).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                    Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of product
;                    sulfur (Mgal/hr)/(Mlbs/hr).
;       REAL(39)  = Constant factor for the process water consumption,
;                    Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of product
;                    sulfur, (Mgal/hr)/(Mlbs/hr).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                    MM SCF/hr of N2.
;       REAL(42)  = Nitrigen consumption per Mlbs/hr of product sulfur,
;                    (MM SCF/hr of N2)/(Mlbs/hr).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                    day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                    (operators/day)/train.
;       REAL(51)  = Reference product sulfur flow rate of a single train
;                    in Mlbs/hr of S for the calculation of the ISBL field
;                    cost of a single train as a function of capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                    product sulfur flow rate in Mlbs/hr of S.
;       REAL(53)  = Minimum size of a single train as defined by the
;                    product sulfur flow rate in Mlbs/hr of S.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          S recovery
     REAL 0.998482    &
;          Future Use (19 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0       &
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 49.60954       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.971388      0.0 -3.022277 &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 0.882473       0.0 1.117916      0.0 7.89929   &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
```

```
;         Opers/day     (Opers/day)/train
          0.0           5.0                  &
;         Ref Flow     Max Flow     Min Flow
          15.4305      16.5         5.0      &
;         Plant cost equation costants.
;         A       B        E      F      Spares   Future use (3 items)
          0.0     11.675   0.7823 1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 11S-FGAS  KODE=2   TEMP = 80.0   PRES = 14.7  /
               STRM = 11S-LIQS  KODE=2   TEMP = 80.0   PRES = 14.7
;
; Plant 31 - The Utilities plant - user Fortran block USR31.
BLOCK P31 USER
   SUBROUTINE MODEL = USR31   REPORT = USR31
   DESCRIPTION 'PLANTS 31 - THE UTILITIES PLANT'
   PARAM  NINT = 20   NREAL = 20
;      The following 20 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Not used.
;               2 => Not used.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL02.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(2).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
;      INT(5) = Future use.
;      INT(6) -  Switches to select which fuels are burned in the steam
;       INT(10)  boiler to produce steam and/or electric power to
;                satisfy the steam demand.  The fuel specified in
;                INT(6) is used until it is all consumed, the steam
;                demand is satisfied, or the capacity to use this fuel
;                is reached.  Then the INT(7) fuel is used, etc.
;                The fuel codes are
;                  1 = Coal
```

```
;                    2 = ROSE-SR unit bottoms
;                    3 = Coke
;                    4 = Natural gas
;                    5 = Plant fuel
;       INT(11) - Switches to select which fuels are burned to satisfy
;        INT(16)  the electric power demand.  The fuel specified in
;                 INT(11) is used until it is all consumed, the power
;                 demand is satisfied, or the capacity to use this fuel
;                 is reached.  Then the INT(12) fuel is used, etc.
;                 The fuel codes are
;                    1 = Coal
;                    2 = ROSE-SR unit bottoms
;                    3 = Coke
;                    4 = Natural gas
;                    5 = Plant fuel
;                    6 = Purchased electric power
;       INT(17) -
;        INT(20)  Future use.
     INT  0  1  0  1  0  4  1  2  3  5    &
          4  1  2  3  5  6  0  0  0  0
;
;       The following 20 real parameters are:
;       REAL(1)  = Reference electric power generation rate of a single
;                  train in MW.
;       REAL(2)  = Maximum size of a single train as defined by the
;                  electric power generation rate in MW.
;       REAL(3)  = Minimum size of a single train as defined by the
;                  electric power generation rate in MW.
;       REAL(4)  = Constant A in the plant costing equation.
;       REAL(5)  = Constant B in the plant costing equation.
;       REAL(6)  = Constant E in the plant costing equation.
;       REAL(7)  = Constant F in the plant costing equation.
;       REAL(8)  = Number of spare trains.
;       REAL(9)  = Future use
;       REAL(10) = Future use
;       REAL(11) = Constant factor for the number of operators per
;                  day, operators/day.
;       REAL(12) = Number of operators per day per train,
;                  (operators/day)/train.
;       REAL(13) -
;        REAL(20) = Future use.
;
;          Ref MW    Max size   Min size
     REAL 79.259    84.0       1.0        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future use (2 items)
           0.0    87.466  0.7    1.0    0.0      0.0   0.0   &
;          Opers/day     (Opers/day)/train
           6.0           2.0                 &
;          Future use (8 items)
           0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
;
; Plants 31.1 and 31.4 - The Fluidized Bed Combustor and Steam Turbine
; Generator unit - user Fortran block USRA6.
BLOCK P314 USER
```

```
    SUBROUTINE MODEL = USRA6   REPORT = USRA6
    DESCRIPTION 'PLANTS 31.1 AND 31.4 - THE FLUIDIZED BED COMBUSTOR AND
    STEAM TURBINE GENERATOR UNIT'
    PARAM  NINT = 4   NREAL = 70
;       The following 4 integer parameters are:
;       INT(1) = User block summary report control switch.
;                0 => Write the complete user block summary report.
;                1 => Skip the capital cost portion of the summary
;                     report.
;                2 => Skip the capital cost and utilities portions
;                     of the summary report.
;                3 => Skip writing the entire user block summary report.
;       INT(2) = User block summary report destination control switch.
;                0 => Write the user block summary report to the normal
;                     ASPEN/SP output report file.
;                1 => Write the user block summary report to a separate
;                     user block output report file on logical unit 62
;                     called DCLA6.REP.
;       INT(3) = Number of operating duplicate trains, excluding spares.
;                If INT(3) = 0, the minimum number of duplicate
;                  trains will be determined so that the capacity
;                  of each train does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate plants.
;       INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
    INT  0  1  0  1
;       The following 70 real parameters are:
;       REAL(1)    = Solids production expressed as fraction of URCOAL
;                    in feed ending up in solids.
;       REAL(2)-
;        REAL(20) = Future use.
;       REAL(21)   = Constant factor for the power consumption, kw.
;       REAL(22)   = Power consumption per Mlbs/hr of unit feed,
;                    kw/(Mlbs/hr of unit feed).
;       REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                    consumption, Mlbs/hr.
;       REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                    unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;       REAL(25)   = Constant factor for the 900 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                    unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;       REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                    consumption, Mlbs/hr.
;       REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                    unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;       REAL(29)   = Constant factor for the 600 psig saturated steam
;                    consumption, Mlbs/hr.
```

```
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of unit feed,
;                   (Mlbs/hr)/(Mlbs/hr of unit feed).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of unit feed,
;                   (Mlbs/hr)/(Mlbs/hr of unit feed).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of unit feed,
;                   (Mlbs/hr)/(Mlbs/hr of unit feed).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of unit feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of unit feed).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference feed rate to a single train in Mlbs/hr of
;                   unit feed for the calculation of the ISBL field cost
;                   of a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   unit feed rate in Mlbs/hr of unit feed.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   unit feed rate in Mlbs/hr of unit feed.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;  NOTE: The number of operators in this plant and Plant 91is set so
;            as to maintain the same total number of operators as used
;            for the baseline design.
;
;         Fraction of URCOAL in feed ending up in solids
   REAL   0.8500914  &
;         Future use (9 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0        &
```

```
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   &
;         Power              900/750 F steam    900 satd steam
          0.0 -552.6474      0.0 0.0            0.0 0.0       &
;         600/720 F steam    600 satd steam     150 satd steam
          0.0 0.0            0.0 0.0            0.0 0.0       &
;         50 satd steam      Plant fuel         Cooling H2O
          0.0 0.0            0.0 0.0            0.0 27.99327  &
;         Process H2O        Nitrogen
          0.0 0.06900667     0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day    (Opers/day)/train
          0.0          20.0                  &
;         Ref Flow     Max Flow   Min Flow
          368.660      400.0      30.0      &
;         Plant cost equation constants.
;         A      B      E      F      Spares   Future use (2 items)
          0.0    0.0    0.75   1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet stream.  These
;  values will override the default values in subroutine USRA6.
   FLASH-SPECS STRM = SA6-01    KODE=2   TEMP = 130.0  PRES = 14.7
;
; Plant 38 - The Ammonia Recovery Plant - use user Fortran block USR38.
BLOCK P38 USER
   SUBROUTINE MODEL = USR38   REPORT = USR38
   DESCRIPTION 'PLANT 38 - THE AMMONIA RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL38.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
```

```
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Ammonia recovery, percent.
;      REAL(2)    = Purity of ammonia product, wt %.
;      REAL(3) -
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per Mlbs/hr of NH3 recovered,
;                   kw/(Mlbs/hr of NH3 recovered).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per Mlbs/hr of NH3 recovered,
;                   (MM BTU/hr)/(Mlbs/hr of NH3 recovered).
;      REAL(37)   = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;      REAL(38)   = Cooling water consumption per Mlbs/hr of NH3
;                   recovered, (Mgal/hr)/(Mlbs/hr of NH3 recovered).
;      REAL(39)   = Constant factor for the process water consumption,
;                   Mgal/hr.
;      REAL(40)   = Process water consumption per Mlbs/hr of NH3
;                   recovered, (Mgal/hr)/(Mlbs/hr of NH3 recovered).
;      REAL(41)   = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;      REAL(42)   = Nitrogen consumption per Mlbs/hr of NH3 recovered,
;                   (MM SCF/hr of N2)/(Mlbs/hr of NH3 recovered).
;      REAL(43) -
;       REAL(48) = Future use.
```

```
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
;       REAL(51)  = Reference NH3 recovery rate of a single train in
;                   Mlbs/hr for the calculation of the ISBL field cost
;                   of a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   NH3 recovery rate in Mlbs/hr of NH3 recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   NH3 recovery rate in Mlbs/hr of NH3 recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          NH3 recovery, %     NH3 purity, wt%
     REAL 99.103               99.552              &
;          Future use (8 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 75.713367      0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0  0.0           0.0 16.124425     0.0 28.745809 &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 0.0            0.0 0.0           0.0 227.9442  &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0            &
;          Opers/day      (Opers/day)/train
           0.0            20.0                 &
;          Ref Flow   Max Flow   Min Flow
           20.221     100.0      5.0          &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future Use (3 items)
           0.0    40.1    0.7807 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR38.
   FLASH-SPECS STRM = NH3-PROD  KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = 38S-OUT   KODE=2   TEMP = 80.   PRES = 14.7
;
;  Component splitter to generate the vapor and liquid streams
;  leaving Plant 38, the ammonia recovery plant.
BLOCK P38A SEP
   FRAC  SUBS = MIXED  STRM = 38AS-VAP                  &
   COMP = H2  N2  O2  H2S  CO  CO2  NH3                 &
          L-SULFUR H2O HCL COS CH4                      &
```

```
          C2H6 C3H8 IC4H10 NC4H10 IC5H12 NC5H12          &
          T125  T175  T225  T275  T325                   &
          T375  T425                                     &
          T475  T525  T575  T625  T675                   &
          P125  P175  P225  P275  P325  P375             &
          P425  P475  P525  P575  P625  P675             &
   FRAC = 1.0  1.0  1.0  0.9956  1.0  0.9985  0.07104   &
          0.0  0.002755  1.0  1.0  0.8888889             &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492      &
          0.9492 0.9492 0.9492 0.9492 0.9492             &
          0.9492 0.9492                                  &
          0.08481 0.08481 0.08481 0.08481 0.9492         &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492      &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492
   FLASH-SPECS STRM = 38AS-VAP  TEMP=90.0  PRES=25.0  NPK=1  KPH=1 /
               STRM = 38AS-LIQ  TEMP=90.0  PRES=25.0  NPK=1  KPH=2
;
;  Flow splitter to generate the waste water stream going to the
;  gasifier, Plant 9, and the stream going to the phenol recovery
;  plant, Plant 39.
BLOCK P38B FSPLIT
   FRAC  WASTE  0.28595
   PARAM NPK=1  KPH=2
;
; Plant 39 - The PHENOL RECOVERY PLANT - Use user Fortran block USR39.
BLOCK P39 USER
   SUBROUTINE MODEL = USR39   REPORT = USR39
   DESCRIPTION 'PLANT 39 - THE PHENOL RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL39.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
```

```
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Phenol recovery, percent.
;      REAL(2)    = Purity of phenol product, wt %.
;      REAL(3) -
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per Mlbs/hr of phenol recovered,
;                   kw/(Mlbs/hr of phenol recovered).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per Mlbs/hr of phenol
;                   recovered,
;                   (MM BTU/hr)/(Mlbs/hr of phenol recovered).
;      REAL(37)   = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;      REAL(39)   = Cooling water consumption per Mlbs/hr of phenol
;                   recovered, (Mgal/hr)/(Mlbs/hr of phenol recovered).
;      REAL(39)   = Constant factor for the process water consumption,
;                   Mgal/hr.
;      REAL(40)   = Process water consumption per Mlbs/hr of phenol
;                   recovered, (Mgal/hr)/(Mlbs/hr of phenol recovered).
;      REAL(41)   = Constant factor for the nitrogen consumption,
```

```
;                    MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of phenol recovered,
;                   (MM SCF/hr of N2)/(Mlbs/hr of phenol recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
;       REAL(51)  = Reference phenol recovery rate of a single train in
;                   Mlbs/hr for the calculation of the IKSBL field cost
;                   of a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   phenol recovery rate in Mlbs/hr of phenol recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   phenol recovery rate in Mlbs/hr of phenol recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;    NOTE: In the above, phenol recovered means pure phenol recovered.
;
;         Phenol recovery, %     Phenol purity, wt%
     REAL 97.0089            89.62                &
;         Future use (8 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 339.16667      0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0  0.0           0.0 0.0           0.0 9.465     &
;         50 satd steam      Plant fuel        Cooling  H20
          0.0 25.652917      0.0 0.0           0.0 111.775   &
;         Process H20        Nitrogen
          0.0 0.0            0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.0           0.0                 &
;         Ref Flow   Max Flow   Min Flow
          2.4        20.0       1.0        &
;         Plant cost equation constants.
;         A      B      E      F      Spares   Future Use (3 items)
          0.0    13.3   0.8056 1.0    0.0      0.0   0.0   &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR39.
   FLASH-SPECS STRM = PHENOL   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = WASTEH2O KODE=2   TEMP = 80.   PRES = 14.7
```

```
;
;  Plant SA6 separates the combined product stream from Plants 31.1
;  and 31.4 into two streams, one for flue gas and another for solids.
;  The separation is set to the URCOAL fraction in the solids stream.
BLOCK SA6 SEP
  FRAC  SUBS=NC    STREAM=FBC-SOL  COMP=URCOAL  FRAC=0.8500914   /
        SUBS=MIXED STREAM=FBC-SOL  COMP=T1000+  FRAC=1.0D-10
;
;  Splitter S1 - The Inlet Coal Splitter.  Used as a switch to divert
;  flow between the three different coal cleaning options, as represented
;  by the three different Coal Cleaning and Preparation Plants:
;  Base Case (1S01), Alternate Case 1 (1S11), and Alternate Case 2 (1S21).
BLOCK S1 FSPLIT
  DESCRIPTION 'INLET ROM COAL SPLITTER - COAL CLEANING SWITCH'
  FRAC  1S01 1.0 / 1S11 0.0 / 1S21 0.0
;
;  Splitter S2 - The Clean Coal Splitter.
BLOCK S2 FSPLIT
  DESCRIPTION 'CLEAN COAL SPLITTER'
  FRAC COALTO14 0.736227
;
;  Splitter S6-SH2O is a component splitter to generate a pseudo
;   sour-water stream from Plant 6 to get the NH3 to Plant 38, the
;   Ammonia Recovery Plant.
BLOCK S6-SH2O SEP
  DESCRIPTION 'SPLITTER TO GENERATE PSEUDO SOUR WATER FROM PLANT 6'
  FRAC  SUBS=MIXED  STREAM=6S-SH2O  COMP=NH3  FRAC=1.0
;
;  Splitter S7 - The Product Naphtha Splitter.  Used as a switch to
;  divert flow between the naphtha reformer, Plant 7 and output to
;  naphtha product.
BLOCK S7 FSPLIT
  DESCRIPTION 'HYDROTREATED NAPHTHA SPLITTER - REFORMER OPTION SWITCH'
;  ==================================================================
;  Use the following line to direct total flow to the reformer, or....
;  FRAC  7-NAPH 1.0
;  Use the following line to direct total flow to the product stream.
  FRAC PNAPHTHA 1.0
;
;  Splitter S8 - The Ash-Concentrate Splitter.  Used as a switch to
;  divert flow between the fluidized bed combustor, Plant 314 and the
;  coal gasification train; Plants M9C, P09, & P10.
BLOCK S8 FSPLIT
  DESCRIPTION 'ASH-CONCENTRATE SPLITTER - FBC OPTION 6 SWITCH'
;  Direct the ash-concentrate flow to coal gasification.
  FRAC  S8-ASHC 1.0
;
;  Splitter S9 - The dummy hydrogen splitter used to switch between
;  the two hydorgen production alternatives, Plant 9.0/10 - coal
;  gasification, or Plant 9.1 - steam reforming of methane.
BLOCK S9 FSPLIT
  DESCRIPTION 'DUMMY H2 SPLITTER - H2 GENERATION OPTION SWITCH'
;  Set an H2 target flow for Plant 9.0/10 - coal gasification.
  FRAC  H9NEED 1.0
  PARAM   NPK=1  KPH=1
```

```
;
; Stream Report Section
; ---------------------
;
STREAM-REPORT P1A
   STREAMS STRM = ROMCOAL 1S-CCOAL 9COAL COALTO14 COALTO2        &
                  14S-XMID 14S-REF 1S-XMID 1S-REFSE              &
                  ASH-CONC S8-ASHC COALTO9 9-FEED SLAG SOLVENT   &
                  2S-BOTTS 81-FEED FBC-FEED SA6-01 FBC-SOL FBC-GAS
   FLOW-FRAC SUBS=MIXED BASES=MASS / SUBS=NC BASES=MASS
   INTENSIVE-PROPS SUBS=MIXED BASES=MASS &
                   PROPS=TEMP PRES MW ENTH ENTR DENS HCAP /
                   SUBS=NC BASES=MASS &
                   PROPS=TEMP PRES MW ENTH DENS
   ATTRIBUTES SUBS=NC COMPONENT
;
STREAM-REPORT P1B
   STREAMS STRM = 1S-WATER 14S-WAT 2-H2OIN 2-H2IN H2MIX 2-H2MIX      &
                  SOLVENT ROSE-XTR 2S-GAS GASES 2S-SH2O              &
                  NAPHTHA GAS-OIL S2-GASIF H2-RICH SOUR-GAS P61-GAS  &
                  H2-2RICH SOUR-2GS GAS-OUT NAPHTHA2 3-GAS           &
                  3S-SGAS 3S-FGAS 3S-PROP 3S-BUT 3S-OIL 3S-SH2O      &
                  4-FEED 4-H2IN 4-H2OIN 4S-GAS 4S-NAPH 4S-SH2O       &
                  5S-HPGAS 5S-LPGAS 5-H2IN 5-H2OIN                   &
                  5S-NAPH P350-450 P450-650 P650-850 5S-SH2O         &
                  PS-NAPH PNAPHTHA 7-NAPH 7S-H2 7S-GAS REFORMED      &
                  61-HYD 62-HYD M9H2 M9H4 M9H5 MHNEED                &
                  H9NEED H91NEED                                     &
                  10-AIRIN 10S01 10S02 9-O2IN 9-H2OIN 9-STEMIN       &
                  H2-GAS H2S-GAS VENT-GAS 9S-SH2O                    &
                  NAT-GAS STEAM H2-PROD FLUE-GAS                     &
                  6-SGAS 6S-SH2O 11-FEED 11S-FGAS 11S-LIQS 31S-01    &
                  38-FEED NH3-PROD 38S-OUT 38AS-VAP 38AS-LIQ         &
                  WASTE 39FEED PHENOL WASTEH2O
   FLOW-FRAC SUBS=MIXED BASES=MASS
   INTENSIVE-PROPS SUBS=MIXED BASES=MASS &
                   PROPS=TEMP PRES MW ENTH ENTR DENS HCAP
;
;  End of input file OPT3.INP
```

APPENDIX I

APPENDIX I

ASPEN/SP PROCESS SIMULATION MODEL

INPUT FILE FOR OPTION 4 --

CATALYTIC-CATALYTIC LIQUEFACTION REACTOR

CONFIGURATION WITH VENT GAS SEPARATION

ASPEN/SP PROCESS SIMULATION MODEL

INPUT FILE FOR OPTION 4 --

CATALYTIC-CATALYTIC LIQUEFACTION REACTOR

CONFIGURATION WITH VENT GAS SEPARATION

```
NEW
;
;   File: OPT4.INP
;
TITLE 'OPT4 - DIRECT COAL LIQUEFACTION - VENT GAS SEPARATION, NTH PLANT'
;
DESCRIPTION &
  "ASPEN/SP INPUT FILE FOR SIMULATING THE VENT GAS SEPARATION OPTION
   FOR THE NTH PLANT.  THIS INPUT FILE ALSO CAN BE USED TO RUN OPTION 6
   (STEAM REFORMING OF NATURAL GAS FOR HYDROGEN PRODUCTION WITH AN FBC
   UNIT) AND OPTION 7 (NAPHTHA REFORMING)."
;
;  NOTES:
;  1.  The dry clean coal feed rate to the Plant 2 coal liquefaction
;      reactors is set in the design specification DES-SPEC COALFLO.
;  2.  The switches LOSBL and LPLANT contained in Fortran block SUMMARY
;      control the costing logic for OSBL and first or Nth plant.
;  3.  Option 6 (hydrogen production by steam reforming of natural
;      gas with an FBC unt) is activated by variable N9 in Fortran
;      block OPTION6.  When N9 = 1, Option 6 is invoked.
;  4.  Option 7 (naphtha reforming) is activated in Block S7 by
;      sending all the hydrotreated naphtha to Plant 7 rather than
;      to the product PNAHTHA.
;  5.  The costing logic is controlled by switches in Fortran block
;      SUMMARY.
;
;   Last revision - July 16, 1992.
;
;   Prepared under DOE contract no. DE-AC22 90PC89857.
;
IN-UNITS  ENG
OUT-UNITS ENG
HISTORY-UNITS ENG
RUN-CONTROL MAX-ERRORS=100
;
;  The following two lines are used with V8.0 to produce the overall
;  and block elemental balances.
;REPORT ATOMBAL
;BLOCK-REPORT ATOMBAL
;
HISTORY  MSG-LEVEL  PROPERTIES=2
  MAX-PRINT  PROPERTIES=100  SIMULATION=2000
;
PROPERTIES SYSOP2 GLOBAL
;
```

```
PSEUDO-COMPS
  METHOD METCCOAL -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 &
                  -1 -1 -1 -1 -1 -1 -1
;  The following APIs and MWs are revised from the ASPEN/SP predictions.
;  Component T1000+ is the 1000+ F material leaving the second coal
;    liquefaction reactor in Plant 2.
;  Component I1000+ is the 1000+ F intermediate material leaving the
;    first coal liquefaction reactor in Plant 2.
   COMPONENT T125   TBP=324.82 <K>  API=67.91  MW= 82.27
   COMPONENT T175   TBP=352.59 <K>  API=61.99  MW= 92.77
   COMPONENT T225   TBP=380.37 <K>  API=56.21  MW=102.84
   COMPONENT T275   TBP=408.15 <K>  API=50.60  MW=112.50
   COMPONENT T325   TBP=435.93 <K>  API=45.18  MW=121.82
   COMPONENT T375   TBP=463.71 <K>  API=39.96  MW=130.86
   COMPONENT T425   TBP=491.48 <K>  API=34.96  MW=139.75
   COMPONENT T475   TBP=519.26 <K>  API=30.19  MW=148.60
   COMPONENT T525   TBP=547.04 <K>  API=25.66  MW=157.54
   COMPONENT T575   TBP=574.82 <K>  API=21.39  MW=166.69
   COMPONENT T625   TBP=602.59 <K>  API=17.38  MW=176.16
   COMPONENT T675   TBP=630.37 <K>  API=13.66  MW=186.05
   COMPONENT T725   TBP=658.15 <K>  API=10.23  MW=196.44
   COMPONENT T775   TBP=685.93 <K>  API= 7.09  MW=207.37
   COMPONENT T825   TBP=713.71 <K>  API= 4.27  MW=218.85
   COMPONENT T875   TBP=741.48 <K>  API= 1.78  MW=230.87
   COMPONENT T925   TBP=769.26 <K>  API=-0.39  MW=243.37
   COMPONENT T975   TBP=797.04 <K>  API=-2.22  MW=256.24
   COMPONENT T1000+ TBP=824.82 <K>  API=-3.69  MW=269.33
   COMPONENT P125   TBP=324.82 <K>  API=67.91  MW= 82.27
   COMPONENT P175   TBP=352.59 <K>  API=61.99  MW= 92.77
   COMPONENT P225   TBP=380.37 <K>  API=56.21  MW=102.84
   COMPONENT P275   TBP=408.15 <K>  API=50.60  MW=112.50
   COMPONENT P325   TBP=435.93 <K>  API=45.18  MW=121.82
   COMPONENT P375   TBP=463.71 <K>  API=39.96  MW=130.86
   COMPONENT P425   TBP=491.48 <K>  API=34.96  MW=139.75
   COMPONENT P475   TBP=519.26 <K>  API=30.19  MW=148.60
   COMPONENT P525   TBP=547.04 <K>  API=25.66  MW=157.54
   COMPONENT P575   TBP=574.82 <K>  API=21.39  MW=166.69
   COMPONENT P625   TBP=602.59 <K>  API=17.38  MW=176.16
   COMPONENT P675   TBP=630.37 <K>  API=13.66  MW=186.05
   COMPONENT P725   TBP=658.15 <K>  API=10.23  MW=196.44
   COMPONENT P775   TBP=685.93 <K>  API= 7.09  MW=207.37
   COMPONENT P825   TBP=713.71 <K>  API= 4.27  MW=218.85
   COMPONENT P875   TBP=741.48 <K>  API= 1.78  MW=230.87
   COMPONENT P925   TBP=769.26 <K>  API=-0.39  MW=243.37
   COMPONENT P975   TBP=797.04 <K>  API=-2.22  MW=256.24
   COMPONENT P1000+ TBP=824.82 <K>  API=-3.69  MW=269.33
   COMPONENT I1000+ TBP=825.00 <K>  API=-4.00  MW=275.00
   COMPONENT REFORMAT TBP=390.00 <K>  API=38.25  MW=100.00
;
COMPONENTS H2 H2 / N2 N2 / O2 O2 / H2S H2S / CO CO / CO2 CO2 / NH3 H3N /
           L-SULFUR SULFUR / H2O H2O / HCL HCL / COS COS / CH4 CH4 /
           C2H6 C2H6 / C3H8 C3H8 / IC4H10 C4H10-2 / NC4H10 C4H10-1 /
           IC5H12 C5H12-2 / NC5H12 C5H12-1 /
;  Pseudocomponents
           T125 / T175 / T225 / T275 / T325 / T375 / T425 / T475 /
```

```
            T525 / T575 / T625 / T675 / T725 / T775 / T825 / T875 /
            T925 / T975 / T1000+ /
            P125 / P175 / P225 / P275 / P325 / P375 / P425 / P475 /
            P525 / P575 / P625 / P675 / P725 / P775 / P825 / P875 /
            P925 / P975 / P1000+ / I1000+ / REFORMAT /
;  Non-conventional components
             COAL / URCOAL / SLAG
;
FORMULA     H2 H2 / N2 N2 / O2 O2 / H2S H2S / CO CO / CO2 CO2 / NH3 H3N /
            L-SULFUR S / H2O H2O / HCL HCL / COS COS / CH4 CH4 /
            C2H6 C2H6 / C3H8 C3H8 / NC4H10 C4H10 / IC4H10 C4H10 /
            NC5H12 C5H12 / IC5H12 C5H12
;
;  Load the liquid sulfur (L-SULFUR) physical properties as taken from
;  DIPPR - MW adjusted to be consistent with ASPEN.
PROP-DATA  IN-UNITS SI
  PROP-LIST        MW     /   TC    /     PC     /    VC    /   ZC
  PVAL L-SULFUR   32.06  / 1313.0 / 1.8208E+7 / 0.15800 / 0.2640
  PROP-LIST       MUP    /  OMEGA /    TB     /   RGYR
  PVAL L-SULFUR   0.0    / 0.2624 /  717.82   /   0.0
  PROP-LIST         DELTA   /  DGFORM   /  DHFORM
  PVAL L-SULFUR   2.0245E+4 / 2.3825E+8 / 2.7880E+8
  PROP-LIST       CPIG
  PVAL L-SULFUR   2.5639E+4  -7.9870  4.7860E-3  -9.5700E-7  0.0  0.0  &
                  273.15  1500.0  0.0  87.113  1.0
;
; Load the solubility parameter for COS from the API Tech Data Book.
  PROP-LIST       DELTA
  PVAL COS        18179.0
;
;  Reset some component molecular weights to be consisitent with the
;  following elemental atomic weights, where needed.
;  H=1.0079, C=12.011, O=15.9994, N=14.0067, S=32.06 & Cl=35.453
  PROP-LIST       MW
  PVAL H2          2.0158
  PVAL N2         28.0134
  PVAL O2         31.9988
  PVAL H2S        34.0758
  PVAL CO         28.0104
  PVAL CO2        44.0098
  PVAL NH3        17.0304
  PVAL H2O        18.0152
  PVAL HCl        36.4609
  PVAL COS        60.0704
  PVAL CH4        16.0426
  PVAL C2H6       30.0694
  PVAL C3H8       44.0962
  PVAL IC4H10     58.1230
  PVAL NC4H10     58.1230
  PVAL IC5H12     72.1498
  PVAL NC5H12     72.1498
;
;  Set the specific gravities of H2, CO, CO2, NH3, H2S, N2 and COS to
;  the values given in the API Technical Data Book - Petroleum Refining.
  PROP-LIST        SPGR
```

```
  PVAL H2          0.3000
  PVAL CO          0.3000
  PVAL CO2         0.8180
  PVAL NH3         0.6162
  PVAL H2S         0.8014
  PVAL N2          0.8094
  PVAL COS         1.0200
;
ATTR-COMPS COAL   PROXANAL ULTANAL SULFANAL AOXANAL
ATTR-COMPS URCOAL PROXANAL ULTANAL SULFANAL AOXANAL
ATTR-COMPS SLAG   PROXANAL ULTANAL SULFANAL AOXANAL
;
NC-PROPS    COAL ENTHALPY  HCOALGEN /
                 DENSITY   DCOALIGT
NC-PROPS  URCOAL ENTHALPY  HCOALGEN /
                 DENSITY   DCHARIGT
NC-PROPS    SLAG ENTHALPY  HCOALGEN /
                 DENSITY   DCHARIGT
;
DEF-STREAMS MIXNC ALL
;
;  Set an initial GUESS for the ROM COAL stream to Plant 1.
STREAM ROMCOAL
   SUBSTREAM MIXED TEMP = 71.0  PRES = 14.7
     MASS-FLOW  H2O 24798.0
   SUBSTREAM NC TEMP = 71.0  PRES = 14.7
     MASS-FLOW  COAL 285035.0 / URCOAL 0.0 / SLAG 0.0
     COMP-ATTR COAL   PROXANAL (0.0 42.06 36.24 21.70) /
                      ULTANAL (21.7 61.1 4.2 1.2 0.1 5.1 6.6) /
                      SULFANAL (3.0 0.3 1.8) /
                      AOXANAL (43.8 17.1 24.1 0.8 0.1 5.6 1.0 0.6 2.1 4.1)
;  Fake the URCOAL properties.
     COMP-ATTR URCOAL PROXANAL (0.0 19.197 16.549 64.254) /
                      ULTANAL (64.254 29.914 0.185 1.304 0.0 4.267 0.076) /
                      SULFANAL (2.507 0.253 1.507) /
                      AOXANAL (43.8 17.1 24.1 0.8 0.1 5.6 1.0 0.6 2.1 4.1)
;  Fake the SLAG properties.
     COMP-ATTR SLAG   PROXANAL (0.0 10.0 0.0 90.0) /
                      ULTANAL (90.0 10.0 0.0 0.0 0.0 0.0 0.0 ) /
                      SULFANAL (0.0 0.0 0.0) /
                      AOXANAL (42.0 17.0 23.0 1.0 1.0 6.0 2.0 1.0 3.0 4.0)
;
;  Set an initial GUESS for the fresh make-up H2 stream to Plant 2.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 2-H2IN
   SUBSTREAM MIXED TEMP = 100.0  PRES = 3440.0
     MASS-FLOW  H2 70300.0 / N2 980.0
;
;  Set an initial GUESS for the total water feed streams (both steam
;  and wash water) to Plant 2.
STREAM 2-H2OIN
   SUBSTREAM MIXED TEMP = 126.0  PRES = 3200.0
     MASS-FLOW  H2O 1073000.0
;
;  Set an initial GUESS for the ROSE EXTRACT stream to Plant 2.
```

```
STREAM ROSE-XTR
   SUBSTREAM MIXED TEMP = 300.0  PRES = 3215.0
     MASS-FLOW  T675 95.0 / T725 95.0 / T775 95.0 /
       T825 95.0 / T875 588.335 / T925 588.335 /
       T975 588.355 /  T1000+ 536585.0
;
;  Set an initial GUESS for the SOLVENT stream to Plant 2.  The user
;  Fortran block model for Plant 2 does not require any solvent, but
;  the input stream is required.  Thus, set a small H2O flow to avoid
;  ASPEN warnings.
STREAM SOLVENT
   SUBSTREAM MIXED TEMP = 500.0  PRES = 500.0
     MASS-FLOW  H2O 1.0
;
;  Set an initial GUESS for the 2S-BOTTS stream leaving Plant 2.
STREAM 2S-BOTTS
   SUBSTREAM MIXED TEMP = 688.0  PRES = 28.0
     MASS-FLOW  H2O 0.0 /
       T825 380.0 / T875 3365.0 /
       T925 3365.0 / T975 3365.0 / T1000+ 642440.0
   SUBSTREAM NC TEMP = 688.0  PRES = 28.0
     MASS-FLOW  COAL 0.0 / URCOAL 254475.0
;
;  Set an initial GUESS for the H2 stream to Plant 4.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 4-H2IN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 500.0
     MASS-FLOW  H2 1400.0 / N2 19.0
;
;  Set an initial GUESS for the H2O stream to Plant 4.
STREAM 4-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 50.0
     MASS-FLOW  H2O 18770.
;
;  Set an initial GUESS for the H2 stream to Plant 5.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 5-H2IN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 500.0
     MASS-FLOW  H2 17000.0 / N2 279.0
;
;  Set an initial GUESS for the H2O stream to Plant 5.
STREAM 5-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 50.0
     MASS-FLOW  H2O 36382.0
;
;  Set an initial GUESS for the pseudo sour H2O from Plant 6.
STREAM 6S-SH2O
   SUBSTREAM MIXED TEMP = 60.0  PRES = 14.7
     MASS-FLOW  NH3 2830.0
;
;  Set an initial GUESS for the H2O stream to Plant 9.0.
STREAM 9-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 14.7
     MASS-FLOW  H2O 967545.0
;
```

```
;  Set an initial GUESS for the STEAM stream to Plant 9.0.
STREAM 9-STEMIN
   SUBSTREAM MIXED TEMP = 450.0  PRES = 500.0
     MASS-FLOW  H2O 167545.0
;
;  Set an initial GUESS for the OXYGEN stream to Plant 9.0.
STREAM 9-O2IN
   SUBSTREAM MIXED TEMP = 80.0  PRES = 300.0
     MASS-FLOW  O2 743531.0 / N2 3269.0
;
;  Set an initial GUESS for the AIR stream to Plant 10.
STREAM 10-AIRIN   TEMP = 70.0  PRES = 14.7
     MASS-FLOW  O2 743531.0 / N2 2463614.0
;
;  Set an initial GUESS for the CH4 stream to Plant 9.1.
STREAM NAT-GAS
   SUBSTREAM MIXED TEMP = 70.0  PRES = 100.0
     MASS-FLOW  CH4 307352.
;
;  Set an initial GUESS for the STEAM stream to Plant 9.1.
STREAM STEAM
   SUBSTREAM MIXED TEMP = 620.0  PRES = 500.0
     MASS-FLOW  H2O 864428.
;
; Model Connectivity
; ------------------
;
FLOWSHEET COAL
; Plant M1 is the clean coal outlet streams mixer.
;   Stream 1S-CCOAL is the combined outlet clean coal product stream.
; Plant M2 is the middling coal outlet streams mixer.
;   Stream 1S-XMID  is the combined outlet middling coal product stream.
; Plant M-2HYD is the mixer to combine H2 streams for Plant 2.
;   Stream 2-H2MIX  is the combined H2 stream from 6.1, 6.2, & source.
; Plant M3 is the refuse outlet streams mixer.
;   Stream 1S-REFSE is the combined outlet refuse product stream.
; Plant M38 is the sour water mixer.
;   Stream 38-FEED  is the combined sour water streams to Plant 38.
; Plant M4 is the waste water outlet streams mixer.
;   Stream 1S-WATER is the combined outlet waste water product stream.
; Plant M-462 is the mixer to combine H2 streams for Plant 6.2.
;   Stream 62-HYD   is the combined H2 stream from Plants 2 & 4.
; Plant M-561 is the mixer to combine H2 streams for Plant 6.1.
;   Stream 61-HYD   is the combined H2 stream from Plants 2 & 5.
; Plant M-6GAS is the heater to combine sour gas streams for Plant 11.
;   Stream 6-SGAS   is the combined sour gas stream from Plants 6.1 & 6.2.
; Plant M-73 is the mixer to combine H2 gas streams for Plant 3.
;   Stream 3-GAS    is the combined H2 gas stream from Plant 3.
; Plant M-HYD is the mixer (flash2) to combine H2 streams for M-2HYD.
;   Stream H2MIX    is the combined H2 stream from Plants 6.1 & 6.2.
;   Stream DUMMY    is the dummy vapor stream that contains no flow.
; Plant M-NAP is the mixer to combine naphtha streams for Plant 4.
;   Stream 4-FEED   is the combined naphtha stream from Plants 2 & 6.2.
; Plant M-PNAP is the mixer to combine product naphtha streams.
;   Stream PS-NAPH is the combined naphtha stream from Plants 4 & 5.
```

```
; Plant P1-ALT1 is the Coal Cleaning and Preparation Plant - ALT CASE 1.
;   Stream 1S12     is the outlet clean coal product stream.
;   Stream 1S13     is the outlet middling coal product stream.
;   Stream 1S14     is the outlet refuse product stream.
;   Stream 1S15     is the outlet waste water product stream.
; Plant P1-ALT2 is the Coal Cleaning and Preparation Plant - ALT CASE 2.
;   Stream 1S22     is the outlet clean coal product stream.
;   Stream 1S23     is the outlet middling coal product stream.
;   Stream 1S24     is the outlet refuse product stream.
;   Stream 1S25     is the outlet waste water product stream.
; Plant P1-BASE is the Coal Cleaning and Preparation Plant - BASE CASE.
;   Stream 1S02     is the outlet clean coal product stream.
;   Stream 1S03     is the outlet middling coal product stream.
;   Stream 1S04     is the outlet refuse product stream.
;   Stream 1S05     is the outlet waste water product stream.
; Plant P14 is the Coal Grinding and Drying Plant.
;   Stream COALTO2  is the outlet clean coal product stream.
;   Stream 14S-XMID is the outlet middling coal product stream.
;   Stream 14S-REF  is the outlet refuse product stream.
;   Stream 14S-WAT  is the outlet waste water product stream.
; Plant P02 is the Coal Liquefaction Plant.
;   Stream 2-H2MIX  is the hydrogen feed stream.
;   Stream COALTO2  is the clean coal feed stream.
;   Stream SOLVENT  is the solvent feed stream.  This stream is used to
;     supply the steam required to Plant 2.
;   Stream ROSE-XTR is the deashed product stream.
;   Stream 2-H2OIN  is the water feed stream to the liquefaction unit.
;   Stream 2S-GAS   is the HP gas product stream going to Plant 6.1.
;   Stream GASES    is the LP gas product stream going to Plant 6.2.
;   Stream NAPHTHA  is the naphtha product stream.
;   Stream GAS-OIL  is the gas-oil product stream going to Plant 5.
;   Stream 2S-BOTTS is the bottoms stream going to Plant 8.1.
;   Stream 2S-SH2O  is the sour water product stream.
; Plant P03 is the Gas Plant.
;   Stream 3S-SGAS  is the sour off-gas product stream.
;   Stream 3S-FGAS  is the fuel gas product stream.
;   Stream 3S-PROP  is the C3 product stream.
;   Stream 3S-BUT   is the C4s product stream.
;   Stream 3S-OIL   is the lean-oil product stream to M-NAP.
;   Stream 3S-SH2O  is the product sour water stream.
; Plant P04 is the simplified model for plant 4, the naphtha hydrotreater.
;   Stream 4-H2IN   is the hydrogen feed stream.
;   Stream 4-H2OIN  is the water feed stream.
;   Stream 4S-GAS   is the hydrotreater off-gas product stream.
;   Stream 4S-NAPH  is the hydrotreated naphtha product stream.
;   Stream 4S-SH2O  is the hydrotreater sour water stream.
; Plant P05 is the simplified model for plant 5, the gas-oil hydrotreater.
;   Stream 5-H2IN   is the hydrogen feed stream.
;   Stream 5-H2OIN  is the water feed stream.
;   Stream 5S-HPGAS is the hydrotreater hi-pressure purge gas stream.
;   Stream 5S-LPGAS is the hydrotreater other gases stream.
;   Stream 5S-NAPH  is the hydrotreated C6-350 F naphtha product stream.
;   Stream P350-450 is the hydrotreated 350 - 450 F product stream.
;   Stream P450-650 is the hydrotreated 450 - 650 F product stream.
;   Stream P650-850 is the hydrotreated 650 - 850 F product stream.
```

```
;   Stream 5S-SH2O  is the hydrotreater sour water stream.
; Plant P61 is the model for the Hydrogen purification by Membrane
;     Separation Plant, Plant 6.1.
;   Stream 61-HYD   is the feed stream to the H2 purification plant.
;   Stream H2-RICH  is the purified H2-rich product gas stream.
;   Stream SOUR-GAS is the sour gas product stream.
;   Stream P61-GAS  is the reject (non-permeate) product gas stream.
; Plant P62 is the model for the Hydrogen purification by Pressure
;     Swing absorption Plant, Plant 6.2.
;   Stream 62-HYD   is the mixed gas feed stream to the PSA hydrogen
;     purification plant.
;   Stream P61-GAS  is the reject gas stream from Plant 6.1, the high
;     pressure section of Plant 6, the hydrogen purification by
;     membrane permeation section.
;   Stream H2-2RICH is the purified h2-rich product gas stream.
;   Stream SOUR-2GS is the sour gas product stream.
;   Stream GAS-OUT  is the reject product gas stream.
;   Stream NAPHTHA2 is the liquid raw naphtha product stream.
; Plant P07 is the simplified model for Plant 7, the naphtha reformer.
;   Stream 7-NAPH   is the naphtha feed stream.
;   Stream 7S-H2    is the hydrogen rich product gas stream.
;   Stream 7S-GAS   is the light hydrocarbon product gas stream.
;   Stream REFORMED is the reformate product stream.
; Plant P81 is the model for the ROSE-SR Critical Solvent Deashing unit.
;   Stream ROSE-XTR is the deashed product stream.
;   Stream ASH-CONC is the ash concentrate stream.
; Plant P11 is the Sulfur plant.
;   Stream 11S-LIQS is the sulfur product stream.
;   Stream 11S-FGAS contains all the other material in the feed that
;     does not leave in the product SULFUR STREAM.
; Plant P31 is the simplified model for the utility plant.
;   Stream 31S-01   is the dummy product stream.
; Plant P314 is the model for the Fluidized Bed Combustor and the
;  Steam Turbine Generator unit.
;   Stream FBC-FEED is the feed stream to Plant P314.
;   Stream SA6-01   is the combined product stream out of Plant P314.
; Plant P38 is the NH3 recovery plant.
;   Stream NH3-PROD is the product NH3.
;   Stream 38S-OUT  is the reject stream.
; Plant P38A is the reject stream component splitter from plant 38.
;   Stream 38AS-VAP is the vapor stream going to Plant 11.
;   Stream 38AS-LIQ is the liquid stream going to Plant 38B.
; Plant P38B is the liquid reject stream splitter from Plant 38A.
;   Stream WASTE    is the reject portion of the inlet stream which
;     in this model is rejected, but actually goes to the coal
;     gasification plant, if present.
;   Stream 39FEED   is the stream going on to Plant 39.
; Plant P39 is the phenol recovery plant.
;   Stream PHENOL   is the phenol product stream.
;   Stream WASTEH2O is the waste water stream.
; Plant SA6 is the product stream separator from Plant P314.
;   Stream FBC-GAS  is the gas product stream from Plant SA6.
;   Stream FBC-SOL  is the solids product stream from Plant SA6.
; Block S1 is the inlet coal splitter.
;   Stream ROMCOAL  is the inlet ROM coal stream.
```

```
;   Stream 1S01     is the splitter outlet to the base case plant.
;   Stream 1S11     is the splitter outlet to the alternate case 1 plant.
;   Stream 1S21     is the splitter outlet to the alternate case 2 plant.
; Block S2 is the clean coal splitter.
;   Stream 1S-CCOAL is the inlet clean coal stream.
;   Stream COALTO14 is the splitter outlet to plant 2.
;   Stream 9-COAL   is the splitter outlet to plant 9.
; Block S6-SH2O is a component splitter to generate a pseudo sour-water
;   stream from Plant 6 to get the NH3 to Plant 38, the Ammonia Recovery
;   Plant.
;   Stream 6S-SH2O  is the pseudo sour-water stream.
;   Stream 11-FEED  is the Plant 11 feed stream.
; Block S7 is the product naphtha splitter.
;   Stream PS-NAPH  is the inlet product naphtha stream.
;   Stream 7-NAPH   is the splitter outlet to the naphtha reformer plant.
;   Stream PNAPHTHA is the splitter outlet as product naphtha.
; Block S8 is the ash-concentrate splitter.
;   Stream ASH-CONC is the inlet ash-concentrate stream from the ROSE.
;   Stream FBC-FEED is the splitter outlet to the FBC plant.
;   Stream S8-ASHC  is the splitter outlet to the M9C coal mixer.
;
 M1        IN = 1S02 1S12 1S22   OUT = 1S-CCOAL
 M2        IN = 1S03 1S13 1S23   OUT = 1S-XMID
 M-2HYD    IN = H2MIX 2-H2IN     OUT = 2-H2MIX
 M3        IN = 1S04 1S14 1S24   OUT = 1S-REFSE
 M38       IN = 2S-SH2O 3S-SH2O 4S-SH2O 5S-SH2O 6S-SH2O 9S-SH2O     &
             OUT = 38-FEED
 M4        IN = 1S05 1S15 1S25   OUT = 1S-WATER
 M-462     IN = 4S-GAS GASES 5S-LPGAS 3S-SGAS 7S-H2     OUT = 62-HYD
 M-561     IN = 5S-HPGAS 2S-GAS  OUT = 61-HYD
 M-6GAS    IN = SOUR-GAS SOUR-2GS H2S-GAS 38AS-VAP      OUT = 6-SGAS
 M-73      IN = GAS-OUT 7S-GAS   OUT = 3-GAS
 M-HYD     IN = H2-RICH H2-2RICH OUT = H2MIX DUMMY
 M-NAP     IN = NAPHTHA2 3S-OIL  OUT = 4-FEED
 M-PNAP    IN = 4S-NAPH 5S-NAPH  OUT = PS-NAPH
 P1-ALT1   IN = 1S11             OUT = 1S12 1S13 1S14 1S15
 P1-ALT2   IN = 1S21             OUT = 1S22 1S23 1S24 1S25
 P1-BASE   IN = 1S01             OUT = 1S02 1S03 1S04 1S05
 P14       IN = COALTO14         OUT = COALTO2 14S-XMID 14S-REF 14S-WAT
 PO2       IN = 2-H2MIX COALTO2 SOLVENT ROSE-XTR 2-H2OIN            &
             OUT = 2S-GAS GASES NAPHTHA GAS-OIL 2S-BOTTS 2S-SH2O
 PO3       IN = NAPHTHA 3-GAS                                       &
             OUT = 3S-SGAS 3S-FGAS 3S-PROP 3S-BUT 3S-OIL 3S-SH2O
 PO4       IN = 4-H2IN 4-FEED 4-H2OIN                               &
             OUT = 4S-GAS 4S-NAPH 4S-SH2O
 PO5       IN = 5-H2IN GAS-OIL 5-H2OIN                              &
             OUT = 5S-HPGAS 5S-LPGAS 5S-NAPH P350-450 P450-650      &
                   P650-850 5S-SH2O
 P61       IN = 61-HYD           OUT = H2-RICH SOUR-GAS P61-GAS
 P62       IN = 62-HYD P61-GAS                                      &
             OUT = H2-2RICH SOUR-2GS GAS-OUT NAPHTHA2
 PO7       IN = 7-NAPH           OUT = 7S-H2 7S-GAS REFORMED
 P81       IN = 2S-BOTTS         OUT = ROSE-XTR ASH-CONC
 P11       IN = 11-FEED          OUT = 11S-FGAS 11S-LIQS
 P31       IN = 3S-FGAS          OUT = 31S-01
```

```
  P314      IN = FBC-FEED          OUT = SA6-01
  P38       IN = 38-FEED           OUT = NH3-PROD 38S-OUT
  P38A      IN = 38S-OUT           OUT = 38AS-VAP 38AS-LIQ
  P38B      IN = 38AS-LIQ          OUT = WASTE 39FEED
  P39       IN = 39FEED            OUT = PHENOL WASTEH2O
  SA6       IN = SA6-01            OUT = FBC-SOL FBC-GAS
  S1        IN = ROMCOAL           OUT = 1S01 1S11 1S21
  S2        IN = 1S-CCOAL          OUT = COALTO14 9COAL
  S6-SH2O   IN = 6-SGAS            OUT = 6S-SH2O 11-FEED
  S7        IN = PS-NAPH           OUT = 7-NAPH PNAPHTHA
  S8        IN = ASH-CONC          OUT = FBC-FEED S8-ASHC
;
FLOWSHEET HYDROGEN
; Plant M9 is the hydrogen stream mixer.
;   Stream M9H2     is the dummy H2 stream to the liquefaction unit.
;   Stream M9H4     is the dummy H2 stream to the naphtha hydrotreater.
;   Stream M9H5     is the dummy H2 stream to the gas-oil hydrotreater.
;   Stream HHNEED   is the dummy H2 stream from the mixer.
; Plant M9C is the coal stream mixer.
;   Stream COALTO9  is the clean coal stream to the mixer.
;   Stream S8-ASHC  is the ash concentrate stream from the ROSE unit.
;   Stream 9-FEED   is the mixed coal stream to the gasifier.
; Plant PO9 is the plant for producing hydrogen by coal gasification.
;   Stream 9-H2OIN  is the water feed stream to the gasifier section.
;   Stream 9-O2IN   is the purified O2 stream from the air sep. plant.
;   Stream 9-STEMIN is the steam that goes to the shift reactors.
;   Stream H2-GAS   is the product hydrogen stream.
;   Stream H2S-GAS  is the product hydrogen sulfide stream.
;   Stream VENT-GAS is the product vent gas stream.
;   Stream 9S-SH2O  is the product sour water stream.
;   Stream SLAG     is the product slag stream.
; Plant P91 is the Steam Reforming of Natural Gas Plant.
;   Stream NAT-GAS  is the inlet natural gas stream.
;   Stream STEAM    is the inlet process water stream.
;   Stream H2-PROD  is the product hydrogen stream.
;   Stream FLUE-GAS is the product flue gas stream.
; Plant P10 is the Air Separation Plant.
;   Stream 10-AIRIN is the air input stream.
;   Stream 10S01    is the product oxygen stream.
;   Stream 10S02    is the product nitrogen stream.
; Plant S9 is the hydrogen stream splitter.
;   Stream H9NEED   is the dummy H2 stream for the gasifier.
;   Stream H91NEED  is the dummy H2 stream for the steam reformer.
;
  M9H       IN = M9H2 M9H4 M9H5    OUT = MHNEED
  M9C       IN = S8-ASHC COALTO9   OUT = 9-FEED
  PO9       IN = 9-FEED 9-H2OIN 9-O2IN 9-STEMIN        &
              OUT = H2-GAS H2S-GAS VENT-GAS 9S-SH2O SLAG
  P91       IN = NAT-GAS STEAM     OUT = H2-PROD FLUE-GAS
  P10       IN = 10-AIRIN          OUT = 10S01  10S02
  S9        IN = MHNEED            OUT = H9NEED H91NEED
;
; Design Specifications
; ---------------------
;
```

```
;  Design spec to set the hydrogen flow rate to Plant 2 (2-H2MIX)
;  to a specified weight percent (HPCT2) of the MAF coal input stream.
DES-SPEC 2H2FLO
   DEFINE CHP2   MASS-FLOW  STREAM=2-H2MIX  COMPONENT=H2
   DEFINE CCOAL  MASS-FLOW  STREAM=COALTO2  SUBSTREAM=NC COMPONENT=COAL
   DEFINE CCASH  COMP-ATTR-VAR STREAM=COALTO2  SUBSTREAM=NC &
                   COMPONENT=COAL ATTRIBUTE=ULTANAL ELEMENT=1
C     Set the specified H2 rate to Plant 2 in wt% in the following line.
F     HPCT2 = 7.9205D0
C     DAFCOAL is the dry ash-free coal (MAF coal).
F     DAFCOAL = CCOAL * (100.0D0 - CCASH) * 0.01D0
F     H2P2 = 0.01D0 * HPCT2 * DAFCOAL
   SPEC CHP2 TO H2P2
   TOL-SPEC 0.1
   VARY STREAM-VAR  STREAM=2-H2IN  VARIABLE=MASS-FLOW
   LIMITS 100 1000000
;
;  Design spec to set the correct ROM coal flow to the splitter to
;  obtain the desired 17,102 TPSD of MF coal flow rate to the coal
;  liquefaction plant, Plant 2.
DES-SPEC COALFLO
   DEFINE CTARG  MASS-FLOW  STREAM=COALTO2   SUBSTREAM=NC  COMPONENT=COAL
;  Set TPD to the target coal rate to Plant 2 in TPSD of MF coal.
;  ==============================================================
;
F     TPD = 17102.0D0
F     WTPHR = (TPD * 2000.0D0) / 24.0D0
   SPEC CTARG TO WTPHR
   TOL-SPEC 0.1
   VARY MASS-FLOW  STREAM=ROMCOAL  SUBSTREAM=NC  COMPONENT=COAL
   LIMITS 100 10000000
;
;  Design spec to set the correct 9-FEED flow rate to the Plant 9,
;  coal gasifier, to obtain the desired hydrogen production rate.
DES-SPEC H2FLO
   DEFINE HOUT   MASS-FLOW   STREAM=H2-GAS   COMPONENT=H2
   DEFINE HTOT   MASS-FLOW   STREAM=H9NEED   COMPONENT=H2
   SPEC HOUT TO HTOT
   TOL-SPEC 1.0
   VARY STREAM-VAR STREAM=COALTO9  SUBSTREAM=NC  VAR=MASS-FLOW
   LIMITS 0.1 10000000
;
;  Design spec to set the heat duty to block M-HYD to zero by
;  varying the temperature. This corrects a temperature calculating
;  error in the ASPEN mixer block algorithm.
DES-SPEC HD-HYD
   DEFINE HDTY BLOCK-VAR BLOCK=M-HYD SENTENCE=RETENTION VARIABLE=HEAT-DUTY
   SPEC HDTY TO 0.0
   TOL-SPEC 1000
   VARY BLOCK-VAR BLOCK=M-HYD SENTENCE=PARAM VARIABLE=TEMPERATURE
   LIMITS 10 500
;
;  Design spec to set the 10-AIRIN stream flow to produce the required
;  amount of oxygen product required by Plant 9, coal gasification.
DES-SPEC O2FLO
```

```
  DEFINE FLO10S STREAM-VAR STREAM=10S01    VAR=MASS-FLOW
  DEFINE FLOOXY STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
    SPEC FLO10S TO FLOOXY
    TOL-SPEC 0.1
    VARY STREAM-VAR  STREAM=10-AIRIN  VARIABLE=MASS-FLOW
    LIMITS 0.1 10000000
;
;  Design spec to set the hydrogen flow rate for Plant 9.1.
DES-SPEC RFMRFLO
    DEFINE HOUT2  MASS-FLOW   STREAM=H2-PROD  COMPONENT=H2
    DEFINE HTOT2  MASS-FLOW   STREAM=H91NEED  COMPONENT=H2
    SPEC HOUT2 TO HTOT2
    TOL-SPEC 0.1
    VARY STREAM-VAR  STREAM=NAT-GAS  VARIABLE=MASS-FLOW
    LIMITS 1000 600000
;
; Transfer Blocks
; ---------------
;
;  Transfer block to set COALTO9 equal to the 9COAL stream (the wet
;  clean coal input).  This duplicates the full property set and
;  provides the initial guess flow rate for COALTO9.
TRANSFER CCOAL
    SET STREAM COALTO9
    EQUAL-TO STREAM 9COAL
;
;  Transfer block used to set the hydrogen flow rates of the input
;  streams to the calculated hydrogen flows to Plant 2 (2-H2IN),
;  Plant 4 (4-H2IN), and Plant 5 (5-H2IN).  M9's represent hydrogen
;  flows from Plant 9.0/10 and M91's are for the Plant 9.1 alternative.
TRANSFER HFLOW
    SET STREAM M9H2
    EQUAL-TO STREAM 2-H2IN
    SET STREAM M9H4
    EQUAL-TO STREAM 4-H2IN
    SET STREAM M9H5
    EQUAL-TO STREAM 5-H2IN
;
; Fortran Blocks
; --------------
;
;  Fortran block to set the correct water flow rate in the clean
;  coal going to Plant 9.
FORTRAN 9COAL
    DEFINE W9COAL MASS-FLOW  STREAM=9COAL   COMPONENT=H2O
    DEFINE C9COAL MASS-FLOW  STREAM=9COAL   SUBSTREAM=NC COMPONENT=COAL
    DEFINE WCTO9  MASS-FLOW  STREAM=COALTO9 COMPONENT=H2O
    DEFINE CCTO9  MASS-FLOW  STREAM=COALTO9 SUBSTREAM=NC COMPONENT=COAL
F      WCTO9 = CCTO9 * (W9COAL / C9COAL)
;
;  This Fortran block resets the split fraction in S2 to provide the
;  flow rate of coal to Plant 9.0.
FORTRAN COALFLOW
    DEFINE C14    STREAM-VAR  STREAM=COALTO14  VAR=MASSFLOW
    DEFINE C9     STREAM-VAR  STREAM=COALTO9   VAR=MASSFLOW
```

```
   DEFINE RC     STREAM-VAR  STREAM=ROMCOAL   VAR=MASSFLOW
   DEFINE CC     STREAM-VAR  STREAM=1S-CCOAL  VAR=MASSFLOW
   DEFINE SFRAC  BLOCK-VAR   BLOCK=S2  SENTENCE=FRAC  VAR=FRAC  &
    ID1=COALTO14  ELEMENT=1
C     Calculate total clean coal.
F     TCC = C14 + C9
C     Reset the ROMCOAL feed rate to match the new value.
F     RC = RC * (TCC / CC)
C     Reset the split fraction in S2 to correct 9COAL flow rate.
F     SFRAC = C14 / (C9 + C14)
;
;  This FORTRAN block will calculate the initial ratio of the MIXED
;  substream flow to the NC substream flow in the stream ROMCOAL.
;  It will store this result in RATIO, and use that value to adjust
;  the MIXED substream flow in proportion to the NC substream flow
;  that is varied by the COALFLO design-spec.  This is needed to set
;  the correct amount of water entering with the ROM coal.
FORTRAN MIXFLO
F     COMMON /RATIO/ RMIXNCP
F     COMMON /RGLOB/ RDUM1, RMIN
 DEFINE FLONCP SUBSTREAM-VAR STREAM=ROMCOAL SUBSTREAM=NC VAR=MASSFLOW
 DEFINE FLOMIX SUBSTREAM-VAR STREAM=ROMCOAL SUBSTREAM=MIXED VAR=MASSFLOW
C  The following should only be true on the first pass.  This prevents
C  writing over the initial substream ratio on subsequent passes.
F     IF (RMIXNCP .LT. RMIN) THEN
F        RMIXNCP = FLONCP / FLOMIX
F     END IF
C  Adjust the other substream flow based on changes to the NC
C  substream.
F     FLOMIX = FLONCP / RMIXNCP
;
;  Fortran block to dynamically set the URCOAL fraction in the
;  separation block, SA6, equal to the solids production parameter,
;  REAL(1), in block P314, the fluidized bed combustor.  This block
;  only has significance when Option 6 is in effect.
FORTRAN SA6SET
   DEFINE FRAC1 BLOCK-VAR BLOCK=P314 SENTENCE=REAL VAR=REAL ELEMENT=1
   DEFINE FRAC2 BLOCK-VAR BLOCK=SA6  SENTENCE=FRAC VAR=FRAC ID1=NC    &
    ID2=FBC-SOL ELEMENT=1
F     FRAC2 = FRAC1
;
;  FORTRAN block to set the COMBINED steam and water flow rate to
;  Plant 2 as a specified weight percent of the dry coal feed.
FORTRAN SETUP2
   DEFINE FEED2 MASS-FLOW  STREAM=COALTO2  SUBSTREAM=NC  COMPONENT=COAL
   DEFINE H2O2  STREAM-VAR STREAM=2-H2OIN  VAR=MASSFLOW
F     H2O2 = 0.75315 * FEED2
;
;  FORTRAN block used to set the hydrogen flow rate to Plant 4 (4-H2IN)
;  to a specified weight percent (HPCT4) of the naphtha feed stream,
;  and the hydrogen flow rate to Plant 5 (5-H2IN) to a specified weight
;  percent (HPCT5) of the gas oil feed stream.  This block also sets
;  the inlet water flow rates for these plants to specified rates
;  as functions of the hydrocarbon feed rates.
FORTRAN SETUP45
```

```
   DEFINE CHP4   MASS-FLOW  STREAM=4-H2IN   COMPONENT=H2
   DEFINE CHP5   MASS-FLOW  STREAM=5-H2IN   COMPONENT=H2
   DEFINE FLP4   STREAM-VAR STREAM=4-H2IN   VAR=MASSFLOW
   DEFINE FLP5   STREAM-VAR STREAM=5-H2IN   VAR=MASSFLOW
   DEFINE XNAPH  STREAM-VAR STREAM=4-FEED   VAR=MASSFLOW
   DEFINE XGOIL  STREAM-VAR STREAM=GAS-OIL  VAR=MASSFLOW
   DEFINE H2O4   STREAM-VAR STREAM=4-H2OIN  VAR=MASSFLOW
   DEFINE H2O5   STREAM-VAR STREAM=5-H2OIN  VAR=MASSFLOW
C     Set the specified H2 rates in wt% in the following two lines.
F     HPCT4 = 1.1855
F     HPCT5 = 2.7554
F     H2P4 = 0.01D0 * HPCT4 * XNAPH
F     FLP4 = H2P4 * (FLP4 / CHP4)
F     H2P5 = 0.01D0 * HPCT5 * XGOIL
F     FLP5 = H2P5 * (FLP5 / CHP5)
C     Set the specified H2O rates in wt% in the following two lines.
F     H2O4 = 0.089017 * XNAPH
F     H2O5 = 0.054217 * XGOIL
;
;  FORTRAN block to set the steam, water and oxygen stream flow rates
;  to Plant 9 based on the inlet flow rate of hydrocarbons and NC
;  components (on a dry ash-free basis).
FORTRAN SETUP9
 DEFINE FL29MX SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=MIXED VAR=MASS-FLOW
 DEFINE ULCOAL COMP-ATTR-VAR STREAM=9-FEED  SUBSTREAM=NC &
        COMPONENT=COAL   ATTRIBUTE=ULTANAL ELEMENT=1
 DEFINE ULURC  COMP-ATTR-VAR STREAM=9-FEED  SUBSTREAM=NC &
        COMPONENT=URCOAL ATTRIBUTE=ULTANAL ELEMENT=1
 DEFINE FL29C   MASS-FLOW  STREAM=9-FEED  SUBSTREAM=NC COMPONENT=COAL
 DEFINE FL29UR  MASS-FLOW  STREAM=9-FEED  SUBSTREAM=NC COMPONENT=URCOAL
 DEFINE FL29W   MASS-FLOW  STREAM=9-FEED  COMPONENT=H2O
 DEFINE FL2STM  STREAM-VAR STREAM=9-STEMIN VAR=MASS-FLOW
 DEFINE FL2H2O  STREAM-VAR STREAM=9-H2OIN  VAR=MASS-FLOW
 DEFINE FL2O2   STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
C  Adjust the steam, water and oxygen stream flow rates based on the
C  inlet flow rate of hydrocarbons and NC components (on a dry basis).
F     X1 = 0.01*FL29C *(100.0-ULCOAL)
F     X2 = 0.01*FL29UR*(100.0-ULURC)
F     FL2STM = 0.25495 * (FL29MX + X1 + X2 - FL29W)
F     FL2H2O = 1.4723 * (FL29MX + X1 + X2 - FL29W)
F     FL2O2  = 1.1365 * (FL29MX + X1 + X2 - FL29W)
;
;  Fortran block to set up the common and OSBL utility consumptions.
FORTRAN SETUP31
F     COMMON /USRC01/ PLNTID(32), UTIL(32,15), CAPCST(32,5), OPCST(32,5)
F     CHARACTER * 6  PLNTID
 DEFINE DCOAL2 SUBSTREAM-VAR STREAM=COALTO2 SUBSTREAM=NC VAR=MASS-FLOW
C     COMMON /USRC03/ is used to transfer variables FIN(5,4),
C       FOUT(20,4), PGAS, PPWR, OPTN6
C     See Subroutine USRSR1 for the definition of the items in named
C     common block /USRC03/.
C     Base all the offsite and OSBL utilities consumptions on the dry
C     coal feed rate to Plant 2, the Coal Liquefaction Plant. Ignore
C     cooling and process water consumptions and productions.
F     PLNTID (19) = 'OTHERS'
```

```
C     Electric Power.
F     UTIL(19,1) = 25.1346 * DCOAL2 * 0.001
F     IF ( OPTN6 .GE. 0.99D0 )   UTIL(19,1) = 29.5411 * DCOAL2 * 0.001
C     600 psig steam at 720F.
F     UTIL(19,4) = 0.05122207 * DCOAL2 * 0.001
C     150 psig saturated steam.
F     UTIL(19,6) = 0.04350367 * DCOAL2 * 0.001
C     50 psig saturated steam.
F     UTIL(19,7) = 0.06757103 * DCOAL2 * 0.001
;
;  Fortran statement to set the molar flow rate of the STEAM stream to
;  be in balance with the feed stream to Plant 9.1.
FORTRAN SETUP91
   DEFINE GS     STREAM-VAR  STREAM=NAT-GAS  VARIABLE=MOLE-FLOW
   DEFINE ST     STREAM-VAR  STREAM=STEAM    VARIABLE=MOLE-FLOW
F     IF ( GS .GT. 0.0D0 )   THEN
F         ST = 2.504543D0 * GS
F       ELSE
F         ST = 0.0D0
F     ENDIF
;
;  Fortran block to switch between Plants 9.0 and 10 (Baseline Design
;  Case) or Plants 9.1, 31.1 and 31.4 (Option 6).
FORTRAN OPTION6
F     COMMON /USRC03/ FIN(5,4), FOUT(20,4), PGAS, PPWR, OPTN6
C     See Subroutine USRSR1 for the definition of the items in named
C     common block /USRC03/.
 DEFINE FSTM   STREAM-VAR STREAM=STEAM    VAR=MOLE-FLOW
 DEFINE FNG    STREAM-VAR STREAM=NAT-GAS  VAR=MOLE-FLOW
 DEFINE F10A   STREAM-VAR STREAM=10-AIRIN VAR=MASS-FLOW
 DEFINE F9H    STREAM-VAR STREAM=9-H2OIN  VAR=MASS-FLOW
 DEFINE F9S    STREAM-VAR STREAM=9-STEMIN VAR=MASS-FLOW
 DEFINE F9O    STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
 DEFINE FC9M   SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=MIXED VAR=MASS-FLOW
 DEFINE FC9NC  SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=NC    VAR=MASS-FLOW
 DEFINE FRAC8  BLOCK-VAR   BLOCK=S8  SENTENCE=FRAC  VAR=FRAC  &
  ID1=S8-ASHC  ELEMENT=1
 DEFINE FRAC9  BLOCK-VAR   BLOCK=S9  SENTENCE=FRAC  VAR=FRAC  &
  ID1=H9NEED   ELEMENT=1
 DEFINE FRAC38 BLOCK-VAR   BLOCK=P38B  SENTENCE=FRAC  VAR=FRAC  &
  ID1=WASTE    ELEMENT=1
C     Set N9 equal to 0 to run Plants 9.0 and 10 (Baseline), or
C     set N9 equal to 1 to run Plants 9.1, 31.1 and 31.4 (OPTION 6).
F     N9 = 0
F     IF (N9 .EQ. 0) THEN
F       OPTN6 = 0.0D0
F       FSTM = 1.0D-6
F       FNG = 1.0D-6
F       FRAC8 = 1.0
F       FRAC9 = 1.0
F       FRAC38 = 0.28595
F     ENDIF
F     IF (N9 .EQ. 1) THEN
F       OPTN6 = 1.0D0
F       F10A = 1.0D-6
```

```
F        F9H = 1.0D-6
F        F9S = 1.0D-6
F        F9O = 1.0D-6
F        FC9M = 1.0D-6
F        FC9NC = 1.0D-6
F        FRAC8 = 0.0
F        FRAC9 = 0.0
F        FRAC38 = 0.0
F      ENDIF
;
FORTRAN SUMMARY
C      This Fortran block writes the summary report to the DCLSUM.REP
C      file, and also writes the DCL1.PRN file for transfering the
C      results to the Lotus spreadsheet economics model.
C      COMMON /USRC03/ is used to transfer variables FIN(5,4),
C        FOUT(20,4), PGAS, PPWR, OPTN6
C      See Subroutine USRSR1 for the definition of the items in named
C      common block /USRC03/.
 DEFINE FIN1   SUBSTREAM-VAR STREAM=ROMCOAL   SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FIN2   STREAM-VAR    STREAM=NAT-GAS   VAR=MASS-FLOW
 DEFINE FOUT1  STREAM-VAR    STREAM=3S-PROP   VAR=MASS-FLOW
 DEFINE FOUT2  STREAM-VAR    STREAM=3S-BUT    VAR=MASS-FLOW
 DEFINE FOUT3A STREAM-VAR    STREAM=PNAPHTHA  VAR=MASS-FLOW
 DEFINE FOUT3B STREAM-VAR    STREAM=REFORMED  VAR=MASS-FLOW
 DEFINE FOUT4  STREAM-VAR    STREAM=P350-450  VAR=MASS-FLOW
 DEFINE FOUT5  STREAM-VAR    STREAM=P450-650  VAR=MASS-FLOW
 DEFINE FOUT6  STREAM-VAR    STREAM=P650-850  VAR=MASS-FLOW
 DEFINE FOUT7  SUBSTREAM-VAR STREAM=1S-REFSE  SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT8  SUBSTREAM-VAR STREAM=SLAG      SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT8A SUBSTREAM-VAR STREAM=FBC-SOL   SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT10 STREAM-VAR    STREAM=NH3-PROD  VAR=MASS-FLOW
 DEFINE FOUT11 STREAM-VAR    STREAM=PHENOL    VAR=MASS-FLOW
 DEFINE FOUT12 STREAM-VAR    STREAM=11S-LIQS  VAR=MASS-FLOW
C      Load the stream flow rates in the FIN() and FOUT() arrays in
C      Mlbs/hr.  All solid stream flow rates are on a dry basis.
F      FIN(1,1)  = 0.001D0 * FIN1
F      FIN(2,1)  = 0.001D0 * FIN2
F      FOUT(1,1) = 0.001D0 * FOUT1
F      FOUT(2,1) = 0.001D0 * FOUT2
F      FOUT(3,1) = 0.001D0 * (FOUT3A + FOUT3B)
F      FOUT(4,1) = 0.001D0 * FOUT4
F      FOUT(5,1) = 0.001D0 * FOUT5
F      FOUT(6,1) = 0.001D0 * FOUT6
F      FOUT(7,1) = 0.001D0 * FOUT7
F      FOUT(8,1) = 0.001D0 * (FOUT8 + FOUT8A)
F      FOUT(10,1) = 0.001D0 * FOUT10
F      FOUT(11,1) = 0.001D0 * FOUT11
F      FOUT(12,1) = 0.001D0 * FOUT12
C
C      Set XOF to the number of extra operators and OSBL operators
C      per dedicated plant operator.
C      ----------------------------
F      XOF = 0.343042
C
C      Set the LOSBL and LPLANT switches, as appropriate, to duplicate
```

```
C     the Bechtel OSBL and first vs. Nth plant costing logic.
C     LOSBL  = 0  - Use baseline case OSBL costing logic.
C     LOSBL  = 1  - Use option case OSBL costing logic.
C     LPLANT = 0  - Use first plant OSBL and engineering costing logic.
C     LPLANT = 1  - Use Nth plant OSBL and engineering costing logic.
C     ================================================================
F     LOSBL = 1
F     LPLANT = 1
C
C     Open the separate output file called DCLSUM.REP to contain the
C     summary report of the simulation results.
F     OPEN (UNIT=62, FILE='DCLSUM.REP', STATUS='UNKNOWN',
F    1  ACCESS='SEQUENTIAL', FORM='FORMATTED',
F    2  BUFFERED='BUFFERED')
C     Call Subroutines USRSR1 and USRSR2 to write the summary report.
F     CALL USRSR1 (62)
F     CALL USRSR2 (62, LOSBL, LPLANT, OPTN6, XOF)
F     CLOSE (UNIT=62, STATUS='KEEP')
C     Now write the LOTUS spreadsheet economics model input file.
F     OPEN (UNIT=62, FILE='DCL1.PRN', STATUS='UNKNOWN',
F    1  ACCESS='SEQUENTIAL', FORM='FORMATTED',
F    2  BUFFERED='BUFFERED')
C     Call Subroutines USRSR3 to write the model input file.
F     CALL USRSR3 (62, OPTN6, XOF)
F     CLOSE (UNIT=62, STATUS='KEEP')
;
; Convergence Blocks
; ------------------
;
CONVERGENCE CBLK1 WEGSTEIN
  TEAR H2MIX 1D-5
  PARAM WAIT=3
;
CONVERGENCE CBLK2 WEGSTEIN
  TEAR 2S-BOTTS 1D-5
;
CONVERGENCE CBLK3 WEGSTEIN
  TEAR 6S-SH2O 1D-5
;
CONVERGENCE COALF ONE-VAR
  SPEC COALFLO
;
CONVERGENCE HD-C1 ONE-VAR
  SPEC HD-HYD
;
CONVERGENCE HYDF BROYDEN-SPEC
  SPEC H2FLO
;
CONVERGENCE 2HYDF ONE-VAR
  SPEC 2H2FLO
;
CONVERGENCE OXYF ONE-VAR
  SPEC O2FLO
;
CONVERGENCE RFMRF ONE-VAR
```

```
  SPEC RFMRFLO
;
; Calculation Sequence
; --------------------
;
;  Define subsequence for coal cleaning complex.
SEQUENCE CLEAN COALF MIXFLO S1 P1-BASE P1-ALT1 P1-ALT2                  &
               M1 S2 P14 (RETURN COALF)                                  &
               M4 M3 M2
;
;  Specify entire flowsheet sequence, including subsequence CLEAN.
SEQUENCE BASE  (SEQUENCE CLEAN)  CCOAL                                  &
               CBLK1   2HYDF M-2HYD (RETURN 2HYDF)                       &
               CBLK2 SETUP2 P02 P81 (RETURN CBLK2)                       &
               P61 P62   HD-C1 M-HYD (RETURN HD-C1)                      &
               M-73 P03 M-NAP SETUP45 P04 M-462 P05 M-561                &
               M-PNAP S7 P07 (RETURN CBLK1)                              &
               HFLOW M9H OPTION6 S9  S8 P314 SA6SET SA6                  &
               HYDF 9COAL M9C SETUP9 P09 (RETURN HYDF)                   &
               OXYF P10 (RETURN OXYF)  COALFLOW  (SEQUENCE CLEAN)        &
               RFMRF SETUP91 P91 (RETURN RFMRF)                          &
               CBLK3 M38 P38 P38A P38B P39 M-6GAS S6-SH20                &
               (RETURN CBLK3)                                            &
               P11 SETUP31 P31 SUMMARY
;
; Unit Operations Blocks
; ----------------------
;
;  Mix the clean coal product streams from the 3 different cases.
BLOCK M1 MIXER
  DESCRIPTION 'PLANT 1 OUTLET CLEAN COAL MIXER'
;
;  Mix the middling coal product streams from the 3 different cases.
BLOCK M2 MIXER
  DESCRIPTION 'PLANT 1 OUTLET MIDDLING COAL MIXER'
;
;  Mix the hydrogen streams going to Plant 2.
BLOCK M-2HYD MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL HYDROGEN STREAM TO PLANT 2'
  PARAM NPK=1  KPH=1
;
;  Mix the refuse product streams from the 3 different cases.
BLOCK M3 MIXER
  DESCRIPTION 'PLANT 1 OUTLET REFUSE MIXER'
;
;  Mix the sour water streams from Plants 2, 3, 4, 5, and 9.
BLOCK M38 MIXER
  DESCRIPTION 'SOUR WATER MIXER FOR PLANT 38 FEED'
;
;  Mix the waste water product streams from the 3 different cases.
BLOCK M4 MIXER
  DESCRIPTION 'PLANT 1 OUTLET WASTE WATER MIXER'
;
;  Mix the hydrogen streams from Plants 4 & 2 for Plant 6.2.
BLOCK M-462 MIXER
```

```
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 6.2 FEED'
;
;  Mix the hydrogen streams from Plants 5 & 2 for Plant 6.1.
BLOCK M-561 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 6.1 FEED'
;
;  Mix the sour gas streams from Plants 6.1, 6.2, 9 and 38 for the
;  Plant 11 feed stream.
BLOCK M-6GAS HEATER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 11 FEED'
  PARAM  TEMP=110.0  PRES=14.7
;
;  Mix the H2 gas streams from Plants 7 & 6.2 for Plant 3.
BLOCK M-73 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 3 FEED'
;
;  Mixer M9C - The hydrogen plant feed mixer; used to mix the coal and
;  ROSE unit ASH-CONC stream that goes to Plant 9.0.
BLOCK M9C MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 9 FEED'
  BLOCK-OPTIONS HMB-RESULTS=2
;
;  Mixer M9 - The dummy hydrogen mixer; used to mix the three
;  streams that go to Plant 2 (M9H2), Plant 4 (M9H4), and
;  Plant 5 (M9H5) into one single output stream (MHNEED) for the
;  S9 splitter.
BLOCK M9H MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL AMOUNT OF HYDROGEN NEEDED'
  PARAM NPK=1  KPH=1
;
;  Mix the hydrogen streams from Plants 6.1 and 6.2. Use a flash2 block
;  to correct a temperature calculating error in the ASPEN mixer block
;  algorithm.
BLOCK M-HYD FLASH2
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL HYDROGEN FROM 6.1 AND 6.2'
  PARAM  TEMP=100.  PRES=3290.
;
;  Mix the naphtha streams from Plants 2 and 6.2.
BLOCK M-NAP MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL PLANT 4 NAPHTHA FEED'
;
;  Mix the product naphtha streams from Plants 4 and 5.
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL PRODUCT NAPHTHA STREAM'
BLOCK M-PNAP MIXER
;
;  Plant P1-ALT1, Coal Cleaning and Preparation Plant. Use User
;  Fortran Model, USR01, within the PLANTS file. ALTERNATE CASE 1 -
;  COAL CLEANING BY HEAVY MEDIUM SEPARATION.
BLOCK P1-ALT1 USER
   SUBROUTINE MODEL = USR01    REPORT = USR01
   DESCRIPTION 'PLANT 1 - ALTERNATE 1 - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following integer and real parameters are for production of
;   the coal cleaned by both jigs and heavy medium separation.  The coal
;   cleaned only by jigs for gasification is handled by a separate plant
```

```
;   that is modeled in BLOCK P1-JIGS.  The operators and cost for this
;   plant includes those associalted with the P1-JIGS portion of the coal
;   cleaning and preparation plant.  All parameters have the same meaning
;   as described below for Plant 1 in BLOCK P1-BASE.
;
    INT  0  1  0  1  1
;        FCP         FCM    FHP          FHM    FNP          FNM
     REAL 0.9120155   0.0    0.9050241    0.0    0.8869236    0.0  &
;        FC1P        FC1M   FSP          FSM    FOP          FOM
         0.7602203   0.0    0.4471884    0.0    0.9905900    0.0  &
;        FAP         FAM
         0.3012854   0.0  &
;        PCWP  PCWM  PCWR  Future Use (3 items)
         9.0   3.0   10.0    0.   0.   0.                    &
;        Power            900/750 F steam   900 satd steam
         0.0 7.400489       0.0 0.0           0.0 0.0        &
;        600/720 F steam    600 satd steam    150 satd steam
         0.0 0.0            0.0 0.0           0.0 0.0        &
;        50 satd steam      Plant fuel        Cooling  H2O
         0.0 0.0            0.0 0.0           0.0 0.0        &
;        Process H2O        Nitrogen
         0.0 0.042246       0.0 0.0         &
;        Future Use (6 items)
         0.0  0.0  0.0  0.0  0.0  0.0      &
;        Opers/day      (Opers/day)/train
         8.0            8.0                &
;        Ref Flow   Max Flow   Min Flow
         285.035    300.0      150.0      &
;        Plant cost equation constants.
;        A      B       E      F      Spares     Future Use (2 items)
         0.0    25.52   0.5942 1.0    0.0        0.0   0.0    &
;        Future Use (10 items)
         0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S12    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S13    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S14    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S15    KODE=2   TEMP = 70.0   PRES = 14.7
;
;  Plant P1-ALT2, Coal Cleaning and Preparation Plant. Use User Fortran
;  Model, USR01, within the PLANTS file. ALTERNATE CASE 2 - COAL CLEANING
;  BY HEAVY MEDIUM SEPARATION FOLLOWED BY SPHERICAL AGGLOMERATION.
BLOCK P1-ALT2 USER
   SUBROUTINE MODEL = USR01    REPORT = USR01
   DESCRIPTION 'PLANT 1 - ALTERNATE 2 - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following integer and real parameters are for production of
;   the coal cleaned by both jigs and heavy medium separation followed
;   by spherical agglomeration.  The coal cleaned only by jigs for
;   gasification is handled by a separate plant that is modeled in
;   BLOCK P1-JIGS.  The operators and cost for this plant includes
;   those associalted with the P1-JIGS portion of the coal cleaning
;   and preparation plant.  All parameters have the same meaning as
```

```
;   described below for Plant 1 in BLOCK P1-BASE.
;
    INT  0  1  0  1  2
;         FCP          FCM    FHP          FHM    FNP          FNM
     REAL 0.9435271    0.0    0.9338663    0.0    0.9250562    0.0  &
;         FC1P         FC1M   FSP          FSM    FOP          FOM
          0.7400450    0.0    0.3772778    0.0    0.9867266    0.0  &
;         FAP          FAM
          0.1295931    0.0  &
;         PCWP   PCWM  PCWR  Future Use (3 items)
          14.16  3.0   10.0  0.0   0.0   0.0                  &
;         Power                900/750 F steam   900 satd steam
          0.0 51.68786         0.0 0.0           0.0 0.0      &
;         600/720 F steam      600 satd steam    150 satd steam
          0.0 0.0              0.0 0.0           0.0 0.0      &
;         50 satd steam        Plant fuel        Cooling  H2O
          0.0 0.0              0.0 0.394967      0.0 0.0      &
;         Process H2O          Nitrogen
          0.0 0.103481         0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0         &
;         Opers/day      (Opers/day)/train
          8.0            8.0                   &
;         Ref Flow    Max Flow    Min Flow
          262.3       300.0       150.0         &
;         Plant cost equation constants.
;         A       B       E       F       Spares      Future Use (2 items)
          0.0     73.78   0.5942  1.0     0.0         0.0   0.0    &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S22    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S23    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S24    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S25    KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 1 - Coal Cleaning, Preparation and Drying Plant, Use User Fortran
;           Model USR01
;           BASE CASE - COAL CLEANING BY JIGS For LIQUEFACTION.
BLOCK P1-BASE USER
   SUBROUTINE MODEL = USR01   REPORT = USR01
   DESCRIPTION 'PLANT 1 - BASE CASE - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following 5 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
```

```
;                    ASPEN/SP output report file.
;                1 => Write the user block summary report to a separate
;                     user block output report file on logical unit 62
;                     called DCL01B.REP, DCL01A1.REP or DCL01A2.REP
;                     depending on the value of the coal cleaning option
;                     control switch, INT(5).
;      INT(3) = Number of operating duplicate trains, excluding spares.
;                If INT(3) = 0, the minimum number of duplicate
;                  trains will be determined so that the capacity
;                  of each train does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-4 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
;      INT(5)  = Coal cleaning, drying and grinding option control
;                switch.  The name of the short plant report file
;                written for each option is option dependent.
;                0 => Base case - Coal cleaning by jigs for coal
;                     liquefaction in plant 2. (Report = DCL01B.REP)
;                1 => Alternate case 1 - Coal cleaning by heavy media
;                     separation.  (Report = DCL01A1.REP)
;                2 => Alternate case 2 - Coal cleaning by heavy media
;                     separation and spherical agglomeration.
;                     (Report = DCL01A2.REP)
;                3 => Coal cleaning by jigs for coal gasification in
;                     plant 9.  (Report = DCL01G.REP)
;                4 => Coal grinding and drying plant.
;                     (Report = DCL01D.REP)
;               NOTE: Values 0, 1 and 2 are used when this model
;                     cleans the coal going to the coal liquefaction
;                     plant, 3 is used only when this model cleans
;                     the coal going to the coal gasification plant,
;                     and 4 is for the grinding and drying plant.
   INT  0  1  0  1  0
;     The following 70 real parameters are:
;     REAL(1)   = Fraction of carbon in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(2)   = Fraction of carbon in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(3)   = Fraction of hydrogen in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(4)   = Fraction of hydrogen in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(5)   = Fraction of nitrogen in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(6)   = Fraction of nitrogen in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(7)   = Fraction of chlorine in the inlet coal leaving
;                 in the clean coal product stream.
```

```
;       REAL(8)   = Fraction of chlorine in the inlet coal leaving
;                   in the middling coal stream.
;       REAL(9)   = Fraction of sulfur in the inlet coal leaving
;                   in the clean coal product stream.  OPTIONAL - See Note 1.
;       REAL(10)  = Fraction of sulfur in the inlet coal leaving
;                   in the middling coal stream.  OPTIONAL - See Note 1.
;       REAL(11)  = Fraction of oxygen in the inlet coal leaving
;                   in the clean coal product stream.
;       REAL(12)  = Fraction of oxygen in the inlet coal leaving
;                   in the middling coal stream.
;       REAL(13)  = Fraction of ash in the inlet coal leaving
;                   in the clean coal product stream.
;       REAL(14)  = Fraction of ash in the inlet coal leaving
;                   in the middling coal stream.
;       REAL(15)  = Moisture content of the clean product coal on a dry
;                   basis, wt%.
;       REAL(16)  = Moisture content of the middling coal on a dry
;                   basis, wt%.
;       REAL(17)  = Moisture content of the refuse on a dry basis, wt%.
;       REAL(18) -
;        REAL(20) = Future use.
;       REAL(21)  = Constant factor for the power consumption, kw.
;       REAL(22)  = Power consumption per Mlbs/hr of dry clean coal,
;                   kw/(Mlbs/hr).
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of dry clean coal,
;                   (MM BTU/hr)/(Mlbs/hr).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of dry clean
```

```
;                    coal (Mgal/hr)/(Mlbs/hr).
;      REAL(39)  = Constant factor for the process water consumption,
;                  Mgal/hr.
;      REAL(40)  = Process water consumption per Mlbs/hr of dry clean
;                  coal, (Mgal/hr)/(Mlbs/hr).
;      REAL(41)  = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2.
;      REAL(42)  = Nitrogen consumption per Mlbs/hr of dry clean coal,
;                  (MM SCF/hr of N2)/(Mlbs/hr).
;      REAL(43) -
;       REAL(48) = Future use.
;      REAL(49)  = Constant factor for the number of operators per
;                  day, operators/day.
;      REAL(50)  = Number of operators per day per train,
;                  (operators/day)/train.
;      REAL(51)  = Reference flow rate of the dry clean coal of a
;                  single train in Mlbs/hr for the calculation of
;                  the ISBL field cost of a single train as a function
;                  of train capacity.
;      REAL(52)  = Maximum size of a single train as defined by the
;                  flow rate of the dry clean coal in Mlbs/hr.
;      REAL(53)  = Minimum size of a single train as defined by the
;                  flow rate of the dry clean coal in Mlbs/hr.
;      REAL(54)  = Constant A in the plant ISBL field cost equation.
;      REAL(55)  = Constant B in the plant ISBL field cost equation.
;      REAL(56)  = Constant E in the plant ISBL field cost equation.
;      REAL(57)  = Constant F in the plant ISBL field cost equation.
;      REAL(58)  = Number of spare trains.
;      REAL(59) -
;       REAL(70) = Future use.
;
;    NOTES:
;      1. If both the sulfur distribution factors, REAL(9) and REAL(10),
;         are zero and a SULFANAL was supplied, the sulfur will be
;         distributed among the products as follows.
;         a. The ORGANIC sulfur will be distributed in the same
;            proportions as the carbon is distributed.
;         b. The PYRITIC and SULFATE sulfur will be distributed in the
;            same proportions as the ash is distributed.
;
;         FCP          FCM    FHP          FHM    FNP          FNM
     REAL 0.9302390    0.0    0.9142857    0.0    0.9533333    0.0  &
;         FClP         FClM   FSP          FSM    FOP          FOM
          0.40000      0.0    0.5019608    0.0    0.9696970    0.0  &
;         FAP          FAM
          0.4229677    0.0  &
;         PCWP   PCWM  PCWR  Future Use (3 items)
          8.576  3.0   10.0  0.0   0.0   0.0                      &
;         Power              900/750 F steam   900 satd steam
          0.0 4.281977       0.0 0.0           0.0 0.0          &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 0.0           0.0 0.0          &
;         50 satd steam      Plant fuel        Cooling  H20
          0.0 0.0            0.0 0.0           0.0 0.0          &
;         Process H20        Nitrogen
```

```
          0.0 0.02433102    0.0 0.0          &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0       &
;         Opers/day     (Opers/day)/train
          8.0           8.0                  &
;         Ref Flow   Max Flow   Min Flow
          387.158    390.0      200.0        &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future use (2 items)
          0.0    18.2    0.5942 1.0    0.0      0.0   0.0        &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S02    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S03    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S04    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S05    KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 1.4 - Coal Grinding and Drying Plant - Fortran Model USR01
;             BASE CASE
BLOCK P14 USER
   SUBROUTINE MODEL = USR01   REPORT = USR01
   DESCRIPTION 'PLANT 1.4 - BASE CASE - COAL GRINDING AND DRYING PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following integer and real parameters have the same meaning
;      as described above for Plant 1 in BLOCK P1-BASE.
    INT  0  1  0  1  4
;         FCP          FCM    FHP          FHM    FNP          FNM
     REAL 1.0          0.0    1.0          0.0    1.0          0.0  &
;         FC1P         FC1M   FSP          FSM    FOP          FOM
          1.0          0.0    1.0          0.0    1.0          0.0  &
;         FAP          FAM
          1.0          0.0   &
;         PCWP   PCWM  PCWR  Future Use (3 items)
          2.0    3.0   10.0  0.0   0.0   0.0                  &
;         Power               900/750 F steam   900 satd steam
          0.0 8.499979        0.0 0.0           0.0 0.0       &
;         600/720 F steam     600 satd steam    150 satd steam
          0.0 0.0             0.0 0.0           0.0 0.0       &
;         50 satd steam       Plant fuel        Cooling  H2O
          0.0 0.0             0.0 0.3410096     0.0 0.010104  &
;         Process H2O         Nitrogen
          0.0 0.0             0.0 3.16015      &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0       &
;         Opers/day     (Opers/day)/train
          7.0           1.0                  &
;         Ref Flow   Max Flow   Min Flow
          142.518    145.0      50.0         &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future use (2 items)
          0.0    8.75    0.8504 1.0    0.0      0.0   0.0        &
;         Future Use (10 items)
```

```
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = COALTO2  KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-XMID KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-REF  KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-WAT  KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 2 - The coal liquefaction plant - user Fortran block USR02.
BLOCK P02 USER
   SUBROUTINE MODEL = USR02   REPORT = USR02
   DESCRIPTION 'PLANT 2 - COAL LIQUEFACTION PLANT - VENT GAS OPTION'
   PARAM  NINT = 6   NREAL = 70
;      The following 6 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL02.REP.
;      INT(3) = Number of operating duplicate plants, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 plants will be determined so that the capacity
;                 of each plant does not exceed the maximum plant
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate plants.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
;      INT(5) = Switch to write the major equipment summary list and
;               cost summary report by plant section for the baseline
;               design to the separate block output summary report file
;               called DCL02.REP on logical unit 62.
;               0 => Do not write the major equipment summary list.
;               1 => Write the major equipment summary list to the
;                    separate block output file only when
;                    INT(1) <= 2, INT(2) = 1, and INT(6) = 0.
;               2 => Write the major equipment summary list and the
;                    cost summary report by plant section to the
;                    separate block output file only when
;                    INT(1) <= 2, INT(2) = 1, and INT(6) = 0.
;      INT(6) = Switch to select which coal liquefaction reactor yields
```

```
;                 are calculated.
;                 0 => Baseline design two-reactor model.
;                 3 => Option 3 - Yields for Thermal/Catalytic two-
;                      reactor model.
;                 4 => Option 4 - Two-reactor model with interstaage
;                      vent gas separation.
;                 5 => Option 5 - Yields for two-reactor coker model.
;                 8 => Improved Baseline (Option 8) - High space velocity
;                      two-reactor model.
    INT  0  1  0  1  2  4
;      The following 70 real parameters are:
;      REAL(1)    = Percent coal conversion based on fresh MAF coal
;                   entering the coal liquefaction reactors.
;      REAL(2)-
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per Mlbs/hr of dry coal feed,
;                   kw/(Mlbs/hr of dry coal).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                   dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                   dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                   dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                   dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per Mlbs/hr of dry coal feed,
;                   (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(37)   = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;      REAL(38)   = Cooling water consumption per Mlbs/hr of dry coal
;                   feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;      REAL(39)   = Constant factor for the process water consumption,
;                   Mgal/hr.
;      REAL(40)   = Process water consumption per Mlbs/hr of dry coal
;                   feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
```

```
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of dry coal feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of dry coal).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference dry coal feed rate to a single train in
;                   Mlbs/hr for the calculation of the ISBL field cost of
;                   a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the dry
;                   coal feed rate in Mlbs/hr of dry coal.
;       REAL(53)  = Minimum size of a single train as defined by the dry
;                   coal feed rate in Mlbs/hr of dry coal.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Percent fresh MAF coal conversion
     REAL 92.7901  &
;          Future use (9 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0    &
;          Power              900/750 F steam    900 satd steam
           0.0 41.83416       0.0 0.0            0.0 0.0        &
;          600/720 F steam    600 satd steam     150 satd steam
           0.0 0.003904784    0.0 -0.1046117     0.0 -0.0632168 &
;          50 satd steam      Plant fuel         Cooling H2O
           0.0 0.0393741      0.0 0.747978       0.0 0.340800   &
;          Process H2O        Nitrogen
           0.0 0.1081972      0.0 0.000029236 &
;          Future Use (6 items)
           0.0  0.0  0.0 0.0  0.0  0.0       &
;          Opers/day     (Opers/day)/train
           0.0           8.0                 &
;          Ref Flow   Max Flow   Min Flow
           285.035    285.05     30.0        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future use (2 items)
           0.0    186.44  0.7142 1.0    0.0      0.0   0.0   &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR02.
   FLASH-SPECS STRM=2S-GAS KODE=2 TEMP=130.0 PRES=2985.0 NPK=1 KPH=1 /
               STRM = GASES     KODE=2   TEMP = 130.0  PRES = 65.0   /
```

```
              STRM = NAPHTHA   KODE=2   TEMP = 140.0  PRES = 16.0   /
              STRM = GAS-OIL   KODE=2   TEMP = 110.0  PRES = 30.0   /
              STRM = 2S-BOTTS  KODE=2   TEMP = 688.0  PRES = 28.0   /
              STRM = 2S-SH2O   KODE=2   TEMP = 100.0  PRES = 30.0
;
; Plant 3 - The gas plant - use user Fortran block USR03.
BLOCK P03 USER
   SUBROUTINE MODEL = USR03   REPORT = USR03
   DESCRIPTION 'PLANT 3 - THE GAS PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL03.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per MM SCF/hr of dry C4- gas,
;                  kw/(MM SCF/hr of dry C4- gas)
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr
;                  of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;      REAL(25)  = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr
;                  of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;      REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
```

```
;       REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of dry C4- gas,
;                   (MM BTU/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of dry C4-
;                   gas, (Mgal/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of dry C4-
;                   gas, (Mgal/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of dry C4- gas,
;                   (MM SCF/hr of N2)/(MM SCF/hr of dry C4- gas).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference gas feed rate to a single train in
;                   MM SCF/hr of dry C4- gas for the calculation of
;                   the ISBL field cost of a single train as a function
;                   of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   gas feed rate in MM SCF/hr of dry C4- gas.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   gas feed rate in MM SCF/hr of dry C4- gas.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Future use (10 items)
      REAL 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
```

```
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power                900/750 F steam   900 satd steam
          0.0 447.6001         0.0 0.0           0.0 0.0       &
;         600/720 F steam      600 satd steam    150 satd steam
          0.0 0.0              0.0 194.4388      0.0 0.0       &
;         50 satd steam        Plant fuel        Cooling  H2O
          0.0 8.425471         0.0 -722.141      0.0 645.8090  &
;         Process H2O          Nitrogen
          0.0 0.0              0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0         &
;         Opers/day      (Opers/day)/train
          0.0             8.0                  &
;         Ref Flow   Max Flow   Min Flow
          2.04       5.0        0.300         &
;         Plant cost equation constants.
;         A      B           E      F      Spares   Future Use (3 items)
          0.0    25.3        0.8013 1.0    0.0      0.0   0.0   &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR03.
   FLASH-SPECS STRM = 3S-SGAS   KODE=2  TEMP = 137.0  PRES = 55.0   /
               STRM = 3S-FGAS   KODE=2  TEMP = 100.0  PRES = 215.0  /
               STRM = 3S-PROP   KODE=2  TEMP = 100.0  PRES = 280.0  /
               STRM = 3S-BUT    KODE=2  TEMP = 100.0  PRES = 280.0  /
               STRM = 3S-OIL    KODE=2  TEMP = 130.0  PRES = 263.0  &
                      NPK=1 KPH=2 /
               STRM = 3S-SH2O   KODE=2  TEMP = 137.0  PRES = 55.0
;
; Plant 4 - The naphtha hydrotreater - use user Fortran block USR04.
BLOCK P04 USER
   SUBROUTINE MODEL = USR04   REPORT = USR04
   DESCRIPTION 'PLANT 4 - THE NAPHTHA HYDROTREATER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL04.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
```

```
;                 If INT(3) > 0, the number of duplicate trains.
;       INT(4) = History file additional output control switch.
;                 0 => Write no additional output to the history file.
;                 1 => Write the only the subroutine entry and exit
;                      messages to the history file.
;                 2 => Write some additional output to the history file.
;               3-5 => Write some more additional output to the history
;                      file.  Larger values generate more intermediate
;                      output.
    INT  0  1  0  1
;       The following 70 real parameters are:
;       REAL(1)   = Percent desulfurization of the C5+ feed; i. e.,
;                   Percent of sulfur removed from the entering C5+ feed.
;       REAL(2)   = Percent denitrogenation of the C5+ feed; i. e.,
;                   Percent of nitrogen removed from the entering C5+ feed.
;       REAL(3)   = Percent deoxygenation of the C5+ feed.
;                   Percent of oxygen removed from the entering C5+ feed.
;       REAL(4)   = Chemical hydrogen consumption in SCF/bbl of C5+ feed.
;       REAL(5) -
;        REAL(20) = Future use.
;       REAL(21)  = Constant factor for the power consumption, kw.
;       REAL(22)  = Power consumption per Mlbs/hr of C5+ feed,
;                   kw/(Mlbs/hr of C5+ feed).
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of C5+ feed,
;                   (MM BTU/hr)/(Mlbs/hr of C5+ feed).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of C5+ feed,
;                   (Mgal/hr)/(Mlbs/hr of C5+ feed).
```

```
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of C5+ feed,
;                   (Mgal/hr)/(Mlbs/hr of C5+ feed).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of C5+ feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of C5+ feed).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference C5+ feed rate to a single train in Mlbs/hr
;                   for the calculation of the ISBL field cost of a
;                   single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   C5+ feed rate in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   C5+ feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          % Desulfurization   % Denitrogenation
     REAL 99.99                99.988       &
;          % Deoxygenation   Chemical H2 consumption in SCF/bbl C5+ feed
           99.5              125.0          &
;          Future use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0     &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power             900/750 F steam   900 satd steam
           0.0 5.098308      0.0 0.0           0.0 0.0       &
;          600/720 F steam   600 satd steam    150 satd steam
           0.0 0.0           0.0 0.126493      0.0 0.0       &
;          50 satd steam     Plant fuel        Cooling  H2O
           0.0 0.0           0.0 0.351607      0.0 0.730963  &
;          Process H2O       Nitrogen
           0.0 0.010833      0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0           8.0                 &
;          Ref Flow   Max Flow   Min Flow
           210.462    400.0      50.0        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future Use (3 items)
           0.0    15.6    0.7843 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
```

```
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR04.
   FLASH-SPECS STRM = 4S-GAS   KODE=2  TEMP = 135.0  PRES = 915.0  /
               STRM = 4S-NAPH  KODE=2  TEMP = 100.0  PRES = 153.0  /
               STRM = 4S-SH2O  KODE=2  TEMP =  70.0  PRES = 14.7
;
; Plant 5 - The gas-oil hydrotreater - use user Fortran block USR05.
BLOCK P05 USER
   SUBROUTINE MODEL = USR05   REPORT = USR05
   DESCRIPTION 'PLANT 5 - THE GAS-OIL HYDROTREATER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL05.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Percent desulfurization of the C6+ feed; i. e.,
;                  Percent of sulfur removed from the entering C6+ feed.
;      REAL(2)   = Percent denitrogenation of the C6+ feed; i. e.,
;                  Percent of nitrogen removed from the entering C6+ feed.
;      REAL(3)   = Percent deoxygenation of the C6+ feed.
;                  Percent of oxygen removed from the entering C6+ feed.
;      REAL(4)   = Chemical hydrogen consumption in SCF/bbl of C6+ feed.
;      REAL(5) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of C6+ feed,
;                  kw/(Mlbs/hr).
```

```
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of C6+ feed,
;                   (MM BTU/hr)/(Mlbs/hr).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of C6+ feed,
;                   (Mgal/hr)/(Mlbs/hr).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of C6+ feed,
;                   (Mgal/hr)/(Mlbs/hr).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of C6+ feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference C6+ feed rate to a single train in Mlbs/hr
;                   for the calculation of the ISBL field cost of a
;                   single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   C6+ feed rate in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   C6+ feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
```

```
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          % Desulfurization   % Denitrogenation
     REAL 92.5                 85.2       &
;          % Deoxygenation   Chemical H2 consumption in SCF/bbl C6+ feed
           97.6              947.00       &
;          Future use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0   &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power             900/750 F steam   900 satd steam
           0.0 3.247198      0.0 0.0           0.0 0.0       &
;          600/720 F steam   600 satd steam    150 satd steam
           0.0 0.0           0.0 0.096936      0.0 -0.050465 &
;          50 satd steam     Plant fuel        Cooling  H2O
           0.0 0.0           0.0 0.241416      0.0 0.735694 &
;          Process H2O       Nitrogen
           0.0 0.0           0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0            4.0               &
;          Ref Flow   Max Flow   Min Flow
           671.04     800.0      150.0      &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future Use (2 items)
           0.0    74.0    0.7467 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR05.
;  The 5S-LPGAS and 5S-NAPH temperature and pressure are those leaving
;  Plant 4 where this fractionation is actually performed.
   FLASH-SPECS STRM = 5S-HPGAS  KODE=2  TEMP = 135.0  PRES = 2690.0 /
               STRM = 5S-LPGAS  KODE=2  TEMP = 135.0  PRES = 915.0  /
               STRM = 5S-NAPH   KODE=2  TEMP = 100.0  PRES = 153.0  /
               STRM = P350-450  KODE=2  TEMP = 110.0  PRES = 80.0   /
               STRM = P450-650  KODE=2  TEMP = 135.0  PRES = 20.0   /
               STRM = P650-850  KODE=2  TEMP = 135.0  PRES = 20.0   /
               STRM = 5S-SH2O   KODE=2  TEMP = 135.0  PRES = 20.0
;
; Plant 6.1 - The Hydrogen purification by Membrane Separation Plant.
BLOCK P61 USER
   SUBROUTINE MODEL = USR61   REPORT = USR61
   DESCRIPTION 'PLANT 6.1 - THE MEMBRANE H2 PURIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
```

```
;                    report.
;                2 => Skip the capital cost and utilities portions
;                     of the summary report.
;                3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;                0 => Write the user block summary report to the normal
;                     ASPEN/SP output report file.
;                1 => Write the user block summary report to a separate
;                     user block output report file on logical unit 62
;                     called DCL61.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;                If INT(3) = 0, the minimum number of duplicate
;                  trains will be determined so that the capacity
;                  of each train does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Percent hydrogen recovery to the hydrogen-rich
;                   product gas stream from the inlet gas stream.
;      REAL(2)    = Concentration of hydrogen in the hydrogen-rich
;                   product gas stream, mole % or vol%.
;      REAL(3)-
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per MM SCF/hr of H2 recovered,
;                   kw/(MM SCF/hr of H2 recovered).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr
;                   of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
```

```
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of H2 recovered,
;                   (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of H2 recovered,
;                   (MMM SCF/hr of N2)/(MM SCF/hr of H2 recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference hydrogen recovery rate for a single train
;                   in MM SCF/hr of H2 for the calculation of the
;                   ISBL field cost of a single train as a function of
;                   capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Percent H2 recovery    H2 purity in mole %
      REAL 43.83285               99.98677                    &
;          Future use (8 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0             &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   &
;          Power              900/750 F steam   900 satd steam
           0.0 12254.04       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.0           0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling H2O
```

```
          0.0 2.054966      0.0 0.0          0.0 42.705864 &
;         Process H2O       Nitrogen
          0.0 0.854117      0.0 0.0        &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0     &
;         Opers/day     (Opers/day)/train
          0.0            12.0              &
;         Ref Flow   Max Flow   Min Flow
          1.966943   2.5        0.5        &
;         Plant cost equation constants.
;         A      B         E      F      Spares   Future use (2 items)
          0.0    152.6     0.8478 1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR61.
   FLASH-SPECS STRM = H2-RICH   KODE=2   TEMP = 100.0  PRES = 3290.0 /
               STRM = SOUR-GAS  KODE=2   TEMP = 250.0  PRES = 14.7   /
               STRM = P61-GAS   KODE=2   TEMP = 111.0  PRES = 500.0
;
; Plant 6.2 - The Hydrogen purification by Pressure Swing Absorption
;             Plant.
BLOCK P62 USER
   SUBROUTINE MODEL = USR62   REPORT = USR62
   DESCRIPTION 'PLANT 6.2 - THE PSA H2 PURIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL62.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
```

```
      INT  0  1  0  1
;        The following 70 real parameters are:
;        REAL(1)    = Percent hydrogen recovery to the hydrogen-rich
;                     product gas stream from the inlet gas stream.
;        REAL(2)    = Concentration of hydrogen in the hydrogen-rich
;                     product gas stream, mole % or vol%.
;        REAL(3)-
;         REAL(20)  = Future use.
;        REAL(21)   = Constant factor for the power consumption, kw.
;        REAL(22)   = Power consumption per MM SCF/hr of H2 recovered,
;                     kw/(MM SCF/hr of H2 recovered).
;        REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                     consumption, Mlbs/hr.
;        REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                     H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;        REAL(25)   = Constant factor for the 900 psig saturated steam
;                     consumption, Mlbs/hr.
;        REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr
;                     of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;        REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                     consumption, Mlbs/hr.
;        REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr of
;                     H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;        REAL(29)   = Constant factor for the 600 psig saturated steam
;                     consumption, Mlbs/hr.
;        REAL(30)   = 600 psig saturated steam consumption per MM SCF/hr of
;                     H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;        REAL(31)   = Constant factor for the 150 psig saturated steam
;                     consumption, Mlbs/hr.
;        REAL(32)   = 150 psig saturated steam consumption per MM SCF/hr of
;                     H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;        REAL(33)   = Constant factor for the 50 psig saturated steam
;                     consumption, Mlbs/hr.
;        REAL(34)   = 50 psig saturated steam consumption per MM SCF/hr of
;                     H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;        REAL(35)   = Constant factor for the plant fuel consumption,
;                     MM BTU/hr.
;        REAL(36)   = Plant fuel consumption per MM SCF/hr of H2 recovered,
;                     (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;        REAL(37)   = Constant factor for the cooling water consumption,
;                     Mgal/hr.
;        REAL(38)   = Cooling water consumption per MM SCF/hr of H2
;                     recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;        REAL(39)   = Constant factor for the process water consumption,
;                     Mgal/hr.
;        REAL(40)   = Process water consumption per MM SCF/hr of H2
;                     recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;        REAL(41)   = Constant factor for the nitrogen consumption,
;                     MM SCF/hr of N2
;        REAL(42)   = Nitrogen consumption per MM SCF/hr of H2 recovered,
;                     (MMM SCF/hr of N2)/(MM SCF/hr of H2 recovered).
;        REAL(43) -
;         REAL(48)  = Future use.
;        REAL(49)   = Constant factor for the number of operators per
;                     day, operators/day.
```

```
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference hydrogen recovery rate for a single train
;                   in MM SCF/hr of H2 for the calculation of the
;                   ISBL field cost of a single train as a function of
;                   capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;        The cost of Plant 6.2 is included in Plant 6.1.
;          Percent H2 recovery    H2 purity in mole %
     REAL 89.5033                90.01665              &
;          Future use (8 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 5485.989       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.0           0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling H2O
           0.0 15.32654       0.0 0.0           0.0 87.29583  &
;          Process H2O        Nitrogen
           0.0 0.530875       0.0 0.0        &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0           0.0                  &
;          Ref Flow   Max Flow   Min Flow
           3.61667    5.0        0.5        &
;          Plant cost equation constants.
;          A      B      E      F      Spares   Future use (2 items)
           0.0    0.0    0.7    1.0    0.0      0.0   0.0    &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR62.
   FLASH-SPECS STRM = H2-2RICH  KODE=2   TEMP = 100.0  PRES = 3290.0 /
               STRM = SOUR-2GS  KODE=2   TEMP = 250.0  PRES = 14.7   /
               STRM = GAS-OUT   KODE=2   TEMP = 111.0  PRES = 25.0   /
               STRM = NAPHTHA2  KODE=2   TEMP = 100.0  PRES = 50.0
;
; Plant 7 - The naphtha reformer - use user Fortran block USR07.
```

```
BLOCK P07 USER
   SUBROUTINE MODEL = USR07   REPORT = USR07
   DESCRIPTION 'PLANT 7 - THE NAPHTHA REFORMER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL07.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of feed,
;                  kw/(Mlbs/hr of feed).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                  feed, (Mlbs/hr)/(Mlbs/hr of feed).
;      REAL(25)  = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                  feed, (Mlbs/hr)/(Mlbs/hr of feed).
;      REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;      REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                  feed, (Mlbs/hr)/(Mlbs/hr of feed).
;      REAL(29)  = Constant factor for the 600 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                  feed, (Mlbs/hr)/(Mlbs/hr of feed).
```

```
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of feed,
;                   (MM BTU/hr)/(Mlbs/hr of feed).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of feed,
;                   (Mgal/hr)/(Mlbs/hr of feed).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of feed,
;                   (Mgal/hr)/(Mlbs/hr of feed).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of feed).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference feed rate to a single train in Mlbs/hr
;                   for the calculation of the ISBL field cost of a
;                   single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   feed rate in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Future use (10 items)
     REAL 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
          0.0 2.26494        0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
          0.0 -0.314772      0.0 0.0           0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 1.41781       0.0 0.123590  &
```

```
;         Process H2O       Nitrogen
          0.0 0.0           0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.            8.                  &
;         Ref Flow   Max Flow   Min Flow
          224.289    400.0      50.0        &
;         Plant cost equation constants.
;         A      B      E      F      Spares   Future Use (3 items)
          0.0    30.7   0.75   1.0    0.0      0.0   0.0   &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0

;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR07.
   FLASH-SPECS STRM = 7S-H2     KODE=2   TEMP = 80.0  PRES = 14.7  /
               STRM = 7S-GAS    KODE=2   TEMP = 80.0  PRES = 14.7  /
               STRM = REFORMED  KODE=2   TEMP = 80.0  PRES = 14.7
;
; Plant 8.1 - The ROSE-SR unit - user Fortran block USR81.
BLOCK P81 USER
   SUBROUTINE MODEL = USR81   REPORT = USR81
   DESCRIPTION 'PLANT 8.1 - THE ROSE-SR UNIT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL81.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate plants.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
```

```
;       REAL(1)    = Hydrocarbon rejection factor.
;       REAL(2)-
;        REAL(20)  = Future use.
;       REAL(21)   = Constant factor for the power consumption, kw.
;       REAL(22)   = Power consumption per Mlbs/hr of extract,
;                    kw/(Mlbs/hr of extract).
;       REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                    consumption, Mlbs/hr.
;       REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                    extract, (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(25)   = Constant factor for the 900 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                    extract, (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                    consumption, Mlbs/hr.
;       REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                    extract, (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(29)   = Constant factor for the 600 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                    extract, (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(31)   = Constant factor for the 150 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                    extract, (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(33)   = Constant factor for the 50 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                    extract, (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(35)   = Constant factor for the plant fuel consumption,
;                    MM BTU/hr.
;       REAL(36)   = Plant fuel consumption per Mlbs/hr of extract,
;                    (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(37)   = Constant factor for the cooling water consumption,
;                    Mgal/hr.
;       REAL(38)   = Cooling water consumption per Mlbs/hr of extract,
;                    (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(39)   = Constant factor for the process water consumption,
;                    Mgal/hr.
;       REAL(40)   = Process water consumption per Mlbs/hr of extract,
;                    (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(41)   = Constant factor for the nitrogen consumption,
;                    MM SCF/hr of N2
;       REAL(42)   = Nitrogen consumption per Mlbs/hr of extract,
;                    (MM SCF/hr of N2)/(Mlbs/hr of extract).
;       REAL(43) -
;        REAL(48)  = Future use.
;       REAL(49)   = Constant factor for the number of operators per
;                    day, operators/day.
;       REAL(50)   = Number of operators per day per train,
;                    (operators/day)/train.
;       REAL(51)   = Reference feed rate to a single train in Mlbs/hr of
;                    unit feed for the calculation of the capital cost of
;                    a single train as a function of train capacity.
```

```
;       REAL(52)  = Maximum size of a single train as defined by the
;                   unit feed rate in Mlbs/hr of unit feed.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   unit feed rate in Mlbs/hr of unit feed.
;       REAL(54)  = Constant A in the plant costing equation.
;       REAL(55)  = Constant B in the plant costing equation.
;       REAL(56)  = Constant E in the plant costing equation.
;       REAL(57)  = Constant F in the plant costing equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;          Hydrocarbon rejection factor
    REAL  1.0  &
;         Future use (9 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam    900 satd steam
          0.0 8.098677       0.0 0.0            0.0 0.0       &
;         600/720 F steam    600 satd steam     150 satd steam
          0.0 0.0            0.0 0.0            0.0 0.0471832 &
;         50 satd steam      Plant fuel         Cooling H2O
          0.0 0.0            0.0 0.393518       0.0 0.0       &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0         &
;         Future Use (6 items)
          0.  0.  0.  0.  0.  0.             &
;         Opers/day     (Opers/day)/train
          0.0           8.0                  &
;         Ref Flow   Max Flow   Min Flow
          907.390   1500.0     500.0         &
;         Plant cost equation constants.
;         A      B        E      F      Spares   Future use (2 items)
          0.0    42.2     0.7215 1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR81.
   FLASH-SPECS STRM = ROSE-XTR  KODE=2   TEMP = 300.0  PRES = 115.0 /
               STRM = ASH-CONC  KODE=2   TEMP = 150.0  PRES = 14.7
;
; Plant 9 - H2 Production by coal gasification, Use the User Fortran
; Block USR09.
BLOCK P09 USER
   SUBROUTINE MODEL = USR09   REPORT = USR09
   DESCRIPTION 'PLANT 9 - H2 PRODUCTION BY COAL GASIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
```

```
;       INT(2) = User block summary report destination control switch.
;                0 => Write the user block summary report to the normal
;                     ASPEN/SP output report file called DCL09.REP.
;                1 => Write the user block summary report to a separate
;                      user block output report file on logical unit 62.
;       INT(3) = Number of operating duplicate trains, excluding spares.
;                If INT(3) = 0, the minimum number of duplicate
;                  trains will be determined so that the capacity
;                  of each train does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate trains.
;       INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
    INT  0  1  0  1
;       The following 70 real parameters are:
;       REAL(1)    = Molar CO/CO2 ratio in the gasifier product gas.
;       REAL(2)    = Fraction of carbon entering the gasifier that goes
;                    to carbonyl sulfide (COS).
;       REAL(3)    = Fraction of carbon entering the gasifier that goes
;                    to methane (CH4).
;       REAL(4)    = Fraction of nitrogen entering the gasifier that goes
;                    to ammonia (NH3).
;       REAL(5)    = Carbon content of the slag produced by the gasifier,
;                    wt %.
;       REAL(6)    = Fraction of carbon monoxide (CO) entering the shift
;                    reactors that is shifted; i.e., converted to carbon
;                    dioxide (CO2) by the chemical reaction
;                        CO + H2O -----> CO2 + H2
;       REAL(7)    = Fraction of carbonyl sulfide (COS) entering the shift
;                    reactor section that is hydrolyzed; i.e., converted
;                    to carbon dioxide (CO2) and hydrogen sulfide (H2S)
;                    by the chemical reaction
;                        COS + H2O -----> CO2 + H2S
;       REAL(8)    = Future use.
;       REAL(9)-
;        REAL(20)  = Rectisol section component distribution factors,
;                    where
;       REAL(9)    = Fraction of inlet H2 going to the hydrogen-rich
;                    gas stream.
;       REAL(10)   = Fraction of inlet H2 going to the acid gas stream.
;       REAL(11)   = Fraction of inlet CO going to the hydrogen-rich
;                    gas stream.
;       REAL(12)   = Fraction of inlet CO going to the acid gas stream.
;       REAL(13)   = Fraction of inlet CO2 going to the hydrogen-rich
;                    gas stream.
;       REAL(14)   = Fraction of inlet CO2 going to the acid gas stream.
;       REAL(15)   = Fraction of inlet CH4 going to the hydrogen-rich
;                    gas stream.
;       REAL(16)   = Fraction of inlet CH4 going to the acid gas stream.
```

```
;       REAL(17)  = Fraction of inlet N2 going to the hydrogen-rich
;                   gas stream.
;       REAL(18)  = Fraction of inlet N2 going to the acid gas stream.
;       REAL(19)  = Fraction of inlet H2S going to the hydrogen-rich
;                   gas stream.
;       REAL(20)  = Fraction of inlet H2S going to the acid gas stream.
;       REAL(21)  = Constant factor for the power consumption, kw.
;       REAL(22)  = Power consumption per MM SCF/hr of hydrogen
;                   produced, kw/(MM SCF/hr of H2).
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of hydrogen
;                   produced, (MM BTU/hr)/(MM SCF/hr of H2).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of hydrogen
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of hydrogen
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of hydrogen
;                   produced, (MM SCF/hr of N2)/(MM SCF/hr of H2).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
```

```
;       REAL(51)  = Reference hydrogen production rate of a single train
;                   in MM SCF/hr of H2 for the calculation of the ISBL
;                   field cost of a single train as a function of train
;                   capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   hydrogen production rate in MM SCF/hr of H2.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   hydrogen production rate in MM SCF/hr of H2.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare plants.
;       REAL(59) -
;        REAL(70) = Future use.
;
;  NOTE:  MM SCF/hr of hydrogen produced means MM SCF/hr of hydrogen
;         in the hydrogen-rich product gas stream and NOT the total
;         flow rate of the hydrogen-rich product gas stream.
;
;                    Frac C       Frac C   Frac N   %C in
;         CO/CO2     to COS       to CH4   to NH3   slag
     REAL 2.419768  0.000804005  0.0      0.05212  5.229154  &
;         Frac CO shifted  Frac COS hydrolyzed  Future use
;         Adjust the fraction of CO shifted to get true H2 rate.
          0.9611           0.9516917            0.0          &
;         Component distribution factors for H2 to H2 and acid gas.
          0.8344      0.00153604                             &
;         Component distribution factors for CO to H2 and acid gas.
          0.0         0.0545937                              &
;         Component distribution factors for CO2 to H2 and acid gas.
          0.0         0.0453275                              &
;         Component distribution factors for CH4 to H2 and acid gas.
          0.0         0.0                                    &
;         Component distribution factors for N2 to H2 and acid gas.
          0.0932727   0.0923972                              &
;         Component distribution factors for H2S to H2 and acid gas.
          0.0         0.990203                               &
;         Power              900/750 F steam   900 satd steam
          0.0 3679.14335     0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 -16.98424     0.0 -44.40466 &
;         50 satd steam      Plant fuel        Cooling  H20
          0.0 -45.47563      0.0 -57.09919     0.0 183.6952  &
;         Process H20        Nitrogen
          0.0 4.176796       0.0 0.0824568   &
;         Future Use (6 items)
          0.  0.  0.  0.  0.  0.             &
;         Opers/day     (Opers/day)/train
          0.0           24.                  &
;         Ref Flow   Max Flow   Min Flow
          3.436      3.5        1.0         &
;         Plant cost equation constants.
;         A      B      E      F      Spares   Future use (3 items)
          0.0    52.7   0.7658 1.0    0.       0.0   0.0    &
```

```
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR09.
   FLASH-SPECS STRM = H2-GAS    KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = H2S-GAS   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = VENT-GAS  KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = 9S-SH2O   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = SLAG      KODE=2   TEMP = 80.   PRES = 14.7
;
;  Plant 9.1 - Steam Reforming of Natural Gas Plant.
BLOCK P91 USER
   SUBROUTINE MODEL = USR91   REPORT = USR91
   DESCRIPTION 'PLANT 9.1 - STEAM REFORMING OF NATURAL GAS PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL91.REP.
;      INT(3) = Number of operating duplicate plants, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 plants will be determined so that the capacity
;                 of each plant does not exceed the maximum plant
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, this number of duplicate plants will
;                 be used.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Fraction of CH4 reacting to produce H2 and CO2.
;      REAL(2)   = Fraction of CH4 reacting to produce H2 and CO.
;      REAL(3)   = Fraction of hydrogen produced that leaves in the
;                  hydrogen-rich product gas stream.
;      REAL(4)   = Purity of the hydrogen-rich product gas. mole %.
;      REAL(5) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
```

```
;       REAL(22)  = Power consumption per MM SCF/hr of hydrogen produced,
;                   kw/(MM SCF/hr of H2).
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of hydrogen
;                   produced, (MM BTU/hr)/(MM SCF/hr of H2).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of hydrogen
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of hydrogen
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2..
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of hydrogen
;                   produced, (MM SCF/hr of N2)/(MM SCF/hr of H2).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
;       REAL(51)  = Reference hydrogen production rate of a single train
;                   in MM SCF/hr of H2 for the calculation of the ISBL
;                   field cost of a single train as a function of train
;                   capacity.
;       REAL(52)  = Maximum plant size as defined by the hydrogen
;                   production rate in MM SCF/hr of H2.
;       REAL(53)  = Minimum plant size as defined by the hydrogen
```

```
;                    production rate in MM SCF/hr of H2.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare plants.
;       REAL(59) -
;        REAL(70) = Future use.
;
;  NOTES: 1. MM SCF/hr of hydrogen produced means MM SCF/hr of hydrogen
;            in the hydrogen rich product gas stream and NOT the total
;            flow rate of the hydrogen rich product gas stream.
;         2. The number of operators in this plant and Plants 31.1 and
;            31.4 is set so as to maintain the same total number of
;            operators as used for the baseline design.
;
;         Frac CH4 to CO2  Frac CH4 to CO  Frac recovered  H2 Purity
     REAL 0.638648         0.04429         0.8862694       100.0 &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0                      &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 354.158        0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 -65.3773      0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 89.0448       0.0 32.6902   &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0           &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0         &
;         Opers/day     (Opers/day)/train
          0.0           8.0                     &
;         Ref Flow      Max Flow     Min Flow
          5.77237       6.25         2.0       &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future Use (2 items)
          0.0    68.1    0.75   1.0    0.0      0.0    0.0    &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR091.
   FLASH-SPECS STRM = H2-PROD    KODE=2  TEMP = 100.0  PRES = 500.0 /
               STRM = FLUE-GAS   KODE=2  TEMP = 250.0  PRES = 14.7
;
; Plant 10 - Air Separation Plant - Use the User Fortran Model USR10.
BLOCK P10 USER
   SUBROUTINE MODEL = USR10   REPORT = USR10
   DESCRIPTION 'PLANT 10 - AIR SEPARATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
```

```
;                1 => Skip the capital cost portion of the summary
;                     report.
;                2 => Skip the capital cost and utilities portions
;                     of the summary report.
;                3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;                0 => Write the complete user block summary report to
;                     the normal ASPEN/SP output report file.
;                1 => Write the complete user block summary report to
;                     a separate user block output report file on
;                     logical unit 62 CALLED DCL10.REP.
;      INT(3) = Number of operating duplicate trains, excluding
;               spares.
;               If INT(3) = 0, the minimun number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
    INT  0  1  0  1
;     The following 70 real parameters are:
;     REAL(1)   = Purity of the product oxygen stream, mole %.
;     REAL(2)   = Purity of the product nitrogen stream, mole %.
;     REAL(3) -
;      REAL(20) = Future use.
;     REAL(21)  = Constant factor for the power consumption, kw.
;     REAL(22)  = Power consumption per MM SCF/hr of the oxygen stream
;                 flow rate, kw/(MM SCF/hr of O2).
;     REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                 consumption, Mlbs/hr.
;     REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr of
;                 the oxygen stream flow rate,
;                 (Mlbs/hr)/(MM SCF/hr of O2).
;     REAL(25)  = Constant factor for the 900 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr of
;                 the oxygen stream flow rate,
;                 (Mlbs/hr)/(MM SCF/hr of O2).
;     REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                 consumption, Mlbs/hr.
;     REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr of
;                 the oxygen stream flow rate,
;                 (Mlbs/hr)/(MM SCF/hr of O2).
;     REAL(29)  = Constant factor for the 600 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr of
;                 the oxygen stream flow rate,
;                 (Mlbs/hr)/(MM SCF/hr of O2).
```

```
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                   the oxygen stream flow rate,
;                   (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                   the oxygen stream flow rate,
;                   (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of the oxygen
;                   stream flow rate, (MM BTU/hr)/(MM SCF/hr of O2).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of the oxygen
;                   stream flow rate, (Mgal/hr)/(MM SCF/hr of O2).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of the oxygen
;                   stream flow rate, (Mgal/hr)/(MM SCF/hr of O2).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of the oxygen
;                   stream flow rate,
;                   (MM SCF/hr of N2)/(MM SCF/hr of O2).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference oxygen production rate for a single train
;                   in MM SCF/hr of O2 for the calculation of the
;                   ISBL field cost of a single train as a function of
;                   train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   oxygen production rate in MM SCF/hr of O2.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   oxygen production rate in MM SCF/hr of O2.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;     NOTES:
;       1.  This model does not consider Argon as a separate element.
;           Hence, argon is lumped with nitrogen.
;       2.  MM SCF/hr of O2 means the oxygen production rate in
;           MM SCF/hr of O2 in the product oxygen stream and NOT
;           the total flow rate of the product oxygen stream.
```

```
;
;         %O2 in O2    %N2 in N2   Future Use (8 items)
     REAL 99.5003      100.0       0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 18143.97       0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 0.0           0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 0.0           0.0 0.0       &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day      (Opers/day)/train
          4.0            0.0                &
;         Ref Flow      Max Flow     Min Flow
          1.763605      1.875        1.0     &
;         Plant cost equation costants.
;         A       B        E       F      Spares   Future use (2 items)
          0.0     38.2     0.7028  1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR10.
   FLASH-SPECS STRM = 10S01   KODE=2   TEMP =   80.0   PRES = 350.0  /
               STRM = 10S02   KODE=2   TEMP = -275.0   PRES = 164.7
;
; Plant 11 - Sulfur Recovery Plant, Use the User Fortran Model USR11.
BLOCK P11 USER
   SUBROUTINE MODEL = USR11   REPORT = USR11
   DESCRIPTION 'PLANT 11 - THE SULFUR RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the
;                    normal ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL11.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimun number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
```

```
;       INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
    INT  0  1  0  1
;       The following 70 real parameters are:
;       REAL(1)    = Fractional sulfur recovery; fraction of sulfur in
;                    the entering H2S and COS that is recovered in the
;                    product liquid sulfur stream.  All entering liquid
;                    sulfur entering in the feed stream is assumed to
;                    be recovered in the liquid sulfur product stream.
;       REAL(2) -
;        REAL(20) = Future use.
;       REAL(21)   = Constant factor for the power consumption, kw.
;       REAL(22)   = Power consumption per Mlbs/hr of product sulfur,
;                    kw/(Mlbs/hr).
;       REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                    consumption, Mlbs/hr.
;       REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                    product sulfur, (Mlbs/hr)/(Mlbs/hr).
;       REAL(25)   = Constant factor for the 900 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                    product sulfur, (Mlbs/hr)/(Mlbs/hr).
;       REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                    consumption, Mlbs/hr.
;       REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                    product sulfur, (Mlbs/hr)/(Mlbs/hr).
;       REAL(29)   = Constant factor for the 600 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                    product sulfur, (Mlbs/hr)/(Mlbs/hr).
;       REAL(31)   = Constant factor for the 150 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                    product sulfur, (Mlbs/hr)/(Mlbs/hr).
;       REAL(33)   = Constant factor for the 50 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                    product sulfur, (Mlbs/hr)/(Mlbs/hr).
;       REAL(35)   = Constant factor for the plant fuel consumption,
;                    MM BTU/hr.
;       REAL(36)   = Plant fuel consumption per Mlbs/hr of product sulfur,
;                    (MM BTU/hr)/(Mlbs/hr).
;       REAL(37)   = Constant factor for the cooling water consumption,
;                    Mgal/hr.
;       REAL(38)   = Cooling water consumption per Mlbs/hr of product
;                    sulfur (Mgal/hr)/(Mlbs/hr).
;       REAL(39)   = Constant factor for the process water consumption,
;                    Mgal/hr.
;       REAL(40)   = Process water consumption per Mlbs/hr of product
```

```
;                   sulfur, (Mgal/hr)/(Mlbs/hr).
;      REAL(41)  = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2.
;      REAL(42)  = Nitrigen consumption per Mlbs/hr of product sulfur,
;                  (MM SCF/hr of N2)/(Mlbs/hr).
;      REAL(43) -
;       REAL(48) = Future use.
;      REAL(49)  = Constant factor for the number of operators per
;                  day, operators/day.
;      REAL(50)  = Number of operators per day per train,
;                  (operators/day)/train.
;      REAL(51)  = Reference product sulfur flow rate of a single train
;                  in Mlbs/hr of S for the calculation of the ISBL field
;                  cost of a single train as a function of capacity.
;      REAL(52)  = Maximum size of a single train as defined by the
;                  product sulfur flow rate in Mlbs/hr of S.
;      REAL(53)  = Minimum size of a single train as defined by the
;                  product sulfur flow rate in Mlbs/hr of S.
;      REAL(54)  = Constant A in the plant ISBL field cost equation.
;      REAL(55)  = Constant B in the plant ISBL field cost equation.
;      REAL(56)  = Constant E in the plant ISBL field cost equation.
;      REAL(57)  = Constant F in the plant ISBL field cost equation.
;      REAL(58)  = Number of spare trains.
;      REAL(59) -
;       REAL(70) = Future use.
;
;         S recovery
    REAL 0.998482    &
;         Future Use (19 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0       &
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 49.60954       0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 0.971388      0.0 -3.022277 &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.882473       0.0 1.117916      0.0 7.89929   &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.0           5.0                &
;         Ref Flow     Max Flow     Min Flow
          15.4305      16.5         5.0      &
;         Plant cost equation costants.
;         A       B        E      F      Spares   Future use (3 items)
          0.0     11.675   0.7823 1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 11S-FGAS  KODE=2   TEMP = 80.0   PRES = 14.7  /
               STRM = 11S-LIQS  KODE=2   TEMP = 80.0   PRES = 14.7
```

```
;
; Plant 31 - The Utilities plant - user Fortran block USR31.
BLOCK P31 USER
   SUBROUTINE MODEL = USR31   REPORT = USR31
   DESCRIPTION 'PLANTS 31 - THE UTILITIES PLANT'
   PARAM  NINT = 20   NREAL = 20
;      The following 20 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Not used.
;               2 => Not used.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL02.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(2).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
;      INT(5) = Future use.
;      INT(6) -  Switches to select which fuels are burned in the steam
;       INT(10)  boiler to produce steam and/or electric power to
;                satisfy the steam demand.  The fuel specified in
;                INT(6) is used until it is all consumed, the steam
;                demand is satisfied, or the capacity to use this fuel
;                is reached.  Then the INT(7) fuel is used, etc.
;                The fuel codes are
;                  1 = Coal
;                  2 = ROSE-SR unit bottoms
;                  3 = Coke
;                  4 = Natural gas
;                  5 = Plant fuel
;      INT(11) - Switches to select which fuels are burned to satisfy
;       INT(16)  the electric power demand.  The fuel specified in
;                INT(11) is used until it is all consumed, the power
;                demand is satisfied, or the capacity to use this fuel
;                is reached.  Then the INT(12) fuel is used, etc.
;                The fuel codes are
;                  1 = Coal
;                  2 = ROSE-SR unit bottoms
;                  3 = Coke
;                  4 = Natural gas
```

```
;                    5 = Plant fuel
;                    6 = Purchased electric power
;       INT(17) -
;        INT(20)  Future use.
    INT  0  1  0  1  0  4  1  2  3  5    &
         4  1  2  3  5  6  0  0  0  0
;
;       The following 20 real parameters are:
;       REAL(1)  = Reference electric power generation rate of a single
;                  train in MW.
;       REAL(2)  = Maximum size of a single train as defined by the
;                  electric power generation rate in MW.
;       REAL(3)  = Minimum size of a single train as defined by the
;                  electric power generation rate in MW.
;       REAL(4)  = Constant A in the plant costing equation.
;       REAL(5)  = Constant B in the plant costing equation.
;       REAL(6)  = Constant E in the plant costing equation.
;       REAL(7)  = Constant F in the plant costing equation.
;       REAL(8)  = Number of spare trains.
;       REAL(9)  = Future use
;       REAL(10) = Future use
;       REAL(11) = Constant factor for the number of operators per
;                  day, operators/day.
;       REAL(12) = Number of operators per day per train,
;                  (operators/day)/train.
;       REAL(13) -
;        REAL(20) = Future use.
;
;          Ref MW    Max size   Min size
     REAL 79.259    84.0       1.0        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future use (2 items)
           0.0    87.466  0.7    1.0    0.0      0.0   0.0   &
;          Opers/day     (Opers/day)/train
           6.0           2.0                 &
;          Future use (8 items)
           0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
;
; Plants 31.1 and 31.4 - The Fluidized Bed Combustor and Steam Turbine
; Generator unit - user Fortran block USRA6.
BLOCK P314 USER
   SUBROUTINE MODEL = USRA6   REPORT = USRA6
   DESCRIPTION 'PLANTS 31.1 AND 31.4 - THE FLUIDIZED BED COMBUSTOR AND
   STEAM TURBINE GENERATOR UNIT'
   PARAM  NINT = 4   NREAL = 70
;       The following 4 integer parameters are:
;       INT(1) = User block summary report control switch.
;                0 => Write the complete user block summary report.
;                1 => Skip the capital cost portion of the summary
;                     report.
;                2 => Skip the capital cost and utilities portions
;                     of the summary report.
;                3 => Skip writing the entire user block summary report.
;       INT(2) = User block summary report destination control switch.
;                0 => Write the user block summary report to the normal
```

```
;                    ASPEN/SP output report file.
;                1 => Write the user block summary report to a separate
;                     user block output report file on logical unit 62
;                     called DCLA6.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;                If INT(3) = 0, the minimum number of duplicate
;                  trains will be determined so that the capacity
;                  of each train does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate plants.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Solids production expressed as fraction of URCOAL
;                   in feed ending up in solids.
;      REAL(2)-
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per Mlbs/hr of unit feed,
;                   kw/(Mlbs/hr of unit feed).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per Mlbs/hr of unit feed,
;                   (Mlbs/hr)/(Mlbs/hr of unit feed).
```

```
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of unit feed,
;                   (Mlbs/hr)/(Mlbs/hr of unit feed).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of unit feed,
;                   (Mlbs/hr)/(Mlbs/hr of unit feed).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of unit feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of unit feed).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference feed rate to a single train in Mlbs/hr of
;                   unit feed for the calculation of the ISBL field cost
;                   of a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   unit feed rate in Mlbs/hr of unit feed.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   unit feed rate in Mlbs/hr of unit feed.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;  NOTE: The number of operators in this plant and Plant 91is set so
;            as to maintain the same total number of operators as used
;            for the baseline design.
;
;          Fraction of URCOAL in feed ending up in solids
    REAL   0.8500914  &
;          Future use (9 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0        &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   &
;          Power              900/750 F steam    900 satd steam
           0.0 -552.6474      0.0 0.0            0.0 0.0       &
;          600/720 F steam    600 satd steam     150 satd steam
           0.0 0.0            0.0 0.0            0.0 0.0       &
;          50 satd steam      Plant fuel         Cooling H2O
           0.0 0.0            0.0 0.0            0.0 27.99327  &
;          Process H2O        Nitrogen
           0.0 0.06900667     0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0           20.0                 &
```

```
;         Ref Flow     Max Flow   Min Flow
          368.660      400.0      30.0      &
;         Plant cost equation constants.
;         A      B      E      F      Spares   Future use (2 items)
          0.0    0.0    0.75   1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet stream.  These
;  values will override the default values in subroutine USRA6.
   FLASH-SPECS STRM = SA6-01    KODE=2   TEMP = 130.0  PRES = 14.7
;
; Plant 38 - The Ammonia Recovery Plant - use user Fortran block USR38.
BLOCK P38 USER
   SUBROUTINE MODEL = USR38   REPORT = USR38
   DESCRIPTION 'PLANT 38 - THE AMMONIA RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL38.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Ammonia recovery, percent.
;      REAL(2)   = Purity of ammonia product, wt %.
;      REAL(3) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of NH3 recovered,
;                  kw/(Mlbs/hr of NH3 recovered).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
```

```
;                 consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of NH3 recovered,
;                   (MM BTU/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of NH3
;                   recovered, (Mgal/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of NH3
;                   recovered, (Mgal/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of NH3 recovered,
;                   (MM SCF/hr of N2)/(Mlbs/hr of NH3 recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
;       REAL(51)  = Reference NH3 recovery rate of a single train in
;                   Mlbs/hr for the calculation of the ISBL field cost
;                   of a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   NH3 recovery rate in Mlbs/hr of NH3 recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   NH3 recovery rate in Mlbs/hr of NH3 recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
```

```
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          NH3 recovery, %     NH3 purity, wt%
     REAL 99.103               99.552              &
;          Future use (8 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 75.713367      0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0  0.0           0.0 16.124425     0.0 28.745809 &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 0.0            0.0 0.0           0.0 227.9442  &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0            &
;          Opers/day      (Opers/day)/train
           0.0            20.0                &
;          Ref Flow   Max Flow   Min Flow
           20.221     100.0      5.0         &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future Use (3 items)
           0.0    40.1    0.7807 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR38.
   FLASH-SPECS STRM = NH3-PROD  KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = 38S-OUT   KODE=2   TEMP = 80.   PRES = 14.7
;
;  Component splitter to generate the vapor and liquid streams
;  leaving Plant 38, the ammonia recovery plant.
BLOCK P38A SEP
   FRAC  SUBS = MIXED  STRM = 38AS-VAP                  &
   COMP = H2  N2  O2  H2S  CO  CO2  NH3                 &
          L-SULFUR H2O HCL COS CH4                      &
          C2H6 C3H8 IC4H10 NC4H10 IC5H12 NC5H12         &
          T125  T175  T225  T275  T325                  &
          T375  T425                                    &
          T475  T525  T575  T625  T675                  &
          P125  P175  P225  P275  P325  P375            &
          P425  P475  P525  P575  P625  P675            &
   FRAC = 1.0  1.0  1.0  0.9956  1.0  0.9985  0.07104   &
          0.0  0.002755  1.0  1.0  0.8888889            &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492     &
          0.9492 0.9492 0.9492 0.9492 0.9492            &
          0.9492 0.9492                                 &
          0.08481 0.08481 0.08481 0.08481 0.9492        &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492     &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492
```

```
   FLASH-SPECS STRM = 38AS-VAP  TEMP=90.0  PRES=25.0  NPK=1  KPH=1 /
               STRM = 38AS-LIQ  TEMP=90.0  PRES=25.0  NPK=1  KPH=2
;
;  Flow splitter to generate the waste water stream going to the
;  gasifier, Plant 9, and the stream going to the phenol recovery
;  plant, Plant 39.
BLOCK P38B FSPLIT
   FRAC  WASTE  0.28595
   PARAM NPK=1  KPH=2
;
; Plant 39 - The PHENOL RECOVERY PLANT - Use user Fortran block USR39.
BLOCK P39 USER
   SUBROUTINE MODEL = USR39   REPORT = USR39
   DESCRIPTION 'PLANT 39 - THE PHENOL RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL39.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Phenol recovery, percent.
;      REAL(2)   = Purity of phenol product, wt %.
;      REAL(3) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of phenol recovered,
;                  kw/(Mlbs/hr of phenol recovered).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
```

```
;                 phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                 recovered).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                 consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                 phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                 recovered).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                 consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                 phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                 recovered).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                 consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                 phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                 recovered).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                 consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                 phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                 recovered).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                 consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                 phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                 recovered).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                 MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of phenol
;                 recovered,
;                 (MM BTU/hr)/(Mlbs/hr of phenol recovered).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                 Mgal/hr.
;       REAL(39)  = Cooling water consumption per Mlbs/hr of phenol
;                 recovered, (Mgal/hr)/(Mlbs/hr of phenol recovered).
;       REAL(39)  = Constant factor for the process water consumption,
;                 Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of phenol
;                 recovered, (Mgal/hr)/(Mlbs/hr of phenol recovered).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                 MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of phenol recovered,
;                 (MM SCF/hr of N2)/(Mlbs/hr of phenol recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                 day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                 (operators/day)/train.
;       REAL(51)  = Reference phenol recovery rate of a single train in
;                 Mlbs/hr for the calculation of the IKSBL field cost
;                 of a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                 phenol recovery rate in Mlbs/hr of phenol recovered.
```

```
;       REAL(53)  = Minimum size of a single train as defined by the
;                   phenol recovery rate in Mlbs/hr of phenol recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;    NOTE: In the above, phenol recovered means pure phenol recovered.
;
;         Phenol recovery, %     Phenol purity, wt%
     REAL 97.0089            89.62                &
;         Future use (8 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power             900/750 F steam   900 satd steam
          0.0 339.16667     0.0 0.0           0.0 0.0       &
;         600/720 F steam   600 satd steam    150 satd steam
          0.0  0.0          0.0 0.0           0.0 9.465     &
;         50 satd steam     Plant fuel        Cooling  H2O
          0.0 25.652917     0.0 0.0           0.0 111.775   &
;         Process H2O       Nitrogen
          0.0 0.0           0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.0           0.0                 &
;         Ref Flow   Max Flow   Min Flow
          2.4        20.0       1.0        &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future Use (3 items)
          0.0    13.3    0.8056 1.0    0.0      0.0   0.0   &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR39.
   FLASH-SPECS STRM = PHENOL   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = WASTEH20 KODE=2   TEMP = 80.   PRES = 14.7
;
;  Plant SA6 separates the combined product stream from Plants 31.1
;  and 31.4 into two streams, one for flue gas and another for solids.
;  The separation is set to the URCOAL fraction in the solids stream.
BLOCK SA6 SEP
  FRAC  SUBS=NC    STREAM=FBC-SOL  COMP=URCOAL  FRAC=0.8500914   /
        SUBS=MIXED STREAM=FBC-SOL  COMP=T1000+  FRAC=1.0D-10
;
;  Splitter S1 - The Inlet Coal Splitter.  Used as a switch to divert
;  flow between the three different coal cleaning options, as represented
;  by the three different Coal Cleaning and Preparation Plants:
;  Base Case (1S01), Alternate Case 1 (1S11), and Alternate Case 2 (1S21).
BLOCK S1 FSPLIT
  DESCRIPTION 'INLET ROM COAL SPLITTER - COAL CLEANING SWITCH'
```

```
  FRAC  1S01 1.0 / 1S11 0.0 / 1S21 0.0
;
;  Splitter S2 - The Clean Coal Splitter.
BLOCK S2 FSPLIT
  DESCRIPTION 'CLEAN COAL SPLITTER'
  FRAC COALTO14 0.736227
;
;  Splitter S6-SH2O is a component splitter to generate a pseudo
;   sour-water stream from Plant 6 to get the NH3 to Plant 38, the
;   Ammonia Recovery Plant.
BLOCK S6-SH2O SEP
  DESCRIPTION 'SPLITTER TO GENERATE PSEUDO SOUR WATER FROM PLANT 6'
  FRAC  SUBS=MIXED  STREAM=6S-SH2O  COMP=NH3  FRAC=1.0
;
;  Splitter S7 - The Product Naphtha Splitter.  Used as a switch to
;  divert flow between the naphtha reformer, Plant 7 and output to
;  naphtha product.
BLOCK S7 FSPLIT
  DESCRIPTION 'HYDROTREATED NAPHTHA SPLITTER - REFORMER OPTION SWITCH'
;  ==================================================================
;  Use the following line to direct total flow to the reformer, or....
;  FRAC  7-NAPH 1.0
;  Use the following line to direct total flow to the product stream.
  FRAC PNAPHTHA 1.0
;
;  Splitter S8 - The Ash-Concentrate Splitter.  Used as a switch to
;  divert flow between the fluidized bed combustor, Plant 314 and the
;  coal gasification train; Plants M9C, P09, & P10.
BLOCK S8 FSPLIT
  DESCRIPTION 'ASH-CONCENTRATE SPLITTER - FBC OPTION 6 SWITCH'
;  Direct the ash-concentrate flow to coal gasification.
  FRAC  S8-ASHC 1.0
;
;  Splitter S9 - The dummy hydrogen splitter used to switch between
;  the two hydorgen production alternatives, Plant 9.0/10 - coal
;  gasification, or Plant 9.1 - steam reforming of methane.
BLOCK S9 FSPLIT
  DESCRIPTION 'DUMMY H2 SPLITTER - H2 GENERATION OPTION SWITCH'
;  Set an H2 target flow for Plant 9.0/10 - coal gasification.
  FRAC  H9NEED 1.0
  PARAM   NPK=1  KPH=1
;
; Stream Report Section
; ---------------------
;
STREAM-REPORT P1A
   STREAMS STRM = ROMCOAL 1S-CCOAL 9COAL COALTO14 COALTO2       &
                  14S-XMID 14S-REF 1S-XMID 1S-REFSE             &
                  ASH-CONC S8-ASHC COALTO9 9-FEED SLAG SOLVENT  &
                  2S-BOTTS FBC-FEED SA6-01 FBC-SOL FBC-GAS
   FLOW-FRAC SUBS=MIXED BASES=MASS / SUBS=NC BASES=MASS
   INTENSIVE-PROPS SUBS=MIXED BASES=MASS &
                   PROPS=TEMP PRES MW ENTH ENTR DENS HCAP /
                   SUBS=NC BASES=MASS &
                   PROPS=TEMP PRES MW ENTH DENS
```

```
   ATTRIBUTES SUBS=NC COMPONENT
;
STREAM-REPORT P1B
   STREAMS STRM = 1S-WATER 14S-WAT 2-H2OIN 2-H2IN H2MIX 2-H2MIX      &
                  SOLVENT ROSE-XTR 2S-GAS GASES 2S-SH2O              &
                  NAPHTHA GAS-OIL H2-RICH SOUR-GAS P61-GAS           &
                  H2-2RICH SOUR-2GS GAS-OUT NAPHTHA2 3-GAS           &
                  3S-SGAS 3S-FGAS 3S-PROP 3S-BUT 3S-OIL 3S-SH2O      &
                  4-FEED 4-H2IN 4-H2OIN 4S-GAS 4S-NAPH 4S-SH2O       &
                  5S-HPGAS 5S-LPGAS 5-H2IN 5-H2OIN                   &
                  5S-NAPH P350-450 P450-650 P650-850 5S-SH2O         &
                  PS-NAPH PNAPHTHA 7-NAPH 7S-H2 7S-GAS REFORMED      &
                  61-HYD 62-HYD M9H2 M9H4 M9H5 MHNEED                &
                  H9NEED H91NEED                                     &
                  10-AIRIN 10S01 10S02 9-O2IN 9-H2OIN 9-STEMIN       &
                  H2-GAS H2S-GAS VENT-GAS 9S-SH2O                    &
                  NAT-GAS STEAM H2-PROD FLUE-GAS                     &
                  6-SGAS 6S-SH2O 11-FEED 11S-FGAS 11S-LIQS 31S-01    &
                  38-FEED NH3-PROD 38S-OUT 38AS-VAP 38AS-LIQ         &
                  WASTE 39FEED PHENOL WASTEH2O
   FLOW-FRAC SUBS=MIXED BASES=MASS
   INTENSIVE-PROPS SUBS=MIXED BASES=MASS &
                   PROPS=TEMP PRES MW ENTH ENTR DENS HCAP
;
;  End of input file OPT4.INP
```

APPENDIX J

APPENDIX J

ASPEN/SP PROCESS SIMULATION MODEL

INPUT FILE FOR OPTION 5 --

FLUID COKING OF VACUUM BOTTOMS

ASPEN/SP PROCESS SIMULATION MODEL

INPUT FILE FOR OPTION 5 --

FLUID COKING OF VACUUM BOTTOMS

```
NEW
;
;   File: OPT5.INP
;
TITLE 'OPT5 - DIRECT COAL LIQUEFACTION - FLUID BED COKER OPTION'
;
DESCRIPTION &
  "ASPEN/SP INPUT FILE FOR SIMULATING THE OPTION 5 DESIGN, FLUID COKING
   OF VACUUM BOTTOMS, FOR THE NTH PLANT.  THIS INPUT FILE ALSO CAN BE
   USED TO RUN OPTION 6 (STEAM REFORMING OF NATURAL GAS FOR HYDROGEN
   PRODUCTION WITH AN FBC UNIT) AND OPTION 7 (NAPHTHA REFORMING)."
;
;  NOTES:
;  1.  The dry clean coal feed rate to the Plant 2 coal liquefaction
;      reactors is set in the design specification DES-SPEC COALFLO.
;  2.  The switches LOSBL and LPLANT contained in Fortran block SUMMARY
;      control the costing logic for OSBL and first or Nth plant.
;  3.  Option 6 (hydrogen production by steam reforming of natural
;      gas with an FBC unt) is activated by variable N9 in Fortran
;      block OPTION6.  When N9 = 1, Option 6 is invoked.
;  4.  Option 7 (naphtha reforming) is activated in Block S7 by
;      sending all the hydrotreated naphtha to Plant 7 rather than
;      to the product PNAHTHA.
;  5.  The costing logic is controlled by switches in Fortran block
;      SUMMARY.
;
;   Last revision - July 13, 1992.
;
;   Prepared under DOE contract no. DE-AC22 90PC89857.
;
IN-UNITS  ENG
OUT-UNITS ENG
HISTORY-UNITS ENG
RUN-CONTROL MAX-ERRORS=100
;
;  The following two lines are used with V8.0 to produce the overall
;  and block elemental balances.
;REPORT ATOMBAL
;BLOCK-REPORT ATOMBAL
;
HISTORY  MSG-LEVEL  PROPERTIES=2
  MAX-PRINT  PROPERTIES=100  SIMULATION=2000
;
PROPERTIES SYSOP2 GLOBAL
;
PSEUDO-COMPS
  METHOD METCCOAL -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 &
```

```
                    -1 -1 -1 -1 -1 -1 -1
;  The following APIs and MWs are revised from the ASPEN/SP predictions.
;  Component T1000+ is the 1000+ F material leaving the second coal
;    liquefaction reactor in Plant 2.
;  Component I1000+ is the 1000+ F intermediate material leaving the
;    first coal liquefaction reactor in Plant 2.
   COMPONENT T125    TBP=324.82 <K>  API=67.91  MW= 82.27
   COMPONENT T175    TBP=352.59 <K>  API=61.99  MW= 92.77
   COMPONENT T225    TBP=380.37 <K>  API=56.21  MW=102.84
   COMPONENT T275    TBP=408.15 <K>  API=50.60  MW=112.50
   COMPONENT T325    TBP=435.93 <K>  API=45.18  MW=121.82
   COMPONENT T375    TBP=463.71 <K>  API=39.96  MW=130.86
   COMPONENT T425    TBP=491.48 <K>  API=34.96  MW=139.75
   COMPONENT T475    TBP=519.26 <K>  API=30.19  MW=148.60
   COMPONENT T525    TBP=547.04 <K>  API=25.66  MW=157.54
   COMPONENT T575    TBP=574.82 <K>  API=21.39  MW=166.69
   COMPONENT T625    TBP=602.59 <K>  API=17.38  MW=176.16
   COMPONENT T675    TBP=630.37 <K>  API=13.66  MW=186.05
   COMPONENT T725    TBP=658.15 <K>  API=10.23  MW=196.44
   COMPONENT T775    TBP=685.93 <K>  API= 7.09  MW=207.37
   COMPONENT T825    TBP=713.71 <K>  API= 4.27  MW=218.85
   COMPONENT T875    TBP=741.48 <K>  API= 1.78  MW=230.87
   COMPONENT T925    TBP=769.26 <K>  API=-0.39  MW=243.37
   COMPONENT T975    TBP=797.04 <K>  API=-2.22  MW=256.24
   COMPONENT T1000+  TBP=824.82 <K>  API=-3.69  MW=269.33
   COMPONENT P125    TBP=324.82 <K>  API=67.91  MW= 82.27
   COMPONENT P175    TBP=352.59 <K>  API=61.99  MW= 92.77
   COMPONENT P225    TBP=380.37 <K>  API=56.21  MW=102.84
   COMPONENT P275    TBP=408.15 <K>  API=50.60  MW=112.50
   COMPONENT P325    TBP=435.93 <K>  API=45.18  MW=121.82
   COMPONENT P375    TBP=463.71 <K>  API=39.96  MW=130.86
   COMPONENT P425    TBP=491.48 <K>  API=34.96  MW=139.75
   COMPONENT P475    TBP=519.26 <K>  API=30.19  MW=148.60
   COMPONENT P525    TBP=547.04 <K>  API=25.66  MW=157.54
   COMPONENT P575    TBP=574.82 <K>  API=21.39  MW=166.69
   COMPONENT P625    TBP=602.59 <K>  API=17.38  MW=176.16
   COMPONENT P675    TBP=630.37 <K>  API=13.66  MW=186.05
   COMPONENT P725    TBP=658.15 <K>  API=10.23  MW=196.44
   COMPONENT P775    TBP=685.93 <K>  API= 7.09  MW=207.37
   COMPONENT P825    TBP=713.71 <K>  API= 4.27  MW=218.85
   COMPONENT P875    TBP=741.48 <K>  API= 1.78  MW=230.87
   COMPONENT P925    TBP=769.26 <K>  API=-0.39  MW=243.37
   COMPONENT P975    TBP=797.04 <K>  API=-2.22  MW=256.24
   COMPONENT P1000+  TBP=824.82 <K>  API=-3.69  MW=269.33
   COMPONENT I1000+  TBP=825.00 <K>  API=-4.00  MW=275.00
   COMPONENT REFORMAT TBP=390.00 <K>  API=38.25  MW=100.00
;
COMPONENTS H2 H2 / N2 N2 / O2 O2 / H2S H2S / CO CO / CO2 CO2 / NH3 H3N /
           L-SULFUR SULFUR / H2O H2O / HCL HCL / COS COS / CH4 CH4 /
           C2H6 C2H6 / C3H8 C3H8 / IC4H10 C4H10-2 / NC4H10 C4H10-1 /
           IC5H12 C5H12-2 / NC5H12 C5H12-1 /
;  Pseudocomponents
           T125 / T175 / T225 / T275 / T325 / T375 / T425 / T475 /
           T525 / T575 / T625 / T675 / T725 / T775 / T825 / T875 /
           T925 / T975 / T1000+ /
```

```
          P125 / P175 / P225 / P275 / P325 / P375 / P425 / P475 /
          P525 / P575 / P625 / P675 / P725 / P775 / P825 / P875 /
          P925 / P975 / P1000+ / I1000+ / REFORMAT /
;  Non-conventional components
           COAL / URCOAL / SLAG
;
FORMULA    H2 H2 / N2 N2 / O2 O2 / H2S H2S / CO CO / CO2 CO2 / NH3 H3N /
           L-SULFUR S / H2O H2O / HCL HCL / COS COS / CH4 CH4 /
           C2H6 C2H6 / C3H8 C3H8 / NC4H10 C4H10 / IC4H10 C4H10 /
           NC5H12 C5H12 / IC5H12 C5H12
;
;  Load the liquid sulfur (L-SULFUR) physical properties as taken from
;  DIPPR - MW adjusted to be consistent with ASPEN.
PROP-DATA  IN-UNITS SI
  PROP-LIST        MW     /   TC    /     PC     /    VC    /   ZC
  PVAL L-SULFUR   32.06  / 1313.0 / 1.8208E+7 / 0.15800 / 0.2640
  PROP-LIST       MUP    /  OMEGA /    TB     /   RGYR
  PVAL L-SULFUR   0.0    / 0.2624 /  717.82   /   0.0
  PROP-LIST         DELTA   /  DGFORM   /  DHFORM
  PVAL L-SULFUR   2.0245E+4 / 2.3825E+8 / 2.7880E+8
  PROP-LIST       CPIG
  PVAL L-SULFUR   2.5639E+4  -7.9870  4.7860E-3  -9.5700E-7  0.0  0.0  &
                  273.15  1500.0  0.0  87.113  1.0
;
; Load the solubility parameter for COS from the API Tech Data Book.
  PROP-LIST       DELTA
  PVAL COS        18179.0
;
;  Reset some component molecular weights to be consisitent with the
;  following elemental atomic weights, where needed.
;  H=1.0079, C=12.011, O=15.9994, N=14.0067, S=32.06 & Cl=35.453
  PROP-LIST       MW
  PVAL H2          2.0158
  PVAL N2         28.0134
  PVAL O2         31.9988
  PVAL H2S        34.0758
  PVAL CO         28.0104
  PVAL CO2        44.0098
  PVAL NH3        17.0304
  PVAL H2O        18.0152
  PVAL HCl        36.4609
  PVAL COS        60.0704
  PVAL CH4        16.0426
  PVAL C2H6       30.0694
  PVAL C3H8       44.0962
  PVAL IC4H10     58.1230
  PVAL NC4H10     58.1230
  PVAL IC5H12     72.1498
  PVAL NC5H12     72.1498
;
;  Set the specific gravities of H2, CO, CO2, NH3, H2S, N2 and COS to
;  the values given in the API Technical Data Book - Petroleum Refining.
  PROP-LIST        SPGR
  PVAL H2         0.3000
  PVAL CO         0.3000
```

```
   PVAL CO2          0.8180
   PVAL NH3          0.6162
   PVAL H2S          0.8014
   PVAL N2           0.8094
   PVAL COS          1.0200
 ;
 ATTR-COMPS COAL   PROXANAL ULTANAL SULFANAL AOXANAL
 ATTR-COMPS URCOAL PROXANAL ULTANAL SULFANAL AOXANAL
 ATTR-COMPS SLAG   PROXANAL ULTANAL SULFANAL AOXANAL
 ;
 NC-PROPS    COAL ENTHALPY  HCOALGEN /
                  DENSITY   DCOALIGT
 NC-PROPS  URCOAL ENTHALPY  HCOALGEN /
                  DENSITY   DCHARIGT
 NC-PROPS    SLAG ENTHALPY  HCOALGEN /
                  DENSITY   DCHARIGT
 ;
 DEF-STREAMS MIXNC ALL
 ;
 ;  Set an initial GUESS for the ROM COAL stream to Plant 1.
 STREAM ROMCOAL
    SUBSTREAM MIXED TEMP = 71.0  PRES = 14.7
      MASS-FLOW  H2O 24798.0
    SUBSTREAM NC TEMP = 71.0  PRES = 14.7
      MASS-FLOW  COAL 285035.0 / URCOAL 0.0 / SLAG 0.0
      COMP-ATTR COAL   PROXANAL (0.0 42.06 36.24 21.70) /
                       ULTANAL (21.7 61.1 4.2 1.2 0.1 5.1 6.6) /
                       SULFANAL (3.0 0.3 1.8) /
                       AOXANAL (43.8 17.1 24.1 0.8 0.1 5.6 1.0 0.6 2.1 4.1)
 ;  Fake the URCOAL properties.
      COMP-ATTR URCOAL PROXANAL (0.0 19.197 16.549 64.254) /
                       ULTANAL (64.254 29.914 0.185 1.304 0.0 4.267 0.076) /
                       SULFANAL (2.507 0.253 1.507) /
                       AOXANAL (43.8 17.1 24.1 0.8 0.1 5.6 1.0 0.6 2.1 4.1)
 ;  Fake the SLAG properties.
      COMP-ATTR SLAG   PROXANAL (0.0 10.0 0.0 90.0) /
                       ULTANAL (90.0 10.0 0.0 0.0 0.0 0.0 0.0 ) /
                       SULFANAL (0.0 0.0 0.0) /
                       AOXANAL (42.0 17.0 23.0 1.0 1.0 6.0 2.0 1.0 3.0 4.0)
 ;
 ;  Set an initial GUESS for the fresh make-up H2 stream to Plant 2.
 ;  Assume the make-up H2 contains 1.396 wt% nitrogen.
 STREAM 2-H2IN
    SUBSTREAM MIXED TEMP = 100.0  PRES = 3440.0
      MASS-FLOW  H2 70300.0 / N2 980.0
 ;
 ;  Set an initial GUESS for the total water feed streams (both steam
 ;  and wash water) to Plant 2.
 STREAM 2-H2OIN
    SUBSTREAM MIXED TEMP = 126.0  PRES = 3200.0
      MASS-FLOW  H2O 1073000.0
 ;
 ;  Set an initial GUESS for the ROSE EXTRACT stream to Plant 2.
 STREAM ROSE-XTR
    SUBSTREAM MIXED TEMP = 300.0  PRES = 3215.0
```

```
     MASS-FLOW  H2O 1.0
;
;  Set an initial GUESS for the SOLVENT stream to Plant 2.  The user
;  Fortran block model for Plant 2 does not require any solvent, but
;  the input stream is required.  Thus, set a small H2O flow to avoid
;  ASPEN warnings.
STREAM SOLVENT
   SUBSTREAM MIXED TEMP = 500.0  PRES = 500.0
     MASS-FLOW  H2O 1.0
;
;  Set an initial GUESS for the 2S-BOTTS stream leaving Plant 2.
STREAM 2S-BOTTS
   SUBSTREAM MIXED TEMP = 688.0  PRES = 28.0
     MASS-FLOW  H2O 0.0 /
       T825 380.0 / T875 3365.0 /
       T925 3365.0 / T975 3365.0 / T1000+ 642440.0
   SUBSTREAM NC TEMP = 688.0  PRES = 28.0
     MASS-FLOW  COAL 0.0 / URCOAL 254475.0
;
;  Set an initial GUESS for the H2 stream to Plant 4.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 4-H2IN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 500.0
     MASS-FLOW  H2 1400.0 / N2 19.0
;
;  Set an initial GUESS for the H2O stream to Plant 4.
STREAM 4-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 50.0
     MASS-FLOW  H2O 18770.
;
;  Set an initial GUESS for the H2 stream to Plant 5.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 5-H2IN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 500.0
     MASS-FLOW  H2 17000.0 / N2 279.0
;
;  Set an initial GUESS for the H2O stream to Plant 5.
STREAM 5-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 50.0
     MASS-FLOW  H2O 36382.0
;
;  Set an initial GUESS for the pseudo sour H2O from Plant 6.
STREAM 6S-SH2O
   SUBSTREAM MIXED TEMP = 60.0  PRES = 14.7
     MASS-FLOW  NH3 2830.0
;
STREAM 82-AIR
   SUBSTREAM MIXED TEMP = 70.0 PRES = 15.0
     MASS-FLOW  O2 3071. / N2 10107.
;
STREAM 82-STM
   SUBSTREAM MIXED TEMP = 500.  PRES = 600.0
     MASS-FLOW  H2O  42000.0
;
;  Stream H2OFEED includes the water entering with the MEA stream.
```

```
STREAM 82-H2O
   SUBSTREAM MIXED TEMP = 100.  PRES = 50.0
     MASS-FLOW  H2O  17122.0
;
;  Set an initial GUESS for the H2O stream to Plant 9.0.
STREAM 9-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 14.7
     MASS-FLOW  H2O 967545.0
;
;  Set an initial GUESS for the STEAM stream to Plant 9.0.
STREAM 9-STEMIN
   SUBSTREAM MIXED TEMP = 450.0  PRES = 500.0
     MASS-FLOW  H2O 167545.0
;
;  Set an initial GUESS for the OXYGEN stream to Plant 9.0.
STREAM 9-O2IN
   SUBSTREAM MIXED TEMP = 80.0  PRES = 300.0
     MASS-FLOW  O2 743531.0 / N2 3269.0
;
;  Set an initial GUESS for the AIR stream to Plant 10.
STREAM 10-AIRIN   TEMP = 70.0  PRES = 14.7
     MASS-FLOW  O2 743531.0 / N2 2463614.0
;
;  Set an initial GUESS for the CH4 stream to Plant 9.1.
STREAM NAT-GAS
   SUBSTREAM MIXED TEMP = 70.0  PRES = 100.0
     MASS-FLOW  CH4 307352.
;
;  Set an initial GUESS for the STEAM stream to Plant 9.1.
STREAM STEAM
   SUBSTREAM MIXED TEMP = 620.0  PRES = 500.0
     MASS-FLOW  H2O 864428.
;
; Model Connectivity
; ------------------
;
FLOWSHEET COAL
; Plant M1 is the clean coal outlet streams mixer.
;   Stream 1S-CCOAL is the combined outlet clean coal product stream.
; Plant M2 is the middling coal outlet streams mixer.
;   Stream 1S-XMID  is the combined outlet middling coal product stream.
; Plant M-2HYD is the mixer to combine H2 streams for Plant 2.
;   Stream 2-H2MIX  is the combined H2 stream from 6.1, 6.2, & source.
; Plant M3 is the refuse outlet streams mixer.
;   Stream 1S-REFSE is the combined outlet refuse product stream.
; Plant M38 is the sour water mixer.
;   Stream 38-FEED  is the combined sour water streams to Plant 38.
; Plant M4 is the waste water outlet streams mixer.
;   Stream 1S-WATER is the combined outlet waste water product stream.
; Plant M-462 is the mixer to combine H2 streams for Plant 6.2.
;   Stream 62-HYD   is the combined H2 stream from Plants 2 & 4.
; Plant M5 is the mixer to combine gas oil streams for Plant 5.
;   Stream GAS-OIL  is the product gas oil stream from P02.
;   Stream 82S-GO   is the product gas oil stream from P82.
;   Stream 5-GO     is the combined gas oil stream to P05.
```

```
; Plant M-561 is the mixer to combine H2 streams for Plant 6.1.
;   Stream 61-HYD   is the combined H2 stream from Plants 2 & 5.
; Plant M-6GAS is the heater to combine sour gas streams for Plant 11.
;   Stream 6-SGAS   is the combined sour gas stream from Plants 6.1 & 6.2.
; Plant M-73 is the mixer to combine H2 gas streams for Plant 3.
;   Stream 3-GAS    is the combined H2 gas stream from Plant 3.
; Plant M-HYD is the mixer (flash2) to combine H2 streams for M-2HYD.
;   Stream H2MIX    is the combined H2 stream from Plants 6.1 & 6.2.
;   Stream DUMMY    is the dummy vapor stream that contains no flow.
; Plant M-NAP is the mixer to combine naphtha streams for Plant 4.
;   Stream 82S-NAP  is the product naphtha stream from P82.
;   Stream 4-FEED   is the combined naphtha stream from Plants 2 & 6.2.
; Plant M-PNAP is the mixer to combine product naphtha streams.
;   Stream PS-NAPH is the combined naphtha stream from Plants 4 & 5.
; Plant P1-ALT1 is the Coal Cleaning and Preparation Plant - ALT CASE 1.
;   Stream 1S12     is the outlet clean coal product stream.
;   Stream 1S13     is the outlet middling coal product stream.
;   Stream 1S14     is the outlet refuse product stream.
;   Stream 1S15     is the outlet waste water product stream.
; Plant P1-ALT2 is the Coal Cleaning and Preparation Plant - ALT CASE 2.
;   Stream 1S22     is the outlet clean coal product stream.
;   Stream 1S23     is the outlet middling coal product stream.
;   Stream 1S24     is the outlet refuse product stream.
;   Stream 1S25     is the outlet waste water product stream.
; Plant P1-BASE is the Coal Cleaning and Preparation Plant - BASE CASE.
;   Stream 1S02     is the outlet clean coal product stream.
;   Stream 1S03     is the outlet middling coal product stream.
;   Stream 1S04     is the outlet refuse product stream.
;   Stream 1S05     is the outlet waste water product stream.
; Plant P14 is the Coal Grinding and Drying Plant.
;   Stream COALTO2  is the outlet clean coal product stream.
;   Stream 14S-XMID is the outlet middling coal product stream.
;   Stream 14S-REF  is the outlet refuse product stream.
;   Stream 14S-WAT  is the outlet waste water product stream.
; Plant P02 is the Coal Liquefaction Plant.
;   Stream 2-H2MIX  is the hydrogen feed stream.
;   Stream COALTO2  is the clean coal feed stream.
;   Stream SOLVENT  is the solvent feed stream.  This stream is used to
;     supply the steam required to Plant 2.
;   Stream ROSE-XTR was the deashed product stream, now only H2O.
;   Stream 2-H2OIN  is the water feed stream to the liquefaction unit.
;   Stream 2S-GAS   is the HP gas product stream going to Plant 6.1.
;   Stream GASES    is the LP gas product stream going to Plant 6.2.
;   Stream NAPHTHA  is the naphtha product stream.
;   Stream GAS-OIL  is the gas-oil product stream going to Plant 5.
;   Stream 2S-BOTTS is the bottoms stream going to Plant 8.2.
;   Stream 2S-SH2O  is the sour water product stream.
; Plant P03 is the Gas Plant.
;   Stream 3S-SGAS  is the sour off-gas product stream.
;   Stream 3S-FGAS  is the fuel gas product stream.
;   Stream 3S-PROP  is the C3 product stream.
;   Stream 3S-BUT   is the C4s product stream.
;   Stream 3S-OIL   is the lean-oil product stream to M-NAP.
;   Stream 3S-SH2O  is the product sour water stream.
; Plant P04 is the simplified model for plant 4, the naphtha hydrotreater.
```

```
;   Stream 4-H2IN   is the hydrogen feed stream.
;   Stream 4-H2OIN  is the water feed stream.
;   Stream 4S-GAS   is the hydrotreater off-gas product stream.
;   Stream 4S-NAPH  is the hydrotreated naphtha product stream.
;   Stream 4S-SH2O  is the hydrotreater sour water stream.
; Plant P05 is the simplified model for plant 5, the gas-oil hydrotreater.
;   Stream 5-H2IN   is the hydrogen feed stream.
;   Stream 5-H2OIN  is the water feed stream.
;   Stream 5S-HPGAS is the hydrotreater hi-pressure purge gas stream.
;   Stream 5S-LPGAS is the hydrotreater other gases stream.
;   Stream 5S-NAPH  is the hydrotreated C6-350 F naphtha product stream.
;   Stream P350-450 is the hydrotreated 350 - 450 F product stream.
;   Stream P450-650 is the hydrotreated 450 - 650 F product stream.
;   Stream P650-850 is the hydrotreated 650 - 850 F product stream.
;   Stream 5S-SH2O  is the hydrotreater sour water stream.
; Plant P61 is the model for the Hydrogen purification by Membrane
;     Separation Plant, Plant 6.1.
;   Stream 61-HYD   is the feed stream to the H2 purification plant.
;   Stream H2-RICH  is the purified H2-rich product gas stream.
;   Stream SOUR-GAS is the sour gas product stream.
;   Stream P61-GAS  is the reject (non-permeate) product gas stream.
; Plant P62 is the model for the Hydrogen purification by Pressure
;     Swing absorption Plant, Plant 6.2.
;   Stream 62-HYD   is the mixed gas feed stream to the PSA hydrogen
;     purification plant.
;   Stream P61-GAS  is the reject gas stream from Plant 6.1, the high
;     pressure section of Plant 6, the hydrogen purification by
;     membrane permeation section.
;   Stream H2-2RICH is the purified h2-rich product gas stream.
;   Stream SOUR-2GS is the sour gas product stream.
;   Stream GAS-OUT  is the reject product gas stream.
;   Stream NAPHTHA2 is the liquid raw naphtha product stream.
; Plant P07 is the simplified model for Plant 7, the naphtha reformer.
;   Stream 7-NAPH   is the naphtha feed stream.
;   Stream 7S-H2    is the hydrogen rich product gas stream.
;   Stream 7S-GAS   is the light hydrocarbon product gas stream.
;   Stream REFORMED is the reformate product stream.
; Plant P82 is the simplified model for plants 8.2 - Fluid Coker.
;   Stream 2S-BOTTS is the bottoms product stream from P02.
;   Stream 82-AIR   is the air inlet stream.
;   Stream 82-STM   is the steam inlet stream.
;   Stream 82-H2O   is the water inlet stream.
;   Stream 82S-GAS  is the gases product stream.
;   Stream 82S-NAP  is the naphtha product stream to P04.
;   Stream 82S-GO   is the gas oil product stream to P05.
;   Stream 82S-BOT  is the 850-1000 product stream to M9C.
;   Stream 82S-COKE is the coke product stream to M9C.
;   Stream 82S01    is the combined acid gas and sour water stream.
; Plant P82A is a splitter to simulate the MEA unit.
;   Stream 82S01    is the combined acid gas and sour water stream.
;   Stream 82AS-GAS is the acid gas product stream to P11.
;   Stream 82AS-H2O is the sour water stream to P38.
; Plant P11 is the Sulfur plant.
;   Stream 11S-LIQS is the sulfur product stream.
;   Stream 11S-FGAS contains all the other material in the feed that
```

```
;     does not leave in the product SULFUR STREAM.
; Plant P31 is the simplified model for the utility plant.
;   Stream 31S-01   is the dummy product stream.
; Plant P38 is the NH3 recovery plant.
;   Stream NH3-PROD is the product NH3.
;   Stream 38S-OUT  is the reject stream.
; Plant P38A is the reject stream component splitter from plant 38.
;   Stream 38AS-VAP is the vapor stream going to Plant 11.
;   Stream 38AS-LIQ is the liquid stream going to Plant 38B.
; Plant P38B is the liquid reject stream splitter from Plant 38A.
;   Stream WASTE    is the reject portion of the inlet stream which
;     in this model is rejected, but actually goes to the coal
;     gasification plant, if present.
;   Stream 39FEED   is the stream going on to Plant 39.
; Plant P39 is the phenol recovery plant.
;   Stream PHENOL   is the phenol product stream.
;   Stream WASTEH2O is the waste water stream.
; Block S1 is the inlet coal splitter.
;   Stream ROMCOAL  is the inlet ROM coal stream.
;   Stream 1S01     is the splitter outlet to the base case plant.
;   Stream 1S11     is the splitter outlet to the alternate case 1 plant.
;   Stream 1S21     is the splitter outlet to the alternate case 2 plant.
; Block S2 is the clean coal splitter.
;   Stream 1S-CCOAL is the inlet clean coal stream.
;   Stream COALTO14 is the splitter outlet to plant 2.
;   Stream 9-COAL   is the splitter outlet to plant 9.
; Block S6-SH2O is a component splitter to generate a pseudo sour-water
;   stream from Plant 6 to get the NH3 to Plant 38, the Ammonia Recovery
;   Plant.
;   Stream 6S-SH2O  is the pseudo sour-water stream.
;   Stream 11-FEED  is the Plant 11 feed stream.
; Block S7 is the product naphtha splitter.
;   Stream PS-NAPH  is the inlet product naphtha stream.
;   Stream 7-NAPH   is the splitter outlet to the naphtha reformer plant.
;   Stream PNAPHTHA is the splitter outlet as product naphtha.
;
  M1        IN = 1S02 1S12 1S22   OUT = 1S-CCOAL
  M2        IN = 1S03 1S13 1S23   OUT = 1S-XMID
  M-2HYD    IN = H2MIX 2-H2IN     OUT = 2-H2MIX
  M3        IN = 1S04 1S14 1S24   OUT = 1S-REFSE
  M38       IN = 2S-SH2O 3S-SH2O 4S-SH2O 5S-SH2O 6S-SH2O 9S-SH2O     &
              OUT = 38-FEED
  M4        IN = 1S05 1S15 1S25   OUT = 1S-WATER
  M-462     IN = 4S-GAS GASES 5S-LPGAS 3S-SGAS 7S-H2     OUT = 62-HYD
  M5        IN = GAS-OIL 82S-GO   OUT = 5-GO
  M-561     IN = 5S-HPGAS 2S-GAS  OUT = 61-HYD
  M-6GAS    IN = SOUR-GAS SOUR-2GS H2S-GAS 38AS-VAP      OUT = 6-SGAS
  M-73      IN = GAS-OUT 7S-GAS   OUT = 3-GAS
  M-HYD     IN = H2-RICH H2-2RICH OUT = H2MIX DUMMY
  M-NAP     IN = NAPHTHA2 3S-OIL 82S-NAP                 OUT = 4-FEED
  M-PNAP    IN = 4S-NAPH 5S-NAPH  OUT = PS-NAPH
  P1-ALT1   IN = 1S11             OUT = 1S12 1S13 1S14 1S15
  P1-ALT2   IN = 1S21             OUT = 1S22 1S23 1S24 1S25
  P1-BASE   IN = 1S01             OUT = 1S02 1S03 1S04 1S05
  P14       IN = COALTO14         OUT = COALTO2 14S-XMID 14S-REF 14S-WAT
```

```
  P02       IN = 2-H2MIX COALTO2 SOLVENT ROSE-XTR 2-H2OIN                &
              OUT = 2S-GAS GASES NAPHTHA GAS-OIL 2S-BOTTS 2S-SH2O
  P03       IN = NAPHTHA 3-GAS                                           &
              OUT = 3S-SGAS 3S-FGAS 3S-PROP 3S-BUT 3S-OIL 3S-SH2O
  P04       IN = 4-H2IN 4-FEED 4-H2OIN                                   &
              OUT = 4S-GAS 4S-NAPH 4S-SH2O
  P05       IN = 5-H2IN 5-GO 5-H2OIN                                  &
              OUT = 5S-HPGAS 5S-LPGAS 5S-NAPH P350-450 P450-650        &
                    P650-850 5S-SH2O
  P61       IN = 61-HYD            OUT = H2-RICH SOUR-GAS P61-GAS
  P62       IN = 62-HYD P61-GAS                                          &
              OUT = H2-2RICH SOUR-2GS GAS-OUT NAPHTHA2
  P07       IN = 7-NAPH            OUT = 7S-H2 7S-GAS REFORMED
  P82       IN = 2S-BOTTS 82-AIR 82-STM 82-H2O                           &
              OUT = 82S-GAS 82S-NAP 82S-GO 82S-BOT 82S-COKE 82S01
  P82A      IN = 82S01             OUT = 82AS-GAS 82AS-H2O
  P11       IN = 11-FEED           OUT = 11S-FGAS 11S-LIQS
  P31       IN = 3S-FGAS           OUT = 31S-01
  P38       IN = 38-FEED           OUT = NH3-PROD 38S-OUT
  P38A      IN = 38S-OUT           OUT = 38AS-VAP 38AS-LIQ
  P38B      IN = 38AS-LIQ          OUT = WASTE 39FEED
  P39       IN = 39FEED            OUT = PHENOL WASTEH2O
  S1        IN = ROMCOAL           OUT = 1S01 1S11 1S21
  S2        IN = 1S-CCOAL          OUT = COALTO14 9COAL
  S6-SH2O   IN = 6-SGAS            OUT = 6S-SH2O 11-FEED
  S7        IN = PS-NAPH           OUT = 7-NAPH PNAPHTHA
;
FLOWSHEET HYDROGEN
; Plant M9 is the hydrogen stream mixer.
;   Stream M9H2     is the dummy H2 stream to the liquefaction unit.
;   Stream M9H4     is the dummy H2 stream to the naphtha hydrotreater.
;   Stream M9H5     is the dummy H2 stream to the gas-oil hydrotreater.
;   Stream HHNEED   is the dummy H2 stream from the mixer.
; Plant M9C is the coal stream mixer.
;   Stream 82S-BOT  is the 850-1000 stream from the fluid bed coker unit.
;   Stream 82S-COKE is the coke stream from the fluid bed coker unit.
;   Stream COALTO9  is the clean coal stream to the mixer.
;   Stream 9-FEED   is the mixed coal stream to the gasifier.
; Plant P09 is the plant for producing hydrogen by coal gasification.
;   Stream 9-H2OIN  is the water feed stream to the gasifier section.
;   Stream 9-O2IN   is the purified O2 stream from the air sep. plant.
;   Stream 9-STEMIN is the steam that goes to the shift reactors.
;   Stream H2-GAS   is the product hydrogen stream.
;   Stream H2S-GAS  is the product hydrogen sulfide stream.
;   Stream VENT-GAS is the product vent gas stream.
;   Stream 9S-SH2O  is the product sour water stream.
;   Stream SLAG     is the product slag stream.
; Plant P91 is the Steam Reforming of Natural Gas Plant.
;   Stream NAT-GAS  is the inlet natural gas stream.
;   Stream STEAM    is the inlet process water stream.
;   Stream H2-PROD  is the product hydrogen stream.
;   Stream FLUE-GAS is the product flue gas stream.
; Plant P10 is the Air Separation Plant.
;   Stream 10-AIRIN is the air input stream.
;   Stream 10S01    is the product oxygen stream.
```

```
;   Stream 10S02    is the product nitrogen stream.
; Plant S9 is the hydrogen stream splitter.
;   Stream H9NEED   is the dummy H2 stream for the gasifier.
;   Stream H91NEED  is the dummy H2 stream for the steam reformer.
;
  M9H       IN = M9H2 M9H4 M9H5    OUT = MHNEED
  M9C       IN = 82S-BOT 82S-COKE COALTO9   OUT = 9-FEED
  P09       IN = 9-FEED 9-H2OIN 9-02IN 9-STEMIN        &
              OUT = H2-GAS H2S-GAS VENT-GAS 9S-SH2O SLAG
  P91       IN = NAT-GAS STEAM     OUT = H2-PROD FLUE-GAS
  P10       IN = 10-AIRIN          OUT = 10S01  10S02
  S9        IN = MHNEED            OUT = H9NEED H91NEED
;
; Design Specifications
; ---------------------
;
;  Design spec to set the hydrogen flow rate to Plant 2 (2-H2MIX)
;  to a specified weight percent (HPCT2) of the MAF coal input stream.
DES-SPEC 2H2FLO
   DEFINE CHP2   MASS-FLOW  STREAM=2-H2MIX  COMPONENT=H2
   DEFINE CCOAL  MASS-FLOW  STREAM=COALTO2  SUBSTREAM=NC COMPONENT=COAL
   DEFINE CCASH  COMP-ATTR-VAR STREAM=COALTO2  SUBSTREAM=NC &
                   COMPONENT=COAL ATTRIBUTE=ULTANAL ELEMENT=1
C     Set the specified H2 rate to Plant 2 in wt% in the following line.
F     HPCT2 = 6.52D0
C     DAFCOAL is the dry ash-free coal (MAF coal).
F     DAFCOAL = CCOAL * (100.0D0 - CCASH) * 0.01D0
F     H2P2 = 0.01D0 * HPCT2 * DAFCOAL
   SPEC CHP2 TO H2P2
   TOL-SPEC 0.1
   VARY STREAM-VAR  STREAM=2-H2IN  VARIABLE=MASS-FLOW
   LIMITS 100 1000000
;
;  Design spec to set the correct ROM coal flow to the splitter to
;  obtain the desired 17,102 TPSD of MF coal flow rate to the coal
;  liquefaction plant, Plant 2.
DES-SPEC COALFLO
   DEFINE CTARG  MASS-FLOW  STREAM=COALTO2   SUBSTREAM=NC  COMPONENT=COAL
;  Set TPD to the target coal rate to Plant 2 in TPSD of MF coal.
;  ==============================================================
;
F     TPD = 17102.0D0
F     WTPHR = (TPD * 2000.0D0) / 24.0D0
   SPEC CTARG TO WTPHR
   TOL-SPEC 0.1
   VARY MASS-FLOW  STREAM=ROMCOAL  SUBSTREAM=NC  COMPONENT=COAL
   LIMITS 100 10000000
;
;  Design spec to set the correct 9-FEED flow rate to the Plant 9,
;  coal gasifier, to obtain the desired hydrogen production rate.
DES-SPEC H2FLO
   DEFINE HOUT   MASS-FLOW   STREAM=H2-GAS   COMPONENT=H2
   DEFINE HTOT   MASS-FLOW   STREAM=H9NEED   COMPONENT=H2
   SPEC HOUT TO HTOT
   TOL-SPEC 1.0
```

```
   VARY STREAM-VAR STREAM=COALTO9  SUBSTREAM=NC  VAR=MASS-FLOW
   LIMITS 0.1 10000000
;
;  Design spec to set the heat duty to block M-HYD to zero by
;  varying the temperature. This corrects a temperature calculating
;  error in the ASPEN mixer block algorithm.
DES-SPEC HD-HYD
   DEFINE HDTY BLOCK-VAR BLOCK=M-HYD SENTENCE=RETENTION VARIABLE=HEAT-DUTY
   SPEC HDTY TO 0.0
   TOL-SPEC 1000
   VARY BLOCK-VAR BLOCK=M-HYD SENTENCE=PARAM VARIABLE=TEMPERATURE
   LIMITS 10 500
;
;  Design spec to set the 10-AIRIN stream flow to produce the required
;  amount of oxygen product required by Plant 9, coal gasification.
DES-SPEC O2FLO
 DEFINE FLO10S STREAM-VAR STREAM=10S01    VAR=MASS-FLOW
 DEFINE FLOOXY STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
   SPEC FLO10S TO FLOOXY
   TOL-SPEC 0.1
   VARY STREAM-VAR  STREAM=10-AIRIN  VARIABLE=MASS-FLOW
   LIMITS 0.1 10000000
;
;  Design spec to set the hydrogen flow rate for Plant 9.1.
DES-SPEC RFMRFLO
   DEFINE HOUT2  MASS-FLOW   STREAM=H2-PROD  COMPONENT=H2
   DEFINE HTOT2  MASS-FLOW   STREAM=H91NEED  COMPONENT=H2
   SPEC HOUT2 TO HTOT2
   TOL-SPEC 0.1
   VARY STREAM-VAR  STREAM=NAT-GAS  VARIABLE=MASS-FLOW
   LIMITS 1000 600000
;
; Transfer Blocks
; ---------------
;
;  Transfer block to set COALTO9 equal to the 9COAL stream (the wet
;  clean coal input).  This duplicates the full property set and
;  provides the initial guess flow rate for COALTO9.
TRANSFER CCOAL
   SET STREAM COALTO9
   EQUAL-TO STREAM 9COAL
;
;  Transfer block used to set the hydrogen flow rates of the input
;  streams to the calculated hydrogen flows to Plant 2 (2-H2IN),
;  Plant 4 (4-H2IN), and Plant 5 (5-H2IN).  M9's represent hydrogen
;  flows from Plant 9.0/10 and M91's are for the Plant 9.1 alternative.
TRANSFER HFLOW
   SET STREAM M9H2
   EQUAL-TO STREAM 2-H2IN
   SET STREAM M9H4
   EQUAL-TO STREAM 4-H2IN
   SET STREAM M9H5
   EQUAL-TO STREAM 5-H2IN
;
; Fortran Blocks
```

```
; --------------
;
;  Fortran block to set the correct water flow rate in the clean
;  coal going to Plant 9.
FORTRAN 9COAL
   DEFINE W9COAL MASS-FLOW  STREAM=9COAL   COMPONENT=H2O
   DEFINE C9COAL MASS-FLOW  STREAM=9COAL   SUBSTREAM=NC COMPONENT=COAL
   DEFINE WCTO9  MASS-FLOW  STREAM=COALTO9 COMPONENT=H2O
   DEFINE CCTO9  MASS-FLOW  STREAM=COALTO9 SUBSTREAM=NC COMPONENT=COAL
F     WCTO9 = CCTO9 * (W9COAL / C9COAL)
;
;  This Fortran block resets the split fraction in S2 to provide the
;  flow rate of coal to Plant 9.0.
FORTRAN COALFLOW
   DEFINE C14    STREAM-VAR  STREAM=COALTO14  VAR=MASSFLOW
   DEFINE C9     STREAM-VAR  STREAM=COALTO9   VAR=MASSFLOW
   DEFINE RC     STREAM-VAR  STREAM=ROMCOAL   VAR=MASSFLOW
   DEFINE CC     STREAM-VAR  STREAM=1S-CCOAL  VAR=MASSFLOW
   DEFINE SFRAC  BLOCK-VAR   BLOCK=S2  SENTENCE=FRAC  VAR=FRAC  &
    ID1=COALTO14  ELEMENT=1
C     Calculate total clean coal.
F     TCC = C14 + C9
C     Reset the ROMCOAL feed rate to match the new value.
F     RC = RC * (TCC / CC)
C     Reset the split fraction in S2 to correct 9COAL flow rate.
F     SFRAC = C14 / (C9 + C14)
;
;  This FORTRAN block will calculate the initial ratio of the MIXED
;  substream flow to the NC substream flow in the stream ROMCOAL.
;  It will store this result in RATIO, and use that value to adjust
;  the MIXED substream flow in proportion to the NC substream flow
;  that is varied by the COALFLO design-spec.  This is needed to set
;  the correct amount of water entering with the ROM coal.
FORTRAN MIXFLO
F     COMMON /RATIO/ RMIXNCP
F     COMMON /RGLOB/ RDUM1, RMIN
 DEFINE FLONCP SUBSTREAM-VAR STREAM=ROMCOAL SUBSTREAM=NC VAR=MASSFLOW
 DEFINE FLOMIX SUBSTREAM-VAR STREAM=ROMCOAL SUBSTREAM=MIXED VAR=MASSFLOW
C  The following should only be true on the first pass.  This prevents
C  writing over the initial substream ratio on subsequent passes.
F     IF (RMIXNCP .LT. RMIN) THEN
F        RMIXNCP = FLONCP / FLOMIX
F     END IF
C  Adjust the other substream flow based on changes to the NC
C  substream.
F     FLOMIX = FLONCP / RMIXNCP
;
;  FORTRAN block to set the COMBINED steam and water flow rate to
;  Plant 2 as a specified weight percent of the dry coal feed.
FORTRAN SETUP2
   DEFINE FEED2 MASS-FLOW  STREAM=COALTO2  SUBSTREAM=NC  COMPONENT=COAL
   DEFINE H2O2  STREAM-VAR STREAM=2-H2OIN  VAR=MASSFLOW
F     H2O2 = 0.75315 * FEED2
;
;  FORTRAN block used to set the hydrogen flow rate to Plant 4 (4-H2IN)
```

```
;  to a specified weight percent (HPCT4) of the naphtha feed stream,
;  and the hydrogen flow rate to Plant 5 (5-H2IN) to a specified weight
;  percent (HPCT5) of the gas oil feed stream.  This block also sets
;  the inlet water flow rates for these plants to specified rates
;  as functions of the hydrocarbon feed rates.
FORTRAN SETUP45
   DEFINE CHP4   MASS-FLOW  STREAM=4-H2IN   COMPONENT=H2
   DEFINE CHP5   MASS-FLOW  STREAM=5-H2IN   COMPONENT=H2
   DEFINE FLP4   STREAM-VAR STREAM=4-H2IN   VAR=MASSFLOW
   DEFINE FLP5   STREAM-VAR STREAM=5-H2IN   VAR=MASSFLOW
   DEFINE XNAPH  STREAM-VAR STREAM=4-FEED   VAR=MASSFLOW
   DEFINE XGOIL  STREAM-VAR STREAM=GAS-OIL  VAR=MASSFLOW
   DEFINE H2O4   STREAM-VAR STREAM=4-H2OIN  VAR=MASSFLOW
   DEFINE H2O5   STREAM-VAR STREAM=5-H2OIN  VAR=MASSFLOW
C     Set the specified H2 rates in wt% in the following two lines.
F     HPCT4 = 1.1855
F     HPCT5 = 2.7554
F     H2P4 = 0.01D0 * HPCT4 * XNAPH
F     FLP4 = H2P4 * (FLP4 / CHP4)
F     H2P5 = 0.01D0 * HPCT5 * XGOIL
F     FLP5 = H2P5 * (FLP5 / CHP5)
C     Set the specified H2O rates in wt% in the following two lines.
F     H2O4 = 0.089017 * XNAPH
F     H2O5 = 0.054217 * XGOIL
;
;  FORTRAN block to set the air, steam and water stream flow rates to
;  Plant 8.2 based on the inlet flow of hydrocarbons and NC components.
FORTRAN SETUP82
 DEFINE FD82MX SUBSTREAM-VAR STREAM=2S-BOTTS SUBSTREAM=MIXED VAR=MASS-FLOW
 DEFINE FD82NC SUBSTREAM-VAR STREAM=2S-BOTTS SUBSTREAM=NC    VAR=MASS-FLOW
 DEFINE AIR82  STREAM-VAR  STREAM=82-AIR    VAR=MASSFLOW
 DEFINE STM82  STREAM-VAR  STREAM=82-STM    VAR=MASSFLOW
 DEFINE H2O82  STREAM-VAR  STREAM=82-H2O    VAR=MASSFLOW
F     FEED82 = FD82MX + FD82NC
F     AIR82  = 0.022228 * FEED82
F     STM82  = 0.070844 * FEED82
F     H2O82  = 0.028881 * FEED82
;
;  FORTRAN block to set the steam, water and oxygen stream flow rates
;  to Plant 9 based on the inlet flow rate of hydrocarbons and NC
;  components (on a dry ash-free basis).
FORTRAN SETUP9
 DEFINE FL29MX SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=MIXED VAR=MASS-FLOW
 DEFINE ULCOAL COMP-ATTR-VAR STREAM=9-FEED  SUBSTREAM=NC &
        COMPONENT=COAL   ATTRIBUTE=ULTANAL ELEMENT=1
 DEFINE ULURC  COMP-ATTR-VAR STREAM=9-FEED  SUBSTREAM=NC &
        COMPONENT=URCOAL ATTRIBUTE=ULTANAL ELEMENT=1
 DEFINE FL29C   MASS-FLOW  STREAM=9-FEED  SUBSTREAM=NC COMPONENT=COAL
 DEFINE FL29UR  MASS-FLOW  STREAM=9-FEED  SUBSTREAM=NC COMPONENT=URCOAL
 DEFINE FL29W   MASS-FLOW  STREAM=9-FEED  COMPONENT=H2O
 DEFINE FL2STM  STREAM-VAR STREAM=9-STEMIN VAR=MASS-FLOW
 DEFINE FL2H2O  STREAM-VAR STREAM=9-H2OIN  VAR=MASS-FLOW
 DEFINE FL2O2   STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
C  Adjust the steam, water and oxygen stream flow rates based on the
C  inlet flow rate of hydrocarbons and NC components (on a dry basis).
```

```
F     X1 = 0.01*FL29C *(100.0-ULCOAL)
F     X2 = 0.01*FL29UR*(100.0-ULURC)
F     FL2STM = 0.25495 * (FL29MX + X1 + X2 - FL29W)
F     FL2H2O = 1.4723 * (FL29MX + X1 + X2 - FL29W)
F     FL2O2  = 1.1365 * (FL29MX + X1 + X2 - FL29W)
;
;  Fortran block to set up the common and OSBL utility consumptions.
FORTRAN SETUP31
F     COMMON /USRC01/ PLNTID(32), UTIL(32,15), CAPCST(32,5), OPCST(32,5)
F     CHARACTER * 6  PLNTID
 DEFINE DCOAL2 SUBSTREAM-VAR STREAM=COALTO2 SUBSTREAM=NC VAR=MASS-FLOW
C     COMMON /USRC03/ is used to transfer variables FIN(5,4),
C       FOUT(20,4), PGAS, PPWR, OPTN6
C     See Subroutine USRSR1 for the definition of the items in named
C     common block /USRC03/.
C     Base all the offsite and OSBL utilities consumptions on the dry
C     coal feed rate to Plant 2, the Coal Liquefaction Plant. Ignore
C     cooling and process water consumptions and productions.
F     PLNTID (19) = 'OTHERS'
C     Electric Power.
F     UTIL(19,1) = 25.1346 * DCOAL2 * 0.001
F     IF ( OPTN6 .GE. 0.99D0 )   UTIL(19,1) = 29.5411 * DCOAL2 * 0.001
C     600 psig steam at 720F.
F     UTIL(19,4) = 0.05122207 * DCOAL2 * 0.001
C     150 psig saturated steam.
F     UTIL(19,6) = 0.04350367 * DCOAL2 * 0.001
C     50 psig saturated steam.
F     UTIL(19,7) = 0.06757103 * DCOAL2 * 0.001
;
;  Fortran statement to set the molar flow rate of the STEAM stream to
;  be in balance with the feed stream to Plant 9.1.
FORTRAN SETUP91
   DEFINE GS     STREAM-VAR  STREAM=NAT-GAS  VARIABLE=MOLE-FLOW
   DEFINE ST     STREAM-VAR  STREAM=STEAM    VARIABLE=MOLE-FLOW
F     IF (GS .GT. 0.0D0 )   THEN
F         ST = 2.504543D0 * GS
F       ELSE
F         ST = 0.0D0
F     ENDIF
;
;  Fortran block to switch between Plants 9.0 and 10 (Baseline Design
;  Case) or Plants 9.1, 31.1 and 31.4 (Option 6).
FORTRAN OPTION6
F     COMMON /USRC03/ FIN(5,4), FOUT(20,4), PGAS, PPWR, OPTN6
C     See Subroutine USRSR1 for the definition of the items in named
C     common block /USRC03/.
 DEFINE FSTM   STREAM-VAR STREAM=STEAM    VAR=MOLE-FLOW
 DEFINE FNG    STREAM-VAR STREAM=NAT-GAS  VAR=MOLE-FLOW
 DEFINE F10A   STREAM-VAR STREAM=10-AIRIN VAR=MASS-FLOW
 DEFINE F9H    STREAM-VAR STREAM=9-H2OIN  VAR=MASS-FLOW
 DEFINE F9S    STREAM-VAR STREAM=9-STEMIN VAR=MASS-FLOW
 DEFINE F9O    STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
 DEFINE FC9M   SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=MIXED VAR=MASS-FLOW
 DEFINE FC9NC  SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=NC    VAR=MASS-FLOW
 DEFINE FRAC9  BLOCK-VAR   BLOCK=S9  SENTENCE=FRAC  VAR=FRAC  &
```

```
  ID1=H9NEED   ELEMENT=1
 DEFINE FRAC38 BLOCK-VAR   BLOCK=P38B  SENTENCE=FRAC  VAR=FRAC  &
  ID1=WASTE    ELEMENT=1
C     Set N9 equal to 0 to run Plants 9.0 and 10 (Baseline), or
C     set N9 equal to 1 to run Plants 9.1, 31.1 and 31.4 (OPTION 6).
F     N9 = 0
F     IF (N9 .EQ. 0) THEN
F       OPTN6 = 0.0D0
F       FSTM = 1.0D-6
F       FNG = 1.0D-6
F       FRAC9 = 1.0
C       FRAC38 value is changed for Option 5 from baseline value.
F       FRAC38 = 0.24055
F     ENDIF
F     IF (N9 .EQ. 1) THEN
F       OPTN6 = 1.0D0
F       F10A = 1.0D-6
F       F9H = 1.0D-6
F       F9S = 1.0D-6
F       F9O = 1.0D-6
F       FC9M = 1.0D-6
F       FC9NC = 1.0D-6
F       FRAC9 = 0.0
F       FRAC38 = 0.0
F     ENDIF
;
FORTRAN SUMMARY
C     This Fortran block writes the summary report to the DCLSUM.REP
C     file, and also writes the DCL1.PRN file for transfering the
C     results to the Lotus spreadsheet economics model.
C     COMMON /USRC03/ is used to transfer variables FIN(5,4),
C       FOUT(20,4), PGAS, PPWR, OPTN6
C     See Subroutine USRSR1 for the definition of the items in named
C     common block /USRC03/.
 DEFINE FIN1   SUBSTREAM-VAR STREAM=ROMCOAL   SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FIN2   STREAM-VAR    STREAM=NAT-GAS   VAR=MASS-FLOW
 DEFINE FOUT1  STREAM-VAR    STREAM=3S-PROP   VAR=MASS-FLOW
 DEFINE FOUT2  STREAM-VAR    STREAM=3S-BUT    VAR=MASS-FLOW
 DEFINE FOUT3A STREAM-VAR    STREAM=PNAPHTHA  VAR=MASS-FLOW
 DEFINE FOUT3B STREAM-VAR    STREAM=REFORMED  VAR=MASS-FLOW
 DEFINE FOUT4  STREAM-VAR    STREAM=P350-450  VAR=MASS-FLOW
 DEFINE FOUT5  STREAM-VAR    STREAM=P450-650  VAR=MASS-FLOW
 DEFINE FOUT6  STREAM-VAR    STREAM=P650-850  VAR=MASS-FLOW
 DEFINE FOUT7  SUBSTREAM-VAR STREAM=1S-REFSE  SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT8  SUBSTREAM-VAR STREAM=SLAG      SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT10 STREAM-VAR    STREAM=NH3-PROD  VAR=MASS-FLOW
 DEFINE FOUT11 STREAM-VAR    STREAM=PHENOL    VAR=MASS-FLOW
 DEFINE FOUT12 STREAM-VAR    STREAM=11S-LIQS  VAR=MASS-FLOW
C     Load the stream flow rates in the FIN() and FOUT() arrays in
C     Mlbs/hr.  All solid stream flow rates are on a dry basis.
F     FIN(1,1)  = 0.001D0 * FIN1
F     FIN(2,1)  = 0.001D0 * FIN2
F     FOUT(1,1) = 0.001D0 * FOUT1
F     FOUT(2,1) = 0.001D0 * FOUT2
F     FOUT(3,1) = 0.001D0 * (FOUT3A + FOUT3B)
```

```
F     FOUT(4,1) = 0.001D0 * FOUT4
F     FOUT(5,1) = 0.001D0 * FOUT5
F     FOUT(6,1) = 0.001D0 * FOUT6
F     FOUT(7,1) = 0.001D0 * FOUT7
F     FOUT(8,1) = 0.001D0 * FOUT8
F     FOUT(10,1) = 0.001D0 * FOUT10
F     FOUT(11,1) = 0.001D0 * FOUT11
F     FOUT(12,1) = 0.001D0 * FOUT12
C
C     Set XOF to the number of extra operators and OSBL operators
C     per dedicated plant operator.
C     ----------------------------
F     XOF = 0.343042
C
C     Set the LOSBL and LPLANT switches, as appropriate, to duplicate
C     the Bechtel OSBL and first vs. Nth plant costing logic.
C     LOSBL  = 0  - Use baseline case OSBL costing logic.
C     LOSBL  = 1  - Use option case OSBL costing logic.
C     LPLANT = 0  - Use first plant OSBL and engineering costing logic.
C     LPLANT = 1  - Use Nth plant OSBL and engineering costing logic.
C     ================================================================
F     LOSBL = 1
F     LPLANT = 1
C
C     Open the separate output file called DCLSUM.REP to contain the
C     summary report of the simulation results.
F     OPEN (UNIT=62, FILE='DCLSUM.REP', STATUS='UNKNOWN',
F    1  ACCESS='SEQUENTIAL', FORM='FORMATTED',
F    2  BUFFERED='BUFFERED')
C     Call Subroutines USRSR1 and USRSR2 to write the summary report.
F     CALL USRSR1 (62)
F     CALL USRSR2 (62, LOSBL, LPLANT, OPTN6, XOF)
F     CLOSE (UNIT=62, STATUS='KEEP')
C     Now write the LOTUS spreadsheet economics model input file.
F     OPEN (UNIT=62, FILE='DCL1.PRN', STATUS='UNKNOWN',
F    1  ACCESS='SEQUENTIAL', FORM='FORMATTED',
F    2  BUFFERED='BUFFERED')
C     Call Subroutines USRSR3 to write the model input file.
F     CALL USRSR3 (62, OPTN6, XOF)
F     CLOSE (UNIT=62, STATUS='KEEP')
;
; Convergence Blocks
; ------------------
;
CONVERGENCE CBLK1 WEGSTEIN
  TEAR H2MIX 1D-5
  PARAM WAIT=3
;
CONVERGENCE CBLK3 WEGSTEIN
  TEAR 6S-SH2O 1D-5
;
CONVERGENCE COALF ONE-VAR
  SPEC COALFLO
;
CONVERGENCE HD-C1 ONE-VAR
```

```
  SPEC HD-HYD
;
CONVERGENCE HYDF BROYDEN-SPEC
  SPEC H2FLO
;
CONVERGENCE 2HYDF ONE-VAR
  SPEC 2H2FLO
;
CONVERGENCE OXYF ONE-VAR
  SPEC O2FLO
;
CONVERGENCE RFMRF ONE-VAR
  SPEC RFMRFLO
;
; Calculation Sequence
; --------------------
;
;  Define subsequence for coal cleaning complex.
SEQUENCE CLEAN COALF MIXFLO S1 P1-BASE P1-ALT1 P1-ALT2                  &
               M1 S2 P14 (RETURN COALF)                                  &
               M4 M3 M2
;
;  Specify entire flowsheet sequence, including subsequence CLEAN.
SEQUENCE BASE  (SEQUENCE CLEAN)  CCOAL                                  &
               CBLK1   2HYDF M-2HYD (RETURN 2HYDF)                       &
               SETUP2 P02 SETUP82 P82                                    &
               P61 P62   HD-C1 M-HYD (RETURN HD-C1)                      &
               M-73 P03 M-NAP M5 SETUP45 P04 M-462 P05 M-561             &
               M-PNAP S7 P07 (RETURN CBLK1)                              &
               HFLOW M9H OPTION6 S9                                      &
               HYDF 9COAL M9C SETUP9 P09 (RETURN HYDF)                   &
               OXYF P10 (RETURN OXYF)  COALFLOW  (SEQUENCE CLEAN)        &
               RFMRF SETUP91 P91 (RETURN RFMRF)                          &
               CBLK3 M38 P38 P38A P38B P39 M-6GAS S6-SH2O                &
               (RETURN CBLK3)                                            &
               P11 SETUP31 P31 SUMMARY
;
; Unit Operations Blocks
; ----------------------
;
;  Mix the clean coal product streams from the 3 different cases.
BLOCK M1 MIXER
  DESCRIPTION 'PLANT 1 OUTLET CLEAN COAL MIXER'
;
;  Mix the middling coal product streams from the 3 different cases.
BLOCK M2 MIXER
  DESCRIPTION 'PLANT 1 OUTLET MIDDLING COAL MIXER'
;
;  Mix the hydrogen streams going to Plant 2.
BLOCK M-2HYD MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL HYDROGEN STREAM TO PLANT 2'
  PARAM NPK=1  KPH=1
;
;  Mix the refuse product streams from the 3 different cases.
BLOCK M3 MIXER
```

```
  DESCRIPTION 'PLANT 1 OUTLET REFUSE MIXER'
;
;  Mix the sour water streams from Plants 2, 3, 4, 5, and 9.
BLOCK M38 MIXER
  DESCRIPTION 'SOUR WATER MIXER FOR PLANT 38 FEED'
;
;  Mix the waste water product streams from the 3 different cases.
BLOCK M4 MIXER
  DESCRIPTION 'PLANT 1 OUTLET WASTE WATER MIXER'
;
;  Mix the hydrogen streams from Plants 4 & 2 for Plant 6.2.
BLOCK M-462 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 6.2 FEED'
;
;  Mix the gas oil streams from Plants 2 & 8.2 for Plant 5.
BLOCK M5 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 5 FEED'
;
;  Mix the hydrogen streams from Plants 5 & 2 for Plant 6.1.
BLOCK M-561 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 6.1 FEED'
;
;  Mix the sour gas streams from Plants 6.1, 6.2, 9 and 38 for the
;  Plant 11 feed stream.
BLOCK M-6GAS HEATER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 11 FEED'
  PARAM  TEMP=110.0  PRES=14.7
;
;  Mix the H2 gas streams from Plants 7 & 6.2 for Plant 3.
BLOCK M-73 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 3 FEED'
;
;  Mixer M9C - The hydrogen plant feed mixer; used to mix the coal and
;  ROSE unit ASH-CONC stream that goes to Plant 9.0.
BLOCK M9C MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 9 FEED'
  BLOCK-OPTIONS HMB-RESULTS=2
;
;  Mixer M9 - The dummy hydrogen mixer; used to mix the three
;  streams that go to Plant 2 (M9H2), Plant 4 (M9H4), and
;  Plant 5 (M9H5) into one single output stream (MHNEED) for the
;  S9 splitter.
BLOCK M9H MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL AMOUNT OF HYDROGEN NEEDED'
  PARAM NPK=1  KPH=1
;
;  Mix the hydrogen streams from Plants 6.1 and 6.2. Use a flash2 block
;  to correct a temperature calculating error in the ASPEN mixer block
;  algorithm.
BLOCK M-HYD FLASH2
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL HYDROGEN FROM 6.1 AND 6.2'
  PARAM  TEMP=100.  PRES=3290.
;
;  Mix the naphtha streams from Plants 2 and 6.2.
BLOCK M-NAP MIXER
```

```
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL PLANT 4 NAPHTHA FEED'
;
;  Mix the product naphtha streams from Plants 4 and 5.
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL PRODUCT NAPHTHA STREAM'
BLOCK M-PNAP MIXER
;
;  Plant P1-ALT1, Coal Cleaning and Preparation Plant. Use User
;  Fortran Model, USR01, within the PLANTS file. ALTERNATE CASE 1 -
;  COAL CLEANING BY HEAVY MEDIUM SEPARATION.
BLOCK P1-ALT1 USER
   SUBROUTINE MODEL = USR01    REPORT = USR01
   DESCRIPTION 'PLANT 1 - ALTERNATE 1 - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following integer and real parameters are for production of
;   the coal cleaned by both jigs and heavy medium separation.  The coal
;   cleaned only by jigs for gasification is handled by a separate plant
;   that is modeled in BLOCK P1-JIGS.  The operators and cost for this
;   plant includes those associalted with the P1-JIGS portion of the coal
;   cleaning and preparation plant.  All parameters have the same meaning
;   as described below for Plant 1 in BLOCK P1-BASE.
;
    INT  0  1  0  1  1
;         FCP          FCM    FHP          FHM    FNP          FNM
     REAL 0.9120155    0.0    0.9050241    0.0    0.8869236    0.0  &
;         FClP         FClM   FSP          FSM    FOP          FOM
         0.7602203    0.0    0.4471884    0.0    0.9905900    0.0  &
;         FAP          FAM
         0.3012854    0.0  &
;         PCWP  PCWM  PCWR  Future Use (3 items)
         9.0   3.0   10.0    0.   0.   0.                    &
;         Power            900/750 F steam   900 satd steam
         0.0 7.400489       0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
         0.0 0.0            0.0 0.0           0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling  H2O
         0.0 0.0            0.0 0.0           0.0 0.0       &
;         Process H2O        Nitrogen
         0.0 0.042246       0.0 0.0         &
;         Future Use (6 items)
         0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
         8.0           8.0                 &
;         Ref Flow   Max Flow   Min Flow
         285.035    300.0      150.0      &
;         Plant cost equation constants.
;         A      B       E      F      Spares     Future Use (2 items)
         0.0    25.52   0.5942 1.0    0.0        0.0   0.0    &
;         Future Use (10 items)
         0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S12    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S13    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S14    KODE=2   TEMP = 70.0   PRES = 14.7  /
```

```
                STRM = 1S15    KODE=2   TEMP = 70.0   PRES = 14.7
;
;  Plant P1-ALT2, Coal Cleaning and Preparation Plant. Use User Fortran
;  Model, USR01, within the PLANTS file. ALTERNATE CASE 2 - COAL CLEANING
;  BY HEAVY MEDIUM SEPARATION FOLLOWED BY SPHERICAL AGGLOMERATION.
BLOCK P1-ALT2 USER
   SUBROUTINE MODEL = USR01    REPORT = USR01
   DESCRIPTION 'PLANT 1 - ALTERNATE 2 - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following integer and real parameters are for production of
;   the coal cleaned by both jigs and heavy medium separation followed
;   by spherical agglomeration.  The coal cleaned only by jigs for
;   gasification is handled by a separate plant that is modeled in
;   BLOCK P1-JIGS.  The operators and cost for this plant includes
;   those associalted with the P1-JIGS portion of the coal cleaning
;   and preparation plant.  All parameters have the same meaning as
;   described below for Plant 1 in BLOCK P1-BASE.
;
    INT  0  1  0  1  2
;        FCP          FCM    FHP          FHM    FNP          FNM
     REAL 0.9435271    0.0    0.9338663    0.0    0.9250562    0.0  &
;        FC1P         FC1M   FSP          FSM    FOP          FOM
         0.7400450    0.0    0.3772778    0.0    0.9867266    0.0  &
;        FAP          FAM
         0.1295931    0.0  &
;        PCWP   PCWM  PCWR  Future Use (3 items)
         14.16  3.0   10.0  0.0   0.0   0.0                  &
;        Power                900/750 F steam   900 satd steam
         0.0 51.68786         0.0 0.0           0.0 0.0      &
;        600/720 F steam      600 satd steam    150 satd steam
         0.0 0.0              0.0 0.0           0.0 0.0      &
;        50 satd steam        Plant fuel        Cooling  H2O
         0.0 0.0              0.0 0.394967      0.0 0.0      &
;        Process H2O          Nitrogen
         0.0 0.103481         0.0 0.0         &
;        Future Use (6 items)
         0.0  0.0  0.0  0.0  0.0  0.0         &
;        Opers/day      (Opers/day)/train
         8.0            8.0                   &
;        Ref Flow   Max Flow   Min Flow
         262.3      300.0      150.0         &
;        Plant cost equation constants.
;        A      B      E      F      Spares     Future Use (2 items)
         0.0    73.78  0.5942 1.0    0.0        0.0   0.0    &
;        Future Use (10 items)
         0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S22    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S23    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S24    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S25    KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 1 - Coal Cleaning, Preparation and Drying Plant, Use User Fortran
```

```
;           Model USR01
;           BASE CASE - COAL CLEANING BY JIGS For LIQUEFACTION.
BLOCK P1-BASE USER
   SUBROUTINE MODEL = USR01   REPORT = USR01
   DESCRIPTION 'PLANT 1 - BASE CASE - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following 5 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL01B.REP, DCL01A1.REP or DCL01A2.REP
;                    depending on the value of the coal cleaning option
;                    control switch, INT(5).
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-4 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
;      INT(5)  = Coal cleaning, drying and grinding option control
;                switch.  The name of the short plant report file
;                written for each option is option dependent.
;                0 => Base case - Coal cleaning by jigs for coal
;                     liquefaction in plant 2. (Report = DCL01B.REP)
;                1 => Alternate case 1 - Coal cleaning by heavy media
;                     separation.  (Report = DCL01A1.REP)
;                2 => Alternate case 2 - Coal cleaning by heavy media
;                     separation and spherical agglomeration.
;                     (Report = DCL01A2.REP)
;                3 => Coal cleaning by jigs for coal gasification in
;                     plant 9.  (Report = DCL01G.REP)
;                4 => Coal grinding and drying plant.
;                     (Report = DCL01D.REP)
;              NOTE: Values 0, 1 and 2 are used when this model
;                     cleans the coal going to the coal liquefaction
;                     plant, 3 is used only when this model cleans
;                     the coal going to the coal gasification plant,
;                     and 4 is for the grinding and drying plant.
```

```
INT  0  1  0  1  0
;     The following 70 real parameters are:
;     REAL(1)   = Fraction of carbon in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(2)   = Fraction of carbon in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(3)   = Fraction of hydrogen in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(4)   = Fraction of hydrogen in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(5)   = Fraction of nitrogen in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(6)   = Fraction of nitrogen in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(7)   = Fraction of chlorine in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(8)   = Fraction of chlorine in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(9)   = Fraction of sulfur in the inlet coal leaving
;                 in the clean coal product stream.  OPTIONAL - See Note 1.
;     REAL(10)  = Fraction of sulfur in the inlet coal leaving
;                 in the middling coal stream.  OPTIONAL - See Note 1.
;     REAL(11)  = Fraction of oxygen in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(12)  = Fraction of oxygen in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(13)  = Fraction of ash in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(14)  = Fraction of ash in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(15)  = Moisture content of the clean product coal on a dry
;                 basis, wt%.
;     REAL(16)  = Moisture content of the middling coal on a dry
;                 basis, wt%.
;     REAL(17)  = Moisture content of the refuse on a dry basis, wt%.
;     REAL(18) -
;      REAL(20) = Future use.
;     REAL(21)  = Constant factor for the power consumption, kw.
;     REAL(22)  = Power consumption per Mlbs/hr of dry clean coal,
;                 kw/(Mlbs/hr).
;     REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                 consumption, Mlbs/hr.
;     REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                 dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;     REAL(25)  = Constant factor for the 900 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                 dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;     REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                 consumption, Mlbs/hr.
;     REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                 dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;     REAL(29)  = Constant factor for the 600 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
```

```
;                 dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;     REAL(31)  = Constant factor for the 150 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                 dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;     REAL(33)  = Constant factor for the 50 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                 dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;     REAL(35)  = Constant factor for the plant fuel consumption,
;                 MM BTU/hr.
;     REAL(36)  = Plant fuel consumption per Mlbs/hr of dry clean coal,
;                 (MM BTU/hr)/(Mlbs/hr).
;     REAL(37)  = Constant factor for the cooling water consumption,
;                 Mgal/hr.
;     REAL(38)  = Cooling water consumption per Mlbs/hr of dry clean
;                 coal (Mgal/hr)/(Mlbs/hr).
;     REAL(39)  = Constant factor for the process water consumption,
;                 Mgal/hr.
;     REAL(40)  = Process water consumption per Mlbs/hr of dry clean
;                 coal, (Mgal/hr)/(Mlbs/hr).
;     REAL(41)  = Constant factor for the nitrogen consumption,
;                 MM SCF/hr of N2.
;     REAL(42)  = Nitrogen consumption per Mlbs/hr of dry clean coal,
;                 (MM SCF/hr of N2)/(Mlbs/hr).
;     REAL(43) -
;      REAL(48) = Future use.
;     REAL(49)  = Constant factor for the number of operators per
;                 day, operators/day.
;     REAL(50)  = Number of operators per day per train,
;                 (operators/day)/train.
;     REAL(51)  = Reference flow rate of the dry clean coal of a
;                 single train in Mlbs/hr for the calculation of
;                 the ISBL field cost of a single train as a function
;                 of train capacity.
;     REAL(52)  = Maximum size of a single train as defined by the
;                 flow rate of the dry clean coal in Mlbs/hr.
;     REAL(53)  = Minimum size of a single train as defined by the
;                 flow rate of the dry clean coal in Mlbs/hr.
;     REAL(54)  = Constant A in the plant ISBL field cost equation.
;     REAL(55)  = Constant B in the plant ISBL field cost equation.
;     REAL(56)  = Constant E in the plant ISBL field cost equation.
;     REAL(57)  = Constant F in the plant ISBL field cost equation.
;     REAL(58)  = Number of spare trains.
;     REAL(59) -
;      REAL(70) = Future use.
;
;   NOTES:
;     1. If both the sulfur distribution factors, REAL(9) and REAL(10),
;        are zero and a SULFANAL was supplied, the sulfur will be
;        distributed among the products as follows.
;        a. The ORGANIC sulfur will be distributed in the same
;           proportions as the carbon is distributed.
;        b. The PYRITIC and SULFATE sulfur will be distributed in the
;           same proportions as the ash is distributed.
```

```
;
;          FCP          FCM    FHP          FHM    FNP          FNM
     REAL 0.9302390    0.0    0.9142857    0.0    0.9533333    0.0  &
;          FC1P         FC1M   FSP          FSM    FOP          FOM
           0.40000      0.0    0.5019608    0.0    0.9696970    0.0  &
;          FAP          FAM
           0.4229677    0.0  &
;          PCWP   PCWM  PCWR  Future Use (3 items)
           8.576  3.0   10.0  0.0   0.0   0.0                  &
;          Power                900/750 F steam   900 satd steam
           0.0 4.281977         0.0 0.0           0.0 0.0       &
;          600/720 F steam      600 satd steam    150 satd steam
           0.0 0.0              0.0 0.0           0.0 0.0       &
;          50 satd steam        Plant fuel        Cooling  H2O
           0.0 0.0              0.0 0.0           0.0 0.0       &
;          Process H2O          Nitrogen
           0.0 0.02433102       0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0         &
;          Opers/day      (Opers/day)/train
           8.0            8.0                   &
;          Ref Flow    Max Flow    Min Flow
           387.158     390.0       200.0         &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future use (2 items)
           0.0    18.2    0.5942 1.0    0.0      0.0   0.0       &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S02    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S03    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S04    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S05    KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 1.4 - Coal Grinding and Drying Plant - Fortran Model USR01
;             BASE CASE
BLOCK P14 USER
   SUBROUTINE MODEL = USR01   REPORT = USR01
   DESCRIPTION 'PLANT 1.4 - BASE CASE - COAL GRINDING AND DRYING PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following integer and real parameters have the same meaning
;      as described above for Plant 1 in BLOCK P1-BASE.
    INT  0  1  0  1  4
;          FCP          FCM    FHP          FHM    FNP          FNM
     REAL 1.0          0.0    1.0          0.0    1.0          0.0  &
;          FC1P         FC1M   FSP          FSM    FOP          FOM
           1.0          0.0    1.0          0.0    1.0          0.0  &
;          FAP          FAM
           1.0          0.0   &
;          PCWP   PCWM  PCWR  Future Use (3 items)
           2.0    3.0   10.0  0.0   0.0   0.0                  &
;          Power                900/750 F steam   900 satd steam
           0.0 8.499979         0.0 0.0           0.0 0.0       &
```

```
;         600/720 F steam   600 satd steam    150 satd steam
          0.0 0.0           0.0 0.0           0.0 0.0       &
;         50 satd steam     Plant fuel        Cooling  H2O
          0.0 0.0           0.0 0.3410096     0.0 0.010104  &
;         Process H2O       Nitrogen
          0.0 0.0           0.0 3.16015     &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          7.0           1.0                 &
;         Ref Flow   Max Flow   Min Flow
          142.518    145.0      50.0       &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future use (2 items)
          0.0    8.75    0.8504 1.0    0.0      0.0   0.0       &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = COALTO2  KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-XMID KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-REF  KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-WAT  KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 2 - The coal liquefaction plant - user Fortran block USR02.
BLOCK P02 USER
   SUBROUTINE MODEL = USR02   REPORT = USR02
   DESCRIPTION 'PLANT 2 - COAL LIQUEFACTION PLANT - COKER OPTION'
   PARAM  NINT = 6   NREAL = 70
;      The following 6 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL02.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
```

```
;            3-5 => Write some more additional output to the history
;                   file.  Larger values generate more intermediate
;                   output.
;     INT(5) = Switch to write the major equipment summary list and
;              cost summary report by plant section for the baseline
;              design to the separate block output summary report file
;              called DCL02.REP on logical unit 62.
;              0 => Do not write the major equipment summary list.
;              1 => Write the major equipment summary list to the
;                   separate block output file only when
;                   INT(1) <= 2, INT(2) = 1, and INT(6) = 0.
;              2 => Write the major equipment summary list and the
;                   cost summary report by plant section to the
;                   separate block output file only when
;                   INT(1) <= 2, INT(2) = 1, and INT(6) = 0.
;     INT(6) = Switch to select which coal liquefaction reactor yields
;              are calculated.
;              0 => Baseline design two reactor model.
;              3 => Option 3 - Yields for Thermal/Catalytic two-
;                   reactor model.
;              4 => Option 4 - Two-reactor model with interstaage
;                   vent gas separation.
;              5 => Option 5 - Yields for two-reactor coker model.
;              8 => Improved Baseline (Option 8) - High space velocity
;                   two-reactor model.
   INT  0  1  0  1  2  5
;     The following 70 real parameters are:
;     REAL(1)    = Percent coal conversion based on fresh MAF coal
;                  entering the coal liquefaction reactors.
;     REAL(2)-
;      REAL(20) = Future use.
;     REAL(21)   = Constant factor for the power consumption, kw.
;     REAL(22)   = Power consumption per Mlbs/hr of dry coal feed,
;                  kw/(Mlbs/hr of dry coal).
;     REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;     REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(25)   = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;     REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(29)   = Constant factor for the 600 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(31)   = Constant factor for the 150 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(33)   = Constant factor for the 50 psig saturated steam
```

```
;                    consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                    dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                    MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of dry coal feed,
;                    (MM BTU/hr)/(Mlbs/hr of dry coal).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                    Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of dry coal
;                    feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;                    produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(39)  = Constant factor for the process water consumption,
;                    Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of dry coal
;                    feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                    MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of dry coal feed,
;                    (MM SCF/hr of N2)/(Mlbs/hr of dry coal).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                    day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                    (operators/day)/train.
;       REAL(51)  = Reference dry coal feed rate to a single train in
;                    Mlbs/hr for the calculation of the ISBL field cost of
;                    a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the dry
;                    coal feed rate in Mlbs/hr of dry coal.
;       REAL(53)  = Minimum size of a single train as defined by the dry
;                    coal feed rate in Mlbs/hr of dry coal.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Percent fresh MAF coal conversion
     REAL 92.7901  &
;          Future use (9 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0    &
;          Power              900/750 F steam    900 satd steam
           0.0 29.830195      0.0 0.0            0.0 0.0        &
;          600/720 F steam    600 satd steam     150 satd steam
           0.0 0.003904784    0.0 -0.075393      0.0 -0.009201  &
;          50 satd steam      Plant fuel         Cooling H2O
           0.0 0.0393743      0.0 0.5515144      0.0 0.2456133  &
;          Process H2O        Nitrogen
           0.0 0.1009987      0.0 0.0000216   &
```

```
;         Future Use (6 items)
          0.0  0.0  0.0 0.0  0.0  0.0       &
;         Opers/day     (Opers/day)/train
          0.0           8.0                 &
;         Ref Flow   Max Flow   Min Flow
          285.035    285.05     30.0        &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future use (2 items)
          0.0    186.44  0.7142 1.0    0.0      0.0   0.0   &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR02.
   FLASH-SPECS STRM = 2S-GAS    KODE=2   TEMP = 130.   PRES = 2985.  / &
               STRM = GASES     KODE=2   TEMP = 130.   PRES = 65.   / &
               STRM = NAPHTHA   KODE=2   TEMP = 140.   PRES = 16.   / &
               STRM = GAS-OIL   KODE=2   TEMP = 110.   PRES = 30.   / &
               STRM = 2S-BOTTS  KODE=2   TEMP = 688.   PRES = 28.   / &
               STRM = 2S-SH2O   KODE=2   TEMP = 100.   PRES = 30.
;
; Plant 3 - The gas plant - use user Fortran block USR03.
BLOCK P03 USER
   SUBROUTINE MODEL = USR03   REPORT = USR03
   DESCRIPTION 'PLANT 3 - THE GAS PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL03.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
```

```
;       The following 70 real parameters are:
;       REAL(1) -
;        REAL(20) = Future use.
;       REAL(21)  = Constant factor for the power consumption, kw.
;       REAL(22)  = Power consumption per MM SCF/hr of dry C4- gas,
;                   kw/(MM SCF/hr of dry C4- gas)
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of dry C4- gas,
;                   (MM BTU/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of dry C4-
;                   gas, (Mgal/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of dry C4-
;                   gas, (Mgal/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of dry C4- gas,
;                   (MM SCF/hr of N2)/(MM SCF/hr of dry C4- gas).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference gas feed rate to a single train in
;                   MM SCF/hr of dry C4- gas for the calculation of
;                   the ISBL field cost of a single train as a function
```

```
;                    of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                    gas feed rate in MM SCF/hr of dry C4- gas.
;       REAL(53)  = Minimum size of a single train as defined by the
;                    gas feed rate in MM SCF/hr of dry C4- gas.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Future use (10 items)
     REAL 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
          0.0 447.6001       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 194.4388      0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling  H2O
          0.0 8.425471       0.0 -722.141      0.0 645.8090  &
;          Process H2O        Nitrogen
          0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day      (Opers/day)/train
          0.0             8.0               &
;          Ref Flow   Max Flow   Min Flow
          2.04       5.0        0.300      &
;          Plant cost equation constants.
;          A      B          E      F      Spares   Future Use (3 items)
          0.0    25.3       0.8013 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR03.
   FLASH-SPECS STRM = 3S-SGAS   KODE=2  TEMP = 137.0  PRES = 55.0   /
               STRM = 3S-FGAS   KODE=2  TEMP = 100.0  PRES = 215.0  /
               STRM = 3S-PROP   KODE=2  TEMP = 100.0  PRES = 280.0  /
               STRM = 3S-BUT    KODE=2  TEMP = 100.0  PRES = 280.0  /
               STRM = 3S-OIL    KODE=2  TEMP = 130.0  PRES = 263.0  &
                      NPK=1 KPH=2 /
               STRM = 3S-SH2O   KODE=2  TEMP = 137.0  PRES = 55.0
;
; Plant 4 - The naphtha hydrotreater - use user Fortran block USR04.
BLOCK P04 USER
   SUBROUTINE MODEL = USR04   REPORT = USR04
   DESCRIPTION 'PLANT 4 - THE NAPHTHA HYDROTREATER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;                0 => Write the complete user block summary report.
```

```
;                1 => Skip the capital cost portion of the summary
;                     report.
;                2 => Skip the capital cost and utilities portions
;                     of the summary report.
;                3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;                0 => Write the user block summary report to the mormal
;                      ASPEN/SP output report file.
;                1 => Write the user block summary report to a separate
;                     user block output report file on logical unit 62
;                     called DCL04.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;                If INT(3) = 0, the minimum number of duplicate
;                  trains will be determined so that the capacity
;                  of each plant does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Percent desulfurization of the C5+ feed; i. e.,
;                  Percent of sulfur removed from the entering C5+ feed.
;      REAL(2)   = Percent denitrogenation of the C5+ feed; i. e.,
;                  Percent of nitrogen removed from the entering C5+ feed.
;      REAL(3)   = Percent deoxygenation of the C5+ feed.
;                  Percent of oxygen removed from the entering C5+ feed.
;      REAL(4)   = Chemical hydrogen consumption in SCF/bbl of C5+ feed.
;      REAL(5) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of C5+ feed,
;                  kw/(Mlbs/hr of C5+ feed).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                  C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(25)  = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                  C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;      REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                  C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(29)  = Constant factor for the 600 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                  C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
```

```
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of C5+ feed,
;                   (MM BTU/hr)/(Mlbs/hr of C5+ feed).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of C5+ feed,
;                   (Mgal/hr)/(Mlbs/hr of C5+ feed).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of C5+ feed,
;                   (Mgal/hr)/(Mlbs/hr of C5+ feed).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of C5+ feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of C5+ feed).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference C5+ feed rate to a single train in Mlbs/hr
;                   for the calculation of the ISBL field cost of a
;                   single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   C5+ feed rate in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   C5+ feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          % Desulfurization   % Denitrogenation
     REAL 99.99                99.988       &
;          % Deoxygenation    Chemical H2 consumption in SCF/bbl C5+ feed
           99.5              125.0          &
;          Future use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0     &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power             900/750 F steam   900 satd steam
           0.0 5.098308      0.0 0.0           0.0 0.0       &
```

```
;       \   600/720 F steam   600 satd steam    150 satd steam
            0.0 0.0           0.0 0.126493      0.0 0.0       &
;           50 satd steam     Plant fuel        Cooling  H2O
            0.0 0.0           0.0 0.351607      0.0 0.730963  &
;           Process H2O       Nitrogen
            0.0 0.010833      0.0 0.0         &
;           Future Use (6 items)
            0.0  0.0  0.0  0.0  0.0  0.0      &
;           Opers/day     (Opers/day)/train
            0.0            8.0               &
;           Ref Flow   Max Flow   Min Flow
            210.462    400.0      50.0       &
;           Plant cost equation constants.
;           A      B      E      F      Spares   Future Use (3 items)
            0.0    15.6   0.7843 1.0    0.0      0.0   0.0   &
;           Future Use (10 items)
            0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR04.
   FLASH-SPECS STRM = 4S-GAS   KODE=2  TEMP = 135.0  PRES = 915.0  /
               STRM = 4S-NAPH  KODE=2  TEMP = 100.0  PRES = 153.0  /
               STRM = 4S-SH2O  KODE=2  TEMP =  70.0  PRES = 14.7
;
; Plant 5 - The gas-oil hydrotreater - use user Fortran block USR05.
BLOCK P05 USER
   SUBROUTINE MODEL = USR05   REPORT = USR05
   DESCRIPTION 'PLANT 5 - THE GAS-OIL HYDROTREATER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL05.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
```

```
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Percent desulfurization of the C6+ feed; i. e.,
;                   Percent of sulfur removed from the entering C6+ feed.
;      REAL(2)    = Percent denitrogenation of the C6+ feed; i. e.,
;                   Percent of nitrogen removed from the entering C6+ feed.
;      REAL(3)    = Percent deoxygenation of the C6+ feed.
;                   Percent of oxygen removed from the entering C6+ feed.
;      REAL(4)    = Chemical hydrogen consumption in SCF/bbl of C6+ feed.
;      REAL(5) -
;       REAL(20)  = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per Mlbs/hr of C6+ feed,
;                   kw/(Mlbs/hr).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per Mlbs/hr of C6+ feed,
;                   (MM BTU/hr)/(Mlbs/hr).
;      REAL(37)   = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;      REAL(38)   = Cooling water consumption per Mlbs/hr of C6+ feed,
;                   (Mgal/hr)/(Mlbs/hr).
;      REAL(39)   = Constant factor for the process water consumption,
;                   Mgal/hr.
;      REAL(40)   = Process water consumption per Mlbs/hr of C6+ feed,
;                   (Mgal/hr)/(Mlbs/hr).
;      REAL(41)   = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;      REAL(42)   = Nitrogen consumption per Mlbs/hr of C6+ feed,
```

```
;                    (MM SCF/hr of N2)/(Mlbs/hr).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference C6+ feed rate to a single train in Mlbs/hr
;                   for the calculation of the ISBL field cost of a
;                   single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   C6+ feed rate in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   C6+ feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          % Desulfurization   % Denitrogenation
    REAL 92.5                  85.2       &
;          % Deoxygenation   Chemical H2 consumption in SCF/bbl C6+ feed
           97.6             947.00       &
;          Future use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0   &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power            900/750 F steam   900 satd steam
           0.0 3.247198     0.0 0.0           0.0 0.0       &
;          600/720 F steam  600 satd steam    150 satd steam
           0.0 0.0          0.0 0.096936      0.0 -0.050465 &
;          50 satd steam    Plant fuel        Cooling  H2O
           0.0 0.0          0.0 0.241416      0.0 0.735694 &
;          Process H2O      Nitrogen
           0.0 0.0          0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0            4.0               &
;          Ref Flow   Max Flow   Min Flow
           671.04     800.0      150.0       &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future Use (2 items)
           0.0    74.0    0.7467 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR05.
;  The 5S-LPGAS and 5S-NAPH temperature and pressure are those leaving
;  Plant 4 where this fractionation is actually performed.
   FLASH-SPECS STRM = 5S-HPGAS  KODE=2  TEMP = 135.0  PRES = 2690.0 /
```

```
                STRM = 5S-LPGAS  KODE=2  TEMP = 135.0  PRES = 915.0  /
                STRM = 5S-NAPH   KODE=2  TEMP = 100.0  PRES = 153.0  /
                STRM = P350-450  KODE=2  TEMP = 110.0  PRES = 80.0   /
                STRM = P450-650  KODE=2  TEMP = 135.0  PRES = 20.0   /
                STRM = P650-850  KODE=2  TEMP = 135.0  PRES = 20.0   /
                STRM = 5S-SH20   KODE=2  TEMP = 135.0  PRES = 20.0
;
; Plant 6.1 - The Hydrogen purification by Membrane Separation Plant.
BLOCK P61 USER
   SUBROUTINE MODEL = USR61   REPORT = USR61
   DESCRIPTION 'PLANT 6.1 - THE MEMBRANE H2 PURIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL61.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Percent hydrogen recovery to the hydrogen-rich
;                   product gas stream from the inlet gas stream.
;      REAL(2)    = Concentration of hydrogen in the hydrogen-rich
;                   product gas stream, mole % or vol%.
;      REAL(3)-
;       REAL(20)  = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per MM SCF/hr of H2 recovered,
;                   kw/(MM SCF/hr of H2 recovered).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
```

```
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr
;                   of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of H2 recovered,
;                   (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of H2 recovered,
;                   (MMM SCF/hr of N2)/(MM SCF/hr of H2 recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference hydrogen recovery rate for a single train
;                   in MM SCF/hr of H2 for the calculation of the
;                   ISBL field cost of a single train as a function of
;                   capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
```

```
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Percent H2 recovery    H2 purity in mole %
      REAL 43.83285               99.98677                    &
;          Future use (8 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0             &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 12254.04       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.0           0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling H2O
           0.0 2.054966       0.0 0.0           0.0 42.705864 &
;          Process H2O        Nitrogen
           0.0 0.854117       0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0       &
;          Opers/day      (Opers/day)/train
           0.0             12.0               &
;          Ref Flow   Max Flow   Min Flow
           1.966943   3.0        0.5         &
;          Plant cost equation constants.
;          A      B         E      F      Spares   Future use (2 items)
           0.0    152.6     0.8478 1.0    0.0      0.0   0.0    &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR61.
   FLASH-SPECS STRM = H2-RICH   KODE=2   TEMP = 100.0  PRES = 3290.0 /
               STRM = SOUR-GAS  KODE=2   TEMP = 250.0  PRES = 14.7   /
               STRM = P61-GAS   KODE=2   TEMP = 111.0  PRES = 500.0
;
; Plant 6.2 - The Hydrogen purification by Pressure Swing Absorption
;             Plant.
BLOCK P62 USER
   SUBROUTINE MODEL = USR62   REPORT = USR62
   DESCRIPTION 'PLANT 6.2 - THE PSA H2 PURIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
```

```
;                    user block output report file on logical unit 62
;                    called DCL62.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Percent hydrogen recovery to the hydrogen-rich
;                   product gas stream from the inlet gas stream.
;      REAL(2)    = Concentration of hydrogen in the hydrogen-rich
;                   product gas stream, mole % or vol%.
;      REAL(3)-
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per MM SCF/hr of H2 recovered,
;                   kw/(MM SCF/hr of H2 recovered).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr
;                   of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per MM SCF/hr of H2 recovered,
;                   (Mlbs/hr)/(MM SCF/hr of H2 recovered).
```

```
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of H2 recovered,
;                   (MMM SCF/hr of N2)/(MM SCF/hr of H2 recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference hydrogen recovery rate for a single train
;                   in MM SCF/hr of H2 for the calculation of the
;                   ISBL field cost of a single train as a function of
;                   capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;       The cost of Plant 6.2 is included in Plant 6.1.
;         Percent H2 recovery    H2 purity in mole %
      REAL 89.5033              90.01665              &
;         Future use (8 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 5485.989       0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 0.0           0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling H20
          0.0 15.32654       0.0 0.0           0.0 87.29583  &
;         Process H20        Nitrogen
          0.0 0.530875       0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day      (Opers/day)/train
          0.0            0.0                &
```

```
;          Ref Flow   Max Flow   Min Flow
           3.61667    6.0        0.5        &
;          Plant cost equation constants.
;          A      B      E      F      Spares   Future use (2 items)
           0.0    0.0    0.7    1.0    0.0      0.0   0.0    &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR62.
   FLASH-SPECS STRM = H2-2RICH  KODE=2   TEMP = 100.0  PRES = 3290.0 /
               STRM = SOUR-2GS  KODE=2   TEMP = 250.0  PRES = 14.7   /
               STRM = GAS-OUT   KODE=2   TEMP = 111.0  PRES = 25.0   /
               STRM = NAPHTHA2  KODE=2   TEMP = 100.0  PRES = 50.0
;
; Plant 7 - The naphtha reformer - use user Fortran block USR07.
BLOCK P07 USER
   SUBROUTINE MODEL = USR07   REPORT = USR07
   DESCRIPTION 'PLANT 7 - THE NAPHTHA REFORMER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL07.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of feed,
;                  kw/(Mlbs/hr of feed).
```

```
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of feed,
;                   (MM BTU/hr)/(Mlbs/hr of feed).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of feed,
;                   (Mgal/hr)/(Mlbs/hr of feed).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of feed,
;                   (Mgal/hr)/(Mlbs/hr of feed).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of feed).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference feed rate to a single train in Mlbs/hr
;                   for the calculation of the ISBL field cost of a
;                   single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   feed rate in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
```

```
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Future use (10 items)
     REAL 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
          0.0 2.26494        0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
          0.0 -0.314772      0.0 0.0           0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 1.41781       0.0 0.123590  &
;          Process H2O        Nitrogen
          0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
          0.            8.                  &
;          Ref Flow   Max Flow   Min Flow
          224.289    400.0      50.0       &
;          Plant cost equation constants.
;          A      B      E      F      Spares   Future Use (3 items)
          0.0    30.7   0.75   1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0

;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR07.
   FLASH-SPECS STRM = 7S-H2     KODE=2   TEMP = 80.0  PRES = 14.7  /
               STRM = 7S-GAS    KODE=2   TEMP = 80.0  PRES = 14.7  /
               STRM = REFORMED  KODE=2   TEMP = 80.0  PRES = 14.7
;
; Plant 8.2 - The Fluid Coking Plant - user Fortran block USR82.
BLOCK P82 USER
   SUBROUTINE MODEL = USR82   REPORT = USR82
   DESCRIPTION 'PLANT 8.2 - FLUID COKING PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL02.REP.
```

```
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;     The following 70 real parameters are:
;     REAL(1)-
;      REAL(20) = Future use.
;     REAL(21)  = Constant factor for the power consumption, kw.
;     REAL(22)  = Power consumption per Mlbs/hr of main feed,
;                 kw/(Mlbs/hr of main feed).
;     REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                 consumption, Mlbs/hr.
;     REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                 main feed, (Mlbs/hr)/(Mlbs/hr of main feed).
;     REAL(25)  = Constant factor for the 900 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                 main feed, (Mlbs/hr)/(Mlbs/hr of main feed).
;     REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                 consumption, Mlbs/hr.
;     REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                 main feed, (Mlbs/hr)/(Mlbs/hr of main feed).
;     REAL(29)  = Constant factor for the 600 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                 main feed, (Mlbs/hr)/(Mlbs/hr of main feed).
;     REAL(31)  = Constant factor for the 150 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                 main feed, (Mlbs/hr)/(Mlbs/hr of main feed).
;     REAL(33)  = Constant factor for the 50 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                 main feed, (Mlbs/hr)/(Mlbs/hr of main feed).
;     REAL(35)  = Constant factor for the plant fuel consumption,
;                 MM BTU/hr.
;     REAL(36)  = Plant fuel consumption per Mlbs/hr of main feed,
;                 (MM BTU/hr)/(Mlbs/hr of main feed).
;     REAL(37)  = Constant factor for the cooling water consumption,
;                 Mgal/hr.
;     REAL(38)  = Cooling water consumption per Mlbs/hr of main feed,
;                 (Mlbs/hr)/(Mlbs/hr of main feed).
;     REAL(39)  = Constant factor for the process water consumption,
;                 Mgal/hr.
```

```
;       REAL(40)  = Process water consumption per Mlbs/hr of main feed,
;                   (Mlbs/hr)/(Mlbs/hr of main feed).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of main feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of main feed).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference main feed rate to a single train in
;                   Mlbs/hr for the calculation of the ISBL field cost
;                   of a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   main feed rate in Mlbs/hr of main feed.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   main feed rate in Mlbs/hr of main feed.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;    NOTE: Main feed is the total feed from Plant 2, the coal
;          liquefaction plant.
;
;         Future use (10 items)
     REAL 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0    &
;         Power              900/750 F steam    900 satd steam
          0.0 11.90173       0.0 0.0            0.0 0.0        &
;         600/720 F steam    600 satd steam     150 satd steam
          0.0 0.0            0.0 -0.0071947     0.0 0.0531732  &
;         50 satd steam      Plant fuel         Cooling H2O
          0.0 0.0            0.0 -1.052534      0.0 0.0989787  &
;         Process H2O        Nitrogen
          0.0 0.002935       0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0 0.0  0.0  0.0        &
;         Opers/day     (Opers/day)/train
          0.0           8.0                  &
;         Ref Flow   Max Flow   Min Flow
          592.855    600.0      60.0        &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future use (2 items)
          0.0    161.06  0.75   1.0    0.0      0.0   0.0   &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
```

```
;  values will override the default values in subroutine USR82.
   FLASH-SPECS STRM = 82S-GAS   KODE=2   TEMP = 140.   PRES = 65.   /
               STRM = 82S-NAP   KODE=2   TEMP = 140.   PRES = 30.   /
               STRM = 82S-GO    KODE=2   TEMP = 110.   PRES = 30.   /
               STRM = 82S-BOT   KODE=2   TEMP = 688.   PRES = 28.   /
               STRM = 82S-COKE  KODE=2   TEMP = 100.   PRES = 15.   /
               STRM = 82S01     KODE=2   TEMP = 100.   PRES = 30.
;
;  Block 82A is used to generate the H2S and sour water streams leaving
;  the fluid coking plant.
BLOCK P82A  SEP
  DESCRIPTION 'SPLITTER TO GENERATE ACID GAS AND SOUR WATER FROM COKER'
  FRAC  SUBS=MIXED  STRM=82AS-GAS  COMP=H2S NH3 H2O  FRAC=1.0 0.0 0.0
;
; Plant 9 - H2 Production by coal gasification, Use the User Fortran
; Block USR09.
BLOCK P09 USER
   SUBROUTINE MODEL = USR09   REPORT = USR09
   DESCRIPTION 'PLANT 9 - H2 PRODUCTION BY COAL GASIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file called DCL09.REP.
;               1 => Write the user block summary report to a separate
;                     user block output report file on logical unit 62.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Molar CO/CO2 ratio in the gasifier product gas.
;      REAL(2)    = Fraction of carbon entering the gasifier that goes
;                   to carbonyl sulfide (COS).
;      REAL(3)    = Fraction of carbon entering the gasifier that goes
;                   to methane (CH4).
;      REAL(4)    = Fraction of nitrogen entering the gasifier that goes
```

```
;                 to ammonia (NH3).
;     REAL(5)   = Carbon content of the slag produced by the gasifier,
;                 wt %.
;     REAL(6)   = Fraction of carbon monoxide (CO) entering the shift
;                 reactors that is shifted; i.e., converted to carbon
;                 dioxide (CO2) by the chemical reaction
;                     CO + H2O -----> CO2 + H2
;     REAL(7)   = Fraction of carbonyl sulfide (COS) entering the shift
;                 reactor section that is hydrolyzed; i.e., converted
;                 to carbon dioxide (CO2) and hydrogen sulfide (H2S)
;                 by the chemical reaction
;                     COS + H2O -----> CO2 + H2S
;     REAL(8)   = Future use.
;     REAL(9)-
;      REAL(20) = Rectisol section component distribution factors,
;                 where
;     REAL(9)   = Fraction of inlet H2 going to the hydrogen-rich
;                 gas stream.
;     REAL(10)  = Fraction of inlet H2 going to the acid gas stream.
;     REAL(11)  = Fraction of inlet CO going to the hydrogen-rich
;                 gas stream.
;     REAL(12)  = Fraction of inlet CO going to the acid gas stream.
;     REAL(13)  = Fraction of inlet CO2 going to the hydrogen-rich
;                 gas stream.
;     REAL(14)  = Fraction of inlet CO2 going to the acid gas stream.
;     REAL(15)  = Fraction of inlet CH4 going to the hydrogen-rich
;                 gas stream.
;     REAL(16)  = Fraction of inlet CH4 going to the acid gas stream.
;     REAL(17)  = Fraction of inlet N2 going to the hydrogen-rich
;                 gas stream.
;     REAL(18)  = Fraction of inlet N2 going to the acid gas stream.
;     REAL(19)  = Fraction of inlet H2S going to the hydrogen-rich
;                 gas stream.
;     REAL(20)  = Fraction of inlet H2S going to the acid gas stream.
;     REAL(21)  = Constant factor for the power consumption, kw.
;     REAL(22)  = Power consumption per MM SCF/hr of hydrogen
;                 produced, kw/(MM SCF/hr of H2).
;     REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                 consumption, Mlbs/hr.
;     REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr of
;                 hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;     REAL(25)  = Constant factor for the 900 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr of
;                 hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;     REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                 consumption, Mlbs/hr.
;     REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr of
;                 hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;     REAL(29)  = Constant factor for the 600 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr of
;                 hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;     REAL(31)  = Constant factor for the 150 psig saturated steam
;                 consumption, Mlbs/hr.
```

```
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of hydrogen
;                   produced, (MM BTU/hr)/(MM SCF/hr of H2).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of hydrogen
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of hydrogen
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of hydrogen
;                   produced, (MM SCF/hr of N2)/(MM SCF/hr of H2).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
;       REAL(51)  = Reference hydrogen production rate of a single train
;                   in MM SCF/hr of H2 for the calculation of the ISBL
;                   field cost of a single train as a function of train
;                   capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   hydrogen production rate in MM SCF/hr of H2.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   hydrogen production rate in MM SCF/hr of H2.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare plants.
;       REAL(59) -
;        REAL(70) = Future use.
;
;  NOTE:  MM SCF/hr of hydrogen produced means MM SCF/hr of hydrogen
;         in the hydrogen-rich product gas stream and NOT the total
;         flow rate of the hydrogen-rich product gas stream.
;
;                    Frac C       Frac C    Frac N    %C in
;         CO/CO2     to COS       to CH4    to NH3    slag
     REAL 2.419768  0.000804005  0.0       0.05212   5.229154  &
;         Frac CO shifted  Frac COS hydrolyzed  Future use
;         Adjust the fraction of CO shifted to get true coal rate.
          0.995            0.9516917            0.0          &
;         Component distribution factors for H2 to H2 and acid gas.
```

```
          0.8344      0.00153604                                &
;         Component distribution factors for CO to H2 and acid gas.
          0.0         0.0545937                                 &
;         Component distribution factors for CO2 to H2 and acid gas.
          0.0         0.0453275                                 &
;         Component distribution factors for CH4 to H2 and acid gas.
          0.0         0.0                                       &
;         Component distribution factors for N2 to H2 and acid gas.
          0.0932727   0.0923972                                 &
;         Component distribution factors for H2S to H2 and acid gas.
          0.0         0.990203                                  &
;         Power               900/750 F steam   900 satd steam
          0.0 3679.14335      0.0 0.0           0.0 0.0         &
;         600/720 F steam     600 satd steam    150 satd steam
          0.0 0.0             0.0 -16.98424     0.0 -44.40466   &
;         50 satd steam       Plant fuel        Cooling  H2O
          0.0 -45.47563       0.0 -57.09919     0.0 183.6952    &
;         Process H2O         Nitrogen
          0.0 4.176796        0.0 0.0824568   &
;         Future Use (6 items)
          0.  0.  0.  0.  0.  0.            &
;         Opers/day     (Opers/day)/train
          0.0           24.                 &
;         Ref Flow   Max Flow   Min Flow
          3.436      3.5        1.0        &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future use (3 items)
          0.0    52.7    0.7658 1.0    0.       0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR09.
   FLASH-SPECS STRM = H2-GAS    KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = H2S-GAS   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = VENT-GAS  KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = 9S-SH2O   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = SLAG      KODE=2   TEMP = 80.   PRES = 14.7
;
;  Plant 9.1 - Steam Reforming of Natural Gas Plant.
BLOCK P91 USER
   SUBROUTINE MODEL = USR91   REPORT = USR91
   DESCRIPTION 'PLANT 9.1 - STEAM REFORMING OF NATURAL GAS PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
```

```
;                1 => Write the user block summary report to a separate
;                     user block output report file on logical unit 62
;                     called DCL91.REP.
;      INT(3) = Number of operating duplicate plants, excluding spares.
;                If INT(3) = 0, the minimum number of duplicate
;                  plants will be determined so that the capacity
;                  of each plant does not exceed the maximum plant
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, this number of duplicate plants will
;                  be used.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
     INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Fraction of CH4 reacting to produce H2 and CO2.
;      REAL(2)    = Fraction of CH4 reacting to produce H2 and CO.
;      REAL(3)    = Fraction of hydrogen produced that leaves in the
;                   hydrogen-rich product gas stream.
;      REAL(4)    = Purity of the hydrogen-rich product gas. mole %.
;      REAL(5) -
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per MM SCF/hr of hydrogen produced,
;                   kw/(MM SCF/hr of H2).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;      REAL(35)   = Constant factor for the plant fuel consumption,
```

```
;                    MM BTU/hr.
;      REAL(36)  = Plant fuel consumption per MM SCF/hr of hydrogen
;                  produced, (MM BTU/hr)/(MM SCF/hr of H2).
;      REAL(37)  = Constant factor for the cooling water consumption,
;                  Mgal/hr.
;      REAL(38)  = Cooling water consumption per MM SCF/hr of hydrogen
;                  produced, (Mgal/hr)/(MM SCF/hr of H2).
;      REAL(39)  = Constant factor for the process water consumption,
;                  Mgal/hr.
;      REAL(40)  = Process water consumption per MM SCF/hr of hydrogen
;                  produced, (Mgal/hr)/(MM SCF/hr of H2).
;      REAL(41)  = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2..
;      REAL(42)  = Nitrogen consumption per MM SCF/hr of hydrogen
;                  produced, (MM SCF/hr of N2)/(MM SCF/hr of H2).
;      REAL(43) -
;       REAL(48) = Future use.
;      REAL(49)  = Constant factor for the number of operators per
;                  day, operators/day.
;      REAL(50)  = Number of operators per day per operating train,
;                  (operators/day)/train.
;      REAL(51)  = Reference hydrogen production rate of a single train
;                  in MM SCF/hr of H2 for the calculation of the ISBL
;                  field cost of a single train as a function of train
;                  capacity.
;      REAL(52)  = Maximum plant size as defined by the hydrogen
;                  production rate in MM SCF/hr of H2.
;      REAL(53)  = Minimum plant size as defined by the hydrogen
;                  production rate in MM SCF/hr of H2.
;      REAL(54)  = Constant A in the plant ISBL field cost equation.
;      REAL(55)  = Constant B in the plant ISBL field cost equation.
;      REAL(56)  = Constant E in the plant ISBL field cost equation.
;      REAL(57)  = Constant F in the plant ISBL field cost equation.
;      REAL(58)  = Number of spare plants.
;      REAL(59) -
;       REAL(70) = Future use.
;
;  NOTES: 1. MM SCF/hr of hydrogen produced means MM SCF/hr of hydrogen
;            in the hydrogen rich product gas stream and NOT the total
;            flow rate of the hydrogen rich product gas stream.
;         2. The number of operators in this plant and Plants 31.1 and
;            31.4 is set so as to maintain the same total number of
;            operators as used for the baseline design.
;
;         Frac CH4 to CO2  Frac CH4 to CO  Frac recovered  H2 Purity
     REAL 0.638648         0.04429         0.8862694       100.0 &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0                      &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power                900/750 F steam   900 satd steam
          0.0 354.158          0.0 0.0           0.0 0.0       &
;         600/720 F steam      600 satd steam    150 satd steam
          0.0 0.0              0.0 -65.3773      0.0 0.0       &
;         50 satd steam        Plant fuel        Cooling  H2O
```

```
          0.0 0.0            0.0 89.0448       0.0 32.6902   &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0           &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0         &
;         Opers/day     (Opers/day)/train
          0.0           8.0                   &
;         Ref Flow      Max Flow     Min Flow
          5.77237       6.25         2.0      &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future Use (2 items)
          0.0    68.1    0.75   1.0    0.0      0.0    0.0    &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR091.
   FLASH-SPECS STRM = H2-PROD    KODE=2  TEMP = 100.0  PRES = 500.0 /
               STRM = FLUE-GAS   KODE=2  TEMP = 250.0  PRES = 14.7
;
; Plant 10 - Air Separation Plant - Use the User Fortran Model USR10.
BLOCK P10 USER
   SUBROUTINE MODEL = USR10   REPORT = USR10
   DESCRIPTION 'PLANT 10 - AIR SEPARATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the complete user block summary report to
;                    the normal ASPEN/SP output report file.
;               1 => Write the complete user block summary report to
;                    a separate user block output report file on
;                    logical unit 62 CALLED DCL10.REP.
;      INT(3) = Number of operating duplicate trains, excluding
;               spares.
;               If INT(3) = 0, the minimun number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
```

```
;       The following 70 real parameters are:
;       REAL(1)    = Purity of the product oxygen stream, mole %.
;       REAL(2)    = Purity of the product nitrogen stream, mole %.
;       REAL(3) -
;        REAL(20)  = Future use.
;       REAL(21)   = Constant factor for the power consumption, kw.
;       REAL(22)   = Power consumption per MM SCF/hr of the oxygen stream
;                    flow rate, kw/(MM SCF/hr of O2).
;       REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                    consumption, Mlbs/hr.
;       REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                    the oxygen stream flow rate,
;                    (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(25)   = Constant factor for the 900 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr of
;                    the oxygen stream flow rate,
;                    (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                    consumption, Mlbs/hr.
;       REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr of
;                    the oxygen stream flow rate,
;                    (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(29)   = Constant factor for the 600 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(30)   = 600 psig saturated steam consumption per MM SCF/hr of
;                    the oxygen stream flow rate,
;                    (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(31)   = Constant factor for the 150 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(32)   = 150 psig saturated steam consumption per MM SCF/hr of
;                    the oxygen stream flow rate,
;                    (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(33)   = Constant factor for the 50 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(34)   = 50 psig saturated steam consumption per MM SCF/hr of
;                    the oxygen stream flow rate,
;                    (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(35)   = Constant factor for the plant fuel consumption,
;                    MM BTU/hr.
;       REAL(36)   = Plant fuel consumption per MM SCF/hr of the oxygen
;                    stream flow rate, (MM BTU/hr)/(MM SCF/hr of O2).
;       REAL(37)   = Constant factor for the cooling water consumption,
;                    Mgal/hr.
;       REAL(38)   = Cooling water consumption per MM SCF/hr of the oxygen
;                    stream flow rate, (Mgal/hr)/(MM SCF/hr of O2).
;       REAL(39)   = Constant factor for the process water consumption,
;                    Mgal/hr.
;       REAL(40)   = Process water consumption per MM SCF/hr of the oxygen
;                    stream flow rate, (Mgal/hr)/(MM SCF/hr of O2).
;       REAL(41)   = Constant factor for the nitrogen consumption,
;                    MM SCF/hr of N2.
;       REAL(42)   = Nitrogen consumption per MM SCF/hr of the oxygen
;                    stream flow rate,
;                    (MM SCF/hr of N2)/(MM SCF/hr of O2).
```

```
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference oxygen production rate for a single train
;                   in MM SCF/hr of O2 for the calculation of the
;                   ISBL field cost of a single train as a function of
;                   train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   oxygen production rate in MM SCF/hr of O2.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   oxygen production rate in MM SCF/hr of O2.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;      NOTES:
;        1.  This model does not consider Argon as a separate element.
;            Hence, argon is lumped with nitrogen.
;        2.  MM SCF/hr of O2 means the oxygen production rate in
;            MM SCF/hr of O2 in the product oxygen stream and NOT
;            the total flow rate of the product oxygen stream.
;
;          %O2 in O2    %N2 in N2   Future Use (8 items)
     REAL 99.5003      100.0       0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 18143.97       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.0           0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 0.0            0.0 0.0           0.0 0.0       &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day      (Opers/day)/train
           4.0            0.0                &
;          Ref Flow      Max Flow     Min Flow
           1.763605      1.875        1.0     &
;          Plant cost equation costants.
;          A       B        E       F      Spares   Future use (2 items)
           0.0     38.2     0.7028  1.0    0.0      0.0   0.0    &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR10.
```

```
   FLASH-SPECS STRM = 10S01   KODE=2   TEMP =   80.0   PRES = 350.0  /
               STRM = 10S02   KODE=2   TEMP = -275.0   PRES = 164.7
;
; Plant 11 - Sulfur Recovery Plant, Use the User Fortran Model USR11.
BLOCK P11 USER
   SUBROUTINE MODEL = USR11   REPORT = USR11
   DESCRIPTION 'PLANT 11 - THE SULFUR RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the
;                    normal ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL11.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimun number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Fractional sulfur recovery; fraction of sulfur in
;                  the entering H2S and COS that is recovered in the
;                  product liquid sulfur stream.  All entering liquid
;                  sulfur entering in the feed stream is assumed to
;                  be recovered in the liquid sulfur product stream.
;      REAL(2) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of product sulfur,
;                  kw/(Mlbs/hr).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                  product sulfur, (Mlbs/hr)/(Mlbs/hr).
;      REAL(25)  = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
```

```
;                 product sulfur, (Mlbs/hr)/(Mlbs/hr).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                 consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                 product sulfur, (Mlbs/hr)/(Mlbs/hr).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                 consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                 product sulfur, (Mlbs/hr)/(Mlbs/hr).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                 consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                 product sulfur, (Mlbs/hr)/(Mlbs/hr).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                 consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                 product sulfur, (Mlbs/hr)/(Mlbs/hr).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                 MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of product sulfur,
;                 (MM BTU/hr)/(Mlbs/hr).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                 Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of product
;                 sulfur (Mgal/hr)/(Mlbs/hr).
;       REAL(39)  = Constant factor for the process water consumption,
;                 Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of product
;                 sulfur, (Mgal/hr)/(Mlbs/hr).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                 MM SCF/hr of N2.
;       REAL(42)  = Nitrigen consumption per Mlbs/hr of product sulfur,
;                 (MM SCF/hr of N2)/(Mlbs/hr).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                 day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                 (operators/day)/train.
;       REAL(51)  = Reference product sulfur flow rate of a single train
;                 in Mlbs/hr of S for the calculation of the ISBL field
;                 cost of a single train as a function of capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                 product sulfur flow rate in Mlbs/hr of S.
;       REAL(53)  = Minimum size of a single train as defined by the
;                 product sulfur flow rate in Mlbs/hr of S.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          S recovery
```

```
      REAL 0.998482    &
;          Future Use (19 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0       &
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 49.60954       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.971388      0.0 -3.022277 &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 0.882473       0.0 1.117916      0.0 7.89929   &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day      (Opers/day)/train
           0.0            5.0               &
;          Ref Flow      Max Flow     Min Flow
           15.4305       16.5         5.0      &
;          Plant cost equation costants.
;          A        B        E      F      Spares   Future use (3 items)
           0.0      11.675   0.7823 1.0    0.0      0.0   0.0    &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 11S-FGAS  KODE=2   TEMP = 80.0   PRES = 14.7  /
               STRM = 11S-LIQS  KODE=2   TEMP = 80.0   PRES = 14.7
;
; Plant 31 - The Utilities plant - user Fortran block USR31.
BLOCK P31 USER
   SUBROUTINE MODEL = USR31   REPORT = USR31
   DESCRIPTION 'PLANTS 31 - THE UTILITIES PLANT'
   PARAM  NINT = 20   NREAL = 20
;      The following 20 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Not used.
;               2 => Not used.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL02.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(2).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
```

```
;                    messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
;      INT(5) = Future use.
;      INT(6) -  Switches to select which fuels are burned in the steam
;       INT(10)  boiler to produce steam and/or electric power to
;                satisfy the steam demand.  The fuel specified in
;                INT(6) is used until it is all consumed, the steam
;                demand is satisfied, or the capacity to use this fuel
;                is reached.  Then the INT(7) fuel is used, etc.
;                The fuel codes are
;                  1 = Coal
;                  2 = ROSE-SR unit bottoms
;                  3 = Coke
;                  4 = Natural gas
;                  5 = Plant fuel
;      INT(11) - Switches to select which fuels are burned to satisfy
;       INT(16)  the electric power demand.  The fuel specified in
;                INT(11) is used until it is all consumed, the power
;                demand is satisfied, or the capacity to use this fuel
;                is reached.  Then the INT(12) fuel is used, etc.
;                The fuel codes are
;                  1 = Coal
;                  2 = ROSE-SR unit bottoms
;                  3 = Coke
;                  4 = Natural gas
;                  5 = Plant fuel
;                  6 = Purchased electric power
;      INT(17) -
;       INT(20)  Future use.
    INT  0  1  0  1  0  4  1  2  3  5    &
         4  1  2  3  5  6  0  0  0  0
;
;      The following 20 real parameters are:
;      REAL(1)  = Reference electric power generation rate of a single
;                 train in MW.
;      REAL(2)  = Maximum size of a single train as defined by the
;                 electric power generation rate in MW.
;      REAL(3)  = Minimum size of a single train as defined by the
;                 electric power generation rate in MW.
;      REAL(4)  = Constant A in the plant costing equation.
;      REAL(5)  = Constant B in the plant costing equation.
;      REAL(6)  = Constant E in the plant costing equation.
;      REAL(7)  = Constant F in the plant costing equation.
;      REAL(8)  = Number of spare trains.
;      REAL(9)  = Future use
;      REAL(10) = Future use
;      REAL(11) = Constant factor for the number of operators per
;                 day, operators/day.
;      REAL(12) = Number of operators per day per train,
;                 (operators/day)/train.
;      REAL(13) -
;       REAL(20) = Future use.
```

```
;
;          Ref MW     Max size    Min size
     REAL 79.259     84.0        1.0        &
;          Plant cost equation constants.
;          A       B        E       F       Spares    Future use (2 items)
           0.0     87.466   0.7     1.0     0.0       0.0    0.0    &
;          Opers/day      (Opers/day)/train
           6.0            2.0                  &
;          Future use (8 items)
           0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
;
; Plant 38 - The Ammonia Recovery Plant - use user Fortran block USR38.
BLOCK P38 USER
   SUBROUTINE MODEL = USR38   REPORT = USR38
   DESCRIPTION 'PLANT 38 - THE AMMONIA RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL38.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Ammonia recovery, percent.
;      REAL(2)   = Purity of ammonia product, wt %.
;      REAL(3) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of NH3 recovered,
;                  kw/(Mlbs/hr of NH3 recovered).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
```

```
;       REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of NH3 recovered,
;                   (MM BTU/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of NH3
;                   recovered, (Mgal/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of NH3
;                   recovered, (Mgal/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of NH3 recovered,
;                   (MM SCF/hr of N2)/(Mlbs/hr of NH3 recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
;       REAL(51)  = Reference NH3 recovery rate of a single train in
;                   Mlbs/hr for the calculation of the ISBL field cost
;                   of a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   NH3 recovery rate in Mlbs/hr of NH3 recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   NH3 recovery rate in Mlbs/hr of NH3 recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
```

```
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          NH3 recovery, %     NH3 purity, wt%
     REAL 99.103              99.552              &
;          Future use (8 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 75.713367      0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0  0.0           0.0 16.124425     0.0 28.745809 &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 0.0            0.0 0.0           0.0 227.9442  &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0            &
;          Opers/day      (Opers/day)/train
           0.0            20.0                 &
;          Ref Flow   Max Flow   Min Flow
           20.221     100.0      5.0          &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future Use (3 items)
           0.0    40.1    0.7807 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR38.
   FLASH-SPECS STRM = NH3-PROD  KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = 38S-OUT   KODE=2   TEMP = 80.   PRES = 14.7
;
;  Component splitter to generate the vapor and liquid streams
;  leaving Plant 38, the ammonia recovery plant.
BLOCK P38A SEP
   FRAC  SUBS = MIXED  STRM = 38AS-VAP                  &
   COMP = H2  N2  O2  H2S  CO  CO2  NH3                 &
          L-SULFUR H2O HCL COS CH4                      &
          C2H6 C3H8 IC4H10 NC4H10 IC5H12 NC5H12         &
          T125  T175  T225  T275  T325                  &
          T375  T425                                    &
          T475  T525  T575  T625  T675                  &
          P125  P175  P225  P275  P325  P375            &
          P425  P475  P525  P575  P625  P675            &
   FRAC = 1.0  1.0  1.0  0.9956  1.0  0.9985  0.07104   &
          0.0  0.002755  1.0  1.0  0.8888889            &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492     &
          0.9492 0.9492 0.9492 0.9492 0.9492            &
          0.9492 0.9492                                 &
          0.08481 0.08481 0.08481 0.08481 0.9492        &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492     &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492
   FLASH-SPECS STRM = 38AS-VAP  TEMP=90.0  PRES=25.0  NPK=1  KPH=1 /
```

```
              STRM = 38AS-LIQ  TEMP=90.0  PRES=25.0  NPK=1  KPH=2
;
;  Flow splitter to generate the waste water stream going to the
;  gasifier, Plant 9, and the stream going to the phenol recovery
;  plant, Plant 39.
BLOCK P38B FSPLIT
   FRAC  WASTE  0.24055
   PARAM NPK=1  KPH=2
;
; Plant 39 - The PHENOL RECOVERY PLANT - Use user Fortran block USR39.
BLOCK P39 USER
   SUBROUTINE MODEL = USR39   REPORT = USR39
   DESCRIPTION 'PLANT 39 - THE PHENOL RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL39.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Phenol recovery, percent.
;      REAL(2)   = Purity of phenol product, wt %.
;      REAL(3) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of phenol recovered,
;                  kw/(Mlbs/hr of phenol recovered).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                  phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
```

```
;                 recovered).
;      REAL(25)  = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                  phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                  recovered).
;      REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;      REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                  phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                  recovered).
;      REAL(29)  = Constant factor for the 600 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                  phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                  recovered).
;      REAL(31)  = Constant factor for the 150 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                  phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                  recovered).
;      REAL(33)  = Constant factor for the 50 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                  phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                  recovered).
;      REAL(35)  = Constant factor for the plant fuel consumption,
;                  MM BTU/hr.
;      REAL(36)  = Plant fuel consumption per Mlbs/hr of phenol
;                  recovered,
;                  (MM BTU/hr)/(Mlbs/hr of phenol recovered).
;      REAL(37)  = Constant factor for the cooling water consumption,
;                  Mgal/hr.
;      REAL(39)  = Cooling water consumption per Mlbs/hr of phenol
;                  recovered, (Mgal/hr)/(Mlbs/hr of phenol recovered).
;      REAL(39)  = Constant factor for the process water consumption,
;                  Mgal/hr.
;      REAL(40)  = Process water consumption per Mlbs/hr of phenol
;                  recovered, (Mgal/hr)/(Mlbs/hr of phenol recovered).
;      REAL(41)  = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2.
;      REAL(42)  = Nitrogen consumption per Mlbs/hr of phenol recovered,
;                  (MM SCF/hr of N2)/(Mlbs/hr of phenol recovered).
;      REAL(43) -
;       REAL(48) = Future use.
;      REAL(49)  = Constant factor for the number of operators per
;                  day, operators/day.
;      REAL(50)  = Number of operators per day per operating train,
;                  (operators/day)/train.
;      REAL(51)  = Reference phenol recovery rate of a single train in
;                  Mlbs/hr for the calculation of the IKSBL field cost
;                  of a single train as a function of train capacity.
;      REAL(52)  = Maximum size of a single train as defined by the
;                  phenol recovery rate in Mlbs/hr of phenol recovered.
;      REAL(53)  = Minimum size of a single train as defined by the
```

```
;                    phenol recovery rate in Mlbs/hr of phenol recovered.
;      REAL(54)  = Constant A in the plant ISBL field cost equation.
;      REAL(55)  = Constant B in the plant ISBL field cost equation.
;      REAL(56)  = Constant E in the plant ISBL field cost equation.
;      REAL(57)  = Constant F in the plant ISBL field cost equation.
;      REAL(58)  = Number of spare trains.
;      REAL(59) -
;       REAL(70) = Future use.
;
;    NOTE: In the above, phenol recovered means pure phenol recovered.
;
;         Phenol recovery, %     Phenol purity, wt%
     REAL 97.0089              89.62                &
;         Future use (8 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 339.16667      0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0  0.0           0.0 0.0           0.0 9.465     &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 25.652917      0.0 0.0           0.0 111.775   &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.0           0.0                 &
;         Ref Flow   Max Flow   Min Flow
          2.4        20.0       1.0        &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future Use (3 items)
          0.0    13.3    0.8056 1.0    0.0      0.0   0.0   &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR39.
   FLASH-SPECS STRM = PHENOL   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = WASTEH2O KODE=2   TEMP = 80.   PRES = 14.7
;
;  Splitter S1 - The Inlet Coal Splitter.  Used as a switch to divert
;  flow between the three different coal cleaning options, as represented
;  by the three different Coal Cleaning and Preparation Plants:
;  Base Case (1S01), Alternate Case 1 (1S11), and Alternate Case 2 (1S21).
BLOCK S1 FSPLIT
  DESCRIPTION 'INLET ROM COAL SPLITTER - COAL CLEANING SWITCH'
  FRAC  1S01 1.0 / 1S11 0.0 / 1S21 0.0
;
;  Splitter S2 - The Clean Coal Splitter.
BLOCK S2 FSPLIT
  DESCRIPTION 'CLEAN COAL SPLITTER'
  FRAC COALT014 0.736227
;
;  Splitter S6-SH2O is a component splitter to generate a pseudo
```

```
;   sour-water stream from Plant 6 to get the NH3 to Plant 38, the
;   Ammonia Recovery Plant.
BLOCK S6-SH2O SEP
  DESCRIPTION 'SPLITTER TO GENERATE PSEUDO SOUR WATER FROM PLANT 6'
  FRAC  SUBS=MIXED  STREAM=6S-SH2O  COMP=NH3  FRAC=1.0
;
;  Splitter S7 - The Product Naphtha Splitter.  Used as a switch to
;  divert flow between the naphtha reformer, Plant 7 and output to
;  naphtha product.
BLOCK S7 FSPLIT
  DESCRIPTION 'HYDROTREATED NAPHTHA SPLITTER - REFORMER OPTION SWITCH'
;  ==================================================================
;  Use the following line to direct total flow to the reformer, or....
;  FRAC  7-NAPH 1.0
;  Use the following line to direct total flow to the product stream.
  FRAC PNAPHTHA 1.0
;
;  Splitter S9 - The dummy hydrogen splitter used to switch between
;  the two hydorgen production alternatives, Plant 9.0/10 - coal
;  gasification, or Plant 9.1 - steam reforming of methane.
BLOCK S9 FSPLIT
  DESCRIPTION 'DUMMY H2 SPLITTER - H2 GENERATION OPTION SWITCH'
;  Set an H2 target flow for Plant 9.0/10 - coal gasification.
  FRAC  H9NEED 1.0
  PARAM   NPK=1  KPH=1
;
; Stream Report Section
; ---------------------
;
STREAM-REPORT P1A
   STREAMS STRM = ROMCOAL 1S-CCOAL 9COAL COALTO14 COALTO2        &
                  14S-XMID 14S-REF 1S-XMID 1S-REFSE              &
                  COALTO9 9-FEED SLAG SOLVENT                    &
                  2S-BOTTS 82S-COKE
   FLOW-FRAC SUBS=MIXED BASES=MASS / SUBS=NC BASES=MASS
   INTENSIVE-PROPS SUBS=MIXED BASES=MASS &
                   PROPS=TEMP PRES MW ENTH ENTR DENS HCAP /
                   SUBS=NC BASES=MASS &
                   PROPS=TEMP PRES MW ENTH DENS
   ATTRIBUTES SUBS=NC COMPONENT
;
STREAM-REPORT P1B
   STREAMS STRM = 1S-WATER 14S-WAT 2-H2OIN 2-H2IN H2MIX 2-H2MIX      &
                  SOLVENT ROSE-XTR 2S-GAS GASES 2S-SH2O              &
                  NAPHTHA GAS-OIL 5-GO H2-RICH SOUR-GAS P61-GAS      &
                  H2-2RICH SOUR-2GS GAS-OUT NAPHTHA2 3-GAS           &
                  3S-SGAS 3S-FGAS 3S-PROP 3S-BUT 3S-OIL 3S-SH2O      &
                  4-FEED 4-H2IN 4-H2OIN 4S-GAS 4S-NAPH 4S-SH2O       &
                  5S-HPGAS 5S-LPGAS 5-H2IN 5-H2OIN                   &
                  5S-NAPH P350-450 P450-650 P650-850 5S-SH2O         &
                  PS-NAPH PNAPHTHA 7-NAPH 7S-H2 7S-GAS REFORMED      &
                  61-HYD 62-HYD M9H2 M9H4 M9H5 MHNEED                &
                  82-AIR 82-STM 82-H2O 82S-GAS 82S-NAP 82S-GO        &
                  82S-BOT 82S01 82AS-GAS 82AS-H2O                    &
                  H9NEED H91NEED                                     &
```

```
                10-AIRIN 10S01 10S02 9-O2IN 9-H2OIN 9-STEMIN        &
                H2-GAS H2S-GAS VENT-GAS 9S-SH2O                     &
                NAT-GAS STEAM H2-PROD FLUE-GAS                      &
                6-SGAS 6S-SH2O 11-FEED 11S-FGAS 11S-LIQS 31S-01     &
                38-FEED NH3-PROD 38S-OUT 38AS-VAP 38AS-LIQ          &
                WASTE 39FEED PHENOL WASTEH2O
  FLOW-FRAC SUBS=MIXED BASES=MASS
  INTENSIVE-PROPS SUBS=MIXED BASES=MASS &
                 PROPS=TEMP PRES MW ENTH ENTR DENS HCAP
;
;  End of input file OPT5.INP
```

APPENDIX K

0

APPENDIX K

ASPEN/SP PROCESS SIMULATION MODEL

INPUT FILE FOR OPTION 6 --

STEAM REFORMING OF NATURAL GAS FOR

HYDROGEN PRODUCTION PLUS AN FBC UNIT

ASPEN/SP PROCESS SIMULATION MODEL

INPUT FILE FOR OPTION 6 --

STEAM REFORMING OF NATURAL GAS FOR

HYDROGEN PRODUCTION PLUS AN FBC UNIT

```
NEW
;
;   File: OPT6.INP
;
TITLE 'OPT6 - DIRECT COAL LIQUEFACTION - BASELINE, NTH PLANT SIMULATION'
;
DESCRIPTION &
  "ASPEN/SP INPUT FILE FOR SIMULATING THE BASELINE DESIGN FOR THE NTH
   PLANT.  THIS INPUT FILE ALSO CAN BE USED TO RUN OPTION 6 (STEAM
   REFORMING OF NATURAL GAS FOR HYDROGEN PRODUCTION WITH AN FBC UNIT)
   AND OPTION 7 (NAPHTHA REFORMING)."
;
;  NOTES:
;  1.  The dry clean coal feed rate to the Plant 2 coal liquefaction
;      reactors is set in the design specification DES-SPEC COALFLO.
;  2.  Option 6 (hydrogen production by steam reforming of natural
;      gas with an FBC unt) is activated by variable N9 in Fortran
;      block OPTION6.  When N9 = 1, Option 6 is invoked.
;  3.  Option 7 (naphtha reforming) is activated in Block S7 by
;      sending all the hydrotreated naphtha to Plant 7 rather than
;      to the product PNAHTHA.
;  4.  The costing logic is controlled by switches in Fortran block
;      SUMMARY.
;
;   Last revision - July 16, 1992.
;
;   Prepared under DOE contract no. DE-AC22 90PC89857.
;
IN-UNITS  ENG
OUT-UNITS ENG
HISTORY-UNITS ENG
RUN-CONTROL MAX-ERRORS=100
;
;  The following two lines are used with V8.0 to produce the overall
;  and block elemental balances.
;REPORT ATOMBAL
;BLOCK-REPORT ATOMBAL
;
HISTORY  MSG-LEVEL  PROPERTIES=2
  MAX-PRINT  PROPERTIES=100  SIMULATION=2000
;
PROPERTIES SYSOP2 GLOBAL
;
PSEUDO-COMPS
  METHOD METCCOAL -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 &
```

```
                    -1 -1 -1 -1 -1 -1 -1
;  The following APIs and MWs are revised from the ASPEN/SP predictions.
;  Component T1000+ is the 1000+ F material leaving the second coal
;    liquefaction reactor in Plant 2.
;  Component I1000+ is the 1000+ F intermediate material leaving the
;    first coal liquefaction reactor in Plant 2.
   COMPONENT T125    TBP=324.82 <K>  API=67.91  MW= 82.27
   COMPONENT T175    TBP=352.59 <K>  API=61.99  MW= 92.77
   COMPONENT T225    TBP=380.37 <K>  API=56.21  MW=102.84
   COMPONENT T275    TBP=408.15 <K>  API=50.60  MW=112.50
   COMPONENT T325    TBP=435.93 <K>  API=45.18  MW=121.82
   COMPONENT T375    TBP=463.71 <K>  API=39.96  MW=130.86
   COMPONENT T425    TBP=491.48 <K>  API=34.96  MW=139.75
   COMPONENT T475    TBP=519.26 <K>  API=30.19  MW=148.60
   COMPONENT T525    TBP=547.04 <K>  API=25.66  MW=157.54
   COMPONENT T575    TBP=574.82 <K>  API=21.39  MW=166.69
   COMPONENT T625    TBP=602.59 <K>  API=17.38  MW=176.16
   COMPONENT T675    TBP=630.37 <K>  API=13.66  MW=186.05
   COMPONENT T725    TBP=658.15 <K>  API=10.23  MW=196.44
   COMPONENT T775    TBP=685.93 <K>  API= 7.09  MW=207.37
   COMPONENT T825    TBP=713.71 <K>  API= 4.27  MW=218.85
   COMPONENT T875    TBP=741.48 <K>  API= 1.78  MW=230.87
   COMPONENT T925    TBP=769.26 <K>  API=-0.39  MW=243.37
   COMPONENT T975    TBP=797.04 <K>  API=-2.22  MW=256.24
   COMPONENT T1000+  TBP=824.82 <K>  API=-3.69  MW=269.33
   COMPONENT P125    TBP=324.82 <K>  API=67.91  MW= 82.27
   COMPONENT P175    TBP=352.59 <K>  API=61.99  MW= 92.77
   COMPONENT P225    TBP=380.37 <K>  API=56.21  MW=102.84
   COMPONENT P275    TBP=408.15 <K>  API=50.60  MW=112.50
   COMPONENT P325    TBP=435.93 <K>  API=45.18  MW=121.82
   COMPONENT P375    TBP=463.71 <K>  API=39.96  MW=130.86
   COMPONENT P425    TBP=491.48 <K>  API=34.96  MW=139.75
   COMPONENT P475    TBP=519.26 <K>  API=30.19  MW=148.60
   COMPONENT P525    TBP=547.04 <K>  API=25.66  MW=157.54
   COMPONENT P575    TBP=574.82 <K>  API=21.39  MW=166.69
   COMPONENT P625    TBP=602.59 <K>  API=17.38  MW=176.16
   COMPONENT P675    TBP=630.37 <K>  API=13.66  MW=186.05
   COMPONENT P725    TBP=658.15 <K>  API=10.23  MW=196.44
   COMPONENT P775    TBP=685.93 <K>  API= 7.09  MW=207.37
   COMPONENT P825    TBP=713.71 <K>  API= 4.27  MW=218.85
   COMPONENT P875    TBP=741.48 <K>  API= 1.78  MW=230.87
   COMPONENT P925    TBP=769.26 <K>  API=-0.39  MW=243.37
   COMPONENT P975    TBP=797.04 <K>  API=-2.22  MW=256.24
   COMPONENT P1000+  TBP=824.82 <K>  API=-3.69  MW=269.33
   COMPONENT I1000+  TBP=825.00 <K>  API=-4.00  MW=275.00
   COMPONENT REFORMAT TBP=390.00 <K>  API=38.25  MW=100.00
;
COMPONENTS H2 H2 / N2 N2 / O2 O2 / H2S H2S / CO CO / CO2 CO2 / NH3 H3N /
           L-SULFUR SULFUR / H2O H2O / HCL HCL / COS COS / CH4 CH4 /
           C2H6 C2H6 / C3H8 C3H8 / IC4H10 C4H10-2 / NC4H10 C4H10-1 /
           IC5H12 C5H12-2 / NC5H12 C5H12-1 /
;  Pseudocomponents
           T125 / T175 / T225 / T275 / T325 / T375 / T425 / T475 /
           T525 / T575 / T625 / T675 / T725 / T775 / T825 / T875 /
           T925 / T975 / T1000+ /
```

```
          P125 / P175 / P225 / P275 / P325 / P375 / P425 / P475 /
          P525 / P575 / P625 / P675 / P725 / P775 / P825 / P875 /
          P925 / P975 / P1000+ / I1000+ / REFORMAT /
;  Non-conventional components
           COAL / URCOAL / SLAG
;
FORMULA    H2 H2 / N2 N2 / O2 O2 / H2S H2S / CO CO / CO2 CO2 / NH3 H3N /
           L-SULFUR S / H2O H2O / HCL HCL / COS COS / CH4 CH4 /
           C2H6 C2H6 / C3H8 C3H8 / NC4H10 C4H10 / IC4H10 C4H10 /
           NC5H12 C5H12 / IC5H12 C5H12
;
;  Load the liquid sulfur (L-SULFUR) physical properties as taken from
;  DIPPR - MW adjusted to be consistent with ASPEN.
PROP-DATA  IN-UNITS SI
  PROP-LIST        MW     /   TC    /     PC     /    VC    /   ZC
  PVAL L-SULFUR   32.06  / 1313.0 / 1.8208E+7 / 0.15800 / 0.2640
  PROP-LIST       MUP    /  OMEGA /    TB     /   RGYR
  PVAL L-SULFUR   0.0    / 0.2624 /  717.82   /   0.0
  PROP-LIST         DELTA   /  DGFORM   /  DHFORM
  PVAL L-SULFUR   2.0245E+4 / 2.3825E+8 / 2.7880E+8
  PROP-LIST       CPIG
  PVAL L-SULFUR   2.5639E+4  -7.9870  4.7860E-3  -9.5700E-7  0.0  0.0  &
                  273.15  1500.0  0.0  87.113  1.0
;
; Load the solubility parameter for COS from the API Tech Data Book.
  PROP-LIST       DELTA
  PVAL COS        18179.0
;
;  Reset some component molecular weights to be consisitent with the
;  following elemental atomic weights, where needed.
;  H=1.0079, C=12.011, O=15.9994, N=14.0067, S=32.06 & Cl=35.453
  PROP-LIST       MW
  PVAL H2          2.0158
  PVAL N2         28.0134
  PVAL O2         31.9988
  PVAL H2S        34.0758
  PVAL CO         28.0104
  PVAL CO2        44.0098
  PVAL NH3        17.0304
  PVAL H2O        18.0152
  PVAL HCl        36.4609
  PVAL COS        60.0704
  PVAL CH4        16.0426
  PVAL C2H6       30.0694
  PVAL C3H8       44.0962
  PVAL IC4H10     58.1230
  PVAL NC4H10     58.1230
  PVAL IC5H12     72.1498
  PVAL NC5H12     72.1498
;
;  Set the specific gravities of H2, CO, CO2, NH3, H2S, N2 and COS to
;  the values given in the API Technical Data Book - Petroleum Refining.
  PROP-LIST        SPGR
  PVAL H2         0.3000
  PVAL CO         0.3000
```

```
  PVAL CO2        0.8180
  PVAL NH3        0.6162
  PVAL H2S        0.8014
  PVAL N2         0.8094
  PVAL COS        1.0200
;
ATTR-COMPS COAL   PROXANAL ULTANAL SULFANAL AOXANAL
ATTR-COMPS URCOAL PROXANAL ULTANAL SULFANAL AOXANAL
ATTR-COMPS SLAG   PROXANAL ULTANAL SULFANAL AOXANAL
;
NC-PROPS    COAL ENTHALPY  HCOALGEN /
                 DENSITY   DCOALIGT
NC-PROPS  URCOAL ENTHALPY  HCOALGEN /
                 DENSITY   DCHARIGT
NC-PROPS    SLAG ENTHALPY  HCOALGEN /
                 DENSITY   DCHARIGT
;
DEF-STREAMS MIXNC ALL
;
;  Set an initial GUESS for the ROM COAL stream to Plant 1.
STREAM ROMCOAL
   SUBSTREAM MIXED TEMP = 71.0  PRES = 14.7
     MASS-FLOW  H2O 24798.0
   SUBSTREAM NC TEMP = 71.0  PRES = 14.7
     MASS-FLOW  COAL 285035.0 / URCOAL 0.0 / SLAG 0.0
     COMP-ATTR COAL   PROXANAL (0.0 42.06 36.24 21.70) /
                      ULTANAL (21.7 61.1 4.2 1.2 0.1 5.1 6.6) /
                      SULFANAL (3.0 0.3 1.8) /
                      AOXANAL (43.8 17.1 24.1 0.8 0.1 5.6 1.0 0.6 2.1 4.1)
;  Fake the URCOAL properties.
     COMP-ATTR URCOAL PROXANAL (0.0 19.197 16.549 64.254) /
                      ULTANAL (64.254 29.914 0.185 1.304 0.0 4.267 0.076) /
                      SULFANAL (2.507 0.253 1.507) /
                      AOXANAL (43.8 17.1 24.1 0.8 0.1 5.6 1.0 0.6 2.1 4.1)
;  Fake the SLAG properties.
     COMP-ATTR SLAG   PROXANAL (0.0 10.0 0.0 90.0) /
                      ULTANAL (90.0 10.0 0.0 0.0 0.0 0.0 0.0 ) /
                      SULFANAL (0.0 0.0 0.0) /
                      AOXANAL (42.0 17.0 23.0 1.0 1.0 6.0 2.0 1.0 3.0 4.0)
;
;  Set an initial GUESS for the fresh make-up H2 stream to Plant 2.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 2-H2IN
   SUBSTREAM MIXED TEMP = 100.0  PRES = 3440.0
     MASS-FLOW  H2 70300.0 / N2 980.0
;
;  Set an initial GUESS for the total water feed streams (both steam
;  and wash water) to Plant 2.
STREAM 2-H2OIN
   SUBSTREAM MIXED TEMP = 126.0  PRES = 3200.0
     MASS-FLOW  H2O 1073000.0
;
;  Set an initial GUESS for the ROSE EXTRACT stream to Plant 2.
STREAM ROSE-XTR
   SUBSTREAM MIXED TEMP = 300.0  PRES = 3215.0
```

```
      MASS-FLOW  T675 95.0 / T725 95.0 / T775 95.0 /
        T825 95.0 / T875 588.335 / T925 588.335 /
        T975 588.355 /  T1000+ 536585.0
;
;  Set an initial GUESS for the SOLVENT stream to Plant 2.  The user
;  Fortran block model for Plant 2 does not require any solvent, but
;  the input stream is required.  Thus, set a small H2O flow to avoid
;  ASPEN warnings.
STREAM SOLVENT
   SUBSTREAM MIXED TEMP = 500.0  PRES = 500.0
     MASS-FLOW  H2O 1.0
;
;  Set an initial GUESS for the 2S-BOTTS stream leaving Plant 2.
STREAM 2S-BOTTS
   SUBSTREAM MIXED TEMP = 688.0  PRES = 28.0
     MASS-FLOW  H2O 0.0 /
       T825 380.0 / T875 3365.0 /
       T925 3365.0 / T975 3365.0 / T1000+ 642440.0
   SUBSTREAM NC TEMP = 688.0  PRES = 28.0
     MASS-FLOW  COAL 0.0 / URCOAL 254475.0
;
;  Set an initial GUESS for the H2 stream to Plant 4.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 4-H2IN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 500.0
     MASS-FLOW  H2 1400.0 / N2 19.0
;
;  Set an initial GUESS for the H2O stream to Plant 4.
STREAM 4-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 50.0
     MASS-FLOW  H2O 18770.
;
;  Set an initial GUESS for the H2 stream to Plant 5.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 5-H2IN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 500.0
     MASS-FLOW  H2 17000.0 / N2 279.0
;
;  Set an initial GUESS for the H2O stream to Plant 5.
STREAM 5-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 50.0
     MASS-FLOW  H2O 36382.0
;
;  Set an initial GUESS for the pseudo sour H2O from Plant 6.
STREAM 6S-SH2O
   SUBSTREAM MIXED TEMP = 60.0  PRES = 14.7
     MASS-FLOW  NH3 2830.0
;
;  Set an initial GUESS for the H2O stream to Plant 9.0.
STREAM 9-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 14.7
     MASS-FLOW  H2O 967545.0
;
;  Set an initial GUESS for the STEAM stream to Plant 9.0.
STREAM 9-STEMIN
```

```
   SUBSTREAM MIXED TEMP = 450.0  PRES = 500.0
     MASS-FLOW  H2O 167545.0
;
;  Set an initial GUESS for the OXYGEN stream to Plant 9.0.
STREAM 9-O2IN
   SUBSTREAM MIXED TEMP = 80.0  PRES = 300.0
     MASS-FLOW  O2 743531.0 / N2 3269.0
;
;  Set an initial GUESS for the AIR stream to Plant 10.
STREAM 10-AIRIN   TEMP = 70.0  PRES = 14.7
     MASS-FLOW  O2 743531.0 / N2 2463614.0
;
;  Set an initial GUESS for the CH4 stream to Plant 9.1.
STREAM NAT-GAS
   SUBSTREAM MIXED TEMP = 70.0  PRES = 100.0
     MASS-FLOW  CH4 307352.
;
;  Set an initial GUESS for the STEAM stream to Plant 9.1.
STREAM STEAM
   SUBSTREAM MIXED TEMP = 620.0  PRES = 500.0
     MASS-FLOW  H2O 864428.
;
; Model Connectivity
; ------------------
;
FLOWSHEET COAL
; Plant M1 is the clean coal outlet streams mixer.
;   Stream 1S-CCOAL is the combined outlet clean coal product stream.
; Plant M2 is the middling coal outlet streams mixer.
;   Stream 1S-XMID  is the combined outlet middling coal product stream.
; Plant M-2HYD is the mixer to combine H2 streams for Plant 2.
;   Stream 2-H2MIX  is the combined H2 stream from 6.1, 6.2, & source.
; Plant M3 is the refuse outlet streams mixer.
;   Stream 1S-REFSE is the combined outlet refuse product stream.
; Plant M38 is the sour water mixer.
;   Stream 38-FEED  is the combined sour water streams to Plant 38.
; Plant M4 is the waste water outlet streams mixer.
;   Stream 1S-WATER is the combined outlet waste water product stream.
; Plant M-462 is the mixer to combine H2 streams for Plant 6.2.
;   Stream 62-HYD   is the combined H2 stream from Plants 2 & 4.
; Plant M-561 is the mixer to combine H2 streams for Plant 6.1.
;   Stream 61-HYD   is the combined H2 stream from Plants 2 & 5.
; Plant M-6GAS is the heater to combine sour gas streams for Plant 11.
;   Stream 6-SGAS   is the combined sour gas stream from Plants 6.1 & 6.2.
; Plant M-73 is the mixer to combine H2 gas streams for Plant 3.
;   Stream 3-GAS    is the combined H2 gas stream from Plant 3.
; Plant M-HYD is the mixer (flash2) to combine H2 streams for M-2HYD.
;   Stream H2MIX    is the combined H2 stream from Plants 6.1 & 6.2.
;   Stream DUMMY    is the dummy vapor stream that contains no flow.
; Plant M-NAP is the mixer to combine naphtha streams for Plant 4.
;   Stream 4-FEED   is the combined naphtha stream from Plants 2 & 6.2.
; Plant M-PNAP is the mixer to combine product naphtha streams.
;   Stream PS-NAPH is the combined naphtha stream from Plants 4 & 5.
; Plant P1-ALT1 is the Coal Cleaning and Preparation Plant - ALT CASE 1.
;   Stream 1S12     is the outlet clean coal product stream.
```

```
;   Stream 1S13     is the outlet middling coal product stream.
;   Stream 1S14     is the outlet refuse product stream.
;   Stream 1S15     is the outlet waste water product stream.
; Plant P1-ALT2 is the Coal Cleaning and Preparation Plant - ALT CASE 2.
;   Stream 1S22     is the outlet clean coal product stream.
;   Stream 1S23     is the outlet middling coal product stream.
;   Stream 1S24     is the outlet refuse product stream.
;   Stream 1S25     is the outlet waste water product stream.
; Plant P1-BASE is the Coal Cleaning and Preparation Plant - BASE CASE.
;   Stream 1S02     is the outlet clean coal product stream.
;   Stream 1S03     is the outlet middling coal product stream.
;   Stream 1S04     is the outlet refuse product stream.
;   Stream 1S05     is the outlet waste water product stream.
; Plant P14 is the Coal Grinding and Drying Plant.
;   Stream COALTO2  is the outlet clean coal product stream.
;   Stream 14S-XMID is the outlet middling coal product stream.
;   Stream 14S-REF  is the outlet refuse product stream.
;   Stream 14S-WAT  is the outlet waste water product stream.
; Plant P02 is the Coal Liquefaction Plant.
;   Stream 2-H2MIX  is the hydrogen feed stream.
;   Stream COALTO2  is the clean coal feed stream.
;   Stream SOLVENT  is the solvent feed stream.  This stream is used to
;     supply the steam required to Plant 2.
;   Stream ROSE-XTR is the deashed product stream.
;   Stream 2-H2OIN  is the water feed stream to the liquefaction unit.
;   Stream 2S-GAS   is the HP gas product stream going to Plant 6.1.
;   Stream GASES    is the LP gas product stream going to Plant 6.2.
;   Stream NAPHTHA  is the naphtha product stream.
;   Stream GAS-OIL  is the gas-oil product stream going to Plant 5.
;   Stream 2S-BOTTS is the bottoms stream going to Plant 8.1.
;   Stream 2S-SH2O  is the sour water product stream.
; Plant P03 is the Gas Plant.
;   Stream 3S-SGAS  is the sour off-gas product stream.
;   Stream 3S-FGAS  is the fuel gas product stream.
;   Stream 3S-PROP  is the C3 product stream.
;   Stream 3S-BUT   is the C4s product stream.
;   Stream 3S-OIL   is the lean-oil product stream to M-NAP.
;   Stream 3S-SH2O  is the product sour water stream.
; Plant P04 is the simplified model for plant 4, the naphtha hydrotreater.
;   Stream 4-H2IN   is the hydrogen feed stream.
;   Stream 4-H2OIN  is the water feed stream.
;   Stream 4S-GAS   is the hydrotreater off-gas product stream.
;   Stream 4S-NAPH  is the hydrotreated naphtha product stream.
;   Stream 4S-SH2O  is the hydrotreater sour water stream.
; Plant P05 is the simplified model for plant 5, the gas-oil hydrotreater.
;   Stream 5-H2IN   is the hydrogen feed stream.
;   Stream 5-H2OIN  is the water feed stream.
;   Stream 5S-HPGAS is the hydrotreater hi-pressure purge gas stream.
;   Stream 5S-LPGAS is the hydrotreater other gases stream.
;   Stream 5S-NAPH  is the hydrotreated C6-350 F naphtha product stream.
;   Stream P350-450 is the hydrotreated 350 - 450 F product stream.
;   Stream P450-650 is the hydrotreated 450 - 650 F product stream.
;   Stream P650-850 is the hydrotreated 650 - 850 F product stream.
;   Stream 5S-SH2O  is the hydrotreater sour water stream.
; Plant P61 is the model for the Hydrogen purification by Membrane
```

```
;     Separation Plant, Plant 6.1.
;   Stream 61-HYD   is the feed stream to the H2 purification plant.
;   Stream H2-RICH  is the purified H2-rich product gas stream.
;   Stream SOUR-GAS is the sour gas product stream.
;   Stream P61-GAS  is the reject (non-permeate) product gas stream.
; Plant P62 is the model for the Hydrogen purification by Pressure
;     Swing absorption Plant, Plant 6.2.
;   Stream 62-HYD   is the mixed gas feed stream to the PSA hydrogen
;     purification plant.
;   Stream P61-GAS  is the reject gas stream from Plant 6.1, the high
;     pressure section of Plant 6, the hydrogen purification by
;     membrane permeation section.
;   Stream H2-2RICH is the purified h2-rich product gas stream.
;   Stream SOUR-2GS is the sour gas product stream.
;   Stream GAS-OUT  is the reject product gas stream.
;   Stream NAPHTHA2 is the liquid raw naphtha product stream.
; Plant P07 is the simplified model for Plant 7, the naphtha reformer.
;   Stream 7-NAPH   is the naphtha feed stream.
;   Stream 7S-H2    is the hydrogen rich product gas stream.
;   Stream 7S-GAS   is the light hydrocarbon product gas stream.
;   Stream REFORMED is the reformate product stream.
; Plant P81 is the model for the ROSE-SR Critical Solvent Deashing unit.
;   Stream ROSE-XTR is the deashed product stream.
;   Stream ASH-CONC is the ash concentrate stream.
; Plant P11 is the Sulfur plant.
;   Stream 11S-LIQS is the sulfur product stream.
;   Stream 11S-FGAS contains all the other material in the feed that
;     does not leave in the product SULFUR STREAM.
; Plant P31 is the simplified model for the utility plant.
;   Stream 31S-01   is the dummy product stream.
; Plant P314 is the model for the Fluidized Bed Combustor and the
;  Steam Turbine Generator unit.
;   Stream FBC-FEED is the feed stream to Plant P314.
;   Stream SA6-01   is the combined product stream out of Plant P314.
; Plant P38 is the NH3 recovery plant.
;   Stream NH3-PROD is the product NH3.
;   Stream 38S-OUT  is the reject stream.
; Plant P38A is the reject stream component splitter from plant 38.
;   Stream 38AS-VAP is the vapor stream going to Plant 11.
;   Stream 38AS-LIQ is the liquid stream going to Plant 38B.
; Plant P38B is the liquid reject stream splitter from Plant 38A.
;   Stream WASTE    is the reject portion of the inlet stream which
;     in this model is rejected, but actually goes to the coal
;     gasification plant, if present.
;   Stream 39FEED   is the stream going on to Plant 39.
; Plant P39 is the phenol recovery plant.
;   Stream PHENOL   is the phenol product stream.
;   Stream WASTEH2O is the waste water stream.
; Plant SA6 is the product stream separator from Plant P314.
;   Stream FBC-GAS  is the gas product stream from Plant SA6.
;   Stream FBC-SOL  is the solids product stream from Plant SA6.
; Block S1 is the inlet coal splitter.
;   Stream ROMCOAL  is the inlet ROM coal stream.
;   Stream 1S01     is the splitter outlet to the base case plant.
;   Stream 1S11     is the splitter outlet to the alternate case 1 plant.
```

```
;   Stream 1S21     is the splitter outlet to the alternate case 2 plant.
; Block S2 is the clean coal splitter.
;   Stream 1S-CCOAL is the inlet clean coal stream.
;   Stream COALTO14 is the splitter outlet to plant 2.
;   Stream 9-COAL   is the splitter outlet to plant 9.
; Block S6-SH2O is a component splitter to generate a pseudo sour-water
;   stream from Plant 6 to get the NH3 to Plant 38, the Ammonia Recovery
;   Plant.
;   Stream 6S-SH2O  is the pseudo sour-water stream.
;   Stream 11-FEED  is the Plant 11 feed stream.
; Block S7 is the product naphtha splitter.
;   Stream PS-NAPH  is the inlet product naphtha stream.
;   Stream 7-NAPH   is the splitter outlet to the naphtha reformer plant.
;   Stream PNAPHTHA is the splitter outlet as product naphtha.
; Block S8 is the ash-concentrate splitter.
;   Stream ASH-CONC is the inlet ash-concentrate stream from the ROSE.
;   Stream FBC-FEED is the splitter outlet to the FBC plant.
;   Stream S8-ASHC  is the splitter outlet to the M9C coal mixer.
;
 M1        IN = 1S02 1S12 1S22   OUT = 1S-CCOAL
 M2        IN = 1S03 1S13 1S23   OUT = 1S-XMID
 M-2HYD    IN = H2MIX 2-H2IN     OUT = 2-H2MIX
 M3        IN = 1S04 1S14 1S24   OUT = 1S-REFSE
 M38       IN = 2S-SH2O 3S-SH2O 4S-SH2O 5S-SH2O 6S-SH2O 9S-SH2O     &
             OUT = 38-FEED
 M4        IN = 1S05 1S15 1S25   OUT = 1S-WATER
 M-462     IN = 4S-GAS GASES 5S-LPGAS 3S-SGAS 7S-H2     OUT = 62-HYD
 M-561     IN = 5S-HPGAS 2S-GAS  OUT = 61-HYD
 M-6GAS    IN = SOUR-GAS SOUR-2GS H2S-GAS 38AS-VAP      OUT = 6-SGAS
 M-73      IN = GAS-OUT 7S-GAS   OUT = 3-GAS
 M-HYD     IN = H2-RICH H2-2RICH OUT = H2MIX DUMMY
 M-NAP     IN = NAPHTHA2 3S-OIL  OUT = 4-FEED
 M-PNAP    IN = 4S-NAPH 5S-NAPH  OUT = PS-NAPH
 P1-ALT1   IN = 1S11             OUT = 1S12 1S13 1S14 1S15
 P1-ALT2   IN = 1S21             OUT = 1S22 1S23 1S24 1S25
 P1-BASE   IN = 1S01             OUT = 1S02 1S03 1S04 1S05
 P14       IN = COALTO14         OUT = COALTO2 14S-XMID 14S-REF 14S-WAT
 P02       IN = 2-H2MIX COALTO2 SOLVENT ROSE-XTR 2-H2OIN            &
             OUT = 2S-GAS GASES NAPHTHA GAS-OIL 2S-BOTTS 2S-SH2O
 P03       IN = NAPHTHA 3-GAS                                       &
             OUT = 3S-SGAS 3S-FGAS 3S-PROP 3S-BUT 3S-OIL 3S-SH2O
 P04       IN = 4-H2IN 4-FEED 4-H2OIN                               &
             OUT = 4S-GAS 4S-NAPH 4S-SH2O
 P05       IN = 5-H2IN GAS-OIL 5-H2OIN                              &
             OUT = 5S-HPGAS 5S-LPGAS 5S-NAPH P350-450 P450-650      &
                   P650-850 5S-SH2O
 P61       IN = 61-HYD           OUT = H2-RICH SOUR-GAS P61-GAS
 P62       IN = 62-HYD P61-GAS                                      &
             OUT = H2-2RICH SOUR-2GS GAS-OUT NAPHTHA2
 P07       IN = 7-NAPH           OUT = 7S-H2 7S-GAS REFORMED
 P81       IN = 2S-BOTTS         OUT = ROSE-XTR ASH-CONC
 P11       IN = 11-FEED          OUT = 11S-FGAS 11S-LIQS
 P31       IN = 3S-FGAS          OUT = 31S-01
 P314      IN = FBC-FEED         OUT = SA6-01
 P38       IN = 38-FEED          OUT = NH3-PROD 38S-OUT
```

```
  P38A      IN = 38S-OUT          OUT = 38AS-VAP 38AS-LIQ
  P38B      IN = 38AS-LIQ         OUT = WASTE 39FEED
  P39       IN = 39FEED           OUT = PHENOL WASTEH2O
  SA6       IN = SA6-01           OUT = FBC-SOL FBC-GAS
  S1        IN = ROMCOAL          OUT = 1S01 1S11 1S21
  S2        IN = 1S-CCOAL         OUT = COALTO14 9COAL
  S6-SH2O   IN = 6-SGAS           OUT = 6S-SH2O 11-FEED
  S7        IN = PS-NAPH          OUT = 7-NAPH PNAPHTHA
  S8        IN = ASH-CONC         OUT = FBC-FEED S8-ASHC
;
FLOWSHEET HYDROGEN
; Plant M9 is the hydrogen stream mixer.
;   Stream M9H2     is the dummy H2 stream to the liquefaction unit.
;   Stream M9H4     is the dummy H2 stream to the naphtha hydrotreater.
;   Stream M9H5     is the dummy H2 stream to the gas-oil hydrotreater.
;   Stream HHNEED   is the dummy H2 stream from the mixer.
; Plant M9C is the coal stream mixer.
;   Stream COALTO9  is the clean coal stream to the mixer.
;   Stream S8-ASHC  is the ash concentrate stream from the ROSE unit.
;   Stream 9-FEED   is the mixed coal stream to the gasifier.
; Plant PO9 is the plant for producing hydrogen by coal gasification.
;   Stream 9-H2OIN  is the water feed stream to the gasifier section.
;   Stream 9-O2IN   is the purified O2 stream from the air sep. plant.
;   Stream 9-STEMIN is the steam that goes to the shift reactors.
;   Stream H2-GAS   is the product hydrogen stream.
;   Stream H2S-GAS  is the product hydrogen sulfide stream.
;   Stream VENT-GAS is the product vent gas stream.
;   Stream 9S-SH2O  is the product sour water stream.
;   Stream SLAG     is the product slag stream.
; Plant P91 is the Steam Reforming of Natural Gas Plant.
;   Stream NAT-GAS  is the inlet natural gas stream.
;   Stream STEAM    is the inlet process water stream.
;   Stream H2-PROD  is the product hydrogen stream.
;   Stream FLUE-GAS is the product flue gas stream.
; Plant P10 is the Air Separation Plant.
;   Stream 10-AIRIN is the air input stream.
;   Stream 10S01    is the product oxygen stream.
;   Stream 10S02    is the product nitrogen stream.
; Plant S9 is the hydrogen stream splitter.
;   Stream H9NEED   is the dummy H2 stream for the gasifier.
;   Stream H91NEED  is the dummy H2 stream for the steam reformer.
;
  M9H       IN = M9H2 M9H4 M9H5     OUT = MHNEED
  M9C       IN = S8-ASHC COALTO9    OUT = 9-FEED
  PO9       IN = 9-FEED 9-H2OIN 9-O2IN 9-STEMIN        &
              OUT = H2-GAS H2S-GAS VENT-GAS 9S-SH2O SLAG
  P91       IN = NAT-GAS STEAM      OUT = H2-PROD FLUE-GAS
  P10       IN = 10-AIRIN           OUT = 10S01  10S02
  S9        IN = MHNEED             OUT = H9NEED H91NEED
;
; Design Specifications
; ---------------------
;
;  Design spec to set the hydrogen flow rate to Plant 2 (2-H2MIX)
;  to a specified weight percent (HPCT2) of the MAF coal input stream.
```

```
DES-SPEC 2H2FLO
   DEFINE CHP2   MASS-FLOW  STREAM=2-H2MIX  COMPONENT=H2
   DEFINE CCOAL  MASS-FLOW  STREAM=COALTO2  SUBSTREAM=NC COMPONENT=COAL
   DEFINE CCASH  COMP-ATTR-VAR STREAM=COALTO2  SUBSTREAM=NC &
                   COMPONENT=COAL ATTRIBUTE=ULTANAL ELEMENT=1
C     Set the specified H2 rate to Plant 2 in wt% in the following line.
F     HPCT2 = 7.9205D0
C     DAFCOAL is the dry ash-free coal (MAF coal).
F     DAFCOAL = CCOAL * (100.0D0 - CCASH) * 0.01D0
F     H2P2 = 0.01D0 * HPCT2 * DAFCOAL
   SPEC CHP2 TO H2P2
   TOL-SPEC 0.1
   VARY STREAM-VAR  STREAM=2-H2IN  VARIABLE=MASS-FLOW
   LIMITS 100 1000000
;
;  Design spec to set the correct ROM coal flow to the splitter to
;  obtain the desired 17,102 TPSD of MF coal flow rate to the coal
;  liquefaction plant, Plant 2.
DES-SPEC COALFLO
   DEFINE CTARG  MASS-FLOW  STREAM=COALTO2   SUBSTREAM=NC  COMPONENT=COAL
;  Set TPD to the target coal rate to Plant 2 in TPSD of MF coal.
;  ==============================================================
;
F     TPD = 17102.0D0
F     WTPHR = (TPD * 2000.0D0) / 24.0D0
   SPEC CTARG TO WTPHR
   TOL-SPEC 0.1
   VARY MASS-FLOW  STREAM=ROMCOAL  SUBSTREAM=NC  COMPONENT=COAL
   LIMITS 100 10000000
;
;  Design spec to set the correct 9-FEED flow rate to the Plant 9,
;  coal gasifier, to obtain the desired hydrogen production rate.
DES-SPEC H2FLO
   DEFINE HOUT   MASS-FLOW   STREAM=H2-GAS   COMPONENT=H2
   DEFINE HTOT   MASS-FLOW   STREAM=H9NEED   COMPONENT=H2
   SPEC HOUT TO HTOT
   TOL-SPEC 1.0
   VARY STREAM-VAR STREAM=COALTO9  SUBSTREAM=NC  VAR=MASS-FLOW
   LIMITS 0.1 10000000
;
;  Design spec to set the heat duty to block M-HYD to zero by
;  varying the temperature. This corrects a temperature calculating
;  error in the ASPEN mixer block algorithm.
DES-SPEC HD-HYD
   DEFINE HDTY BLOCK-VAR BLOCK=M-HYD SENTENCE=RETENTION VARIABLE=HEAT-DUTY
   SPEC HDTY TO 0.0
   TOL-SPEC 1000
   VARY BLOCK-VAR BLOCK=M-HYD SENTENCE=PARAM VARIABLE=TEMPERATURE
   LIMITS 10 500
;
;  Design spec to set the 10-AIRIN stream flow to produce the required
;  amount of oxygen product required by Plant 9, coal gasification.
DES-SPEC O2FLO
 DEFINE FLO10S STREAM-VAR STREAM=10S01    VAR=MASS-FLOW
 DEFINE FLOOXY STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
```

```
    SPEC FL010S TO FLOOXY
    TOL-SPEC 0.1
    VARY STREAM-VAR  STREAM=10-AIRIN  VARIABLE=MASS-FLOW
    LIMITS 0.1 10000000
;
;  Design spec to set the hydrogen flow rate for Plant 9.1.
DES-SPEC RFMRFLO
    DEFINE HOUT2  MASS-FLOW   STREAM=H2-PROD  COMPONENT=H2
    DEFINE HTOT2  MASS-FLOW   STREAM=H91NEED  COMPONENT=H2
    SPEC HOUT2 TO HTOT2
    TOL-SPEC 0.1
    VARY STREAM-VAR  STREAM=NAT-GAS  VARIABLE=MASS-FLOW
    LIMITS 1000 600000
;
; Transfer Blocks
; ---------------
;
;  Transfer block to set COALTO9 equal to the 9COAL stream (the wet
;  clean coal input).  This duplicates the full property set and
;  provides the initial guess flow rate for COALTO9.
TRANSFER CCOAL
    SET STREAM COALTO9
    EQUAL-TO STREAM 9COAL
;
;  Transfer block used to set the hydrogen flow rates of the input
;  streams to the calculated hydrogen flows to Plant 2 (2-H2IN),
;  Plant 4 (4-H2IN), and Plant 5 (5-H2IN).  M9's represent hydrogen
;  flows from Plant 9.0/10 and M91's are for the Plant 9.1 alternative.
TRANSFER HFLOW
    SET STREAM M9H2
    EQUAL-TO STREAM 2-H2IN
    SET STREAM M9H4
    EQUAL-TO STREAM 4-H2IN
    SET STREAM M9H5
    EQUAL-TO STREAM 5-H2IN
;
; Fortran Blocks
; --------------
;
;  Fortran block to set the correct water flow rate in the clean
;  coal going to Plant 9.
FORTRAN 9COAL
    DEFINE W9COAL MASS-FLOW  STREAM=9COAL   COMPONENT=H2O
    DEFINE C9COAL MASS-FLOW  STREAM=9COAL   SUBSTREAM=NC COMPONENT=COAL
    DEFINE WCTO9  MASS-FLOW  STREAM=COALTO9 COMPONENT=H2O
    DEFINE CCTO9  MASS-FLOW  STREAM=COALTO9 SUBSTREAM=NC COMPONENT=COAL
F      WCTO9 = CCTO9 * (W9COAL / C9COAL)
;
;  This Fortran block resets the split fraction in S2 to provide the
;  flow rate of coal to Plant 9.0.
FORTRAN COALFLOW
    DEFINE C14    STREAM-VAR  STREAM=COALTO14  VAR=MASSFLOW
    DEFINE C9     STREAM-VAR  STREAM=COALTO9   VAR=MASSFLOW
    DEFINE RC     STREAM-VAR  STREAM=ROMCOAL   VAR=MASSFLOW
    DEFINE CC     STREAM-VAR  STREAM=1S-CCOAL  VAR=MASSFLOW
```

```
   DEFINE SFRAC  BLOCK-VAR   BLOCK=S2  SENTENCE=FRAC  VAR=FRAC  &
    ID1=COALTO14  ELEMENT=1
C     Calculate total clean coal.
F     TCC = C14 + C9
C     Reset the ROMCOAL feed rate to match the new value.
F     RC = RC * (TCC / CC)
C     Reset the split fraction in S2 to correct 9COAL flow rate.
F     SFRAC = C14 / (C9 + C14)
;
;  This FORTRAN block will calculate the initial ratio of the MIXED
;  substream flow to the NC substream flow in the stream ROMCOAL.
;  It will store this result in RATIO, and use that value to adjust
;  the MIXED substream flow in proportion to the NC substream flow
;  that is varied by the COALFLO design-spec.  This is needed to set
;  the correct amount of water entering with the ROM coal.
FORTRAN MIXFLO
F     COMMON /RATIO/ RMIXNCP
F     COMMON /RGLOB/ RDUM1, RMIN
 DEFINE FLONCP SUBSTREAM-VAR STREAM=ROMCOAL SUBSTREAM=NC VAR=MASSFLOW
 DEFINE FLOMIX SUBSTREAM-VAR STREAM=ROMCOAL SUBSTREAM=MIXED VAR=MASSFLOW
C  The following should only be true on the first pass.  This prevents
C  writing over the initial substream ratio on subsequent passes.
F     IF (RMIXNCP .LT. RMIN) THEN
F        RMIXNCP = FLONCP / FLOMIX
F     END IF
C  Adjust the other substream flow based on changes to the NC
C  substream.
F     FLOMIX = FLONCP / RMIXNCP
;
;  Fortran block to dynamically set the URCOAL fraction in the
;  separation block, SA6, equal to the solids production parameter,
;  REAL(1), in block P314, the fluidized bed combustor.  This block
;  only has significance when Option 6 is in effect.
FORTRAN SA6SET
   DEFINE FRAC1 BLOCK-VAR BLOCK=P314 SENTENCE=REAL VAR=REAL ELEMENT=1
   DEFINE FRAC2 BLOCK-VAR BLOCK=SA6  SENTENCE=FRAC VAR=FRAC ID1=NC    &
    ID2=FBC-SOL ELEMENT=1
F     FRAC2 = FRAC1
;
;  FORTRAN block to set the COMBINED steam and water flow rate to
;  Plant 2 as a specified weight percent of the dry coal feed.
FORTRAN SETUP2
   DEFINE FEED2 MASS-FLOW  STREAM=COALTO2  SUBSTREAM=NC  COMPONENT=COAL
   DEFINE H2O2  STREAM-VAR STREAM=2-H2OIN  VAR=MASSFLOW
F     H2O2 = 0.75315 * FEED2
;
;  FORTRAN block used to set the hydrogen flow rate to Plant 4 (4-H2IN)
;  to a specified weight percent (HPCT4) of the naphtha feed stream,
;  and the hydrogen flow rate to Plant 5 (5-H2IN) to a specified weight
;  percent (HPCT5) of the gas oil feed stream.  This block also sets
;  the inlet water flow rates for these plants to specified rates
;  as functions of the hydrocarbon feed rates.
FORTRAN SETUP45
   DEFINE CHP4   MASS-FLOW  STREAM=4-H2IN   COMPONENT=H2
   DEFINE CHP5   MASS-FLOW  STREAM=5-H2IN   COMPONENT=H2
```

```
   DEFINE FLP4   STREAM-VAR STREAM=4-H2IN   VAR=MASSFLOW
   DEFINE FLP5   STREAM-VAR STREAM=5-H2IN   VAR=MASSFLOW
   DEFINE XNAPH  STREAM-VAR STREAM=4-FEED   VAR=MASSFLOW
   DEFINE XGOIL  STREAM-VAR STREAM=GAS-OIL  VAR=MASSFLOW
   DEFINE H2O4   STREAM-VAR STREAM=4-H2OIN  VAR=MASSFLOW
   DEFINE H2O5   STREAM-VAR STREAM=5-H2OIN  VAR=MASSFLOW
C     Set the specified H2 rates in wt% in the following two lines.
F     HPCT4 = 1.1855
F     HPCT5 = 2.7554
F     H2P4 = 0.01D0 * HPCT4 * XNAPH
F     FLP4 = H2P4 * (FLP4 / CHP4)
F     H2P5 = 0.01D0 * HPCT5 * XGOIL
F     FLP5 = H2P5 * (FLP5 / CHP5)
C     Set the specified H2O rates in wt% in the following two lines.
F     H2O4 = 0.089017 * XNAPH
F     H2O5 = 0.054217 * XGOIL
;
;  FORTRAN block to set the steam, water and oxygen stream flow rates
;  to Plant 9 based on the inlet flow rate of hydrocarbons and NC
;  components (on a dry ash-free basis).
FORTRAN SETUP9
 DEFINE FL29MX SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=MIXED VAR=MASS-FLOW
 DEFINE ULCOAL COMP-ATTR-VAR STREAM=9-FEED  SUBSTREAM=NC &
        COMPONENT=COAL   ATTRIBUTE=ULTANAL ELEMENT=1
 DEFINE ULURC  COMP-ATTR-VAR STREAM=9-FEED  SUBSTREAM=NC &
        COMPONENT=URCOAL ATTRIBUTE=ULTANAL ELEMENT=1
 DEFINE FL29C   MASS-FLOW  STREAM=9-FEED  SUBSTREAM=NC COMPONENT=COAL
 DEFINE FL29UR  MASS-FLOW  STREAM=9-FEED  SUBSTREAM=NC COMPONENT=URCOAL
 DEFINE FL29W   MASS-FLOW  STREAM=9-FEED  COMPONENT=H2O
 DEFINE FL2STM  STREAM-VAR STREAM=9-STEMIN VAR=MASS-FLOW
 DEFINE FL2H2O  STREAM-VAR STREAM=9-H2OIN  VAR=MASS-FLOW
 DEFINE FL2O2   STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
C  Adjust the steam, water and oxygen stream flow rates based on the
C  inlet flow rate of hydrocarbons and NC components (on a dry basis).
F     X1 = 0.01*FL29C *(100.0-ULCOAL)
F     X2 = 0.01*FL29UR*(100.0-ULURC)
F     FL2STM = 0.25495 * (FL29MX + X1 + X2 - FL29W)
F     FL2H2O = 1.4723 * (FL29MX + X1 + X2 - FL29W)
F     FL2O2  = 1.1365 * (FL29MX + X1 + X2 - FL29W)
;
;  Fortran block to set up the common and OSBL utility consumptions.
FORTRAN SETUP31
F     COMMON /USRC01/ PLNTID(32), UTIL(32,15), CAPCST(32,5), OPCST(32,5)
F     CHARACTER * 6  PLNTID
 DEFINE DCOAL2 SUBSTREAM-VAR STREAM=COALTO2 SUBSTREAM=NC VAR=MASS-FLOW
C     COMMON /USRC03/ is used to transfer variables FIN(5,4),
C       FOUT(20,4), PGAS, PPWR, OPTN6
C     See Subroutine USRSR1 for the definition of the items in named
C     common block /USRC03/.
C     Base all the offsite and OSBL utilities consumptions on the dry
C     coal feed rate to Plant 2, the Coal Liquefaction Plant. Ignore
C     cooling and process water consumptions and productions.
F     PLNTID (19) = 'OTHERS'
C     Electric Power.
F     UTIL(19,1) = 25.1346 * DCOAL2 * 0.001
```

```
F     IF ( OPTN6 .GE. 0.99D0 )   UTIL(19,1) = 29.5411 * DCOAL2 * 0.001
C     600 psig steam at 720F.
F     UTIL(19,4) = 0.05122207 * DCOAL2 * 0.001
C     150 psig saturated steam.
F     UTIL(19,6) = 0.04350367 * DCOAL2 * 0.001
C  50 psig saturated steam.
F     UTIL(19,7) = 0.06757103 * DCOAL2 * 0.001
;
;  Fortran statement to set the molar flow rate of the STEAM stream to
;  be in balance with the feed stream to Plant 9.1.
FORTRAN SETUP91
   DEFINE GS     STREAM-VAR  STREAM=NAT-GAS  VARIABLE=MOLE-FLOW
   DEFINE ST     STREAM-VAR  STREAM=STEAM    VARIABLE=MOLE-FLOW
F     IF ( GS .GT. 0.0D0 )   THEN
F         ST = 2.504543D0 * GS
F       ELSE
F         ST = 0.0D0
F     ENDIF
;
;  Fortran block to switch between Plant 9.0 & 10 or just Plant 9.1.
FORTRAN OPTION6
F     COMMON /USRC03/ FIN(5,4), FOUT(20,4), PGAS, PPWR, OPTN6
C     See Subroutine USRSR1 for the definition of the items in named
C     common block /USRC03/.
 DEFINE FSTM   STREAM-VAR STREAM=STEAM    VAR=MOLE-FLOW
 DEFINE FNG    STREAM-VAR STREAM=NAT-GAS  VAR=MOLE-FLOW
 DEFINE F10A   STREAM-VAR STREAM=10-AIRIN VAR=MASS-FLOW
 DEFINE F9H    STREAM-VAR STREAM=9-H2OIN  VAR=MASS-FLOW
 DEFINE F9S    STREAM-VAR STREAM=9-STEMIN VAR=MASS-FLOW
 DEFINE F9O    STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
 DEFINE FC9M   SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=MIXED VAR=MASS-FLOW
 DEFINE FC9NC  SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=NC    VAR=MASS-FLOW
 DEFINE FRAC8  BLOCK-VAR   BLOCK=S8  SENTENCE=FRAC  VAR=FRAC  &
  ID1=S8-ASHC  ELEMENT=1
 DEFINE FRAC9  BLOCK-VAR   BLOCK=S9  SENTENCE=FRAC  VAR=FRAC  &
  ID1=H9NEED   ELEMENT=1
 DEFINE FRAC38 BLOCK-VAR   BLOCK=P38B  SENTENCE=FRAC  VAR=FRAC  &
  ID1=WASTE    ELEMENT=1
C     Set N9 equal to 0 to run Plant 9.0 & 10, or
C     set N9 equal to 1 to run Plant 9.1 (OPTION 6).
F     N9=1
F     IF (N9 .EQ. 0) THEN
F       OPTN6 = 0.0D0
F       FSTM = 1.0D-6
F       FNG = 1.0D-6
F       FRAC8 = 1.0
F       FRAC9 = 1.0
F       FRAC38 = 0.28595
F     ENDIF
F     IF (N9 .EQ. 1) THEN
F       OPTN6 = 1.0D0
F       F10A = 1.0D-6
F       F9H = 1.0D-6
F       F9S = 1.0D-6
F       F9O = 1.0D-6
```

```
F        FC9M = 1.0D-6
F        FC9NC = 1.0D-6
F        FRAC8 = 0.0
F        FRAC9 = 0.0
F        FRAC38 = 0.0
F      ENDIF
;
FORTRAN SUMMARY
C      This Fortran block writes the summary report to the DCLSUM.REP
C      file, and also writes the DCL1.PRN file for transfering the
C      results to the Lotus spreadsheet economics model.
C      COMMON /USRC03/ is used to transfer variables FIN(5,4),
C        FOUT(20,4), PGAS, PPWR, OPTN6
C      See Subroutine USRSR1 for the definition of the items in named
C      common block /USRC03/.
 DEFINE FIN1   SUBSTREAM-VAR STREAM=ROMCOAL   SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FIN2   STREAM-VAR    STREAM=NAT-GAS   VAR=MASS-FLOW
 DEFINE FOUT1  STREAM-VAR    STREAM=3S-PROP   VAR=MASS-FLOW
 DEFINE FOUT2  STREAM-VAR    STREAM=3S-BUT    VAR=MASS-FLOW
 DEFINE FOUT3A STREAM-VAR    STREAM=PNAPHTHA  VAR=MASS-FLOW
 DEFINE FOUT3B STREAM-VAR    STREAM=REFORMED  VAR=MASS-FLOW
 DEFINE FOUT4  STREAM-VAR    STREAM=P350-450  VAR=MASS-FLOW
 DEFINE FOUT5  STREAM-VAR    STREAM=P450-650  VAR=MASS-FLOW
 DEFINE FOUT6  STREAM-VAR    STREAM=P650-850  VAR=MASS-FLOW
 DEFINE FOUT7  SUBSTREAM-VAR STREAM=1S-REFSE  SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT8  SUBSTREAM-VAR STREAM=SLAG      SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT8A SUBSTREAM-VAR STREAM=FBC-SOL   SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT10 STREAM-VAR    STREAM=NH3-PROD  VAR=MASS-FLOW
 DEFINE FOUT11 STREAM-VAR    STREAM=PHENOL    VAR=MASS-FLOW
 DEFINE FOUT12 STREAM-VAR    STREAM=11S-LIQS  VAR=MASS-FLOW
C      Load the stream flow rates in the FIN() and FOUT() arrays in
C      Mlbs/hr.  All solid stream flow rates are on a dry basis.
F      FIN(1,1)  = 0.001D0 * FIN1
F      FIN(2,1)  = 0.001D0 * FIN2
F      FOUT(1,1) = 0.001D0 * FOUT1
F      FOUT(2,1) = 0.001D0 * FOUT2
F      FOUT(3,1) = 0.001D0 * (FOUT3A + FOUT3B)
F      FOUT(4,1) = 0.001D0 * FOUT4
F      FOUT(5,1) = 0.001D0 * FOUT5
F      FOUT(6,1) = 0.001D0 * FOUT6
F      FOUT(7,1) = 0.001D0 * FOUT7
F      FOUT(8,1) = 0.001D0 * (FOUT8 + FOUT8A)
F      FOUT(10,1) = 0.001D0 * FOUT10
F      FOUT(11,1) = 0.001D0 * FOUT11
F      FOUT(12,1) = 0.001D0 * FOUT12
C
C      Set XOF to the number of extra operators and OSBL operators
C      per dedicated plant operator.
C      ----------------------------
F      XOF = 0.343042
C
C      Set the LOSBL and LPLANT switches, as appropriate, to duplicate
C      the Bechtel OSBL and first vs. Nth plant costing logic.
C      LOSBL  = 0  - Use baseline case OSBL costing logic.
C      LOSBL  = 1  - Use option case OSBL costing logic.
```

```
C     LPLANT = 0  - Use first plant OSBL and engineering costing logic.
C     LPLANT = 1  - Use Nth plant OSBL and engineering costing logic.
C     ==================================================================
F     LOSBL = 1
F     LPLANT = 1
C
C     Open the separate output file called DCLSUM.REP to contain the
C     summary report of the simulation results.
F     OPEN (UNIT=62, FILE='DCLSUM.REP', STATUS='UNKNOWN',
F    1  ACCESS='SEQUENTIAL', FORM='FORMATTED',
F    2  BUFFERED='BUFFERED')
C     Call Subroutines USRSR1 and USRSR2 to write the summary report.
F     CALL USRSR1 (62)
F     CALL USRSR2 (62, LOSBL, LPLANT, OPTN6, XOF)
F     CLOSE (UNIT=62, STATUS='KEEP')
C     Now write the LOTUS spreadsheet economics model input file.
F     OPEN (UNIT=62, FILE='DCL1.PRN', STATUS='UNKNOWN',
F    1  ACCESS='SEQUENTIAL', FORM='FORMATTED',
F    2  BUFFERED='BUFFERED')
C     Call Subroutines USRSR3 to write the model input file.
F     CALL USRSR3 (62, OPTN6, XOF)
F     CLOSE (UNIT=62, STATUS='KEEP')
;
; Convergence Blocks
; ------------------
;
CONVERGENCE CBLK1 WEGSTEIN
  TEAR H2MIX 1D-5
  PARAM WAIT=3
;
CONVERGENCE CBLK2 WEGSTEIN
  TEAR 2S-BOTTS 1D-5
;
CONVERGENCE CBLK3 WEGSTEIN
  TEAR 6S-SH2O 1D-5
;
CONVERGENCE COALF ONE-VAR
  SPEC COALFLO
;
CONVERGENCE HD-C1 ONE-VAR
  SPEC HD-HYD
;
CONVERGENCE HYDF BROYDEN-SPEC
  SPEC H2FLO
;
CONVERGENCE 2HYDF ONE-VAR
  SPEC 2H2FLO
;
CONVERGENCE OXYF ONE-VAR
  SPEC O2FLO
;
CONVERGENCE RFMRF ONE-VAR
  SPEC RFMRFLO
;
; Calculation Sequence
```

```
; -------------------
;
;  Define subsequence for coal cleaning complex.
SEQUENCE CLEAN COALF MIXFLO S1 P1-BASE P1-ALT1 P1-ALT2                &
               M1 S2 P14 (RETURN COALF)                               &
               M4 M3 M2
;
;  Specify entire flowsheet sequence, including subsequence CLEAN.
SEQUENCE BASE  (SEQUENCE CLEAN)  CCOAL                                &
               CBLK1   2HYDF M-2HYD (RETURN 2HYDF)                    &
               CBLK2 SETUP2 P02 P81 (RETURN CBLK2)                    &
               P61 P62   HD-C1 M-HYD (RETURN HD-C1)                   &
               M-73 P03 M-NAP SETUP45 P04 M-462 P05 M-561             &
               M-PNAP S7 P07 (RETURN CBLK1)                           &
               HFLOW M9H OPTION6 S9  S8 P314 SA6SET SA6               &
               HYDF 9COAL M9C SETUP9 P09 (RETURN HYDF)                &
               OXYF P10 (RETURN OXYF)  COALFLOW  (SEQUENCE CLEAN)     &
               RFMRF SETUP91 P91 (RETURN RFMRF)                       &
               CBLK3 M38 P38 P38A P38B P39 M-6GAS S6-SH2O             &
               (RETURN CBLK3)                                         &
               P11 SETUP31 P31 SUMMARY
;
; Unit Operations Blocks
; ----------------------
;
;  Mix the clean coal product streams from the 3 different cases.
BLOCK M1 MIXER
  DESCRIPTION 'PLANT 1 OUTLET CLEAN COAL MIXER'
;
;  Mix the middling coal product streams from the 3 different cases.
BLOCK M2 MIXER
  DESCRIPTION 'PLANT 1 OUTLET MIDDLING COAL MIXER'
;
;  Mix the hydrogen streams going to Plant 2.
BLOCK M-2HYD MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL HYDROGEN STREAM TO PLANT 2'
  PARAM NPK=1  KPH=1
;
;  Mix the refuse product streams from the 3 different cases.
BLOCK M3 MIXER
  DESCRIPTION 'PLANT 1 OUTLET REFUSE MIXER'
;
;  Mix the sour water streams from Plants 2, 3, 4, 5, and 9.
BLOCK M38 MIXER
  DESCRIPTION 'SOUR WATER MIXER FOR PLANT 38 FEED'
;
;  Mix the waste water product streams from the 3 different cases.
BLOCK M4 MIXER
  DESCRIPTION 'PLANT 1 OUTLET WASTE WATER MIXER'
;
;  Mix the hydrogen streams from Plants 4 & 2 for Plant 6.2.
BLOCK M-462 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 6.2 FEED'
;
;  Mix the hydrogen streams from Plants 5 & 2 for Plant 6.1.
```

```
BLOCK M-561 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 6.1 FEED'
;
;  Mix the sour gas streams from Plants 6.1, 6.2, 9 and 38 for the
;  Plant 11 feed stream.
BLOCK M-6GAS HEATER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 11 FEED'
  PARAM  TEMP=110.0  PRES=14.7
;
;  Mix the H2 gas streams from Plants 7 & 6.2 for Plant 3.
BLOCK M-73 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 3 FEED'
;
;  Mixer M9C - The hydrogen plant feed mixer; used to mix the coal and
;  ROSE unit ASH-CONC stream that goes to Plant 9.0.
BLOCK M9C MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 9 FEED'
  BLOCK-OPTIONS HMB-RESULTS=2
;
;  Mixer M9 - The dummy hydrogen mixer; used to mix the three
;  streams that go to Plant 2 (M9H2), Plant 4 (M9H4), and
;  Plant 5 (M9H5) into one single output stream (MHNEED) for the
;  S9 splitter.
BLOCK M9H MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL AMOUNT OF HYDROGEN NEEDED'
  PARAM NPK=1  KPH=1
;
;  Mix the hydrogen streams from Plants 6.1 and 6.2. Use a flash2 block
;  to correct a temperature calculating error in the ASPEN mixer block
;  algorithm.
BLOCK M-HYD FLASH2
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL HYDROGEN FROM 6.1 AND 6.2'
  PARAM  TEMP=100.  PRES=3290.
;
;  Mix the naphtha streams from Plants 2 and 6.2.
BLOCK M-NAP MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL PLANT 4 NAPHTHA FEED'
;
;  Mix the product naphtha streams from Plants 4 and 5.
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL PRODUCT NAPHTHA STREAM'
BLOCK M-PNAP MIXER
;
;  Plant P1-ALT1, Coal Cleaning and Preparation Plant. Use User
;  Fortran Model, USR01, within the PLANTS file. ALTERNATE CASE 1 -
;  COAL CLEANING BY HEAVY MEDIUM SEPARATION.
BLOCK P1-ALT1 USER
   SUBROUTINE MODEL = USR01    REPORT = USR01
   DESCRIPTION 'PLANT 1 - ALTERNATE 1 - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following integer and real parameters are for production of
;   the coal cleaned by both jigs and heavy medium separation.  The coal
;   cleaned only by jigs for gasification is handled by a separate plant
;   that is modeled in BLOCK P1-JIGS.  The operators and cost for this
;   plant includes those associalted with the P1-JIGS portion of the coal
;   cleaning and preparation plant.  All parameters have the same meaning
```

```
;   as described below for Plant 1 in BLOCK P1-BASE.
;
    INT  0  1  0  1  1
;         FCP          FCM    FHP          FHM    FNP          FNM
     REAL 0.9120155    0.0    0.9050241    0.0    0.8869236    0.0  &
;         FC1P         FC1M   FSP          FSM    FOP          FOM
          0.7602203    0.0    0.4471884    0.0    0.9905900    0.0  &
;         FAP          FAM
          0.3012854    0.0  &
;         PCWP  PCWM  PCWR  Future Use (3 items)
          9.0   3.0   10.0    0.   0.   0.                    &
;         Power            900/750 F steam   900 satd steam
          0.0 7.400489       0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 0.0           0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 0.0           0.0 0.0       &
;         Process H2O        Nitrogen
          0.0 0.042246       0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day      (Opers/day)/train
          8.0            8.0                &
;         Ref Flow   Max Flow   Min Flow
          285.035    300.0      150.0      &
;         Plant cost equation constants.
;         A      B       E      F      Spares     Future Use (2 items)
          0.0    25.52   0.5942 1.0    0.0        0.0   0.0    &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S12    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S13    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S14    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S15    KODE=2   TEMP = 70.0   PRES = 14.7
;
;  Plant P1-ALT2, Coal Cleaning and Preparation Plant. Use User Fortran
;  Model, USR01, within the PLANTS file. ALTERNATE CASE 2 - COAL CLEANING
;  BY HEAVY MEDIUM SEPARATION FOLLOWED BY SPHERICAL AGGLOMERATION.
BLOCK P1-ALT2 USER
   SUBROUTINE MODEL = USR01    REPORT = USR01
   DESCRIPTION 'PLANT 1 - ALTERNATE 2 - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following integer and real parameters are for production of
;   the coal cleaned by both jigs and heavy medium separation followed
;   by spherical agglomeration.  The coal cleaned only by jigs for
;   gasification is handled by a separate plant that is modeled in
;   BLOCK P1-JIGS.  The operators and cost for this plant includes
;   those associalted with the P1-JIGS portion of the coal cleaning
;   and preparation plant.  All parameters have the same meaning as
;   described below for Plant 1 in BLOCK P1-BASE.
;
    INT  0  1  0  1  2
```

```
;          FCP          FCM    FHP          FHM    FNP          FNM
     REAL 0.9435271    0.0    0.9338663    0.0    0.9250562    0.0  &
;          FC1P         FC1M   FSP          FSM    FOP          FOM
           0.7400450    0.0    0.3772778    0.0    0.9867266    0.0  &
;          FAP          FAM
           0.1295931    0.0  &
;          PCWP   PCWM  PCWR  Future Use (3 items)
           14.16  3.0   10.0  0.0   0.0   0.0                  &
;          Power              900/750 F steam   900 satd steam
           0.0 51.68786       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.0           0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 0.0            0.0 0.394967      0.0 0.0       &
;          Process H2O        Nitrogen
           0.0 0.103481       0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           8.0           8.0                 &
;          Ref Flow   Max Flow   Min Flow
           262.3      300.0      150.0      &
;          Plant cost equation constants.
;          A      B      E      F      Spares     Future Use (2 items)
           0.0    73.78  0.5942 1.0    0.0        0.0   0.0    &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S22    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S23    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S24    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S25    KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 1 - Coal Cleaning, Preparation and Drying Plant, Use User Fortran
;           Model USR01
;           BASE CASE - COAL CLEANING BY JIGS For LIQUEFACTION.
BLOCK P1-BASE USER
   SUBROUTINE MODEL = USR01   REPORT = USR01
   DESCRIPTION 'PLANT 1 - BASE CASE - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following 5 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
```

```
;                    called DCL01B.REP, DCL01A1.REP or DCL01A2.REP
;                    depending on the value of the coal cleaning option
;                    control switch, INT(5).
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-4 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
;      INT(5)  = Coal cleaning, drying and grinding option control
;                switch.  The name of the short plant report file
;                written for each option is option dependent.
;                0 => Base case - Coal cleaning by jigs for coal
;                     liquefaction in plant 2. (Report = DCL01B.REP)
;                1 => Alternate case 1 - Coal cleaning by heavy media
;                     separation.  (Report = DCL01A1.REP)
;                2 => Alternate case 2 - Coal cleaning by heavy media
;                     separation and spherical agglomeration.
;                     (Report = DCL01A2.REP)
;                3 => Coal cleaning by jigs for coal gasification in
;                     plant 9.  (Report = DCL01G.REP)
;                4 => Coal grinding and drying plant.
;                     (Report = DCL01D.REP)
;               NOTE: Values 0, 1 and 2 are used when this model
;                     cleans the coal going to the coal liquefaction
;                     plant, 3 is used only when this model cleans
;                     the coal going to the coal gasification plant,
;                     and 4 is for the grinding and drying plant.
   INT  0  1  0  1  0
;     The following 70 real parameters are:
;     REAL(1)   = Fraction of carbon in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(2)   = Fraction of carbon in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(3)   = Fraction of hydrogen in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(4)   = Fraction of hydrogen in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(5)   = Fraction of nitrogen in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(6)   = Fraction of nitrogen in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(7)   = Fraction of chlorine in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(8)   = Fraction of chlorine in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(9)   = Fraction of sulfur in the inlet coal leaving
```

```
;                 in the clean coal product stream.  OPTIONAL - See Note 1.
;      REAL(10)  = Fraction of sulfur in the inlet coal leaving
;                  in the middling coal stream.  OPTIONAL - See Note 1.
;      REAL(11)  = Fraction of oxygen in the inlet coal leaving
;                  in the clean coal product stream.
;      REAL(12)  = Fraction of oxygen in the inlet coal leaving
;                  in the middling coal stream.
;      REAL(13)  = Fraction of ash in the inlet coal leaving
;                  in the clean coal product stream.
;      REAL(14)  = Fraction of ash in the inlet coal leaving
;                  in the middling coal stream.
;      REAL(15)  = Moisture content of the clean product coal on a dry
;                  basis, wt%.
;      REAL(16)  = Moisture content of the middling coal on a dry
;                  basis, wt%.
;      REAL(17)  = Moisture content of the refuse on a dry basis, wt%.
;      REAL(18) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of dry clean coal,
;                  kw/(Mlbs/hr).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                  dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;      REAL(25)  = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                  dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;      REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;      REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                  dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;      REAL(29)  = Constant factor for the 600 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                  dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;      REAL(31)  = Constant factor for the 150 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                  dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;      REAL(33)  = Constant factor for the 50 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                  dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;      REAL(35)  = Constant factor for the plant fuel consumption,
;                  MM BTU/hr.
;      REAL(36)  = Plant fuel consumption per Mlbs/hr of dry clean coal,
;                  (MM BTU/hr)/(Mlbs/hr).
;      REAL(37)  = Constant factor for the cooling water consumption,
;                  Mgal/hr.
;      REAL(38)  = Cooling water consumption per Mlbs/hr of dry clean
;                  coal (Mgal/hr)/(Mlbs/hr).
;      REAL(39)  = Constant factor for the process water consumption,
;                  Mgal/hr.
```

```
;       REAL(40)  = Process water consumption per Mlbs/hr of dry clean
;                   coal, (Mgal/hr)/(Mlbs/hr).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of dry clean coal,
;                   (MM SCF/hr of N2)/(Mlbs/hr).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference flow rate of the dry clean coal of a
;                   single train in Mlbs/hr for the calculation of
;                   the ISBL field cost of a single train as a function
;                   of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   flow rate of the dry clean coal in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   flow rate of the dry clean coal in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;     NOTES:
;       1. If both the sulfur distribution factors, REAL(9) and REAL(10),
;          are zero and a SULFANAL was supplied, the sulfur will be
;          distributed among the products as follows.
;          a. The ORGANIC sulfur will be distributed in the same
;             proportions as the carbon is distributed.
;          b. The PYRITIC and SULFATE sulfur will be distributed in the
;             same proportions as the ash is distributed.
;
;          FCP          FCM    FHP          FHM    FNP          FNM
     REAL 0.9302390    0.0    0.9142857    0.0    0.9533333    0.0  &
;          FClP         FClM   FSP          FSM    FOP          FOM
          0.40000      0.0    0.5019608    0.0    0.9696970    0.0  &
;          FAP          FAM
          0.4229677    0.0  &
;          PCWP   PCWM  PCWR  Future Use (3 items)
          8.576  3.0   10.0  0.0   0.0   0.0                    &
;          Power              900/750 F steam   900 satd steam
          0.0 4.281977       0.0 0.0           0.0 0.0        &
;          600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 0.0           0.0 0.0        &
;          50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 0.0           0.0 0.0        &
;          Process H2O        Nitrogen
          0.0 0.02433102     0.0 0.0         &
;          Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
```

```
;          Opers/day     (Opers/day)/train
           8.0           8.0                 &
;          Ref Flow   Max Flow   Min Flow
           387.158    390.0      200.0       &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future use (2 items)
           0.0    18.2    0.5942 1.0    0.0      0.0   0.0       &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S02    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S03    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S04    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S05    KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 1.4 - Coal Grinding and Drying Plant - Fortran Model USR01
;             BASE CASE
BLOCK P14 USER
   SUBROUTINE MODEL = USR01   REPORT = USR01
   DESCRIPTION 'PLANT 1.4 - BASE CASE - COAL GRINDING AND DRYING PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following integer and real parameters have the same meaning
;      as described above for Plant 1 in BLOCK P1-BASE.
    INT  0  1  0  1  4
;          FCP          FCM    FHP          FHM    FNP          FNM
     REAL 1.0          0.0    1.0          0.0    1.0          0.0  &
;          FC1P         FC1M   FSP          FSM    FOP          FOM
           1.0          0.0    1.0          0.0    1.0          0.0  &
;          FAP          FAM
           1.0          0.0   &
;          PCWP   PCWM  PCWR  Future Use (3 items)
           2.0    3.0   10.0  0.0   0.0   0.0                  &
;          Power                900/750 F steam   900 satd steam
           0.0 8.499979         0.0 0.0           0.0 0.0      &
;          600/720 F steam      600 satd steam    150 satd steam
           0.0 0.0              0.0 0.0           0.0 0.0      &
;          50 satd steam        Plant fuel        Cooling  H2O
           0.0 0.0              0.0 0.3410096     0.0 0.010104 &
;          Process H2O          Nitrogen
           0.0 0.0              0.0 3.16015     &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           7.0           1.0                 &
;          Ref Flow   Max Flow   Min Flow
           142.518    145.0      50.0        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future use (2 items)
           0.0    8.75    0.8504 1.0    0.0      0.0   0.0       &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
```

```
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = COALT02  KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-XMID KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-REF  KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-WAT  KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 2 - The coal liquefaction plant - user Fortran block USR02.
BLOCK P02 USER
   SUBROUTINE MODEL = USR02   REPORT = USR02
   DESCRIPTION 'PLANT 2 - COAL LIQUEFACTION PLANT'
   PARAM  NINT = 6   NREAL = 70
;      The following 5 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL02.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
;      INT(5) = Switch to write the major equipment summary list and
;               cost summary report by plant section for the baseline
;               design to the separate block output summary report file
;               called DCL02.REP on logical unit 62.
;               0 => Do not write the major equipment summary list.
;               1 => Write the major equipment summary list to the
;                    separate block output file only when
;                    INT(1) <= 2, INT(2) = 1, and INT(6) = 0.
;               2 => Write the major equipment summary list and the
;                    cost summary report by plant section to the
;                    separate block output file only when
;                    INT(1) <= 2, INT(2) = 1, and INT(6) = 0.
;      INT(6) = Switch to select which coal liquefaction reactor yields
;               are calculated.
;               0 => Baseline design two reactor model.
;               3 => Option 3 - Yields for Thermal/Catalytic two-
```

```
;                    reactor model.
;               4 => Option 4 - Two-reactor model with interstaage
;                    vent gas separation.
;               5 => Option 5 - Yields for two-reactor coker model.
;               8 => Improved Baseline (Option 8) - High space velocity
;                    two-reactor model.
   INT  0  1  0  1  2  0
;     The following 70 real parameters are:
;     REAL(1)    = Percent coal conversion based on fresh MAF coal
;                  entering the coal liquefaction reactors.
;     REAL(2)-
;      REAL(20) = Future use.
;     REAL(21)   = Constant factor for the power consumption, kw.
;     REAL(22)   = Power consumption per Mlbs/hr of dry coal feed,
;                  kw/(Mlbs/hr of dry coal).
;     REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;     REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(25)   = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;     REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(29)   = Constant factor for the 600 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(31)   = Constant factor for the 150 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(33)   = Constant factor for the 50 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                  dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(35)   = Constant factor for the plant fuel consumption,
;                  MM BTU/hr.
;     REAL(36)   = Plant fuel consumption per Mlbs/hr of dry coal feed,
;                  (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(37)   = Constant factor for the cooling water consumption,
;                  Mgal/hr.
;     REAL(38)   = Cooling water consumption per Mlbs/hr of dry coal
;                  feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;                  produced, (Mgal/hr)/(MM SCF/hr of H2).
;     REAL(39)   = Constant factor for the process water consumption,
;                  Mgal/hr.
;     REAL(40)   = Process water consumption per Mlbs/hr of dry coal
;                  feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;     REAL(41)   = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2
;     REAL(42)   = Nitrogen consumption per Mlbs/hr of dry coal feed,
```

```
;                    (MM SCF/hr of N2)/(Mlbs/hr of dry coal).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference dry coal feed rate to a single train in
;                   Mlbs/hr for the calculation of the ISBL field cost of
;                   a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the dry
;                   coal feed rate in Mlbs/hr of dry coal.
;       REAL(53)  = Minimum size of a single train as defined by the dry
;                   coal feed rate in Mlbs/hr of dry coal.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Percent fresh MAF coal conversion
     REAL 92.7901  &
;          Future use (9 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0    &
;          Power              900/750 F steam    900 satd steam
           0.0 41.39141       0.0 0.0            0.0 0.0        &
;          600/720 F steam    600 satd steam     150 satd steam
           0.0 0.003904784    0.0 -0.1046117     0.0 -0.0632168 &
;          50 satd steam      Plant fuel         Cooling H2O
           0.0 0.0393741      0.0 0.764818       0.0 0.340800   &
;          Process H2O        Nitrogen
           0.0 0.1081972      0.0 0.000029236 &
;          Future Use (6 items)
           0.0  0.0  0.0 0.0  0.0  0.0       &
;          Opers/day     (Opers/day)/train
           0.0           8.0                 &
;          Ref Flow   Max Flow   Min Flow
           285.035    285.05     30.0        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future use (2 items)
           0.0    186.44  0.7142 1.0    0.0      0.0   0.0   &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR02.
   FLASH-SPECS STRM=2S-GAS KODE=2 TEMP=130.0 PRES=2985.0 NPK=1 KPH=1 /
               STRM = GASES     KODE=2   TEMP = 130.0  PRES = 65.0   /
               STRM = NAPHTHA   KODE=2   TEMP = 140.0  PRES = 16.0   /
               STRM = GAS-OIL   KODE=2   TEMP = 110.0  PRES = 30.0   /
               STRM = 2S-BOTTS  KODE=2   TEMP = 688.0  PRES = 28.0   /
```

```
                STRM = 2S-SH2O   KODE=2   TEMP = 100.0  PRES = 30.0
;
; Plant 3 - The gas plant - use user Fortran block USR03.
BLOCK P03 USER
   SUBROUTINE MODEL = USR03   REPORT = USR03
   DESCRIPTION 'PLANT 3 - THE GAS PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL03.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per MM SCF/hr of dry C4- gas,
;                  kw/(MM SCF/hr of dry C4- gas)
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr
;                  of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;      REAL(25)  = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr
;                  of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;      REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;      REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr
;                  of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;      REAL(29)  = Constant factor for the 600 psig saturated steam
```

```
;                    consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr
;                    of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr
;                    of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr
;                    of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                    MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of dry C4- gas,
;                    (MM BTU/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                    Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of dry C4-
;                    gas, (Mgal/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(39)  = Constant factor for the process water consumption,
;                    Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of dry C4-
;                    gas, (Mgal/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                    MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of dry C4- gas,
;                    (MM SCF/hr of N2)/(MM SCF/hr of dry C4- gas).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                    day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                    (operators/day)/train.
;       REAL(51)  = Reference gas feed rate to a single train in
;                    MM SCF/hr of dry C4- gas for the calculation of
;                    the ISBL field cost of a single train as a function
;                    of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                    gas feed rate in MM SCF/hr of dry C4- gas.
;       REAL(53)  = Minimum size of a single train as defined by the
;                    gas feed rate in MM SCF/hr of dry C4- gas.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Future use (10 items)
     REAL 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
          0.0 447.6001       0.0 0.0           0.0 0.0       &
```

```
;         600/720 F steam   600 satd steam    150 satd steam
          0.0 0.0           0.0 194.4388      0.0 0.0       &
;         50 satd steam     Plant fuel        Cooling  H2O
          0.0 8.425471      0.0 -722.141      0.0 645.8090  &
;         Process H2O       Nitrogen
          0.0 0.0           0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.0            8.0                &
;         Ref Flow   Max Flow   Min Flow
          2.04       5.0        0.300      &
;         Plant cost equation constants.
;         A      B          E      F      Spares   Future Use (3 items)
          0.0    25.3       0.8013 1.0    0.0      0.0   0.0   &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR03.
   FLASH-SPECS STRM = 3S-SGAS   KODE=2  TEMP = 137.0  PRES = 55.0   /
               STRM = 3S-FGAS   KODE=2  TEMP = 100.0  PRES = 215.0  /
               STRM = 3S-PROP   KODE=2  TEMP = 100.0  PRES = 280.0  /
               STRM = 3S-BUT    KODE=2  TEMP = 100.0  PRES = 280.0  /
               STRM = 3S-OIL    KODE=2  TEMP = 130.0  PRES = 263.0  &
                      NPK=1 KPH=2 /
               STRM = 3S-SH2O   KODE=2  TEMP = 137.0  PRES = 55.0
;
; Plant 4 - The naphtha hydrotreater - use user Fortran block USR04.
BLOCK P04 USER
   SUBROUTINE MODEL = USR04   REPORT = USR04
   DESCRIPTION 'PLANT 4 - THE NAPHTHA HYDROTREATER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL04.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
```

```
;                 1 => Write the only the subroutine entry and exit
;                      messages to the history file.
;                 2 => Write some additional output to the history file.
;               3-5 => Write some more additional output to the history
;                      file.  Larger values generate more intermediate
;                      output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Percent desulfurization of the C5+ feed; i. e.,
;                   Percent of sulfur removed from the entering C5+ feed.
;      REAL(2)    = Percent denitrogenation of the C5+ feed; i. e.,
;                   Percent of nitrogen removed from the entering C5+ feed.
;      REAL(3)    = Percent deoxygenation of the C5+ feed.
;                   Percent of oxygen removed from the entering C5+ feed.
;      REAL(4)    = Chemical hydrogen consumption in SCF/bbl of C5+ feed.
;      REAL(5) -
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per Mlbs/hr of C5+ feed,
;                   kw/(Mlbs/hr of C5+ feed).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per Mlbs/hr of C5+ feed,
;                   (MM BTU/hr)/(Mlbs/hr of C5+ feed).
;      REAL(37)   = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;      REAL(38)   = Cooling water consumption per Mlbs/hr of C5+ feed,
;                   (Mgal/hr)/(Mlbs/hr of C5+ feed).
;      REAL(39)   = Constant factor for the process water consumption,
;                   Mgal/hr.
;      REAL(40)   = Process water consumption per Mlbs/hr of C5+ feed,
```

```
;                    (Mgal/hr)/(Mlbs/hr of C5+ feed).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                    MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of C5+ feed,
;                    (MM SCF/hr of N2)/(Mlbs/hr of C5+ feed).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                    day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                    (operators/day)/train.
;       REAL(51)  = Reference C5+ feed rate to a single train in Mlbs/hr
;                    for the calculation of the ISBL field cost of a
;                    single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                    C5+ feed rate in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                    C5+ feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          % Desulfurization   % Denitrogenation
     REAL 99.99                99.988        &
;          % Deoxygenation    Chemical H2 consumption in SCF/bbl C5+ feed
           99.5               125.0          &
;          Future use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 5.098308       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.126493      0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 0.0            0.0 0.351607      0.0 0.730963  &
;          Process H2O        Nitrogen
           0.0 0.010833       0.0 0.0          &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day      (Opers/day)/train
           0.0            8.0                &
;          Ref Flow   Max Flow   Min Flow
           210.462    400.0      50.0       &
;          Plant cost equation constants.
;          A      B      E      F      Spares   Future Use (3 items)
           0.0    15.6   0.7843 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
```

```
;  values will override the default values in subroutine USR04.
   FLASH-SPECS STRM = 4S-GAS   KODE=2  TEMP = 135.0  PRES = 915.0  /
               STRM = 4S-NAPH  KODE=2  TEMP = 100.0  PRES = 153.0  /
               STRM = 4S-SH2O  KODE=2  TEMP =  70.0  PRES = 14.7
;
; Plant 5 - The gas-oil hydrotreater - use user Fortran block USR05.
BLOCK P05 USER
   SUBROUTINE MODEL = USR05   REPORT = USR05
   DESCRIPTION 'PLANT 5 - THE GAS-OIL HYDROTREATER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL05.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Percent desulfurization of the C6+ feed; i. e.,
;                  Percent of sulfur removed from the entering C6+ feed.
;      REAL(2)   = Percent denitrogenation of the C6+ feed; i. e.,
;                  Percent of nitrogen removed from the entering C6+ feed.
;      REAL(3)   = Percent deoxygenation of the C6+ feed.
;                  Percent of oxygen removed from the entering C6+ feed.
;      REAL(4)   = Chemical hydrogen consumption in SCF/bbl of C6+ feed.
;      REAL(5) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of C6+ feed,
;                  kw/(Mlbs/hr).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
```

```
;                 C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;     REAL(25)  = Constant factor for the 900 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                 C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;     REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                 consumption, Mlbs/hr.
;     REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                 C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;     REAL(29)  = Constant factor for the 600 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                 C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;     REAL(31)  = Constant factor for the 150 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                 C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;     REAL(33)  = Constant factor for the 50 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                 C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;     REAL(35)  = Constant factor for the plant fuel consumption,
;                 MM BTU/hr.
;     REAL(36)  = Plant fuel consumption per Mlbs/hr of C6+ feed,
;                 (MM BTU/hr)/(Mlbs/hr).
;     REAL(37)  = Constant factor for the cooling water consumption,
;                 Mgal/hr.
;     REAL(38)  = Cooling water consumption per Mlbs/hr of C6+ feed,
;                 (Mgal/hr)/(Mlbs/hr).
;     REAL(39)  = Constant factor for the process water consumption,
;                 Mgal/hr.
;     REAL(40)  = Process water consumption per Mlbs/hr of C6+ feed,
;                 (Mgal/hr)/(Mlbs/hr).
;     REAL(41)  = Constant factor for the nitrogen consumption,
;                 MM SCF/hr of N2.
;     REAL(42)  = Nitrogen consumption per Mlbs/hr of C6+ feed,
;                 (MM SCF/hr of N2)/(Mlbs/hr).
;     REAL(43) -
;      REAL(48) = Future use.
;     REAL(49)  = Constant factor for the number of operators per
;                 day, operators/day.
;     REAL(50)  = Number of operators per day per train,
;                 (operators/day)/train.
;     REAL(51)  = Reference C6+ feed rate to a single train in Mlbs/hr
;                 for the calculation of the ISBL field cost of a
;                 single train as a function of train capacity.
;     REAL(52)  = Maximum size of a single train as defined by the
;                 C6+ feed rate in Mlbs/hr.
;     REAL(53)  = Minimum size of a single train as defined by the
;                 C6+ feed rate in Mlbs/hr.
;     REAL(54)  = Constant A in the plant ISBL field cost equation.
;     REAL(55)  = Constant B in the plant ISBL field cost equation.
;     REAL(56)  = Constant E in the plant ISBL field cost equation.
;     REAL(57)  = Constant F in the plant ISBL field cost equation.
;     REAL(58)  = Number of spare trains.
```

```
;       REAL(59) -
;        REAL(70) = Future use.
;
;          % Desulfurization   % Denitrogenation
      REAL 92.5                85.2       &
;          % Deoxygenation   Chemical H2 consumption in SCF/bbl C6+ feed
           97.6             947.00       &
;          Future use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0   &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power            900/750 F steam   900 satd steam
           0.0 3.247198     0.0 0.0           0.0 0.0       &
;          600/720 F steam  600 satd steam    150 satd steam
           0.0 0.0          0.0 0.096936      0.0 -0.050465 &
;          50 satd steam    Plant fuel        Cooling  H2O
           0.0 0.0          0.0 0.241416      0.0 0.735694 &
;          Process H2O      Nitrogen
           0.0 0.0          0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0            4.0               &
;          Ref Flow   Max Flow   Min Flow
           671.04     800.0      150.0      &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future Use (2 items)
           0.0    74.0    0.7467 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR05.
;  The 5S-LPGAS and 5S-NAPH temperature and pressure are those leaving
;  Plant 4 where this fractionation is actually performed.
   FLASH-SPECS STRM = 5S-HPGAS  KODE=2  TEMP = 135.0  PRES = 2690.0 /
               STRM = 5S-LPGAS  KODE=2  TEMP = 135.0  PRES = 915.0  /
               STRM = 5S-NAPH   KODE=2  TEMP = 100.0  PRES = 153.0  /
               STRM = P350-450  KODE=2  TEMP = 110.0  PRES = 80.0   /
               STRM = P450-650  KODE=2  TEMP = 135.0  PRES = 20.0   /
               STRM = P650-850  KODE=2  TEMP = 135.0  PRES = 20.0   /
               STRM = 5S-SH2O   KODE=2  TEMP = 135.0  PRES = 20.0
;
; Plant 6.1 - The Hydrogen purification by Membrane Separation Plant.
BLOCK P61 USER
   SUBROUTINE MODEL = USR61   REPORT = USR61
   DESCRIPTION 'PLANT 6.1 - THE MEMBRANE H2 PURIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
```

```
;                3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;                0 => Write the user block summary report to the normal
;                     ASPEN/SP output report file.
;                1 => Write the user block summary report to a separate
;                     user block output report file on logical unit 62
;                     called DCL61.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;                If INT(3) = 0, the minimum number of duplicate
;                  trains will be determined so that the capacity
;                  of each train does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Percent hydrogen recovery to the hydrogen-rich
;                   product gas stream from the inlet gas stream.
;      REAL(2)    = Concentration of hydrogen in the hydrogen-rich
;                   product gas stream, mole % or vol%.
;      REAL(3)-
;       REAL(20)  = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per MM SCF/hr of H2 recovered,
;                   kw/(MM SCF/hr of H2 recovered).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr
;                   of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per MM SCF/hr of
```

```
;                 H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(35)  = Constant factor for the plant fuel consumption,
;                  MM BTU/hr.
;      REAL(36)  = Plant fuel consumption per MM SCF/hr of H2 recovered,
;                  (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(37)  = Constant factor for the cooling water consumption,
;                  Mgal/hr.
;      REAL(38)  = Cooling water consumption per MM SCF/hr of H2
;                  recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(39)  = Constant factor for the process water consumption,
;                  Mgal/hr.
;      REAL(40)  = Process water consumption per MM SCF/hr of H2
;                  recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(41)  = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2
;      REAL(42)  = Nitrogen consumption per MM SCF/hr of H2 recovered,
;                  (MMM SCF/hr of N2)/(MM SCF/hr of H2 recovered).
;      REAL(43) -
;       REAL(48) = Future use.
;      REAL(49)  = Constant factor for the number of operators per
;                  day, operators/day.
;      REAL(50)  = Number of operators per day per train,
;                  (operators/day)/train.
;      REAL(51)  = Reference hydrogen recovery rate for a single train
;                  in MM SCF/hr of H2 for the calculation of the
;                  ISBL field cost of a single train as a function of
;                  capacity.
;      REAL(52)  = Maximum size of a single train as defined by the
;                  hydrogen recovery rate in MM SCF/hr of H2
;                  recovered.
;      REAL(53)  = Minimum size of a single train as defined by the
;                  hydrogen recovery rate in MM SCF/hr of H2
;                  recovered.
;      REAL(54)  = Constant A in the plant ISBL field cost equation.
;      REAL(55)  = Constant B in the plant ISBL field cost equation.
;      REAL(56)  = Constant E in the plant ISBL field cost equation.
;      REAL(57)  = Constant F in the plant ISBL field cost equation.
;      REAL(58)  = Number of spare trains.
;      REAL(59) -
;       REAL(70) = Future use.
;
;         Percent H2 recovery    H2 purity in mole %
    REAL 43.83285               99.98677                    &
;         Future use (8 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0            &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 12254.04       0.0 0.0           0.0 0.0      &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 0.0           0.0 0.0      &
;         50 satd steam      Plant fuel        Cooling H2O
          0.0 2.054966       0.0 0.0           0.0 42.705864 &
;         Process H2O        Nitrogen
          0.0 0.854117       0.0 0.0         &
```

```
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.0            12.0               &
;         Ref Flow   Max Flow   Min Flow
          1.966943   2.5        0.5         &
;         Plant cost equation constants.
;         A      B         E      F      Spares   Future use (2 items)
          0.0    152.6     0.8478 1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR61.
   FLASH-SPECS STRM = H2-RICH   KODE=2   TEMP = 100.0  PRES = 3290.0 /
               STRM = SOUR-GAS  KODE=2   TEMP = 250.0  PRES = 14.7   /
               STRM = P61-GAS   KODE=2   TEMP = 111.0  PRES = 500.0
;
; Plant 6.2 - The Hydrogen purification by Pressure Swing Absorption
;             Plant.
BLOCK P62 USER
   SUBROUTINE MODEL = USR62   REPORT = USR62
   DESCRIPTION 'PLANT 6.2 - THE PSA H2 PURIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL62.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Percent hydrogen recovery to the hydrogen-rich
```

```
;                 product gas stream from the inlet gas stream.
;      REAL(2)    = Concentration of hydrogen in the hydrogen-rich
;                   product gas stream, mole % or vol%.
;      REAL(3)-
;       REAL(20)  = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per MM SCF/hr of H2 recovered,
;                   kw/(MM SCF/hr of H2 recovered).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr
;                   of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per MM SCF/hr of H2 recovered,
;                   (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(37)   = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;      REAL(38)   = Cooling water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(39)   = Constant factor for the process water consumption,
;                   Mgal/hr.
;      REAL(40)   = Process water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(41)   = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;      REAL(42)   = Nitrogen consumption per MM SCF/hr of H2 recovered,
;                   (MMM SCF/hr of N2)/(MM SCF/hr of H2 recovered).
;      REAL(43) -
;       REAL(48)  = Future use.
;      REAL(49)   = Constant factor for the number of operators per
;                   day, operators/day.
;      REAL(50)   = Number of operators per day per train,
;                   (operators/day)/train.
;      REAL(51)   = Reference hydrogen recovery rate for a single train
```

```
;                 in MM SCF/hr of H2 for the calculation of the
;                 ISBL field cost of a single train as a function of
;                 capacity.
;     REAL(52)  = Maximum size of a single train as defined by the
;                 hydrogen recovery rate in MM SCF/hr of H2
;                 recovered.
;     REAL(53)  = Minimum size of a single train as defined by the
;                 hydrogen recovery rate in MM SCF/hr of H2
;                 recovered.
;     REAL(54)  = Constant A in the plant ISBL field cost equation.
;     REAL(55)  = Constant B in the plant ISBL field cost equation.
;     REAL(56)  = Constant E in the plant ISBL field cost equation.
;     REAL(57)  = Constant F in the plant ISBL field cost equation.
;     REAL(58)  = Number of spare trains.
;     REAL(59) -
;      REAL(70) = Future use.
;
;      The cost of Plant 6.2 is included in Plant 6.1.
;        Percent H2 recovery    H2 purity in mole %
    REAL 89.5033                90.01665              &
;        Future use (8 items)
         0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;        Future use (10 items)
         0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;        Power              900/750 F steam   900 satd steam
         0.0 5485.989       0.0 0.0           0.0 0.0       &
;        600/720 F steam    600 satd steam    150 satd steam
         0.0 0.0            0.0 0.0           0.0 0.0       &
;        50 satd steam      Plant fuel        Cooling H2O
         0.0 15.32654       0.0 0.0           0.0 87.29583  &
;        Process H2O        Nitrogen
         0.0 0.530875       0.0 0.0         &
;        Future Use (6 items)
         0.0  0.0  0.0  0.0  0.0  0.0      &
;        Opers/day     (Opers/day)/train
         0.0           0.0                 &
;        Ref Flow   Max Flow   Min Flow
         3.61667    5.0        0.5        &
;        Plant cost equation constants.
;        A      B      E      F      Spares   Future use (2 items)
         0.0    0.0    0.7    1.0    0.0      0.0   0.0    &
;        Future use (10 items)
         0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR62.
   FLASH-SPECS STRM = H2-2RICH  KODE=2   TEMP = 100.0  PRES = 3290.0 /
               STRM = SOUR-2GS  KODE=2   TEMP = 250.0  PRES = 14.7   /
               STRM = GAS-OUT   KODE=2   TEMP = 111.0  PRES = 25.0   /
               STRM = NAPHTHA2  KODE=2   TEMP = 100.0  PRES = 50.0
;
; Plant 7 - The naphtha reformer - use user Fortran block USR07.
BLOCK P07 USER
   SUBROUTINE MODEL = USR07   REPORT = USR07
   DESCRIPTION 'PLANT 7 - THE NAPHTHA REFORMER'
```

```
   PARAM  NINT = 4   NREAL = 70
;     The following 4 integer parameters are:
;     INT(1) = User block summary report control switch.
;              0 => Write the complete user block summary report.
;              1 => Skip the capital cost portion of the summary
;                   report.
;              2 => Skip the capital cost and utilities portions
;                   of the summary report.
;              3 => Skip writing the entire user block summary report.
;     INT(2) = User block summary report destination control switch.
;              0 => Write the user block summary report to the mormal
;                    ASPEN/SP output report file.
;              1 => Write the user block summary report to a separate
;                   user block output report file on logical unit 62
;                   called DCL07.REP.
;     INT(3) = Number of operating duplicate trains, excluding spares.
;              If INT(3) = 0, the minimum number of duplicate
;                trains will be determined so that the capacity
;                of each plant does not exceed the maximum train
;                capacity specified by variable REAL(52).
;              If INT(3) > 0, the number of duplicate trains.
;     INT(4) = History file additional output control switch.
;              0 => Write no additional output to the history file.
;              1 => Write the only the subroutine entry and exit
;                   messages to the history file.
;              2 => Write some additional output to the history file.
;            3-5 => Write some more additional output to the history
;                   file.  Larger values generate more intermediate
;                   output.
   INT  0  1  0  1
;     The following 70 real parameters are:
;     REAL(1) -
;      REAL(20) = Future use.
;     REAL(21)  = Constant factor for the power consumption, kw.
;     REAL(22)  = Power consumption per Mlbs/hr of feed,
;                 kw/(Mlbs/hr of feed).
;     REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                 consumption, Mlbs/hr.
;     REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                 feed, (Mlbs/hr)/(Mlbs/hr of feed).
;     REAL(25)  = Constant factor for the 900 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                 feed, (Mlbs/hr)/(Mlbs/hr of feed).
;     REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                 consumption, Mlbs/hr.
;     REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                 feed, (Mlbs/hr)/(Mlbs/hr of feed).
;     REAL(29)  = Constant factor for the 600 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                 feed, (Mlbs/hr)/(Mlbs/hr of feed).
;     REAL(31)  = Constant factor for the 150 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
```

```
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of feed,
;                   (MM BTU/hr)/(Mlbs/hr of feed).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of feed,
;                   (Mgal/hr)/(Mlbs/hr of feed).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of feed,
;                   (Mgal/hr)/(Mlbs/hr of feed).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of feed).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference feed rate to a single train in Mlbs/hr
;                   for the calculation of the ISBL field cost of a
;                   single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   feed rate in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Future use (10 items)
     REAL 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
          0.0 2.26494        0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
          0.0 -0.314772      0.0 0.0           0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 1.41781       0.0 0.123590  &
;          Process H2O        Nitrogen
          0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
```

```
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.            8.                   &
;         Ref Flow   Max Flow   Min Flow
          224.289    400.0      50.0        &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future Use (3 items)
          0.0    30.7    0.75   1.0    0.0      0.0   0.0   &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0

;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR07.
   FLASH-SPECS STRM = 7S-H2      KODE=2   TEMP = 80.0  PRES = 14.7  /
               STRM = 7S-GAS     KODE=2   TEMP = 80.0  PRES = 14.7  /
               STRM = REFORMED   KODE=2   TEMP = 80.0  PRES = 14.7
;
; Plant 8.1 - The ROSE-SR unit - user Fortran block USR81.
BLOCK P81 USER
   SUBROUTINE MODEL = USR81   REPORT = USR81
   DESCRIPTION 'PLANT 8.1 - THE ROSE-SR UNIT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL81.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate plants.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Hydrocarbon rejection factor.
;      REAL(2)-
;       REAL(20) = Future use.
```

```
;       REAL(21)  = Constant factor for the power consumption, kw.
;       REAL(22)  = Power consumption per Mlbs/hr of extract,
;                   kw/(Mlbs/hr of extract).
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   extract, (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   extract, (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   extract, (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   extract, (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   extract, (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   extract, (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of extract,
;                   (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of extract,
;                   (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of extract,
;                   (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of extract,
;                   (MM SCF/hr of N2)/(Mlbs/hr of extract).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference feed rate to a single train in Mlbs/hr of
;                   unit feed for the calculation of the capital cost of
;                   a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   unit feed rate in Mlbs/hr of unit feed.
;       REAL(53)  = Minimum size of a single train as defined by the
```

```
;                   unit feed rate in Mlbs/hr of unit feed.
;      REAL(54)  = Constant A in the plant costing equation.
;      REAL(55)  = Constant B in the plant costing equation.
;      REAL(56)  = Constant E in the plant costing equation.
;      REAL(57)  = Constant F in the plant costing equation.
;      REAL(58)  = Number of spare trains.
;      REAL(59) -
;       REAL(70) = Future use.
;         Hydrocarbon rejection factor
    REAL  1.0  &
;         Future use (9 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam    900 satd steam
          0.0 8.098677       0.0 0.0            0.0 0.0       &
;         600/720 F steam    600 satd steam     150 satd steam
          0.0 0.0            0.0 0.0            0.0 0.0471832 &
;         50 satd steam      Plant fuel         Cooling H2O
          0.0 0.0            0.0 0.393518       0.0 0.0       &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0         &
;         Future Use (6 items)
          0.  0.  0.  0.  0.  0.             &
;         Opers/day     (Opers/day)/train
          0.0           8.0                  &
;         Ref Flow   Max Flow   Min Flow
          907.390   1500.0     500.0         &
;         Plant cost equation constants.
;         A      B        E      F      Spares   Future use (2 items)
          0.0    42.2     0.7215 1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR81.
   FLASH-SPECS STRM = ROSE-XTR  KODE=2   TEMP = 300.0  PRES = 115.0 /
               STRM = ASH-CONC  KODE=2   TEMP = 150.0  PRES = 14.7
;
; Plant 9 - H2 Production by coal gasification, Use the User Fortran
; Block USR09.
BLOCK P09 USER
   SUBROUTINE MODEL = USR09   REPORT = USR09
   DESCRIPTION 'PLANT 9 - H2 PRODUCTION BY COAL GASIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
```

```
;                    ASPEN/SP output report file called DCL09.REP.
;                1 => Write the user block summary report to a separate
;                     user block output report file on logical unit 62.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;                If INT(3) = 0, the minimum number of duplicate
;                  trains will be determined so that the capacity
;                  of each train does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Molar CO/CO2 ratio in the gasifier product gas.
;      REAL(2)    = Fraction of carbon entering the gasifier that goes
;                   to carbonyl sulfide (COS).
;      REAL(3)    = Fraction of carbon entering the gasifier that goes
;                   to methane (CH4).
;      REAL(4)    = Fraction of nitrogen entering the gasifier that goes
;                   to ammonia (NH3).
;      REAL(5)    = Carbon content of the slag produced by the gasifier,
;                   wt %.
;      REAL(6)    = Fraction of carbon monoxide (CO) entering the shift
;                   reactors that is shifted; i.e., converted to carbon
;                   dioxide (CO2) by the chemical reaction
;                       CO + H2O -----> CO2 + H2
;      REAL(7)    = Fraction of carbonyl sulfide (COS) entering the shift
;                   reactor section that is hydrolyzed; i.e., converted
;                   to carbon dioxide (CO2) and hydrogen sulfide (H2S)
;                   by the chemical reaction
;                       COS + H2O -----> CO2 + H2S
;      REAL(8)    = Future use.
;      REAL(9)-
;       REAL(20)  = Rectisol section component distribution factors,
;                   where
;      REAL(9)    = Fraction of inlet H2 going to the hydrogen-rich
;                   gas stream.
;      REAL(10)   = Fraction of inlet H2 going to the acid gas stream.
;      REAL(11)   = Fraction of inlet CO going to the hydrogen-rich
;                   gas stream.
;      REAL(12)   = Fraction of inlet CO going to the acid gas stream.
;      REAL(13)   = Fraction of inlet CO2 going to the hydrogen-rich
;                   gas stream.
;      REAL(14)   = Fraction of inlet CO2 going to the acid gas stream.
;      REAL(15)   = Fraction of inlet CH4 going to the hydrogen-rich
;                   gas stream.
;      REAL(16)   = Fraction of inlet CH4 going to the acid gas stream.
;      REAL(17)   = Fraction of inlet N2 going to the hydrogen-rich
;                   gas stream.
```

```
;       REAL(18)  = Fraction of inlet N2 going to the acid gas stream.
;       REAL(19)  = Fraction of inlet H2S going to the hydrogen-rich
;                   gas stream.
;       REAL(20)  = Fraction of inlet H2S going to the acid gas stream.
;       REAL(21)  = Constant factor for the power consumption, kw.
;       REAL(22)  = Power consumption per MM SCF/hr of hydrogen
;                   produced, kw/(MM SCF/hr of H2).
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of hydrogen
;                   produced, (MM BTU/hr)/(MM SCF/hr of H2).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of hydrogen
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of hydrogen
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of hydrogen
;                   produced, (MM SCF/hr of N2)/(MM SCF/hr of H2).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
;       REAL(51)  = Reference hydrogen production rate of a single train
;                   in MM SCF/hr of H2 for the calculation of the ISBL
```

```
;                 field cost of a single train as a function of train
;                 capacity.
;     REAL(52)  = Maximum size of a single train as defined by the
;                 hydrogen production rate in MM SCF/hr of H2.
;     REAL(53)  = Minimum size of a single train as defined by the
;                 hydrogen production rate in MM SCF/hr of H2.
;     REAL(54)  = Constant A in the plant ISBL field cost equation.
;     REAL(55)  = Constant B in the plant ISBL field cost equation.
;     REAL(56)  = Constant E in the plant ISBL field cost equation.
;     REAL(57)  = Constant F in the plant ISBL field cost equation.
;     REAL(58)  = Number of spare plants.
;     REAL(59) -
;      REAL(70) = Future use.
;
;  NOTE:  MM SCF/hr of hydrogen produced means MM SCF/hr of hydrogen
;         in the hydrogen-rich product gas stream and NOT the total
;         flow rate of the hydrogen-rich product gas stream.
;
;                   Frac C       Frac C   Frac N   %C in
;        CO/CO2     to COS       to CH4   to NH3   slag
    REAL 2.419768  0.000804005  0.0      0.05212  5.229154  &
;        Frac CO shifted  Frac COS hydrolyzed  Future use
;        Adjust the fraction of CO shifted to get true H2 rate.
         0.9611           0.9516917            0.0          &
;        Component distribution factors for H2 to H2 and acid gas.
         0.8344      0.00153604                             &
;        Component distribution factors for CO to H2 and acid gas.
         0.0         0.0545937                              &
;        Component distribution factors for CO2 to H2 and acid gas.
         0.0         0.0453275                              &
;        Component distribution factors for CH4 to H2 and acid gas.
         0.0         0.0                                    &
;        Component distribution factors for N2 to H2 and acid gas.
         0.0932727   0.0923972                              &
;        Component distribution factors for H2S to H2 and acid gas.
         0.0         0.990203                               &
;        Power              900/750 F steam   900 satd steam
         0.0 3679.14335     0.0 0.0           0.0 0.0       &
;        600/720 F steam    600 satd steam    150 satd steam
         0.0 0.0            0.0 -16.98424     0.0 -44.40466  &
;        50 satd steam      Plant fuel        Cooling  H20
         0.0 -45.47563      0.0 -57.09919     0.0 183.6952   &
;        Process H20        Nitrogen
         0.0 4.176796       0.0 0.0824568   &
;        Future Use (6 items)
         0.  0.  0.  0.  0.  0.             &
;        Opers/day     (Opers/day)/train
         0.0           24.                  &
;        Ref Flow   Max Flow   Min Flow
         3.436      3.5        1.0         &
;        Plant cost equation constants.
;        A      B       E      F      Spares   Future use (3 items)
         0.0    52.7    0.7658 1.0    0.       0.0   0.0    &
;        Future use (10 items)
         0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
```

```
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR09.
   FLASH-SPECS STRM = H2-GAS    KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = H2S-GAS   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = VENT-GAS  KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = 9S-SH2O   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = SLAG      KODE=2   TEMP = 80.   PRES = 14.7
;
;  Plant 9.1 - Steam Reforming of Natural Gas Plant.
BLOCK P91 USER
   SUBROUTINE MODEL = USR91   REPORT = USR91
   DESCRIPTION 'PLANT 9.1 - STEAM REFORMING OF NATURAL GAS PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL91.REP.
;      INT(3) = Number of operating duplicate plants, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 plants will be determined so that the capacity
;                 of each plant does not exceed the maximum plant
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, this number of duplicate plants will
;                 be used.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Fraction of CH4 reacting to produce H2 and CO2.
;      REAL(2)   = Fraction of CH4 reacting to produce H2 and CO.
;      REAL(3)   = Fraction of hydrogen produced that leaves in the
;                  hydrogen-rich product gas stream.
;      REAL(4)   = Purity of the hydrogen-rich product gas. mole %.
;      REAL(5) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per MM SCF/hr of hydrogen produced,
;                  kw/(MM SCF/hr of H2).
```

```
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of hydrogen
;                   produced, (MM BTU/hr)/(MM SCF/hr of H2).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of hydrogen
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of hydrogen
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2..
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of hydrogen
;                   produced, (MM SCF/hr of N2)/(MM SCF/hr of H2).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
;       REAL(51)  = Reference hydrogen production rate of a single train
;                   in MM SCF/hr of H2 for the calculation of the ISBL
;                   field cost of a single train as a function of train
;                   capacity.
;       REAL(52)  = Maximum plant size as defined by the hydrogen
;                   production rate in MM SCF/hr of H2.
;       REAL(53)  = Minimum plant size as defined by the hydrogen
;                   production rate in MM SCF/hr of H2.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
```

```
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare plants.
;       REAL(59) -
;        REAL(70) = Future use.
;
;  NOTES: 1. MM SCF/hr of hydrogen produced means MM SCF/hr of hydrogen
;            in the hydrogen rich product gas stream and NOT the total
;            flow rate of the hydrogen rich product gas stream.
;         2. The number of operators in this plant and Plants 31.1 and
;            31.4 is set so as to maintain the same total number of
;            operators as used for the baseline design.
;
;         Frac CH4 to CO2  Frac CH4 to CO  Frac recovered  H2 Purity
     REAL 0.638648         0.04429         0.8862694       100.0 &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0                      &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 354.158        0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 -65.3773      0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 89.0448       0.0 32.6902   &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0           &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0         &
;         Opers/day      (Opers/day)/train
          0.0            8.0                   &
;         Ref Flow       Max Flow     Min Flow
          5.77237        6.25         2.0      &
;         Plant cost equation constants.
;         A      B      E      F      Spares   Future Use (2 items)
          0.0    68.1   0.75   1.0    0.0      0.0    0.0    &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR091.
   FLASH-SPECS STRM = H2-PROD    KODE=2  TEMP = 100.0  PRES = 500.0 /
               STRM = FLUE-GAS   KODE=2  TEMP = 250.0  PRES = 14.7
;
; Plant 10 - Air Separation Plant - Use the User Fortran Model USR10.
BLOCK P10 USER
   SUBROUTINE MODEL = USR10   REPORT = USR10
   DESCRIPTION 'PLANT 10 - AIR SEPARATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
```

```
;                2 => Skip the capital cost and utilities portions
;                     of the summary report.
;                3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;                0 => Write the complete user block summary report to
;                     the normal ASPEN/SP output report file.
;                1 => Write the complete user block summary report to
;                     a separate user block output report file on
;                     logical unit 62 CALLED DCL10.REP.
;      INT(3) = Number of operating duplicate trains, excluding
;                spares.
;                If INT(3) = 0, the minimun number of duplicate
;                  trains will be determined so that the capacity
;                  of each train does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
     INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Purity of the product oxygen stream, mole %.
;      REAL(2)    = Purity of the product nitrogen stream, mole %.
;      REAL(3) -
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per MM SCF/hr of the oxygen stream
;                   flow rate, kw/(MM SCF/hr of O2).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   the oxygen stream flow rate,
;                   (Mlbs/hr)/(MM SCF/hr of O2).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr of
;                   the oxygen stream flow rate,
;                   (Mlbs/hr)/(MM SCF/hr of O2).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   the oxygen stream flow rate,
;                   (Mlbs/hr)/(MM SCF/hr of O2).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per MM SCF/hr of
;                   the oxygen stream flow rate,
;                   (Mlbs/hr)/(MM SCF/hr of O2).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
```

```
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                   the oxygen stream flow rate,
;                   (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                   the oxygen stream flow rate,
;                   (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of the oxygen
;                   stream flow rate, (MM BTU/hr)/(MM SCF/hr of O2).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of the oxygen
;                   stream flow rate, (Mgal/hr)/(MM SCF/hr of O2).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of the oxygen
;                   stream flow rate, (Mgal/hr)/(MM SCF/hr of O2).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of the oxygen
;                   stream flow rate,
;                   (MM SCF/hr of N2)/(MM SCF/hr of O2).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference oxygen production rate for a single train
;                   in MM SCF/hr of O2 for the calculation of the
;                   ISBL field cost of a single train as a function of
;                   train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   oxygen production rate in MM SCF/hr of O2.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   oxygen production rate in MM SCF/hr of O2.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;     NOTES:
;       1.  This model does not consider Argon as a separate element.
;           Hence, argon is lumped with nitrogen.
;       2.  MM SCF/hr of O2 means the oxygen production rate in
;           MM SCF/hr of O2 in the product oxygen stream and NOT
;           the total flow rate of the product oxygen stream.
;
;         %O2 in O2    %N2 in N2   Future Use (8 items)
```

```
     REAL 99.5003      100.0       0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 18143.97       0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 0.0           0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 0.0           0.0 0.0       &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          4.0           0.0                 &
;         Ref Flow     Max Flow     Min Flow
          1.763605     1.875        1.0     &
;         Plant cost equation costants.
;         A       B        E       F      Spares   Future use (2 items)
          0.0     38.2     0.7028  1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR10.
   FLASH-SPECS STRM = 10S01   KODE=2   TEMP =   80.0   PRES = 350.0  /
               STRM = 10S02   KODE=2   TEMP = -275.0   PRES = 164.7
;
; Plant 11 - Sulfur Recovery Plant, Use the User Fortran Model USR11.
BLOCK P11 USER
   SUBROUTINE MODEL = USR11   REPORT = USR11
   DESCRIPTION 'PLANT 11 - THE SULFUR RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the
;                    normal ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL11.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimun number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
```

```
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Fractional sulfur recovery; fraction of sulfur in
;                   the entering H2S and COS that is recovered in the
;                   product liquid sulfur stream.  All entering liquid
;                   sulfur entering in the feed stream is assumed to
;                   be recovered in the liquid sulfur product stream.
;      REAL(2) -
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per Mlbs/hr of product sulfur,
;                   kw/(Mlbs/hr).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   product sulfur, (Mlbs/hr)/(Mlbs/hr).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                   product sulfur, (Mlbs/hr)/(Mlbs/hr).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   product sulfur, (Mlbs/hr)/(Mlbs/hr).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                   product sulfur, (Mlbs/hr)/(Mlbs/hr).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                   product sulfur, (Mlbs/hr)/(Mlbs/hr).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                   product sulfur, (Mlbs/hr)/(Mlbs/hr).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per Mlbs/hr of product sulfur,
;                   (MM BTU/hr)/(Mlbs/hr).
;      REAL(37)   = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;      REAL(38)   = Cooling water consumption per Mlbs/hr of product
;                   sulfur (Mgal/hr)/(Mlbs/hr).
;      REAL(39)   = Constant factor for the process water consumption,
;                   Mgal/hr.
;      REAL(40)   = Process water consumption per Mlbs/hr of product
;                   sulfur, (Mgal/hr)/(Mlbs/hr).
;      REAL(41)   = Constant factor for the nitrogen consumption,
```

```
;                    MM SCF/hr of N2.
;       REAL(42)  = Nitrigen consumption per Mlbs/hr of product sulfur,
;                   (MM SCF/hr of N2)/(Mlbs/hr).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference product sulfur flow rate of a single train
;                   in Mlbs/hr of S for the calculation of the ISBL field
;                   cost of a single train as a function of capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   product sulfur flow rate in Mlbs/hr of S.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   product sulfur flow rate in Mlbs/hr of S.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          S recovery
     REAL 0.998482    &
;          Future Use (19 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0       &
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 49.60954       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.971388      0.0 -3.022277 &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 0.882473       0.0 1.117916      0.0 7.89929   &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0           5.0                &
;          Ref Flow     Max Flow     Min Flow
           15.4305      16.5         5.0      &
;          Plant cost equation costants.
;          A       B        E      F      Spares   Future use (3 items)
           0.0     11.675   0.7823 1.0    0.0      0.0   0.0    &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 11S-FGAS  KODE=2   TEMP = 80.0   PRES = 14.7  /
               STRM = 11S-LIQS  KODE=2   TEMP = 80.0   PRES = 14.7
;
; Plant 31 - The Utilities plant - user Fortran block USR31.
```

```
BLOCK P31 USER
   SUBROUTINE MODEL = USR31   REPORT = USR31
   DESCRIPTION 'PLANTS 31 - THE UTILITIES PLANT'
   PARAM  NINT = 20   NREAL = 20
;      The following 20 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Not used.
;               2 => Not used.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL02.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(2).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
;      INT(5) = Future use.
;      INT(6) -  Switches to select which fuels are burned in the steam
;       INT(10)  boiler to produce steam and/or electric power to
;                satisfy the steam demand.  The fuel specified in
;                INT(6) is used until it is all consumed, the steam
;                demand is satisfied, or the capacity to use this fuel
;                is reached.  Then the INT(7) fuel is used, etc.
;                The fuel codes are
;                  1 = Coal
;                  2 = ROSE-SR unit bottoms
;                  3 = Coke
;                  4 = Natural gas
;                  5 = Plant fuel
;      INT(11) - Switches to select which fuels are burned to satisfy
;       INT(16)  the electric power demand.  The fuel specified in
;                INT(11) is used until it is all consumed, the power
;                demand is satisfied, or the capacity to use this fuel
;                is reached.  Then the INT(12) fuel is used, etc.
;                The fuel codes are
;                  1 = Coal
;                  2 = ROSE-SR unit bottoms
;                  3 = Coke
;                  4 = Natural gas
;                  5 = Plant fuel
;                  6 = Purchased electric power
```

```
;       INT(17) -
;        INT(20)  Future use.
    INT  0  1  0  1  0  4  1  2  3  5    &
         4  1  2  3  5  6  0  0  0  0
;
;       The following 20 real parameters are:
;       REAL(1)  = Reference electric power generation rate of a single
;                  train in MW.
;       REAL(2)  = Maximum size of a single train as defined by the
;                  electric power generation rate in MW.
;       REAL(3)  = Minimum size of a single train as defined by the
;                  electric power generation rate in MW.
;       REAL(4)  = Constant A in the plant costing equation.
;       REAL(5)  = Constant B in the plant costing equation.
;       REAL(6)  = Constant E in the plant costing equation.
;       REAL(7)  = Constant F in the plant costing equation.
;       REAL(8)  = Number of spare trains.
;       REAL(9)  = Future use
;       REAL(10) = Future use
;       REAL(11) = Constant factor for the number of operators per
;                  day, operators/day.
;       REAL(12) = Number of operators per day per train,
;                  (operators/day)/train.
;       REAL(13) -
;        REAL(20) = Future use.
;
;          Ref MW    Max size   Min size
     REAL 79.259    84.0       1.0        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future use (2 items)
           0.0    87.466  0.7    1.0    0.0      0.0   0.0   &
;          Opers/day     (Opers/day)/train
           6.0           2.0                 &
;          Future use (8 items)
           0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
;
; Plants 31.1 and 31.4 - The Fluidized Bed Combustor and Steam Turbine
; Generator unit - user Fortran block USRA6.
BLOCK P314 USER
   SUBROUTINE MODEL = USRA6   REPORT = USRA6
   DESCRIPTION 'PLANTS 31.1 AND 31.4 - THE FLUIDIZED BED COMBUSTOR AND
   STEAM TURBINE GENERATOR UNIT'
   PARAM  NINT = 4   NREAL = 70
;       The following 4 integer parameters are:
;       INT(1) = User block summary report control switch.
;                0 => Write the complete user block summary report.
;                1 => Skip the capital cost portion of the summary
;                     report.
;                2 => Skip the capital cost and utilities portions
;                     of the summary report.
;                3 => Skip writing the entire user block summary report.
;       INT(2) = User block summary report destination control switch.
;                0 => Write the user block summary report to the normal
;                     ASPEN/SP output report file.
;                1 => Write the user block summary report to a separate
```

```
;                    user block output report file on logical unit 62
;                    called DCLA6.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate plants.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Solids production expressed as fraction of URCOAL
;                   in feed ending up in solids.
;      REAL(2)-
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per Mlbs/hr of unit feed,
;                   kw/(Mlbs/hr of unit feed).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per Mlbs/hr of unit feed,
;                   (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(37)   = Constant factor for the cooling water consumption,
;                   Mgal/hr.
```

```
;       REAL(38)  = Cooling water consumption per Mlbs/hr of unit feed,
;                   (Mlbs/hr)/(Mlbs/hr of unit feed).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of unit feed,
;                   (Mlbs/hr)/(Mlbs/hr of unit feed).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of unit feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of unit feed).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference feed rate to a single train in Mlbs/hr of
;                   unit feed for the calculation of the ISBL field cost
;                   of a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   unit feed rate in Mlbs/hr of unit feed.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   unit feed rate in Mlbs/hr of unit feed.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;  NOTE: The number of operators in this plant and Plant 91is set so
;            as to maintain the same total number of operators as used
;            for the baseline design.
;
;         Fraction of URCOAL in feed ending up in solids
   REAL   0.8500914  &
;         Future use (9 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0        &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   &
;         Power              900/750 F steam    900 satd steam
          0.0 -552.6474      0.0 0.0            0.0 0.0       &
;         600/720 F steam    600 satd steam     150 satd steam
          0.0 0.0            0.0 0.0            0.0 0.0       &
;         50 satd steam      Plant fuel         Cooling H2O
          0.0 0.0            0.0 0.0            0.0 27.99327  &
;         Process H2O        Nitrogen
          0.0 0.06900667     0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day    (Opers/day)/train
          0.0          20.0                  &
;         Ref Flow     Max Flow   Min Flow
          368.660      400.0      30.0       &
```

```
;         Plant cost equation constants.
;         A      B      E      F      Spares   Future use (2 items)
          0.0    0.0    0.75   1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet stream.  These
;  values will override the default values in subroutine USRA6.
   FLASH-SPECS STRM = SA6-01    KODE=2   TEMP = 130.0  PRES = 14.7
;
; Plant 38 - The Ammonia Recovery Plant - use user Fortran block USR38.
BLOCK P38 USER
   SUBROUTINE MODEL = USR38   REPORT = USR38
   DESCRIPTION 'PLANT 38 - THE AMMONIA RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL38.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Ammonia recovery, percent.
;      REAL(2)   = Purity of ammonia product, wt %.
;      REAL(3) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of NH3 recovered,
;                  kw/(Mlbs/hr of NH3 recovered).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
```

```
;                 NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of NH3 recovered,
;                   (MM BTU/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of NH3
;                   recovered, (Mgal/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of NH3
;                   recovered, (Mgal/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of NH3 recovered,
;                   (MM SCF/hr of N2)/(Mlbs/hr of NH3 recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
;       REAL(51)  = Reference NH3 recovery rate of a single train in
;                   Mlbs/hr for the calculation of the ISBL field cost
;                   of a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   NH3 recovery rate in Mlbs/hr of NH3 recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   NH3 recovery rate in Mlbs/hr of NH3 recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
```

```
;       REAL(59) -
;        REAL(70) = Future use.
;
;          NH3 recovery, %     NH3 purity, wt%
      REAL 99.103              99.552              &
;          Future use (8 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 75.713367      0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0  0.0           0.0 16.124425     0.0 28.745809 &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 0.0            0.0 0.0           0.0 227.9442  &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0            &
;          Opers/day      (Opers/day)/train
           0.0            20.0                 &
;          Ref Flow   Max Flow   Min Flow
           20.221     100.0      5.0          &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future Use (3 items)
           0.0    40.1    0.7807 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR38.
   FLASH-SPECS STRM = NH3-PROD  KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = 38S-OUT   KODE=2   TEMP = 80.   PRES = 14.7
;
;  Component splitter to generate the vapor and liquid streams
;  leaving Plant 38, the ammonia recovery plant.
BLOCK P38A SEP
   FRAC  SUBS = MIXED  STRM = 38AS-VAP                  &
   COMP = H2  N2  O2  H2S  CO  CO2  NH3                 &
          L-SULFUR H2O HCL COS CH4                      &
          C2H6 C3H8 IC4H10 NC4H10 IC5H12 NC5H12         &
          T125  T175  T225  T275  T325                  &
          T375  T425                                    &
          T475  T525  T575  T625  T675                  &
          P125  P175  P225  P275  P325  P375            &
          P425  P475  P525  P575  P625  P675            &
   FRAC = 1.0  1.0  1.0  0.9956  1.0  0.9985  0.07104   &
          0.0  0.002755  1.0  1.0  0.8888889            &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492     &
          0.9492 0.9492 0.9492 0.9492 0.9492            &
          0.9492 0.9492                                 &
          0.08481 0.08481 0.08481 0.08481 0.9492        &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492     &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492
   FLASH-SPECS STRM = 38AS-VAP  TEMP=90.0  PRES=25.0  NPK=1  KPH=1 /
               STRM = 38AS-LIQ  TEMP=90.0  PRES=25.0  NPK=1  KPH=2
```

```
;
;  Flow splitter to generate the waste water stream going to the
;  gasifier, Plant 9, and the stream going to the phenol recovery
;  plant, Plant 39.
BLOCK P38B FSPLIT
   FRAC  WASTE  0.28595
   PARAM NPK=1  KPH=2
;
; Plant 39 - The PHENOL RECOVERY PLANT - Use user Fortran block USR39.
BLOCK P39 USER
   SUBROUTINE MODEL = USR39   REPORT = USR39
   DESCRIPTION 'PLANT 39 - THE PHENOL RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL39.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Phenol recovery, percent.
;      REAL(2)   = Purity of phenol product, wt %.
;      REAL(3) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of phenol recovered,
;                  kw/(Mlbs/hr of phenol recovered).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                  phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                  recovered).
```

```
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                   recovered).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of phenol
;                   recovered,
;                   (MM BTU/hr)/(Mlbs/hr of phenol recovered).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(39)  = Cooling water consumption per Mlbs/hr of phenol
;                   recovered, (Mgal/hr)/(Mlbs/hr of phenol recovered).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of phenol
;                   recovered, (Mgal/hr)/(Mlbs/hr of phenol recovered).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of phenol recovered,
;                   (MM SCF/hr of N2)/(Mlbs/hr of phenol recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
;       REAL(51)  = Reference phenol recovery rate of a single train in
;                   Mlbs/hr for the calculation of the IKSBL field cost
;                   of a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   phenol recovery rate in Mlbs/hr of phenol recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   phenol recovery rate in Mlbs/hr of phenol recovered.
```

```
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;     NOTE: In the above, phenol recovered means pure phenol recovered.
;
;          Phenol recovery, %     Phenol purity, wt%
     REAL 97.0089            89.62                &
;          Future use (8 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 339.16667      0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0  0.0           0.0 0.0           0.0 9.465     &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 25.652917      0.0 0.0           0.0 111.775   &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0           0.0                 &
;          Ref Flow   Max Flow   Min Flow
           2.4        20.0       1.0        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future Use (3 items)
           0.0    13.3    0.8056 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR39.
   FLASH-SPECS STRM = PHENOL   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = WASTEH20 KODE=2   TEMP = 80.   PRES = 14.7
;
;  Plant SA6 separates the combined product stream from Plants 31.1
;  and 31.4 into two streams, one for flue gas and another for solids.
;  The separation is set to the URCOAL fraction in the solids stream.
BLOCK SA6 SEP
  FRAC  SUBS=NC    STREAM=FBC-SOL  COMP=URCOAL  FRAC=0.8500914   /
        SUBS=MIXED STREAM=FBC-SOL  COMP=T1000+  FRAC=1.0D-10
;
;  Splitter S1 - The Inlet Coal Splitter.  Used as a switch to divert
;  flow between the three different coal cleaning options, as represented
;  by the three different Coal Cleaning and Preparation Plants:
;  Base Case (1S01), Alternate Case 1 (1S11), and Alternate Case 2 (1S21).
BLOCK S1 FSPLIT
  DESCRIPTION 'INLET ROM COAL SPLITTER - COAL CLEANING SWITCH'
  FRAC  1S01 1.0 / 1S11 0.0 / 1S21 0.0
;
```

```
;  Splitter S2 - The Clean Coal Splitter.
BLOCK S2 FSPLIT
  DESCRIPTION 'CLEAN COAL SPLITTER'
  FRAC COALTO14 0.736227
;
;  Splitter S6-SH2O is a component splitter to generate a pseudo
;   sour-water stream from Plant 6 to get the NH3 to Plant 38, the
;   Ammonia Recovery Plant.
BLOCK S6-SH2O SEP
  DESCRIPTION 'SPLITTER TO GENERATE PSEUDO SOUR WATER FROM PLANT 6'
  FRAC  SUBS=MIXED  STREAM=6S-SH2O  COMP=NH3  FRAC=1.0
;
;  Splitter S7 - The Product Naphtha Splitter.  Used as a switch to
;  divert flow between the naphtha reformer, Plant 7 and output to
;  naphtha product.
BLOCK S7 FSPLIT
  DESCRIPTION 'HYDROTREATED NAPHTHA SPLITTER - REFORMER OPTION SWITCH'
;  ==================================================================
;  Use the following line to direct total flow to the reformer, or....
;  FRAC  7-NAPH 1.0
;  Use the following line to direct total flow to the product stream.
  FRAC PNAPHTHA 1.0
;
;  Splitter S8 - The Ash-Concentrate Splitter.  Used as a switch to
;  divert flow between the fluidized bed combustor, Plant 314 and the
;  coal gasification train; Plants M9C, P09, & P10.
BLOCK S8 FSPLIT
  DESCRIPTION 'ASH-CONCENTRATE SPLITTER - FBC OPTION 6 SWITCH'
;  Direct the ash-concentrate flow to coal gasification.
  FRAC  S8-ASHC 1.0
;
;  Splitter S9 - The dummy hydrogen splitter used to switch between
;  the two hydorgen production alternatives, Plant 9.0/10 - coal
;  gasification, or Plant 9.1 - steam reforming of methane.
BLOCK S9 FSPLIT
  DESCRIPTION 'DUMMY H2 SPLITTER - H2 GENERATION OPTION SWITCH'
;  Set an H2 target flow for Plant 9.0/10 - coal gasification.
  FRAC  H9NEED 1.0
  PARAM   NPK=1  KPH=1
;
; Stream Report Section
; ---------------------
;
STREAM-REPORT P1A
   STREAMS STRM = ROMCOAL 1S-CCOAL 9COAL COALTO14 COALTO2       &
                  14S-XMID 14S-REF 1S-XMID 1S-REFSE             &
                  ASH-CONC S8-ASHC COALTO9 9-FEED SLAG SOLVENT  &
                  2S-BOTTS FBC-FEED SA6-01 FBC-SOL FBC-GAS
   FLOW-FRAC SUBS=MIXED BASES=MASS / SUBS=NC BASES=MASS
   INTENSIVE-PROPS SUBS=MIXED BASES=MASS &
                   PROPS=TEMP PRES MW ENTH ENTR DENS HCAP /
                   SUBS=NC BASES=MASS &
                   PROPS=TEMP PRES MW ENTH DENS
   ATTRIBUTES SUBS=NC COMPONENT
;
```

```
STREAM-REPORT P1B
   STREAMS STRM = 1S-WATER 14S-WAT 2-H2OIN 2-H2IN H2MIX 2-H2MIX      &
                  SOLVENT ROSE-XTR 2S-GAS GASES 2S-SH2O              &
                  NAPHTHA GAS-OIL H2-RICH SOUR-GAS P61-GAS           &
                  H2-2RICH SOUR-2GS GAS-OUT NAPHTHA2 3-GAS           &
                  3S-SGAS 3S-FGAS 3S-PROP 3S-BUT 3S-OIL 3S-SH2O      &
                  4-FEED 4-H2IN 4-H2OIN 4S-GAS 4S-NAPH 4S-SH2O       &
                  5S-HPGAS 5S-LPGAS 5-H2IN 5-H2OIN                   &
                  5S-NAPH P350-450 P450-650 P650-850 5S-SH2O         &
                  PS-NAPH PNAPHTHA 7-NAPH 7S-H2 7S-GAS REFORMED      &
                  61-HYD 62-HYD M9H2 M9H4 M9H5 MHNEED                &
                  H9NEED H91NEED                                     &
                  10-AIRIN 10S01 10S02 9-O2IN 9-H2OIN 9-STEMIN       &
                  H2-GAS H2S-GAS VENT-GAS 9S-SH2O                    &
                  NAT-GAS STEAM H2-PROD FLUE-GAS                     &
                  6-SGAS 6S-SH2O 11-FEED 11S-FGAS 11S-LIQS 31S-01    &
                  38-FEED NH3-PROD 38S-OUT 38AS-VAP 38AS-LIQ         &
                  WASTE 39FEED PHENOL WASTEH2O
   FLOW-FRAC SUBS=MIXED BASES=MASS
   INTENSIVE-PROPS SUBS=MIXED BASES=MASS &
                   PROPS=TEMP PRES MW ENTH ENTR DENS HCAP
;
;  End of input file OPT6.INP
```

APPENDIX L

APPENDIX L

ASPEN/SP PROCESS SIMULATION MODEL

INPUT FILE FOR OPTION 7 --

ADDITION OF A NAPHTHA REFORMER

ASPEN/SP PROCESS SIMULATION MODEL

INPUT FILE FOR OPTION 7 --

ADDITION OF A NAPHTHA REFORMER

```
NEW
;
;   File: OPT7.INP
;
TITLE 'DCLN - DIRECT COAL LIQUEFACTION - BASELINE, NTH PLANT SIMULATION'
;
DESCRIPTION &
  "ASPEN/SP INPUT FILE FOR SIMULATING THE BASELINE DESIGN FOR THE NTH
   PLANT.  THIS INPUT FILE ALSO CAN BE USED TO RUN OPTION 6 (STEAM
   REFORMING OF NATURAL GAS FOR HYDROGEN PRODUCTION WITH AN FBC UNIT)
   AND OPTION 7 (NAPHTHA REFORMING)."
;
;  NOTES:
;  1.  The dry clean coal feed rate to the Plant 2 coal liquefaction
;      reactors is set in the design specification DES-SPEC COALFLO.
;  2.  The switches LOSBL and LPLANT contained in Fortran block SUMMARY
;      control the costing logic for OSBL and first or Nth plant.
;  3.  Option 6 (hydrogen production by steam reforming of natural
;      gas with an FBC unt) is activated by variable N9 in Fortran
;      block OPTION6.  When N9 = 1, Option 6 is invoked.
;  4.  Option 7 (naphtha reforming) is activated in Block S7 by
;      sending all the hydrotreated naphtha to Plant 7 rather than
;      to the product PNAHTHA.
;  5.  The costing logic is controlled by switches in Fortran block
;      SUMMARY.
;
;   Last revision - July 16, 1992.
;
;   Prepared under DOE contract no. DE-AC22 90PC89857.
;
IN-UNITS  ENG
OUT-UNITS ENG
HISTORY-UNITS ENG
RUN-CONTROL MAX-ERRORS=100
;
;  The following two lines are used with V8.0 to produce the overall
;  and block elemental balances.
;REPORT ATOMBAL
;BLOCK-REPORT ATOMBAL
;
HISTORY  MSG-LEVEL  PROPERTIES=2
  MAX-PRINT  PROPERTIES=100  SIMULATION=2000
;
PROPERTIES SYSOP2 GLOBAL
;
PSEUDO-COMPS
  METHOD METCCOAL -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 &
```

```
                    -1 -1 -1 -1 -1 -1 -1
;  The following APIs and MWs are revised from the ASPEN/SP predictions.
;  Component T1000+ is the 1000+ F material leaving the second coal
;    liquefaction reactor in Plant 2.
;  Component I1000+ is the 1000+ F intermediate material leaving the
;    first coal liquefaction reactor in Plant 2.
   COMPONENT T125    TBP=324.82 <K>  API=67.91  MW= 82.27
   COMPONENT T175    TBP=352.59 <K>  API=61.99  MW= 92.77
   COMPONENT T225    TBP=380.37 <K>  API=56.21  MW=102.84
   COMPONENT T275    TBP=408.15 <K>  API=50.60  MW=112.50
   COMPONENT T325    TBP=435.93 <K>  API=45.18  MW=121.82
   COMPONENT T375    TBP=463.71 <K>  API=39.96  MW=130.86
   COMPONENT T425    TBP=491.48 <K>  API=34.96  MW=139.75
   COMPONENT T475    TBP=519.26 <K>  API=30.19  MW=148.60
   COMPONENT T525    TBP=547.04 <K>  API=25.66  MW=157.54
   COMPONENT T575    TBP=574.82 <K>  API=21.39  MW=166.69
   COMPONENT T625    TBP=602.59 <K>  API=17.38  MW=176.16
   COMPONENT T675    TBP=630.37 <K>  API=13.66  MW=186.05
   COMPONENT T725    TBP=658.15 <K>  API=10.23  MW=196.44
   COMPONENT T775    TBP=685.93 <K>  API= 7.09  MW=207.37
   COMPONENT T825    TBP=713.71 <K>  API= 4.27  MW=218.85
   COMPONENT T875    TBP=741.48 <K>  API= 1.78  MW=230.87
   COMPONENT T925    TBP=769.26 <K>  API=-0.39  MW=243.37
   COMPONENT T975    TBP=797.04 <K>  API=-2.22  MW=256.24
   COMPONENT T1000+ TBP=824.82 <K>  API=-3.69  MW=269.33
   COMPONENT P125    TBP=324.82 <K>  API=67.91  MW= 82.27
   COMPONENT P175    TBP=352.59 <K>  API=61.99  MW= 92.77
   COMPONENT P225    TBP=380.37 <K>  API=56.21  MW=102.84
   COMPONENT P275    TBP=408.15 <K>  API=50.60  MW=112.50
   COMPONENT P325    TBP=435.93 <K>  API=45.18  MW=121.82
   COMPONENT P375    TBP=463.71 <K>  API=39.96  MW=130.86
   COMPONENT P425    TBP=491.48 <K>  API=34.96  MW=139.75
   COMPONENT P475    TBP=519.26 <K>  API=30.19  MW=148.60
   COMPONENT P525    TBP=547.04 <K>  API=25.66  MW=157.54
   COMPONENT P575    TBP=574.82 <K>  API=21.39  MW=166.69
   COMPONENT P625    TBP=602.59 <K>  API=17.38  MW=176.16
   COMPONENT P675    TBP=630.37 <K>  API=13.66  MW=186.05
   COMPONENT P725    TBP=658.15 <K>  API=10.23  MW=196.44
   COMPONENT P775    TBP=685.93 <K>  API= 7.09  MW=207.37
   COMPONENT P825    TBP=713.71 <K>  API= 4.27  MW=218.85
   COMPONENT P875    TBP=741.48 <K>  API= 1.78  MW=230.87
   COMPONENT P925    TBP=769.26 <K>  API=-0.39  MW=243.37
   COMPONENT P975    TBP=797.04 <K>  API=-2.22  MW=256.24
   COMPONENT P1000+ TBP=824.82 <K>  API=-3.69  MW=269.33
   COMPONENT I1000+ TBP=825.00 <K>  API=-4.00  MW=275.00
   COMPONENT REFORMAT TBP=390.00 <K>  API=38.25  MW=100.00
;
COMPONENTS H2 H2 / N2 N2 / O2 O2 / H2S H2S / CO CO / CO2 CO2 / NH3 H3N /
           L-SULFUR SULFUR / H2O H2O / HCL HCL / COS COS / CH4 CH4 /
           C2H6 C2H6 / C3H8 C3H8 / IC4H10 C4H10-2 / NC4H10 C4H10-1 /
           IC5H12 C5H12-2 / NC5H12 C5H12-1 /
;  Pseudocomponents
           T125 / T175 / T225 / T275 / T325 / T375 / T425 / T475 /
           T525 / T575 / T625 / T675 / T725 / T775 / T825 / T875 /
           T925 / T975 / T1000+ /
```

```
            P125 / P175 / P225 / P275 / P325 / P375 / P425 / P475 /
            P525 / P575 / P625 / P675 / P725 / P775 / P825 / P875 /
            P925 / P975 / P1000+ / I1000+ / REFORMAT /
;  Non-conventional components
             COAL / URCOAL / SLAG
;
FORMULA     H2 H2 / N2 N2 / O2 O2 / H2S H2S / CO CO / CO2 CO2 / NH3 H3N /
            L-SULFUR S / H2O H2O / HCL HCL / COS COS / CH4 CH4 /
            C2H6 C2H6 / C3H8 C3H8 / NC4H10 C4H10 / IC4H10 C4H10 /
            NC5H12 C5H12 / IC5H12 C5H12
;
;  Load the liquid sulfur (L-SULFUR) physical properties as taken from
;  DIPPR - MW adjusted to be consistent with ASPEN.
PROP-DATA  IN-UNITS SI
  PROP-LIST        MW    /   TC    /     PC     /    VC    /   ZC
  PVAL L-SULFUR   32.06  / 1313.0 / 1.8208E+7 / 0.15800 / 0.2640
  PROP-LIST       MUP    /  OMEGA /    TB     /   RGYR
  PVAL L-SULFUR   0.0    / 0.2624 /  717.82   /   0.0
  PROP-LIST         DELTA   /  DGFORM   /  DHFORM
  PVAL L-SULFUR   2.0245E+4 / 2.3825E+8 / 2.7880E+8
  PROP-LIST       CPIG
  PVAL L-SULFUR   2.5639E+4  -7.9870  4.7860E-3  -9.5700E-7  0.0  0.0  &
                  273.15  1500.0  0.0  87.113  1.0
;
; Load the solubility parameter for COS from the API Tech Data Book.
  PROP-LIST       DELTA
  PVAL COS        18179.0
;
;  Reset some component molecular weights to be consisitent with the
;  following elemental atomic weights, where needed.
;  H=1.0079, C=12.011, O=15.9994, N=14.0067, S=32.06 & Cl=35.453
  PROP-LIST       MW
  PVAL H2          2.0158
  PVAL N2         28.0134
  PVAL O2         31.9988
  PVAL H2S        34.0758
  PVAL CO         28.0104
  PVAL CO2        44.0098
  PVAL NH3        17.0304
  PVAL H2O        18.0152
  PVAL HCl        36.4609
  PVAL COS        60.0704
  PVAL CH4        16.0426
  PVAL C2H6       30.0694
  PVAL C3H8       44.0962
  PVAL IC4H10     58.1230
  PVAL NC4H10     58.1230
  PVAL IC5H12     72.1498
  PVAL NC5H12     72.1498
;
;  Set the specific gravities of H2, CO, CO2, NH3, H2S, N2 and COS to
;  the values given in the API Technical Data Book - Petroleum Refining.
  PROP-LIST        SPGR
  PVAL H2         0.3000
  PVAL CO         0.3000
```

```
  PVAL CO2        0.8180
  PVAL NH3        0.6162
  PVAL H2S        0.8014
  PVAL N2         0.8094
  PVAL COS        1.0200
;
ATTR-COMPS COAL   PROXANAL ULTANAL SULFANAL AOXANAL
ATTR-COMPS URCOAL PROXANAL ULTANAL SULFANAL AOXANAL
ATTR-COMPS SLAG   PROXANAL ULTANAL SULFANAL AOXANAL
;
NC-PROPS    COAL ENTHALPY  HCOALGEN /
                 DENSITY   DCOALIGT
NC-PROPS  URCOAL ENTHALPY  HCOALGEN /
                 DENSITY   DCHARIGT
NC-PROPS    SLAG ENTHALPY  HCOALGEN /
                 DENSITY   DCHARIGT
;
DEF-STREAMS MIXNC ALL
;
;  Set an initial GUESS for the ROM COAL stream to Plant 1.
STREAM ROMCOAL
   SUBSTREAM MIXED TEMP = 71.0  PRES = 14.7
     MASS-FLOW  H2O 24798.0
   SUBSTREAM NC TEMP = 71.0  PRES = 14.7
     MASS-FLOW  COAL 285035.0 / URCOAL 0.0 / SLAG 0.0
     COMP-ATTR COAL   PROXANAL (0.0 42.06 36.24 21.70) /
                      ULTANAL (21.7 61.1 4.2 1.2 0.1 5.1 6.6) /
                      SULFANAL (3.0 0.3 1.8) /
                      AOXANAL (43.8 17.1 24.1 0.8 0.1 5.6 1.0 0.6 2.1 4.1)
;  Fake the URCOAL properties.
     COMP-ATTR URCOAL PROXANAL (0.0 19.197 16.549 64.254) /
                      ULTANAL (64.254 29.914 0.185 1.304 0.0 4.267 0.076) /
                      SULFANAL (2.507 0.253 1.507) /
                      AOXANAL (43.8 17.1 24.1 0.8 0.1 5.6 1.0 0.6 2.1 4.1)
;  Fake the SLAG properties.
     COMP-ATTR SLAG   PROXANAL (0.0 10.0 0.0 90.0) /
                      ULTANAL (90.0 10.0 0.0 0.0 0.0 0.0 0.0 ) /
                      SULFANAL (0.0 0.0 0.0) /
                      AOXANAL (42.0 17.0 23.0 1.0 1.0 6.0 2.0 1.0 3.0 4.0)
;
;  Set an initial GUESS for the fresh make-up H2 stream to Plant 2.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 2-H2IN
   SUBSTREAM MIXED TEMP = 100.0  PRES = 3440.0
     MASS-FLOW  H2 70300.0 / N2 980.0
;
;  Set an initial GUESS for the total water feed streams (both steam
;  and wash water) to Plant 2.
STREAM 2-H2OIN
   SUBSTREAM MIXED TEMP = 126.0  PRES = 3200.0
     MASS-FLOW  H2O 1073000.0
;
;  Set an initial GUESS for the ROSE EXTRACT stream to Plant 2.
STREAM ROSE-XTR
   SUBSTREAM MIXED TEMP = 300.0  PRES = 3215.0
```

```
      MASS-FLOW  T675 95.0 / T725 95.0 / T775 95.0 /
        T825 95.0 / T875 588.335 / T925 588.335 /
        T975 588.355 /  T1000+ 536585.0
;
;  Set an initial GUESS for the SOLVENT stream to Plant 2.  The user
;  Fortran block model for Plant 2 does not require any solvent, but
;  the input stream is required.  Thus, set a small H2O flow to avoid
;  ASPEN warnings.
STREAM SOLVENT
   SUBSTREAM MIXED TEMP = 500.0  PRES = 500.0
     MASS-FLOW  H2O 1.0
;
;  Set an initial GUESS for the 2S-BOTTS stream leaving Plant 2.
STREAM 2S-BOTTS
   SUBSTREAM MIXED TEMP = 688.0  PRES = 28.0
     MASS-FLOW  H2O 0.0 /
       T825 380.0 / T875 3365.0 /
       T925 3365.0 / T975 3365.0 / T1000+ 642440.0
   SUBSTREAM NC TEMP = 688.0  PRES = 28.0
     MASS-FLOW  COAL 0.0 / URCOAL 254475.0
;
;  Set an initial GUESS for the H2 stream to Plant 4.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 4-H2IN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 500.0
     MASS-FLOW  H2 1400.0 / N2 19.0
;
;  Set an initial GUESS for the H2O stream to Plant 4.
STREAM 4-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 50.0
     MASS-FLOW  H2O 18770.
;
;  Set an initial GUESS for the H2 stream to Plant 5.
;  Assume the make-up H2 contains 1.396 wt% nitrogen.
STREAM 5-H2IN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 500.0
     MASS-FLOW  H2 17000.0 / N2 279.0
;
;  Set an initial GUESS for the H2O stream to Plant 5.
STREAM 5-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 50.0
     MASS-FLOW  H2O 36382.0
;
;  Set an initial GUESS for the pseudo sour H2O from Plant 6.
STREAM 6S-SH2O
   SUBSTREAM MIXED TEMP = 60.0  PRES = 14.7
     MASS-FLOW  NH3 2830.0
;
;  Set an initial GUESS for the H2O stream to Plant 9.0.
STREAM 9-H2OIN
   SUBSTREAM MIXED TEMP = 70.0  PRES = 14.7
     MASS-FLOW  H2O 967545.0
;
;  Set an initial GUESS for the STEAM stream to Plant 9.0.
STREAM 9-STEMIN
```

```
   SUBSTREAM MIXED TEMP = 450.0  PRES = 500.0
     MASS-FLOW  H2O 167545.0
;
;  Set an initial GUESS for the OXYGEN stream to Plant 9.0.
STREAM 9-O2IN
   SUBSTREAM MIXED TEMP = 80.0  PRES = 300.0
     MASS-FLOW  O2 743531.0 / N2 3269.0
;
;  Set an initial GUESS for the AIR stream to Plant 10.
STREAM 10-AIRIN   TEMP = 70.0  PRES = 14.7
     MASS-FLOW  O2 743531.0 / N2 2463614.0
;
;  Set an initial GUESS for the CH4 stream to Plant 9.1.
STREAM NAT-GAS
   SUBSTREAM MIXED TEMP = 70.0  PRES = 100.0
     MASS-FLOW  CH4 307352.
;
;  Set an initial GUESS for the STEAM stream to Plant 9.1.
STREAM STEAM
   SUBSTREAM MIXED TEMP = 620.0  PRES = 500.0
     MASS-FLOW  H2O 864428.
;
; Model Connectivity
; ------------------
;
FLOWSHEET COAL
; Plant M1 is the clean coal outlet streams mixer.
;   Stream 1S-CCOAL is the combined outlet clean coal product stream.
; Plant M2 is the middling coal outlet streams mixer.
;   Stream 1S-XMID  is the combined outlet middling coal product stream.
; Plant M-2HYD is the mixer to combine H2 streams for Plant 2.
;   Stream 2-H2MIX  is the combined H2 stream from 6.1, 6.2, & source.
; Plant M3 is the refuse outlet streams mixer.
;   Stream 1S-REFSE is the combined outlet refuse product stream.
; Plant M38 is the sour water mixer.
;   Stream 38-FEED  is the combined sour water streams to Plant 38.
; Plant M4 is the waste water outlet streams mixer.
;   Stream 1S-WATER is the combined outlet waste water product stream.
; Plant M-462 is the mixer to combine H2 streams for Plant 6.2.
;   Stream 62-HYD   is the combined H2 stream from Plants 2 & 4.
; Plant M-561 is the mixer to combine H2 streams for Plant 6.1.
;   Stream 61-HYD   is the combined H2 stream from Plants 2 & 5.
; Plant M-6GAS is the heater to combine sour gas streams for Plant 11.
;   Stream 6-SGAS   is the combined sour gas stream from Plants 6.1 & 6.2.
; Plant M-73 is the mixer to combine H2 gas streams for Plant 3.
;   Stream 3-GAS    is the combined H2 gas stream from Plant 3.
; Plant M-HYD is the mixer (flash2) to combine H2 streams for M-2HYD.
;   Stream H2MIX    is the combined H2 stream from Plants 6.1 & 6.2.
;   Stream DUMMY    is the dummy vapor stream that contains no flow.
; Plant M-NAP is the mixer to combine naphtha streams for Plant 4.
;   Stream 4-FEED   is the combined naphtha stream from Plants 2 & 6.2.
; Plant M-PNAP is the mixer to combine product naphtha streams.
;   Stream PS-NAPH is the combined naphtha stream from Plants 4 & 5.
; Plant P1-ALT1 is the Coal Cleaning and Preparation Plant - ALT CASE 1.
;   Stream 1S12     is the outlet clean coal product stream.
```

```
;   Stream 1S13     is the outlet middling coal product stream.
;   Stream 1S14     is the outlet refuse product stream.
;   Stream 1S15     is the outlet waste water product stream.
; Plant P1-ALT2 is the Coal Cleaning and Preparation Plant - ALT CASE 2.
;   Stream 1S22     is the outlet clean coal product stream.
;   Stream 1S23     is the outlet middling coal product stream.
;   Stream 1S24     is the outlet refuse product stream.
;   Stream 1S25     is the outlet waste water product stream.
; Plant P1-BASE is the Coal Cleaning and Preparation Plant - BASE CASE.
;   Stream 1S02     is the outlet clean coal product stream.
;   Stream 1S03     is the outlet middling coal product stream.
;   Stream 1S04     is the outlet refuse product stream.
;   Stream 1S05     is the outlet waste water product stream.
; Plant P14 is the Coal Grinding and Drying Plant.
;   Stream COALTO2  is the outlet clean coal product stream.
;   Stream 14S-XMID is the outlet middling coal product stream.
;   Stream 14S-REF  is the outlet refuse product stream.
;   Stream 14S-WAT  is the outlet waste water product stream.
; Plant P02 is the Coal Liquefaction Plant.
;   Stream 2-H2MIX  is the hydrogen feed stream.
;   Stream COALTO2  is the clean coal feed stream.
;   Stream SOLVENT  is the solvent feed stream.  This stream is used to
;     supply the steam required to Plant 2.
;   Stream ROSE-XTR is the deashed product stream.
;   Stream 2-H2OIN  is the water feed stream to the liquefaction unit.
;   Stream 2S-GAS   is the HP gas product stream going to Plant 6.1.
;   Stream GASES    is the LP gas product stream going to Plant 6.2.
;   Stream NAPHTHA  is the naphtha product stream.
;   Stream GAS-OIL  is the gas-oil product stream going to Plant 5.
;   Stream 2S-BOTTS is the bottoms stream going to Plant 8.1.
;   Stream 2S-SH2O  is the sour water product stream.
; Plant P03 is the Gas Plant.
;   Stream 3S-SGAS  is the sour off-gas product stream.
;   Stream 3S-FGAS  is the fuel gas product stream.
;   Stream 3S-PROP  is the C3 product stream.
;   Stream 3S-BUT   is the C4s product stream.
;   Stream 3S-OIL   is the lean-oil product stream to M-NAP.
;   Stream 3S-SH2O  is the product sour water stream.
; Plant P04 is the simplified model for plant 4, the naphtha hydrotreater.
;   Stream 4-H2IN   is the hydrogen feed stream.
;   Stream 4-H2OIN  is the water feed stream.
;   Stream 4S-GAS   is the hydrotreater off-gas product stream.
;   Stream 4S-NAPH  is the hydrotreated naphtha product stream.
;   Stream 4S-SH2O  is the hydrotreater sour water stream.
; Plant P05 is the simplified model for plant 5, the gas-oil hydrotreater.
;   Stream 5-H2IN   is the hydrogen feed stream.
;   Stream 5-H2OIN  is the water feed stream.
;   Stream 5S-HPGAS is the hydrotreater hi-pressure purge gas stream.
;   Stream 5S-LPGAS is the hydrotreater other gases stream.
;   Stream 5S-NAPH  is the hydrotreated C6-350 F naphtha product stream.
;   Stream P350-450 is the hydrotreated 350 - 450 F product stream.
;   Stream P450-650 is the hydrotreated 450 - 650 F product stream.
;   Stream P650-850 is the hydrotreated 650 - 850 F product stream.
;   Stream 5S-SH2O  is the hydrotreater sour water stream.
; Plant P61 is the model for the Hydrogen purification by Membrane
```

```
;     Separation Plant, Plant 6.1.
;   Stream 61-HYD   is the feed stream to the H2 purification plant.
;   Stream H2-RICH  is the purified H2-rich product gas stream.
;   Stream SOUR-GAS is the sour gas product stream.
;   Stream P61-GAS  is the reject (non-permeate) product gas stream.
; Plant P62 is the model for the Hydrogen purification by Pressure
;     Swing absorption Plant, Plant 6.2.
;   Stream 62-HYD   is the mixed gas feed stream to the PSA hydrogen
;     purification plant.
;   Stream P61-GAS  is the reject gas stream from Plant 6.1, the high
;     pressure section of Plant 6, the hydrogen purification by
;     membrane permeation section.
;   Stream H2-2RICH is the purified h2-rich product gas stream.
;   Stream SOUR-2GS is the sour gas product stream.
;   Stream GAS-OUT  is the reject product gas stream.
;   Stream NAPHTHA2 is the liquid raw naphtha product stream.
; Plant P07 is the simplified model for Plant 7, the naphtha reformer.
;   Stream 7-NAPH   is the naphtha feed stream.
;   Stream 7S-H2    is the hydrogen rich product gas stream.
;   Stream 7S-GAS   is the light hydrocarbon product gas stream.
;   Stream REFORMED is the reformate product stream.
; Plant P81 is the model for the ROSE-SR Critical Solvent Deashing unit.
;   Stream ROSE-XTR is the deashed product stream.
;   Stream ASH-CONC is the ash concentrate stream.
; Plant P11 is the Sulfur plant.
;   Stream 11S-LIQS is the sulfur product stream.
;   Stream 11S-FGAS contains all the other material in the feed that
;     does not leave in the product SULFUR STREAM.
; Plant P31 is the simplified model for the utility plant.
;   Stream 31S-01   is the dummy product stream.
; Plant P314 is the model for the Fluidized Bed Combustor and the
;  Steam Turbine Generator unit.
;   Stream FBC-FEED is the feed stream to Plant P314.
;   Stream SA6-01   is the combined product stream out of Plant P314.
; Plant P38 is the NH3 recovery plant.
;   Stream NH3-PROD is the product NH3.
;   Stream 38S-OUT  is the reject stream.
; Plant P38A is the reject stream component splitter from plant 38.
;   Stream 38AS-VAP is the vapor stream going to Plant 11.
;   Stream 38AS-LIQ is the liquid stream going to Plant 38B.
; Plant P38B is the liquid reject stream splitter from Plant 38A.
;   Stream WASTE    is the reject portion of the inlet stream which
;     in this model is rejected, but actually goes to the coal
;     gasification plant, if present.
;   Stream 39FEED   is the stream going on to Plant 39.
; Plant P39 is the phenol recovery plant.
;   Stream PHENOL   is the phenol product stream.
;   Stream WASTEH2O is the waste water stream.
; Plant SA6 is the product stream separator from Plant P314.
;   Stream FBC-GAS  is the gas product stream from Plant SA6.
;   Stream FBC-SOL  is the solids product stream from Plant SA6.
; Block S1 is the inlet coal splitter.
;   Stream ROMCOAL  is the inlet ROM coal stream.
;   Stream 1S01     is the splitter outlet to the base case plant.
;   Stream 1S11     is the splitter outlet to the alternate case 1 plant.
```

```
;   Stream 1S21     is the splitter outlet to the alternate case 2 plant.
; Block S2 is the clean coal splitter.
;   Stream 1S-CCOAL is the inlet clean coal stream.
;   Stream COALTO14 is the splitter outlet to plant 2.
;   Stream 9-COAL   is the splitter outlet to plant 9.
; Block S6-SH2O is a component splitter to generate a pseudo sour-water
;   stream from Plant 6 to get the NH3 to Plant 38, the Ammonia Recovery
;   Plant.
;   Stream 6S-SH2O  is the pseudo sour-water stream.
;   Stream 11-FEED  is the Plant 11 feed stream.
; Block S7 is the product naphtha splitter.
;   Stream PS-NAPH  is the inlet product naphtha stream.
;   Stream 7-NAPH   is the splitter outlet to the naphtha reformer plant.
;   Stream PNAPHTHA is the splitter outlet as product naphtha.
; Block S8 is the ash-concentrate splitter.
;   Stream ASH-CONC is the inlet ash-concentrate stream from the ROSE.
;   Stream FBC-FEED is the splitter outlet to the FBC plant.
;   Stream S8-ASHC  is the splitter outlet to the M9C coal mixer.
;
 M1        IN = 1S02 1S12 1S22   OUT = 1S-CCOAL
 M2        IN = 1S03 1S13 1S23   OUT = 1S-XMID
 M-2HYD    IN = H2MIX 2-H2IN     OUT = 2-H2MIX
 M3        IN = 1S04 1S14 1S24   OUT = 1S-REFSE
 M38       IN = 2S-SH2O 3S-SH2O 4S-SH2O 5S-SH2O 6S-SH2O 9S-SH2O     &
             OUT = 38-FEED
 M4        IN = 1S05 1S15 1S25   OUT = 1S-WATER
 M-462     IN = 4S-GAS GASES 5S-LPGAS 3S-SGAS 7S-H2     OUT = 62-HYD
 M-561     IN = 5S-HPGAS 2S-GAS  OUT = 61-HYD
 M-6GAS    IN = SOUR-GAS SOUR-2GS H2S-GAS 38AS-VAP      OUT = 6-SGAS
 M-73      IN = GAS-OUT 7S-GAS   OUT = 3-GAS
 M-HYD     IN = H2-RICH H2-2RICH OUT = H2MIX DUMMY
 M-NAP     IN = NAPHTHA2 3S-OIL  OUT = 4-FEED
 M-PNAP    IN = 4S-NAPH 5S-NAPH  OUT = PS-NAPH
 P1-ALT1   IN = 1S11             OUT = 1S12 1S13 1S14 1S15
 P1-ALT2   IN = 1S21             OUT = 1S22 1S23 1S24 1S25
 P1-BASE   IN = 1S01             OUT = 1S02 1S03 1S04 1S05
 P14       IN = COALTO14         OUT = COALTO2 14S-XMID 14S-REF 14S-WAT
 P02       IN = 2-H2MIX COALTO2 SOLVENT ROSE-XTR 2-H2OIN              &
             OUT = 2S-GAS GASES NAPHTHA GAS-OIL 2S-BOTTS 2S-SH2O
 P03       IN = NAPHTHA 3-GAS                                         &
             OUT = 3S-SGAS 3S-FGAS 3S-PROP 3S-BUT 3S-OIL 3S-SH2O
 P04       IN = 4-H2IN 4-FEED 4-H2OIN                                 &
             OUT = 4S-GAS 4S-NAPH 4S-SH2O
 P05       IN = 5-H2IN GAS-OIL 5-H2OIN                                &
             OUT = 5S-HPGAS 5S-LPGAS 5S-NAPH P350-450 P450-650        &
                   P650-850 5S-SH2O
 P61       IN = 61-HYD           OUT = H2-RICH SOUR-GAS P61-GAS
 P62       IN = 62-HYD P61-GAS                                        &
             OUT = H2-2RICH SOUR-2GS GAS-OUT NAPHTHA2
 P07       IN = 7-NAPH           OUT = 7S-H2 7S-GAS REFORMED
 P81       IN = 2S-BOTTS         OUT = ROSE-XTR ASH-CONC
 P11       IN = 11-FEED          OUT = 11S-FGAS 11S-LIQS
 P31       IN = 3S-FGAS          OUT = 31S-01
 P314      IN = FBC-FEED         OUT = SA6-01
 P38       IN = 38-FEED          OUT = NH3-PROD 38S-OUT
```

```
  P38A      IN = 38S-OUT          OUT = 38AS-VAP 38AS-LIQ
  P38B      IN = 38AS-LIQ         OUT = WASTE 39FEED
  P39       IN = 39FEED           OUT = PHENOL WASTEH2O
  SA6       IN = SA6-01           OUT = FBC-SOL FBC-GAS
  S1        IN = ROMCOAL          OUT = 1S01 1S11 1S21
  S2        IN = 1S-CCOAL         OUT = COALTO14 9COAL
  S6-SH2O   IN = 6-SGAS           OUT = 6S-SH2O 11-FEED
  S7        IN = PS-NAPH          OUT = 7-NAPH PNAPHTHA
  S8        IN = ASH-CONC         OUT = FBC-FEED S8-ASHC
;
FLOWSHEET HYDROGEN
; Plant M9 is the hydrogen stream mixer.
;   Stream M9H2     is the dummy H2 stream to the liquefaction unit.
;   Stream M9H4     is the dummy H2 stream to the naphtha hydrotreater.
;   Stream M9H5     is the dummy H2 stream to the gas-oil hydrotreater.
;   Stream HHNEED   is the dummy H2 stream from the mixer.
; Plant M9C is the coal stream mixer.
;   Stream COALTO9  is the clean coal stream to the mixer.
;   Stream S8-ASHC  is the ash concentrate stream from the ROSE unit.
;   Stream 9-FEED   is the mixed coal stream to the gasifier.
; Plant P09 is the plant for producing hydrogen by coal gasification.
;   Stream 9-H2OIN  is the water feed stream to the gasifier section.
;   Stream 9-O2IN   is the purified O2 stream from the air sep. plant.
;   Stream 9-STEMIN is the steam that goes to the shift reactors.
;   Stream H2-GAS   is the product hydrogen stream.
;   Stream H2S-GAS  is the product hydrogen sulfide stream.
;   Stream VENT-GAS is the product vent gas stream.
;   Stream 9S-SH2O  is the product sour water stream.
;   Stream SLAG     is the product slag stream.
; Plant P91 is the Steam Reforming of Natural Gas Plant.
;   Stream NAT-GAS  is the inlet natural gas stream.
;   Stream STEAM    is the inlet process water stream.
;   Stream H2-PROD  is the product hydrogen stream.
;   Stream FLUE-GAS is the product flue gas stream.
; Plant P10 is the Air Separation Plant.
;   Stream 10-AIRIN is the air input stream.
;   Stream 10S01    is the product oxygen stream.
;   Stream 10S02    is the product nitrogen stream.
; Plant S9 is the hydrogen stream splitter.
;   Stream H9NEED   is the dummy H2 stream for the gasifier.
;   Stream H91NEED  is the dummy H2 stream for the steam reformer.
;
  M9H       IN = M9H2 M9H4 M9H5     OUT = MHNEED
  M9C       IN = S8-ASHC COALTO9    OUT = 9-FEED
  P09       IN = 9-FEED 9-H2OIN 9-O2IN 9-STEMIN        &
              OUT = H2-GAS H2S-GAS VENT-GAS 9S-SH2O SLAG
  P91       IN = NAT-GAS STEAM      OUT = H2-PROD FLUE-GAS
  P10       IN = 10-AIRIN           OUT = 10S01  10S02
  S9        IN = MHNEED             OUT = H9NEED H91NEED
;
; Design Specifications
; ---------------------
;
;  Design spec to set the hydrogen flow rate to Plant 2 (2-H2MIX)
;  to a specified weight percent (HPCT2) of the MAF coal input stream.
```

```
DES-SPEC 2H2FLO
   DEFINE CHP2   MASS-FLOW  STREAM=2-H2MIX  COMPONENT=H2
   DEFINE CCOAL  MASS-FLOW  STREAM=COALTO2  SUBSTREAM=NC COMPONENT=COAL
   DEFINE CCASH  COMP-ATTR-VAR STREAM=COALTO2  SUBSTREAM=NC &
                   COMPONENT=COAL ATTRIBUTE=ULTANAL ELEMENT=1
C     Set the specified H2 rate to Plant 2 in wt% in the following line.
F     HPCT2 = 7.9205D0
C     DAFCOAL is the dry ash-free coal (MAF coal).
F     DAFCOAL = CCOAL * (100.0D0 - CCASH) * 0.01D0
F     H2P2 = 0.01D0 * HPCT2 * DAFCOAL
   SPEC CHP2 TO H2P2
   TOL-SPEC 0.1
   VARY STREAM-VAR  STREAM=2-H2IN  VARIABLE=MASS-FLOW
   LIMITS 100 1000000
;
;  Design spec to set the correct ROM coal flow to the splitter to
;  obtain the desired 17,102 TPSD of MF coal flow rate to the coal
;  liquefaction plant, Plant 2.
DES-SPEC COALFLO
   DEFINE CTARG  MASS-FLOW  STREAM=COALTO2   SUBSTREAM=NC  COMPONENT=COAL
;  Set TPD to the target coal rate to Plant 2 in TPSD of MF coal.
;  ==============================================================
;
F     TPD = 17102.0D0
F     WTPHR = (TPD * 2000.0D0) / 24.0D0
   SPEC CTARG TO WTPHR
   TOL-SPEC 0.1
   VARY MASS-FLOW  STREAM=ROMCOAL  SUBSTREAM=NC  COMPONENT=COAL
   LIMITS 100 10000000
;
;  Design spec to set the correct 9-FEED flow rate to the Plant 9,
;  coal gasifier, to obtain the desired hydrogen production rate.
DES-SPEC H2FLO
   DEFINE HOUT   MASS-FLOW   STREAM=H2-GAS   COMPONENT=H2
   DEFINE HTOT   MASS-FLOW   STREAM=H9NEED   COMPONENT=H2
   SPEC HOUT TO HTOT
   TOL-SPEC 1.0
   VARY STREAM-VAR STREAM=COALTO9  SUBSTREAM=NC  VAR=MASS-FLOW
   LIMITS 0.1 10000000
;
;  Design spec to set the heat duty to block M-HYD to zero by
;  varying the temperature. This corrects a temperature calculating
;  error in the ASPEN mixer block algorithm.
DES-SPEC HD-HYD
   DEFINE HDTY BLOCK-VAR BLOCK=M-HYD SENTENCE=RETENTION VARIABLE=HEAT-DUTY
   SPEC HDTY TO 0.0
   TOL-SPEC 1000
   VARY BLOCK-VAR BLOCK=M-HYD SENTENCE=PARAM VARIABLE=TEMPERATURE
   LIMITS 10 500
;
;  Design spec to set the 10-AIRIN stream flow to produce the required
;  amount of oxygen product required by Plant 9, coal gasification.
DES-SPEC O2FLO
 DEFINE FLO10S STREAM-VAR STREAM=10S01    VAR=MASS-FLOW
 DEFINE FLOOXY STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
```

```
   SPEC FLO10S TO FLOOXY
   TOL-SPEC 0.1
   VARY STREAM-VAR  STREAM=10-AIRIN  VARIABLE=MASS-FLOW
   LIMITS 0.1 10000000
;
;  Design spec to set the hydrogen flow rate for Plant 9.1.
DES-SPEC RFMRFLO
   DEFINE HOUT2  MASS-FLOW   STREAM=H2-PROD  COMPONENT=H2
   DEFINE HTOT2  MASS-FLOW   STREAM=H91NEED  COMPONENT=H2
   SPEC HOUT2 TO HTOT2
   TOL-SPEC 0.1
   VARY STREAM-VAR  STREAM=NAT-GAS  VARIABLE=MASS-FLOW
   LIMITS 1000 600000
;
; Transfer Blocks
; ---------------
;
;  Transfer block to set COALTO9 equal to the 9COAL stream (the wet
;  clean coal input).  This duplicates the full property set and
;  provides the initial guess flow rate for COALTO9.
TRANSFER CCOAL
   SET STREAM COALTO9
   EQUAL-TO STREAM 9COAL
;
;  Transfer block used to set the hydrogen flow rates of the input
;  streams to the calculated hydrogen flows to Plant 2 (2-H2IN),
;  Plant 4 (4-H2IN), and Plant 5 (5-H2IN).  M9's represent hydrogen
;  flows from Plant 9.0/10 and M91's are for the Plant 9.1 alternative.
TRANSFER HFLOW
   SET STREAM M9H2
   EQUAL-TO STREAM 2-H2IN
   SET STREAM M9H4
   EQUAL-TO STREAM 4-H2IN
   SET STREAM M9H5
   EQUAL-TO STREAM 5-H2IN
;
; Fortran Blocks
; --------------
;
;  Fortran block to set the correct water flow rate in the clean
;  coal going to Plant 9.
FORTRAN 9COAL
   DEFINE W9COAL MASS-FLOW  STREAM=9COAL   COMPONENT=H2O
   DEFINE C9COAL MASS-FLOW  STREAM=9COAL   SUBSTREAM=NC COMPONENT=COAL
   DEFINE WCTO9  MASS-FLOW  STREAM=COALTO9 COMPONENT=H2O
   DEFINE CCTO9  MASS-FLOW  STREAM=COALTO9 SUBSTREAM=NC COMPONENT=COAL
F     WCTO9 = CCTO9 * (W9COAL / C9COAL)
;
;  This Fortran block resets the split fraction in S2 to provide the
;  flow rate of coal to Plant 9.0.
FORTRAN COALFLOW
   DEFINE C14    STREAM-VAR  STREAM=COALTO14  VAR=MASSFLOW
   DEFINE C9     STREAM-VAR  STREAM=COALTO9   VAR=MASSFLOW
   DEFINE RC     STREAM-VAR  STREAM=ROMCOAL   VAR=MASSFLOW
   DEFINE CC     STREAM-VAR  STREAM=1S-CCOAL  VAR=MASSFLOW
```

```
   DEFINE SFRAC  BLOCK-VAR   BLOCK=S2  SENTENCE=FRAC  VAR=FRAC  &
    ID1=COALTO14  ELEMENT=1
C     Calculate total clean coal.
F     TCC = C14 + C9
C     Reset the ROMCOAL feed rate to match the new value.
F     RC = RC * (TCC / CC)
C     Reset the split fraction in S2 to correct 9COAL flow rate.
F     SFRAC = C14 / (C9 + C14)
;
;  This FORTRAN block will calculate the initial ratio of the MIXED
;  substream flow to the NC substream flow in the stream ROMCOAL.
;  It will store this result in RATIO, and use that value to adjust
;  the MIXED substream flow in proportion to the NC substream flow
;  that is varied by the COALFLO design-spec.  This is needed to set
;  the correct amount of water entering with the ROM coal.
FORTRAN MIXFLO
F     COMMON /RATIO/ RMIXNCP
F     COMMON /RGLOB/ RDUM1, RMIN
 DEFINE FLONCP SUBSTREAM-VAR STREAM=ROMCOAL SUBSTREAM=NC VAR=MASSFLOW
 DEFINE FLOMIX SUBSTREAM-VAR STREAM=ROMCOAL SUBSTREAM=MIXED VAR=MASSFLOW
C  The following should only be true on the first pass.  This prevents
C  writing over the initial substream ratio on subsequent passes.
F     IF (RMIXNCP .LT. RMIN) THEN
F        RMIXNCP = FLONCP / FLOMIX
F     END IF
C  Adjust the other substream flow based on changes to the NC
C  substream.
F     FLOMIX = FLONCP / RMIXNCP
;
;  Fortran block to dynamically set the URCOAL fraction in the
;  separation block, SA6, equal to the solids production parameter,
;  REAL(1), in block P314, the fluidized bed combustor.  This block
;  only has significance when Option 6 is in effect.
FORTRAN SA6SET
   DEFINE FRAC1 BLOCK-VAR BLOCK=P314 SENTENCE=REAL VAR=REAL ELEMENT=1
   DEFINE FRAC2 BLOCK-VAR BLOCK=SA6  SENTENCE=FRAC VAR=FRAC ID1=NC    &
    ID2=FBC-SOL ELEMENT=1
F     FRAC2 = FRAC1
;
;  FORTRAN block to set the COMBINED steam and water flow rate to
;  Plant 2 as a specified weight percent of the dry coal feed.
FORTRAN SETUP2
   DEFINE FEED2 MASS-FLOW  STREAM=COALTO2  SUBSTREAM=NC  COMPONENT=COAL
   DEFINE H2O2  STREAM-VAR STREAM=2-H2OIN  VAR=MASSFLOW
F     H2O2 = 0.75315 * FEED2
;
;  FORTRAN block used to set the hydrogen flow rate to Plant 4 (4-H2IN)
;  to a specified weight percent (HPCT4) of the naphtha feed stream,
;  and the hydrogen flow rate to Plant 5 (5-H2IN) to a specified weight
;  percent (HPCT5) of the gas oil feed stream.  This block also sets
;  the inlet water flow rates for these plants to specified rates
;  as functions of the hydrocarbon feed rates.
FORTRAN SETUP45
   DEFINE CHP4   MASS-FLOW  STREAM=4-H2IN   COMPONENT=H2
   DEFINE CHP5   MASS-FLOW  STREAM=5-H2IN   COMPONENT=H2
```

```
   DEFINE FLP4   STREAM-VAR STREAM=4-H2IN   VAR=MASSFLOW
   DEFINE FLP5   STREAM-VAR STREAM=5-H2IN   VAR=MASSFLOW
   DEFINE XNAPH  STREAM-VAR STREAM=4-FEED   VAR=MASSFLOW
   DEFINE XGOIL  STREAM-VAR STREAM=GAS-OIL  VAR=MASSFLOW
   DEFINE H2O4   STREAM-VAR STREAM=4-H2OIN  VAR=MASSFLOW
   DEFINE H2O5   STREAM-VAR STREAM=5-H2OIN  VAR=MASSFLOW
C     Set the specified H2 rates in wt% in the following two lines.
F     HPCT4 = 1.1855
F     HPCT5 = 2.7554
F     H2P4 = 0.01D0 * HPCT4 * XNAPH
F     FLP4 = H2P4 * (FLP4 / CHP4)
F     H2P5 = 0.01D0 * HPCT5 * XGOIL
F     FLP5 = H2P5 * (FLP5 / CHP5)
C     Set the specified H2O rates in wt% in the following two lines.
F     H2O4 = 0.089017 * XNAPH
F     H2O5 = 0.054217 * XGOIL
;
;  FORTRAN block to set the steam, water and oxygen stream flow rates
;  to Plant 9 based on the inlet flow rate of hydrocarbons and NC
;  components (on a dry ash-free basis).
FORTRAN SETUP9
 DEFINE FL29MX SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=MIXED VAR=MASS-FLOW
 DEFINE ULCOAL COMP-ATTR-VAR STREAM=9-FEED  SUBSTREAM=NC &
        COMPONENT=COAL   ATTRIBUTE=ULTANAL ELEMENT=1
 DEFINE ULURC  COMP-ATTR-VAR STREAM=9-FEED  SUBSTREAM=NC &
        COMPONENT=URCOAL ATTRIBUTE=ULTANAL ELEMENT=1
 DEFINE FL29C   MASS-FLOW  STREAM=9-FEED  SUBSTREAM=NC COMPONENT=COAL
 DEFINE FL29UR  MASS-FLOW  STREAM=9-FEED  SUBSTREAM=NC COMPONENT=URCOAL
 DEFINE FL29W   MASS-FLOW  STREAM=9-FEED  COMPONENT=H2O
 DEFINE FL2STM  STREAM-VAR STREAM=9-STEMIN VAR=MASS-FLOW
 DEFINE FL2H2O  STREAM-VAR STREAM=9-H2OIN  VAR=MASS-FLOW
 DEFINE FL2O2   STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
C  Adjust the steam, water and oxygen stream flow rates based on the
C  inlet flow rate of hydrocarbons and NC components (on a dry basis).
F     X1 = 0.01*FL29C *(100.0-ULCOAL)
F     X2 = 0.01*FL29UR*(100.0-ULURC)
F     FL2STM = 0.25495 * (FL29MX + X1 + X2 - FL29W)
F     FL2H2O = 1.4723 * (FL29MX + X1 + X2 - FL29W)
F     FL2O2  = 1.1365 * (FL29MX + X1 + X2 - FL29W)
;
;  Fortran block to set up the common and OSBL utility consumptions.
FORTRAN SETUP31
F     COMMON /USRC01/ PLNTID(32), UTIL(32,15), CAPCST(32,5), OPCST(32,5)
F     CHARACTER * 6  PLNTID
 DEFINE DCOAL2 SUBSTREAM-VAR STREAM=COALTO2 SUBSTREAM=NC VAR=MASS-FLOW
C     COMMON /USRC03/ is used to transfer variables FIN(5,4),
C       FOUT(20,4), PGAS, PPWR, OPTN6
C     See Subroutine USRSR1 for the definition of the items in named
C     common block /USRC03/.
C     Base all the offsite and OSBL utilities consumptions on the dry
C     coal feed rate to Plant 2, the Coal Liquefaction Plant. Ignore
C     cooling and process water consumptions and productions.
F     PLNTID (19) = 'OTHERS'
C     Electric Power.
F     UTIL(19,1) = 25.1346 * DCOAL2 * 0.001
```

```
F     IF ( OPTN6 .GE. 0.99D0 )   UTIL(19,1) = 29.5411 * DCOAL2 * 0.001
C     600 psig steam at 720F.
F     UTIL(19,4) = 0.05122207 * DCOAL2 * 0.001
C     150 psig saturated steam.
F     UTIL(19,6) = 0.04350367 * DCOAL2 * 0.001
C     50 psig saturated steam.
F     UTIL(19,7) = 0.06757103 * DCOAL2 * 0.001
;
;  Fortran statement to set the molar flow rate of the STEAM stream to
;  be in balance with the feed stream to Plant 9.1.
FORTRAN SETUP91
   DEFINE GS     STREAM-VAR  STREAM=NAT-GAS  VARIABLE=MOLE-FLOW
   DEFINE ST     STREAM-VAR  STREAM=STEAM    VARIABLE=MOLE-FLOW
F     IF (GS .GT. 0.0D0 )   THEN
F         ST = 2.504543D0 * GS
F       ELSE
F         ST = 0.0D0
F     ENDIF
;
;  Fortran block to switch between Plants 9.0 and 10 (Baseline Design
;  Case) or Plants 9.1, 31.1 and 31.4 (Option 6).
FORTRAN OPTION6
F     COMMON /USRC03/ FIN(5,4), FOUT(20,4), PGAS, PPWR, OPTN6
C     See Subroutine USRSR1 for the definition of the items in named
C     common block /USRC03/.
 DEFINE FSTM   STREAM-VAR STREAM=STEAM    VAR=MOLE-FLOW
 DEFINE FNG    STREAM-VAR STREAM=NAT-GAS  VAR=MOLE-FLOW
 DEFINE F10A   STREAM-VAR STREAM=10-AIRIN VAR=MASS-FLOW
 DEFINE F9H    STREAM-VAR STREAM=9-H2OIN  VAR=MASS-FLOW
 DEFINE F9S    STREAM-VAR STREAM=9-STEMIN VAR=MASS-FLOW
 DEFINE F9O    STREAM-VAR STREAM=9-O2IN   VAR=MASS-FLOW
 DEFINE FC9M   SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=MIXED VAR=MASS-FLOW
 DEFINE FC9NC  SUBSTREAM-VAR STREAM=9-FEED  SUBSTREAM=NC    VAR=MASS-FLOW
 DEFINE FRAC8  BLOCK-VAR   BLOCK=S8  SENTENCE=FRAC  VAR=FRAC  &
  ID1=S8-ASHC  ELEMENT=1
 DEFINE FRAC9  BLOCK-VAR   BLOCK=S9  SENTENCE=FRAC  VAR=FRAC  &
  ID1=H9NEED   ELEMENT=1
 DEFINE FRAC38 BLOCK-VAR   BLOCK=P38B  SENTENCE=FRAC  VAR=FRAC  &
  ID1=WASTE    ELEMENT=1
C     Set N9 equal to 0 to run Plants 9.0 and 10 (Baseline), or
C     set N9 equal to 1 to run Plants 9.1, 31.1 and 31.4 (OPTION 6).
F     N9 = 0
F     IF (N9 .EQ. 0) THEN
F       OPTN6 = 0.0D0
F       FSTM = 1.0D-6
F       FNG = 1.0D-6
F       FRAC8 = 1.0
F       FRAC9 = 1.0
F       FRAC38 = 0.28595
F     ENDIF
F     IF (N9 .EQ. 1) THEN
F       OPTN6 = 1.0D0
F       F10A = 1.0D-6
F       F9H = 1.0D-6
F       F9S = 1.0D-6
```

```
F        F9O = 1.0D-6
F        FC9M = 1.0D-6
F        FC9NC = 1.0D-6
F        FRAC8 = 0.0
F        FRAC9 = 0.0
F        FRAC38 = 0.0
F      ENDIF
;
FORTRAN SUMMARY
C      This Fortran block writes the summary report to the DCLSUM.REP
C      file, and also writes the DCL1.PRN file for transfering the
C      results to the Lotus spreadsheet economics model.
C      COMMON /USRC03/ is used to transfer variables FIN(5,4),
C        FOUT(20,4), PGAS, PPWR, OPTN6
C      See Subroutine USRSR1 for the definition of the items in named
C      common block /USRC03/.
 DEFINE FIN1   SUBSTREAM-VAR STREAM=ROMCOAL   SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FIN2   STREAM-VAR    STREAM=NAT-GAS   VAR=MASS-FLOW
 DEFINE FOUT1  STREAM-VAR    STREAM=3S-PROP   VAR=MASS-FLOW
 DEFINE FOUT2  STREAM-VAR    STREAM=3S-BUT    VAR=MASS-FLOW
 DEFINE FOUT3A STREAM-VAR    STREAM=PNAPHTHA  VAR=MASS-FLOW
 DEFINE FOUT3B STREAM-VAR    STREAM=REFORMED  VAR=MASS-FLOW
 DEFINE FOUT4  STREAM-VAR    STREAM=P350-450  VAR=MASS-FLOW
 DEFINE FOUT5  STREAM-VAR    STREAM=P450-650  VAR=MASS-FLOW
 DEFINE FOUT6  STREAM-VAR    STREAM=P650-850  VAR=MASS-FLOW
 DEFINE FOUT7  SUBSTREAM-VAR STREAM=1S-REFSE  SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT8  SUBSTREAM-VAR STREAM=SLAG      SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT8A SUBSTREAM-VAR STREAM=FBC-SOL   SUBSTREAM=NC VAR=MASS-FLOW
 DEFINE FOUT10 STREAM-VAR    STREAM=NH3-PROD  VAR=MASS-FLOW
 DEFINE FOUT11 STREAM-VAR    STREAM=PHENOL    VAR=MASS-FLOW
 DEFINE FOUT12 STREAM-VAR    STREAM=11S-LIQS  VAR=MASS-FLOW
C      Load the stream flow rates in the FIN() and FOUT() arrays in
C      Mlbs/hr.  All solid stream flow rates are on a dry basis.
F      FIN(1,1)  = 0.001D0 * FIN1
F      FIN(2,1)  = 0.001D0 * FIN2
F      FOUT(1,1) = 0.001D0 * FOUT1
F      FOUT(2,1) = 0.001D0 * FOUT2
F      FOUT(3,1) = 0.001D0 * (FOUT3A + FOUT3B)
F      FOUT(4,1) = 0.001D0 * FOUT4
F      FOUT(5,1) = 0.001D0 * FOUT5
F      FOUT(6,1) = 0.001D0 * FOUT6
F      FOUT(7,1) = 0.001D0 * FOUT7
F      FOUT(8,1) = 0.001D0 * (FOUT8 + FOUT8A)
F      FOUT(10,1) = 0.001D0 * FOUT10
F      FOUT(11,1) = 0.001D0 * FOUT11
F      FOUT(12,1) = 0.001D0 * FOUT12
C
C      Set XOF to the number of extra operators and OSBL operators
C      per dedicated plant operator.
C      ----------------------------
F      XOF = 0.343042
C
C      Set the LOSBL and LPLANT switches, as appropriate, to duplicate
C      the Bechtel OSBL and first vs. Nth plant costing logic.
C      LOSBL  = 0  - Use baseline case OSBL costing logic.
```

```
C     LOSBL  = 1  - Use option case OSBL costing logic.
C     LPLANT = 0  - Use first plant OSBL and engineering costing logic.
C     LPLANT = 1  - Use Nth plant OSBL and engineering costing logic.
C     ================================================================
F     LOSBL = 1
F     LPLANT = 1
C
C     Open the separate output file called DCLSUM.REP to contain the
C     summary report of the simulation results.
F     OPEN (UNIT=62, FILE='DCLSUM.REP', STATUS='UNKNOWN',
F    1  ACCESS='SEQUENTIAL', FORM='FORMATTED',
F    2  BUFFERED='BUFFERED')
C     Call Subroutines USRSR1 and USRSR2 to write the summary report.
F     CALL USRSR1 (62)
F     CALL USRSR2 (62, LOSBL, LPLANT, OPTN6, XOF)
F     CLOSE (UNIT=62, STATUS='KEEP')
C     Now write the LOTUS spreadsheet economics model input file.
F     OPEN (UNIT=62, FILE='DCL1.PRN', STATUS='UNKNOWN',
F    1  ACCESS='SEQUENTIAL', FORM='FORMATTED',
F    2  BUFFERED='BUFFERED')
C     Call Subroutines USRSR3 to write the model input file.
F     CALL USRSR3 (62, OPTN6, XOF)
F     CLOSE (UNIT=62, STATUS='KEEP')
;
; Convergence Blocks
; ------------------
;
CONVERGENCE CBLK1 WEGSTEIN
  TEAR H2MIX 1D-5
  PARAM WAIT=3
;
CONVERGENCE CBLK2 WEGSTEIN
  TEAR 2S-BOTTS 1D-5
;
CONVERGENCE CBLK3 WEGSTEIN
  TEAR 6S-SH2O 1D-5
;
CONVERGENCE COALF ONE-VAR
  SPEC COALFLO
;
CONVERGENCE HD-C1 ONE-VAR
  SPEC HD-HYD
;
CONVERGENCE HYDF BROYDEN-SPEC
  SPEC H2FLO
;
CONVERGENCE 2HYDF ONE-VAR
  SPEC 2H2FLO
;
CONVERGENCE OXYF ONE-VAR
  SPEC O2FLO
;
CONVERGENCE RFMRF ONE-VAR
  SPEC RFMRFLO
;
```

```
; Calculation Sequence
; --------------------
;
;  Define subsequence for coal cleaning complex.
SEQUENCE CLEAN COALF MIXFLO S1 P1-BASE P1-ALT1 P1-ALT2                  &
               M1 S2 P14 (RETURN COALF)                                  &
               M4 M3 M2
;
;  Specify entire flowsheet sequence, including subsequence CLEAN.
SEQUENCE BASE  (SEQUENCE CLEAN)  CCOAL                                  &
               CBLK1   2HYDF M-2HYD (RETURN 2HYDF)                       &
               CBLK2 SETUP2 P02 P81 (RETURN CBLK2)                       &
               P61 P62   HD-C1 M-HYD (RETURN HD-C1)                      &
               M-73 P03 M-NAP SETUP45 P04 M-462 P05 M-561                &
               M-PNAP S7 P07 (RETURN CBLK1)                              &
               HFLOW M9H OPTION6 S9  S8 P314 SA6SET SA6                  &
               HYDF 9COAL M9C SETUP9 P09 (RETURN HYDF)                   &
               OXYF P10 (RETURN OXYF)  COALFLOW  (SEQUENCE CLEAN)        &
               RFMRF SETUP91 P91 (RETURN RFMRF)                          &
               CBLK3 M38 P38 P38A P38B P39 M-6GAS S6-SH2O                &
               (RETURN CBLK3)                                            &
               P11 SETUP31 P31 SUMMARY
;
; Unit Operations Blocks
; ----------------------
;
;  Mix the clean coal product streams from the 3 different cases.
BLOCK M1 MIXER
  DESCRIPTION 'PLANT 1 OUTLET CLEAN COAL MIXER'
;
;  Mix the middling coal product streams from the 3 different cases.
BLOCK M2 MIXER
  DESCRIPTION 'PLANT 1 OUTLET MIDDLING COAL MIXER'
;
;  Mix the hydrogen streams going to Plant 2.
BLOCK M-2HYD MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL HYDROGEN STREAM TO PLANT 2'
  PARAM NPK=1  KPH=1
;
;  Mix the refuse product streams from the 3 different cases.
BLOCK M3 MIXER
  DESCRIPTION 'PLANT 1 OUTLET REFUSE MIXER'
;
;  Mix the sour water streams from Plants 2, 3, 4, 5, and 9.
BLOCK M38 MIXER
  DESCRIPTION 'SOUR WATER MIXER FOR PLANT 38 FEED'
;
;  Mix the waste water product streams from the 3 different cases.
BLOCK M4 MIXER
  DESCRIPTION 'PLANT 1 OUTLET WASTE WATER MIXER'
;
;  Mix the hydrogen streams from Plants 4 & 2 for Plant 6.2.
BLOCK M-462 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 6.2 FEED'
;
```

```
;  Mix the hydrogen streams from Plants 5 & 2 for Plant 6.1.
BLOCK M-561 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 6.1 FEED'
;
;  Mix the sour gas streams from Plants 6.1, 6.2, 9 and 38 for the
;  Plant 11 feed stream.
BLOCK M-6GAS HEATER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 11 FEED'
  PARAM  TEMP=110.0  PRES=14.7
;
;  Mix the H2 gas streams from Plants 7 & 6.2 for Plant 3.
BLOCK M-73 MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 3 FEED'
;
;  Mixer M9C - The hydrogen plant feed mixer; used to mix the coal and
;  ROSE unit ASH-CONC stream that goes to Plant 9.0.
BLOCK M9C MIXER
  DESCRIPTION 'MIXER TO GENERATE THE PLANT 9 FEED'
  BLOCK-OPTIONS HMB-RESULTS=2
;
;  Mixer M9 - The dummy hydrogen mixer; used to mix the three
;  streams that go to Plant 2 (M9H2), Plant 4 (M9H4), and
;  Plant 5 (M9H5) into one single output stream (MHNEED) for the
;  S9 splitter.
BLOCK M9H MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL AMOUNT OF HYDROGEN NEEDED'
  PARAM NPK=1  KPH=1
;
;  Mix the hydrogen streams from Plants 6.1 and 6.2. Use a flash2 block
;  to correct a temperature calculating error in the ASPEN mixer block
;  algorithm.
BLOCK M-HYD FLASH2
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL HYDROGEN FROM 6.1 AND 6.2'
  PARAM  TEMP=100.  PRES=3290.
;
;  Mix the naphtha streams from Plants 2 and 6.2.
BLOCK M-NAP MIXER
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL PLANT 4 NAPHTHA FEED'
;
;  Mix the product naphtha streams from Plants 4 and 5.
  DESCRIPTION 'MIXER TO GENERATE THE TOTAL PRODUCT NAPHTHA STREAM'
BLOCK M-PNAP MIXER
;
;  Plant P1-ALT1, Coal Cleaning and Preparation Plant. Use User
;  Fortran Model, USR01, within the PLANTS file. ALTERNATE CASE 1 -
;  COAL CLEANING BY HEAVY MEDIUM SEPARATION.
BLOCK P1-ALT1 USER
   SUBROUTINE MODEL = USR01    REPORT = USR01
   DESCRIPTION 'PLANT 1 - ALTERNATE 1 - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following integer and real parameters are for production of
;   the coal cleaned by both jigs and heavy medium separation.  The coal
;   cleaned only by jigs for gasification is handled by a separate plant
;   that is modeled in BLOCK P1-JIGS.  The operators and cost for this
;   plant includes those associalted with the P1-JIGS portion of the coal
```

```
;   cleaning and preparation plant.  All parameters have the same meaning
;   as described below for Plant 1 in BLOCK P1-BASE.
;
    INT  0  1  0  1  1
;        FCP         FCM    FHP          FHM    FNP          FNM
     REAL 0.9120155   0.0    0.9050241    0.0    0.8869236    0.0  &
;        FC1P        FC1M   FSP          FSM    FOP          FOM
         0.7602203   0.0    0.4471884    0.0    0.9905900    0.0  &
;        FAP         FAM
         0.3012854   0.0  &
;        PCWP  PCWM  PCWR  Future Use (3 items)
         9.0   3.0   10.0    0.   0.   0.                    &
;        Power           900/750 F steam   900 satd steam
         0.0 7.400489      0.0 0.0           0.0 0.0        &
;        600/720 F steam   600 satd steam    150 satd steam
         0.0 0.0           0.0 0.0           0.0 0.0        &
;        50 satd steam     Plant fuel        Cooling  H2O
         0.0 0.0           0.0 0.0           0.0 0.0        &
;        Process H2O       Nitrogen
         0.0 0.042246      0.0 0.0         &
;        Future Use (6 items)
         0.0  0.0  0.0  0.0  0.0  0.0      &
;        Opers/day     (Opers/day)/train
         8.0           8.0                 &
;        Ref Flow   Max Flow   Min Flow
         285.035    300.0      150.0      &
;        Plant cost equation constants.
;        A      B       E      F      Spares     Future Use (2 items)
         0.0    25.52   0.5942 1.0    0.0        0.0   0.0    &
;        Future Use (10 items)
         0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S12    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S13    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S14    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S15    KODE=2   TEMP = 70.0   PRES = 14.7
;
;  Plant P1-ALT2, Coal Cleaning and Preparation Plant. Use User Fortran
;  Model, USR01, within the PLANTS file. ALTERNATE CASE 2 - COAL CLEANING
;  BY HEAVY MEDIUM SEPARATION FOLLOWED BY SPHERICAL AGGLOMERATION.
BLOCK P1-ALT2 USER
   SUBROUTINE MODEL = USR01    REPORT = USR01
   DESCRIPTION 'PLANT 1 - ALTERNATE 2 - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following integer and real parameters are for production of
;   the coal cleaned by both jigs and heavy medium separation followed
;   by spherical agglomeration.  The coal cleaned only by jigs for
;   gasification is handled by a separate plant that is modeled in
;   BLOCK P1-JIGS.  The operators and cost for this plant includes
;   those associalted with the P1-JIGS portion of the coal cleaning
;   and preparation plant.  All parameters have the same meaning as
;   described below for Plant 1 in BLOCK P1-BASE.
;
```

```
    INT  0  1  0  1  2
;        FCP          FCM    FHP          FHM    FNP          FNM
     REAL 0.9435271   0.0    0.933o663    0.0    0.9250562    0.0  &
;        FClP         FClM   FSP          FSM    FOP          FOM
         0.7400450    0.0    0.3772778    0.0    0.9867266    0.0  &
;        FAP          FAM
         0.1295931    0.0  &
;        PCWP   PCWM  PCWR  Future Use (3 items)
         14.16  3.0   10.0  0.0   0.0   0.0                  &
;        Power                900/750 F steam   900 satd steam
         0.0 51.68786         0.0 0.0           0.0 0.0      &
;        600/720 F steam      600 satd steam    150 satd steam
         0.0 0.0              0.0 0.0           0.0 0.0      &
;        50 satd steam        Plant fuel        Cooling  H2O
         0.0 0.0              0.0 0.394967      0.0 0.0      &
;        Process H2O          Nitrogen
         0.0 0.103481         0.0 0.0         &
;        Future Use (6 items)
         0.0  0.0  0.0  0.0  0.0  0.0      &
;        Opers/day     (Opers/day)/train
         8.0           8.0                 &
;        Ref Flow   Max Flow   Min Flow
         262.3      300.0      150.0      &
;        Plant cost equation constants.
;        A      B       E      F      Spares     Future Use (2 items)
         0.0    73.78   0.5942 1.0    0.0        0.0   0.0    &
;        Future Use (10 items)
         0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S22    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S23    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S24    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S25    KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 1 - Coal Cleaning, Preparation and Drying Plant, Use User Fortran
;           Model USR01
;           BASE CASE - COAL CLEANING BY JIGS For LIQUEFACTION.
BLOCK P1-BASE USER
   SUBROUTINE MODEL = USR01   REPORT = USR01
   DESCRIPTION 'PLANT 1 - BASE CASE - COAL CLEANING AND PREPARATION PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following 5 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
```

```
;                    user block output report file on logical unit 62
;                    called DCL01B.REP, DCL01A1.REP or DCL01A2.REP
;                    depending on the value of the coal cleaning option
;                    control switch, INT(5).
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-4 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
;      INT(5)  = Coal cleaning, drying and grinding option control
;                switch.  The name of the short plant report file
;                written for each option is option dependent.
;                0 => Base case - Coal cleaning by jigs for coal
;                     liquefaction in plant 2. (Report = DCL01B.REP)
;                1 => Alternate case 1 - Coal cleaning by heavy media
;                     separation.  (Report = DCL01A1.REP)
;                2 => Alternate case 2 - Coal cleaning by heavy media
;                     separation and spherical agglomeration.
;                     (Report = DCL01A2.REP)
;                3 => Coal cleaning by jigs for coal gasification in
;                     plant 9.  (Report = DCL01G.REP)
;                4 => Coal grinding and drying plant.
;                     (Report = DCL01D.REP)
;               NOTE: Values 0, 1 and 2 are used when this model
;                     cleans the coal going to the coal liquefaction
;                     plant, 3 is used only when this model cleans
;                     the coal going to the coal gasification plant,
;                     and 4 is for the grinding and drying plant.
   INT  0  1  0  1  0
;     The following 70 real parameters are:
;     REAL(1)   = Fraction of carbon in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(2)   = Fraction of carbon in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(3)   = Fraction of hydrogen in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(4)   = Fraction of hydrogen in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(5)   = Fraction of nitrogen in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(6)   = Fraction of nitrogen in the inlet coal leaving
;                 in the middling coal stream.
;     REAL(7)   = Fraction of chlorine in the inlet coal leaving
;                 in the clean coal product stream.
;     REAL(8)   = Fraction of chlorine in the inlet coal leaving
;                 in the middling coal stream.
```

```
;       REAL(9)   = Fraction of sulfur in the inlet coal leaving
;                   in the clean coal product stream.  OPTIONAL - See Note 1.
;       REAL(10)  = Fraction of sulfur in the inlet coal leaving
;                   in the middling coal stream.  OPTIONAL - See Note 1.
;       REAL(11)  = Fraction of oxygen in the inlet coal leaving
;                   in the clean coal product stream.
;       REAL(12)  = Fraction of oxygen in the inlet coal leaving
;                   in the middling coal stream.
;       REAL(13)  = Fraction of ash in the inlet coal leaving
;                   in the clean coal product stream.
;       REAL(14)  = Fraction of ash in the inlet coal leaving
;                   in the middling coal stream.
;       REAL(15)  = Moisture content of the clean product coal on a dry
;                   basis, wt%.
;       REAL(16)  = Moisture content of the middling coal on a dry
;                   basis, wt%.
;       REAL(17)  = Moisture content of the refuse on a dry basis, wt%.
;       REAL(18) -
;        REAL(20) = Future use.
;       REAL(21)  = Constant factor for the power consumption, kw.
;       REAL(22)  = Power consumption per Mlbs/hr of dry clean coal,
;                   kw/(Mlbs/hr).
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   dry clean coal, (Mlbs/hr)/(Mlbs/hr).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of dry clean coal,
;                   (MM BTU/hr)/(Mlbs/hr).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of dry clean
;                   coal (Mgal/hr)/(Mlbs/hr).
;       REAL(39)  = Constant factor for the process water consumption,
```

```
;                   Mgal/hr.
;      REAL(40)  = Process water consumption per Mlbs/hr of dry clean
;                  coal, (Mgal/hr)/(Mlbs/hr).
;      REAL(41)  = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2.
;      REAL(42)  = Nitrogen consumption per Mlbs/hr of dry clean coal,
;                  (MM SCF/hr of N2)/(Mlbs/hr).
;      REAL(43) -
;       REAL(48) = Future use.
;      REAL(49)  = Constant factor for the number of operators per
;                  day, operators/day.
;      REAL(50)  = Number of operators per day per train,
;                  (operators/day)/train.
;      REAL(51)  = Reference flow rate of the dry clean coal of a
;                  single train in Mlbs/hr for the calculation of
;                  the ISBL field cost of a single train as a function
;                  of train capacity.
;      REAL(52)  = Maximum size of a single train as defined by the
;                  flow rate of the dry clean coal in Mlbs/hr.
;      REAL(53)  = Minimum size of a single train as defined by the
;                  flow rate of the dry clean coal in Mlbs/hr.
;      REAL(54)  = Constant A in the plant ISBL field cost equation.
;      REAL(55)  = Constant B in the plant ISBL field cost equation.
;      REAL(56)  = Constant E in the plant ISBL field cost equation.
;      REAL(57)  = Constant F in the plant ISBL field cost equation.
;      REAL(58)  = Number of spare trains.
;      REAL(59) -
;       REAL(70) = Future use.
;
;    NOTES:
;      1. If both the sulfur distribution factors, REAL(9) and REAL(10),
;         are zero and a SULFANAL was supplied, the sulfur will be
;         distributed among the products as follows.
;         a. The ORGANIC sulfur will be distributed in the same
;            proportions as the carbon is distributed.
;         b. The PYRITIC and SULFATE sulfur will be distributed in the
;            same proportions as the ash is distributed.
;
;         FCP          FCM    FHP          FHM    FNP          FNM
     REAL 0.9302390    0.0    0.9142857    0.0    0.9533333    0.0  &
;         FClP         FClM   FSP          FSM    FOP          FOM
          0.40000      0.0    0.5019608    0.0    0.9696970    0.0  &
;         FAP          FAM
          0.4229677    0.0  &
;         PCWP   PCWM  PCWR  Future Use (3 items)
          8.576  3.0   10.0  0.0   0.0   0.0                    &
;         Power              900/750 F steam   900 satd steam
          0.0 4.281977       0.0 0.0           0.0 0.0        &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 0.0           0.0 0.0        &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 0.0           0.0 0.0        &
;         Process H2O        Nitrogen
          0.0 0.02433102     0.0 0.0         &
;         Future Use (6 items)
```

```
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          8.0           8.0                  &
;         Ref Flow   Max Flow   Min Flow
          387.158    390.0      200.0       &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future use (2 items)
          0.0    18.2    0.5942 1.0    0.0      0.0   0.0       &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 1S02    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S03    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S04    KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 1S05    KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 1.4 - Coal Grinding and Drying Plant - Fortran Model USR01
;             BASE CASE
BLOCK P14 USER
   SUBROUTINE MODEL = USR01   REPORT = USR01
   DESCRIPTION 'PLANT 1.4 - BASE CASE - COAL GRINDING AND DRYING PLANT'
   PARAM  NINT = 5   NREAL = 70
;      The following integer and real parameters have the same meaning
;      as described above for Plant 1 in BLOCK P1-BASE.
    INT  0  1  0  1  4
;         FCP          FCM    FHP          FHM    FNP          FNM
     REAL 1.0          0.0    1.0          0.0    1.0          0.0  &
;         FC1P         FC1M   FSP          FSM    FOP          FOM
          1.0          0.0    1.0          0.0    1.0          0.0  &
;         FAP          FAM
          1.0          0.0   &
;         PCWP   PCWM  PCWR  Future Use (3 items)
          2.0    3.0   10.0  0.0   0.0   0.0                  &
;         Power                900/750 F steam   900 satd steam
          0.0 8.499979         0.0 0.0           0.0 0.0       &
;         600/720 F steam      600 satd steam    150 satd steam
          0.0 0.0              0.0 0.0           0.0 0.0       &
;         50 satd steam        Plant fuel        Cooling  H2O
          0.0 0.0              0.0 0.3410096     0.0 0.010104  &
;         Process H2O          Nitrogen
          0.0 0.0              0.0 3.16015     &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          7.0           1.0                  &
;         Ref Flow   Max Flow   Min Flow
          142.518    145.0      50.0        &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future use (2 items)
          0.0    8.75    0.8504 1.0    0.0      0.0   0.0       &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
```

```
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = COALTO2  KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-XMID KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-REF  KODE=2   TEMP = 70.0   PRES = 14.7  /
               STRM = 14S-WAT  KODE=2   TEMP = 70.0   PRES = 14.7
;
; Plant 2 - The coal liquefaction plant - user Fortran block USR02.
BLOCK P02 USER
   SUBROUTINE MODEL = USR02   REPORT = USR02
   DESCRIPTION 'PLANT 2 - COAL LIQUEFACTION PLANT'
   PARAM  NINT = 6   NREAL = 70
;      The following 5 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL02.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
;      INT(5) = Switch to write the major equipment summary list and
;               cost summary report by plant section for the baseline
;               design to the separate block output summary report file
;               called DCL02.REP on logical unit 62.
;               0 => Do not write the major equipment summary list.
;               1 => Write the major equipment summary list to the
;                    separate block output file only when
;                    INT(1) <= 2, INT(2) = 1, and INT(6) = 0.
;               2 => Write the major equipment summary list and the
;                    cost summary report by plant section to the
;                    separate block output file only when
;                    INT(1) <= 2, INT(2) = 1, and INT(6) = 0.
;      INT(6) = Switch to select which coal liquefaction reactor yields
;               are calculated.
;               0 => Baseline design two reactor model.
```

```
;                3 => Option 3 - Yields for Thermal/Catalytic two-
;                     reactor model.
;                4 => Option 4 - Two-reactor model with interstaage
;                     vent gas separation.
;                5 => Option 5 - Yields for two-reactor coker model.
;                8 => Improved Baseline (Option 8) - High space velocity
;                     two-reactor model.
    INT  0  1  0  1  2  0
;      The following 70 real parameters are:
;      REAL(1)    = Percent coal conversion based on fresh MAF coal
;                   entering the coal liquefaction reactors.
;      REAL(2)-
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per Mlbs/hr of dry coal feed,
;                   kw/(Mlbs/hr of dry coal).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                   dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                   dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                   dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                   dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per Mlbs/hr of dry coal feed,
;                   (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(37)   = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;      REAL(38)   = Cooling water consumption per Mlbs/hr of dry coal
;                   feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;      REAL(39)   = Constant factor for the process water consumption,
;                   Mgal/hr.
;      REAL(40)   = Process water consumption per Mlbs/hr of dry coal
;                   feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
;      REAL(41)   = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
```

```
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of dry coal feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of dry coal).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference dry coal feed rate to a single train in
;                   Mlbs/hr for the calculation of the ISBL field cost of
;                   a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the dry
;                   coal feed rate in Mlbs/hr of dry coal.
;       REAL(53)  = Minimum size of a single train as defined by the dry
;                   coal feed rate in Mlbs/hr of dry coal.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Percent fresh MAF coal conversion
     REAL 92.7901  &
;          Future use (9 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0    &
;          Power              900/750 F steam    900 satd steam
           0.0 41.39141       0.0 0.0            0.0 0.0        &
;          600/720 F steam    600 satd steam     150 satd steam
           0.0 0.003904784    0.0 -0.1046117     0.0 -0.0632168 &
;          50 satd steam      Plant fuel         Cooling H2O
           0.0 0.0393741      0.0 0.764818       0.0 0.340800   &
;          Process H2O        Nitrogen
           0.0 0.1081972      0.0 0.000029236 &
;          Future Use (6 items)
           0.0  0.0  0.0 0.0  0.0  0.0       &
;          Opers/day     (Opers/day)/train
           0.0           8.0                 &
;          Ref Flow   Max Flow   Min Flow
           285.035    285.05     30.0        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future use (2 items)
           0.0    186.44  0.7142 1.0    0.0      0.0   0.0   &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR02.
   FLASH-SPECS STRM=2S-GAS KODE=2 TEMP=130.0 PRES=2985.0 NPK=1 KPH=1 /
               STRM = GASES     KODE=2   TEMP = 130.0  PRES = 65.0   /
               STRM = NAPHTHA   KODE=2   TEMP = 140.0  PRES = 16.0   /
               STRM = GAS-OIL   KODE=2   TEMP = 110.0  PRES = 30.0   /
```

```
              STRM = 2S-BOTTS  KODE=2   TEMP = 688.0  PRES = 28.0   /
              STRM = 2S-SH2O   KODE=2   TEMP = 100.0  PRES = 30.0
;
; Plant 3 - The gas plant - use user Fortran block USR03.
BLOCK P03 USER
   SUBROUTINE MODEL = USR03   REPORT = USR03
   DESCRIPTION 'PLANT 3 - THE GAS PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL03.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per MM SCF/hr of dry C4- gas,
;                  kw/(MM SCF/hr of dry C4- gas)
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr
;                  of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;      REAL(25)  = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr
;                  of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;      REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;      REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr
;                  of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
```

```
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr
;                   of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of dry C4- gas,
;                   (MM BTU/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of dry C4-
;                   gas, (Mgal/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of dry C4-
;                   gas, (Mgal/hr)/(MM SCF/hr of dry C4- gas).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of dry C4- gas,
;                   (MM SCF/hr of N2)/(MM SCF/hr of dry C4- gas).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference gas feed rate to a single train in
;                   MM SCF/hr of dry C4- gas for the calculation of
;                   the ISBL field cost of a single train as a function
;                   of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   gas feed rate in MM SCF/hr of dry C4- gas.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   gas feed rate in MM SCF/hr of dry C4- gas.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Future use (10 items)
     REAL 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power            900/750 F steam   900 satd steam
```

```
          0.0 447.6001      0.0 0.0           0.0 0.0       &
;         600/720 F steam   600 satd steam    150 satd steam
          0.0 0.0           0.0 194.4388      0.0 0.0       &
;         50 satd steam     Plant fuel        Cooling  H2O
          0.0 8.425471      0.0 -722.141      0.0 645.8090  &
;         Process H2O       Nitrogen
          0.0 0.0           0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.0            8.0               &
;         Ref Flow   Max Flow   Min Flow
          2.04       5.0        0.300      &
;         Plant cost equation constants.
;         A      B          E      F      Spares   Future Use (3 items)
          0.0    25.3       0.8013 1.0    0.0      0.0   0.0   &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR03.
   FLASH-SPECS STRM = 3S-SGAS   KODE=2  TEMP = 137.0  PRES = 55.0   /
               STRM = 3S-FGAS   KODE=2  TEMP = 100.0  PRES = 215.0  /
               STRM = 3S-PROP   KODE=2  TEMP = 100.0  PRES = 280.0  /
               STRM = 3S-BUT    KODE=2  TEMP = 100.0  PRES = 280.0  /
               STRM = 3S-OIL    KODE=2  TEMP = 130.0  PRES = 263.0  &
                      NPK=1 KPH=2 /
               STRM = 3S-SH2O   KODE=2  TEMP = 137.0  PRES = 55.0
;
; Plant 4 - The naphtha hydrotreater - use user Fortran block USR04.
BLOCK P04 USER
   SUBROUTINE MODEL = USR04   REPORT = USR04
   DESCRIPTION 'PLANT 4 - THE NAPHTHA HYDROTREATER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL04.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
```

```
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Percent desulfurization of the C5+ feed; i. e.,
;                   Percent of sulfur removed from the entering C5+ feed.
;      REAL(2)    = Percent denitrogenation of the C5+ feed; i. e.,
;                   Percent of nitrogen removed from the entering C5+ feed.
;      REAL(3)    = Percent deoxygenation of the C5+ feed.
;                   Percent of oxygen removed from the entering C5+ feed.
;      REAL(4)    = Chemical hydrogen consumption in SCF/bbl of C5+ feed.
;      REAL(5) -
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per Mlbs/hr of C5+ feed,
;                   kw/(Mlbs/hr of C5+ feed).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                   C5+ feed, (Mlbs/hr)/(Mlbs/hr of C5+ feed).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per Mlbs/hr of C5+ feed,
;                   (MM BTU/hr)/(Mlbs/hr of C5+ feed).
;      REAL(37)   = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;      REAL(38)   = Cooling water consumption per Mlbs/hr of C5+ feed,
;                   (Mgal/hr)/(Mlbs/hr of C5+ feed).
;      REAL(39)   = Constant factor for the process water consumption,
;                   Mgal/hr.
```

```
;       REAL(40)  = Process water consumption per Mlbs/hr of C5+ feed,
;                   (Mgal/hr)/(Mlbs/hr of C5+ feed).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of C5+ feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of C5+ feed).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference C5+ feed rate to a single train in Mlbs/hr
;                   for the calculation of the ISBL field cost of a
;                   single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   C5+ feed rate in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   C5+ feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          % Desulfurization   % Denitrogenation
     REAL 99.99                99.988        &
;          % Deoxygenation   Chemical H2 consumption in SCF/bbl C5+ feed
           99.5              125.0          &
;          Future use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0     &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power             900/750 F steam   900 satd steam
           0.0 5.098308      0.0 0.0           0.0 0.0       &
;          600/720 F steam   600 satd steam    150 satd steam
           0.0 0.0           0.0 0.126493      0.0 0.0       &
;          50 satd steam     Plant fuel        Cooling  H2O
           0.0 0.0           0.0 0.351607      0.0 0.730963  &
;          Process H2O       Nitrogen
           0.0 0.010833      0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0           8.0                &
;          Ref Flow   Max Flow   Min Flow
           210.462    400.0      50.0       &
;          Plant cost equation constants.
;          A      B      E      F      Spares   Future Use (3 items)
           0.0    15.6   0.7843 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
```

```
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR04.
   FLASH-SPECS STRM = 4S-GAS   KODE=2  TEMP = 135.0  PRES = 915.0  /
               STRM = 4S-NAPH  KODE=2  TEMP = 100.0  PRES = 153.0  /
               STRM = 4S-SH2O  KODE=2  TEMP =  70.0  PRES = 14.7
;
; Plant 5 - The gas-oil hydrotreater - use user Fortran block USR05.
BLOCK P05 USER
   SUBROUTINE MODEL = USR05   REPORT = USR05
   DESCRIPTION 'PLANT 5 - THE GAS-OIL HYDROTREATER'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL05.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Percent desulfurization of the C6+ feed; i. e.,
;                  Percent of sulfur removed from the entering C6+ feed.
;      REAL(2)   = Percent denitrogenation of the C6+ feed; i. e.,
;                  Percent of nitrogen removed from the entering C6+ feed.
;      REAL(3)   = Percent deoxygenation of the C6+ feed.
;                  Percent of oxygen removed from the entering C6+ feed.
;      REAL(4)   = Chemical hydrogen consumption in SCF/bbl of C6+ feed.
;      REAL(5) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of C6+ feed,
;                  kw/(Mlbs/hr).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
```

```
;       REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   C6+ feed, (Mlbs/hr)/(Mlbs/hr).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of C6+ feed,
;                   (MM BTU/hr)/(Mlbs/hr).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of C6+ feed,
;                   (Mgal/hr)/(Mlbs/hr).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of C6+ feed,
;                   (Mgal/hr)/(Mlbs/hr).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of C6+ feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference C6+ feed rate to a single train in Mlbs/hr
;                   for the calculation of the ISBL field cost of a
;                   single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   C6+ feed rate in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   C6+ feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
```

```
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          % Desulfurization   % Denitrogenation
     REAL 92.5                 85.2       &
;          % Deoxygenation   Chemical H2 consumption in SCF/bbl C6+ feed
           97.6              947.00       &
;          Future use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0   &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power             900/750 F steam   900 satd steam
           0.0 3.247198      0.0 0.0           0.0 0.0       &
;          600/720 F steam   600 satd steam    150 satd steam
           0.0 0.0           0.0 0.096936      0.0 -0.050465 &
;          50 satd steam     Plant fuel        Cooling  H2O
           0.0 0.0           0.0 0.241416      0.0 0.735694 &
;          Process H2O       Nitrogen
           0.0 0.0           0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0            4.0               &
;          Ref Flow   Max Flow   Min Flow
           671.04     800.0      150.0      &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future Use (2 items)
           0.0    74.0    0.7467 1.0    0.0      0.0   0.0   &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR05.
;  The 5S-LPGAS and 5S-NAPH temperature and pressure are those leaving
;  Plant 4 where this fractionation is actually performed.
   FLASH-SPECS STRM = 5S-HPGAS  KODE=2  TEMP = 135.0  PRES = 2690.0 /
               STRM = 5S-LPGAS  KODE=2  TEMP = 135.0  PRES = 915.0  /
               STRM = 5S-NAPH   KODE=2  TEMP = 100.0  PRES = 153.0  /
               STRM = P350-450  KODE=2  TEMP = 110.0  PRES = 80.0   /
               STRM = P450-650  KODE=2  TEMP = 135.0  PRES = 20.0   /
               STRM = P650-850  KODE=2  TEMP = 135.0  PRES = 20.0   /
               STRM = 5S-SH2O   KODE=2  TEMP = 135.0  PRES = 20.0
;
; Plant 6.1 - The Hydrogen purification by Membrane Separation Plant.
BLOCK P61 USER
   SUBROUTINE MODEL = USR61   REPORT = USR61
   DESCRIPTION 'PLANT 6.1 - THE MEMBRANE H2 PURIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
```

```
;                    of the summary report.
;                 3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;                 0 => Write the user block summary report to the normal
;                      ASPEN/SP output report file.
;                 1 => Write the user block summary report to a separate
;                      user block output report file on logical unit 62
;                      called DCL61.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;                 If INT(3) = 0, the minimum number of duplicate
;                   trains will be determined so that the capacity
;                   of each train does not exceed the maximum train
;                   capacity specified by variable REAL(52).
;                 If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;                 0 => Write no additional output to the history file.
;                 1 => Write the only the subroutine entry and exit
;                      messages to the history file.
;                 2 => Write some additional output to the history file.
;               3-5 => Write some more additional output to the history
;                      file.  Larger values generate more intermediate
;                      output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Percent hydrogen recovery to the hydrogen-rich
;                   product gas stream from the inlet gas stream.
;      REAL(2)    = Concentration of hydrogen in the hydrogen-rich
;                   product gas stream, mole % or vol%.
;      REAL(3)-
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per MM SCF/hr of H2 recovered,
;                   kw/(MM SCF/hr of H2 recovered).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr
;                   of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
```

```
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                   H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of H2 recovered,
;                   (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of H2
;                   recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of H2 recovered,
;                   (MMM SCF/hr of N2)/(MM SCF/hr of H2 recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference hydrogen recovery rate for a single train
;                   in MM SCF/hr of H2 for the calculation of the
;                   ISBL field cost of a single train as a function of
;                   capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Percent H2 recovery    H2 purity in mole %
     REAL 43.83285               99.98677                    &
;          Future use (8 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0             &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 12254.04       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.0           0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling H2O
           0.0 2.054966       0.0 0.0           0.0 42.705864 &
;          Process H2O        Nitrogen
```

```
          0.0 0.854117      0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.0            12.0               &
;         Ref Flow   Max Flow   Min Flow
          1.966943   2.5        0.5         &
;         Plant cost equation constants.
;         A      B          E      F      Spares   Future use (2 items)
          0.0    152.6      0.8478 1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR61.
   FLASH-SPECS STRM = H2-RICH   KODE=2   TEMP = 100.0  PRES = 3290.0 /
               STRM = SOUR-GAS  KODE=2   TEMP = 250.0  PRES = 14.7   /
               STRM = P61-GAS   KODE=2   TEMP = 111.0  PRES = 500.0
;
; Plant 6.2 - The Hydrogen purification by Pressure Swing Absorption
;             Plant.
BLOCK P62 USER
   SUBROUTINE MODEL = USR62   REPORT = USR62
   DESCRIPTION 'PLANT 6.2 - THE PSA H2 PURIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL62.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
```

```
;       REAL(1)    = Percent hydrogen recovery to the hydrogen-rich
;                    product gas stream from the inlet gas stream.
;       REAL(2)    = Concentration of hydrogen in the hydrogen-rich
;                    product gas stream, mole % or vol%.
;       REAL(3)-
;        REAL(20)  = Future use.
;       REAL(21)   = Constant factor for the power consumption, kw.
;       REAL(22)   = Power consumption per MM SCF/hr of H2 recovered,
;                    kw/(MM SCF/hr of H2 recovered).
;       REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                    consumption, Mlbs/hr.
;       REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr of
;                    H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(25)   = Constant factor for the 900 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr
;                    of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                    consumption, Mlbs/hr.
;       REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr of
;                    H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(29)   = Constant factor for the 600 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(30)   = 600 psig saturated steam consumption per MM SCF/hr of
;                    H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(31)   = Constant factor for the 150 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(32)   = 150 psig saturated steam consumption per MM SCF/hr of
;                    H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(33)   = Constant factor for the 50 psig saturated steam
;                    consumption, Mlbs/hr.
;       REAL(34)   = 50 psig saturated steam consumption per MM SCF/hr of
;                    H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(35)   = Constant factor for the plant fuel consumption,
;                    MM BTU/hr.
;       REAL(36)   = Plant fuel consumption per MM SCF/hr of H2 recovered,
;                    (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(37)   = Constant factor for the cooling water consumption,
;                    Mgal/hr.
;       REAL(38)   = Cooling water consumption per MM SCF/hr of H2
;                    recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(39)   = Constant factor for the process water consumption,
;                    Mgal/hr.
;       REAL(40)   = Process water consumption per MM SCF/hr of H2
;                    recovered, (Mlbs/hr)/(MM SCF/hr of H2 recovered).
;       REAL(41)   = Constant factor for the nitrogen consumption,
;                    MM SCF/hr of N2
;       REAL(42)   = Nitrogen consumption per MM SCF/hr of H2 recovered,
;                    (MMM SCF/hr of N2)/(MM SCF/hr of H2 recovered).
;       REAL(43) -
;        REAL(48)  = Future use.
;       REAL(49)   = Constant factor for the number of operators per
;                    day, operators/day.
;       REAL(50)   = Number of operators per day per train,
;                    (operators/day)/train.
```

```
;       REAL(51)  = Reference hydrogen recovery rate for a single train
;                   in MM SCF/hr of H2 for the calculation of the
;                   ISBL field cost of a single train as a function of
;                   capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   hydrogen recovery rate in MM SCF/hr of H2
;                   recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;        The cost of Plant 6.2 is included in Plant 6.1.
;          Percent H2 recovery    H2 purity in mole %
     REAL 89.5033                90.01665              &
;          Future use (8 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 5485.989       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.0           0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling H2O
           0.0 15.32654       0.0 0.0           0.0 87.29583  &
;          Process H2O        Nitrogen
           0.0 0.530875       0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0           0.0                 &
;          Ref Flow   Max Flow   Min Flow
           3.61667    5.0        0.5        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future use (2 items)
           0.0    0.0     0.7    1.0    0.0      0.0   0.0    &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR62.
   FLASH-SPECS STRM = H2-2RICH  KODE=2   TEMP = 100.0  PRES = 3290.0 /
               STRM = SOUR-2GS  KODE=2   TEMP = 250.0  PRES = 14.7   /
               STRM = GAS-OUT   KODE=2   TEMP = 111.0  PRES = 25.0   /
               STRM = NAPHTHA2  KODE=2   TEMP = 100.0  PRES = 50.0
;
; Plant 7 - The naphtha reformer - use user Fortran block USR07.
BLOCK P07 USER
   SUBROUTINE MODEL = USR07   REPORT = USR07
```

```
   DESCRIPTION 'PLANT 7 - THE NAPHTHA REFORMER'
   PARAM  NINT = 4   NREAL = 70
;     The following 4 integer parameters are:
;     INT(1) = User block summary report control switch.
;              0 => Write the complete user block summary report.
;              1 => Skip the capital cost portion of the summary
;                   report.
;              2 => Skip the capital cost and utilities portions
;                   of the summary report.
;              3 => Skip writing the entire user block summary report.
;     INT(2) = User block summary report destination control switch.
;              0 => Write the user block summary report to the mormal
;                    ASPEN/SP output report file.
;              1 => Write the user block summary report to a separate
;                   user block output report file on logical unit 62
;                   called DCL07.REP.
;     INT(3) = Number of operating duplicate trains, excluding spares.
;              If INT(3) = 0, the minimum number of duplicate
;                trains will be determined so that the capacity
;                of each plant does not exceed the maximum train
;                capacity specified by variable REAL(52).
;              If INT(3) > 0, the number of duplicate trains.
;     INT(4) = History file additional output control switch.
;              0 => Write no additional output to the history file.
;              1 => Write the only the subroutine entry and exit
;                   messages to the history file.
;              2 => Write some additional output to the history file.
;            3-5 => Write some more additional output to the history
;                   file.  Larger values generate more intermediate
;                   output.
    INT  0  1  0  1
;     The following 70 real parameters are:
;     REAL(1) -
;      REAL(20) = Future use.
;     REAL(21)  = Constant factor for the power consumption, kw.
;     REAL(22)  = Power consumption per Mlbs/hr of feed,
;                 kw/(Mlbs/hr of feed).
;     REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                 consumption, Mlbs/hr.
;     REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                 feed, (Mlbs/hr)/(Mlbs/hr of feed).
;     REAL(25)  = Constant factor for the 900 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                 feed, (Mlbs/hr)/(Mlbs/hr of feed).
;     REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                 consumption, Mlbs/hr.
;     REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                 feed, (Mlbs/hr)/(Mlbs/hr of feed).
;     REAL(29)  = Constant factor for the 600 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                 feed, (Mlbs/hr)/(Mlbs/hr of feed).
;     REAL(31)  = Constant factor for the 150 psig saturated steam
;                 consumption, Mlbs/hr.
```

```
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   feed, (Mlbs/hr)/(Mlbs/hr of feed).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of feed,
;                   (MM BTU/hr)/(Mlbs/hr of feed).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of feed,
;                   (Mgal/hr)/(Mlbs/hr of feed).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of feed,
;                   (Mgal/hr)/(Mlbs/hr of feed).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of feed,
;                   (MM SCF/hr of N2)/(Mlbs/hr of feed).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference feed rate to a single train in Mlbs/hr
;                   for the calculation of the ISBL field cost of a
;                   single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   feed rate in Mlbs/hr.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   feed rate in Mlbs/hr.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          Future use (10 items)
     REAL 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
          0.0 2.26494        0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
          0.0 -0.314772      0.0 0.0           0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling  H20
          0.0 0.0            0.0 1.41781       0.0 0.123590  &
;          Process H20        Nitrogen
          0.0 0.0            0.0 0.0         &
```

```
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.            8.                  &
;         Ref Flow   Max Flow   Min Flow
          224.289    400.0      50.0        &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future Use (3 items)
          0.0    30.7    0.75   1.0    0.0      0.0   0.0   &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0

;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR07.
   FLASH-SPECS STRM = 7S-H2      KODE=2   TEMP = 80.0  PRES = 14.7  /
               STRM = 7S-GAS     KODE=2   TEMP = 80.0  PRES = 14.7  /
               STRM = REFORMED   KODE=2   TEMP = 80.0  PRES = 14.7
;
; Plant 8.1 - The ROSE-SR unit - user Fortran block USR81.
BLOCK P81 USER
   SUBROUTINE MODEL = USR81   REPORT = USR81
   DESCRIPTION 'PLANT 8.1 - THE ROSE-SR UNIT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL81.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate plants.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Hydrocarbon rejection factor.
;      REAL(2)-
```

```
;       REAL(20) = Future use.
;       REAL(21) = Constant factor for the power consumption, kw.
;       REAL(22) = Power consumption per Mlbs/hr of extract,
;                  kw/(Mlbs/hr of extract).
;       REAL(23) = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;       REAL(24) = 900 psig / 750 F steam consumption per Mlbs/hr of
;                  extract, (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(25) = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;       REAL(26) = 900 psig saturated steam consumption per Mlbs/hr of
;                  extract, (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(27) = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;       REAL(28) = 600 psig / 720 F steam consumption per Mlbs/hr of
;                  extract, (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(29) = Constant factor for the 600 psig saturated steam
;                  consumption, Mlbs/hr.
;       REAL(30) = 600 psig saturated steam consumption per Mlbs/hr of
;                  extract, (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(31) = Constant factor for the 150 psig saturated steam
;                  consumption, Mlbs/hr.
;       REAL(32) = 150 psig saturated steam consumption per Mlbs/hr of
;                  extract, (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(33) = Constant factor for the 50 psig saturated steam
;                  consumption, Mlbs/hr.
;       REAL(34) = 50 psig saturated steam consumption per Mlbs/hr of
;                  extract, (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(35) = Constant factor for the plant fuel consumption,
;                  MM BTU/hr.
;       REAL(36) = Plant fuel consumption per Mlbs/hr of extract,
;                  (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(37) = Constant factor for the cooling water consumption,
;                  Mgal/hr.
;       REAL(38) = Cooling water consumption per Mlbs/hr of extract,
;                  (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(39) = Constant factor for the process water consumption,
;                  Mgal/hr.
;       REAL(40) = Process water consumption per Mlbs/hr of extract,
;                  (Mlbs/hr)/(Mlbs/hr of extract).
;       REAL(41) = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2
;       REAL(42) = Nitrogen consumption per Mlbs/hr of extract,
;                  (MM SCF/hr of N2)/(Mlbs/hr of extract).
;       REAL(43) -
;       REAL(48) = Future use.
;       REAL(49) = Constant factor for the number of operators per
;                  day, operators/day.
;       REAL(50) = Number of operators per day per train,
;                  (operators/day)/train.
;       REAL(51) = Reference feed rate to a single train in Mlbs/hr of
;                  unit feed for the calculation of the capital cost of
;                  a single train as a function of train capacity.
;       REAL(52) = Maximum size of a single train as defined by the
;                  unit feed rate in Mlbs/hr of unit feed.
```

```
;       REAL(53)  = Minimum size of a single train as defined by the
;                   unit feed rate in Mlbs/hr of unit feed.
;       REAL(54)  = Constant A in the plant costing equation.
;       REAL(55)  = Constant B in the plant costing equation.
;       REAL(56)  = Constant E in the plant costing equation.
;       REAL(57)  = Constant F in the plant costing equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;          Hydrocarbon rejection factor
    REAL  1.0  &
;          Future use (9 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam    900 satd steam
           0.0 8.098677       0.0 0.0            0.0 0.0       &
;          600/720 F steam    600 satd steam     150 satd steam
           0.0 0.0            0.0 0.0            0.0 0.0471832 &
;          50 satd steam      Plant fuel         Cooling H2O
           0.0 0.0            0.0 0.393518       0.0 0.0       &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.  0.  0.  0.  0.  0.             &
;          Opers/day     (Opers/day)/train
           0.0           8.0                  &
;          Ref Flow   Max Flow   Min Flow
           907.390   1500.0     500.0         &
;          Plant cost equation constants.
;          A      B        E      F      Spares   Future use (2 items)
           0.0    42.2     0.7215 1.0    0.0      0.0   0.0    &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR81.
   FLASH-SPECS STRM = ROSE-XTR  KODE=2   TEMP = 300.0  PRES = 115.0 /
               STRM = ASH-CONC  KODE=2   TEMP = 150.0  PRES = 14.7
;
; Plant 9 - H2 Production by coal gasification, Use the User Fortran
; Block USR09.
BLOCK P09 USER
   SUBROUTINE MODEL = USR09   REPORT = USR09
   DESCRIPTION 'PLANT 9 - H2 PRODUCTION BY COAL GASIFICATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;       The following 4 integer parameters are:
;       INT(1) = User block summary report control switch.
;                0 => Write the complete user block summary report.
;                1 => Skip the capital cost portion of the summary
;                     report.
;                2 => Skip the capital cost and utilities portions
;                     of the summary report.
;                3 => Skip writing the entire user block summary report.
;       INT(2) = User block summary report destination control switch.
```

```
;                0 => Write the user block summary report to the normal
;                     ASPEN/SP output report file called DCL09.REP.
;                1 => Write the user block summary report to a separate
;                      user block output report file on logical unit 62.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;                If INT(3) = 0, the minimum number of duplicate
;                  trains will be determined so that the capacity
;                  of each train does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Molar CO/CO2 ratio in the gasifier product gas.
;      REAL(2)    = Fraction of carbon entering the gasifier that goes
;                   to carbonyl sulfide (COS).
;      REAL(3)    = Fraction of carbon entering the gasifier that goes
;                   to methane (CH4).
;      REAL(4)    = Fraction of nitrogen entering the gasifier that goes
;                   to ammonia (NH3).
;      REAL(5)    = Carbon content of the slag produced by the gasifier,
;                   wt %.
;      REAL(6)    = Fraction of carbon monoxide (CO) entering the shift
;                   reactors that is shifted; i.e., converted to carbon
;                   dioxide (CO2) by the chemical reaction
;                       CO + H2O -----> CO2 + H2
;      REAL(7)    = Fraction of carbonyl sulfide (COS) entering the shift
;                   reactor section that is hydrolyzed; i.e., converted
;                   to carbon dioxide (CO2) and hydrogen sulfide (H2S)
;                   by the chemical reaction
;                       COS + H2O -----> CO2 + H2S
;      REAL(8)    = Future use.
;      REAL(9)-
;       REAL(20)  = Rectisol section component distribution factors,
;                   where
;      REAL(9)    = Fraction of inlet H2 going to the hydrogen-rich
;                   gas stream.
;      REAL(10)   = Fraction of inlet H2 going to the acid gas stream.
;      REAL(11)   = Fraction of inlet CO going to the hydrogen-rich
;                   gas stream.
;      REAL(12)   = Fraction of inlet CO going to the acid gas stream.
;      REAL(13)   = Fraction of inlet CO2 going to the hydrogen-rich
;                   gas stream.
;      REAL(14)   = Fraction of inlet CO2 going to the acid gas stream.
;      REAL(15)   = Fraction of inlet CH4 going to the hydrogen-rich
;                   gas stream.
;      REAL(16)   = Fraction of inlet CH4 going to the acid gas stream.
;      REAL(17)   = Fraction of inlet N2 going to the hydrogen-rich
```

```
;                 gas stream.
;     REAL(18)  = Fraction of inlet N2 going to the acid gas stream.
;     REAL(19)  = Fraction of inlet H2S going to the hydrogen-rich
;                 gas stream.
;     REAL(20)  = Fraction of inlet H2S going to the acid gas stream.
;     REAL(21)  = Constant factor for the power consumption, kw.
;     REAL(22)  = Power consumption per MM SCF/hr of hydrogen
;                 produced, kw/(MM SCF/hr of H2).
;     REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                 consumption, Mlbs/hr.
;     REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr of
;                 hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;     REAL(25)  = Constant factor for the 900 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr of
;                 hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;     REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                 consumption, Mlbs/hr.
;     REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr of
;                 hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;     REAL(29)  = Constant factor for the 600 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr of
;                 hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;     REAL(31)  = Constant factor for the 150 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                 hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;     REAL(33)  = Constant factor for the 50 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                 hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;     REAL(35)  = Constant factor for the plant fuel consumption,
;                 MM BTU/hr.
;     REAL(36)  = Plant fuel consumption per MM SCF/hr of hydrogen
;                 produced, (MM BTU/hr)/(MM SCF/hr of H2).
;     REAL(37)  = Constant factor for the cooling water consumption,
;                 Mgal/hr.
;     REAL(38)  = Cooling water consumption per MM SCF/hr of hydrogen
;                 produced, (Mgal/hr)/(MM SCF/hr of H2).
;     REAL(39)  = Constant factor for the process water consumption,
;                 Mgal/hr.
;     REAL(40)  = Process water consumption per MM SCF/hr of hydrogen
;                 produced, (Mgal/hr)/(MM SCF/hr of H2).
;     REAL(41)  = Constant factor for the nitrogen consumption,
;                 MM SCF/hr of N2.
;     REAL(42)  = Nitrogen consumption per MM SCF/hr of hydrogen
;                 produced, (MM SCF/hr of N2)/(MM SCF/hr of H2).
;     REAL(43) -
;      REAL(48) = Future use.
;     REAL(49)  = Constant factor for the number of operators per
;                 day, operators/day.
;     REAL(50)  = Number of operators per day per operating train,
;                 (operators/day)/train.
;     REAL(51)  = Reference hydrogen production rate of a single train
```

```
;                 in MM SCF/hr of H2 for the calculation of the ISBL
;                 field cost of a single train as a function of train
;                 capacity.
;     REAL(52)  = Maximum size of a single train as defined by the
;                 hydrogen production rate in MM SCF/hr of H2.
;     REAL(53)  = Minimum size of a single train as defined by the
;                 hydrogen production rate in MM SCF/hr of H2.
;     REAL(54)  = Constant A in the plant ISBL field cost equation.
;     REAL(55)  = Constant B in the plant ISBL field cost equation.
;     REAL(56)  = Constant E in the plant ISBL field cost equation.
;     REAL(57)  = Constant F in the plant ISBL field cost equation.
;     REAL(58)  = Number of spare plants.
;     REAL(59) -
;      REAL(70) = Future use.
;
;  NOTE:  MM SCF/hr of hydrogen produced means MM SCF/hr of hydrogen
;         in the hydrogen-rich product gas stream and NOT the total
;         flow rate of the hydrogen-rich product gas stream.
;
;                   Frac C       Frac C   Frac N   %C in
;         CO/CO2    to COS       to CH4   to NH3   slag
    REAL 2.419768  0.000804005  0.0      0.05212  5.229154  &
;         Frac CO shifted  Frac COS hydrolyzed  Future use
;         Adjust the fraction of CO shifted to get true H2 rate.
          0.9611           0.9516917            0.0          &
;         Component distribution factors for H2 to H2 and acid gas.
          0.8344      0.00153604                             &
;         Component distribution factors for CO to H2 and acid gas.
          0.0         0.0545937                              &
;         Component distribution factors for CO2 to H2 and acid gas.
          0.0         0.0453275                              &
;         Component distribution factors for CH4 to H2 and acid gas.
          0.0         0.0                                    &
;         Component distribution factors for N2 to H2 and acid gas.
          0.0932727   0.0923972                              &
;         Component distribution factors for H2S to H2 and acid gas.
          0.0         0.990203                               &
;         Power              900/750 F steam   900 satd steam
          0.0 3679.14335     0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 -16.98424     0.0 -44.40466 &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 -45.47563      0.0 -57.09919     0.0 183.6952  &
;         Process H2O        Nitrogen
          0.0 4.176796       0.0 0.0824568   &
;         Future Use (6 items)
          0.  0.  0.  0.  0.  0.             &
;         Opers/day     (Opers/day)/train
          0.0           24.                  &
;         Ref Flow   Max Flow   Min Flow
          3.436      3.5        1.0         &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future use (3 items)
          0.0    52.7    0.7658 1.0    0.       0.0   0.0    &
;         Future use (10 items)
```

```
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR09.
   FLASH-SPECS STRM = H2-GAS    KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = H2S-GAS   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = VENT-GAS  KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = 9S-SH2O   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = SLAG      KODE=2   TEMP = 80.   PRES = 14.7
;
;  Plant 9.1 - Steam Reforming of Natural Gas Plant.
BLOCK P91 USER
   SUBROUTINE MODEL = USR91   REPORT = USR91
   DESCRIPTION 'PLANT 9.1 - STEAM REFORMING OF NATURAL GAS PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL91.REP.
;      INT(3) = Number of operating duplicate plants, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 plants will be determined so that the capacity
;                 of each plant does not exceed the maximum plant
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, this number of duplicate plants will
;                 be used.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Fraction of CH4 reacting to produce H2 and CO2.
;      REAL(2)   = Fraction of CH4 reacting to produce H2 and CO.
;      REAL(3)   = Fraction of hydrogen produced that leaves in the
;                  hydrogen-rich product gas stream.
;      REAL(4)   = Purity of the hydrogen-rich product gas. mole %.
;      REAL(5) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per MM SCF/hr of hydrogen produced,
```

```
;                 kw/(MM SCF/hr of H2).
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                   hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per MM SCF/hr of hydrogen
;                   produced, (MM BTU/hr)/(MM SCF/hr of H2).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per MM SCF/hr of hydrogen
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per MM SCF/hr of hydrogen
;                   produced, (Mgal/hr)/(MM SCF/hr of H2).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2..
;       REAL(42)  = Nitrogen consumption per MM SCF/hr of hydrogen
;                   produced, (MM SCF/hr of N2)/(MM SCF/hr of H2).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
;       REAL(51)  = Reference hydrogen production rate of a single train
;                   in MM SCF/hr of H2 for the calculation of the ISBL
;                   field cost of a single train as a function of train
;                   capacity.
;       REAL(52)  = Maximum plant size as defined by the hydrogen
;                   production rate in MM SCF/hr of H2.
;       REAL(53)  = Minimum plant size as defined by the hydrogen
;                   production rate in MM SCF/hr of H2.
;
```

```
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare plants.
;       REAL(59) -
;        REAL(70) = Future use.
;
;  NOTES: 1. MM SCF/hr of hydrogen produced means MM SCF/hr of hydrogen
;            in the hydrogen rich product gas stream and NOT the total
;            flow rate of the hydrogen rich product gas stream.
;         2. The number of operators in this plant and Plants 31.1 and
;            31.4 is set so as to maintain the same total number of
;            operators as used for the baseline design.
;
;         Frac CH4 to CO2  Frac CH4 to CO  Frac recovered  H2 Purity
     REAL 0.638648         0.04429         0.8862694       100.0 &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0                      &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 354.158        0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0 0.0            0.0 -65.3773      0.0 0.0       &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 89.0448       0.0 32.6902   &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0           &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0         &
;         Opers/day      (Opers/day)/train
          0.0            8.0                   &
;         Ref Flow       Max Flow     Min Flow
          5.77237        6.25         2.0      &
;         Plant cost equation constants.
;         A      B      E      F      Spares   Future Use (2 items)
          0.0    68.1   0.75   1.0    0.0      0.0    0.0    &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR091.
   FLASH-SPECS STRM = H2-PROD    KODE=2  TEMP = 100.0  PRES = 500.0 /
               STRM = FLUE-GAS   KODE=2  TEMP = 250.0  PRES = 14.7
;
; Plant 10 - Air Separation Plant - Use the User Fortran Model USR10.
BLOCK P10 USER
   SUBROUTINE MODEL = USR10   REPORT = USR10
   DESCRIPTION 'PLANT 10 - AIR SEPARATION PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
```

```
;                    report.
;                 2 => Skip the capital cost and utilities portions
;                      of the summary report.
;                 3 => Skip writing the entire user block summary report.
;       INT(2) = User block summary report destination control switch.
;                 0 => Write the complete user block summary report to
;                      the normal ASPEN/SP output report file.
;                 1 => Write the complete user block summary report to
;                      a separate user block output report file on
;                      logical unit 62 CALLED DCL10.REP.
;       INT(3) = Number of operating duplicate trains, excluding
;                spares.
;                If INT(3) = 0, the minimun number of duplicate
;                  trains will be determined so that the capacity
;                  of each train does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate trains.
;       INT(4) = History file additional output control switch.
;                 0 => Write no additional output to the history file.
;                 1 => Write the only the subroutine entry and exit
;                      messages to the history file.
;                 2 => Write some additional output to the history file.
;               3-5 => Write some more additional output to the history
;                      file.  Larger values generate more intermediate
;                      output.
      INT  0  1  0  1
;       The following 70 real parameters are:
;       REAL(1)   = Purity of the product oxygen stream, mole %.
;       REAL(2)   = Purity of the product nitrogen stream, mole %.
;       REAL(3) -
;        REAL(20) = Future use.
;       REAL(21)  = Constant factor for the power consumption, kw.
;       REAL(22)  = Power consumption per MM SCF/hr of the oxygen stream
;                   flow rate, kw/(MM SCF/hr of O2).
;       REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;       REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr of
;                   the oxygen stream flow rate,
;                   (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr of
;                   the oxygen stream flow rate,
;                   (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr of
;                   the oxygen stream flow rate,
;                   (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr of
;                   the oxygen stream flow rate,
;                   (Mlbs/hr)/(MM SCF/hr of O2).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
```

```
;                 consumption, Mlbs/hr.
;      REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr of
;                  the oxygen stream flow rate,
;                  (Mlbs/hr)/(MM SCF/hr of O2).
;      REAL(33)  = Constant factor for the 50 psig saturated steam
;                  consumption, Mlbs/hr.
;      REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr of
;                  the oxygen stream flow rate,
;                  (Mlbs/hr)/(MM SCF/hr of O2).
;      REAL(35)  = Constant factor for the plant fuel consumption,
;                  MM BTU/hr.
;      REAL(36)  = Plant fuel consumption per MM SCF/hr of the oxygen
;                  stream flow rate, (MM BTU/hr)/(MM SCF/hr of O2).
;      REAL(37)  = Constant factor for the cooling water consumption,
;                  Mgal/hr.
;      REAL(38)  = Cooling water consumption per MM SCF/hr of the oxygen
;                  stream flow rate, (Mgal/hr)/(MM SCF/hr of O2).
;      REAL(39)  = Constant factor for the process water consumption,
;                  Mgal/hr.
;      REAL(40)  = Process water consumption per MM SCF/hr of the oxygen
;                  stream flow rate, (Mgal/hr)/(MM SCF/hr of O2).
;      REAL(41)  = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2.
;      REAL(42)  = Nitrogen consumption per MM SCF/hr of the oxygen
;                  stream flow rate,
;                  (MM SCF/hr of N2)/(MM SCF/hr of O2).
;      REAL(43) -
;       REAL(48) = Future use.
;      REAL(49)  = Constant factor for the number of operators per
;                  day, operators/day.
;      REAL(50)  = Number of operators per day per train,
;                  (operators/day)/train.
;      REAL(51)  = Reference oxygen production rate for a single train
;                  in MM SCF/hr of O2 for the calculation of the
;                  ISBL field cost of a single train as a function of
;                  train capacity.
;      REAL(52)  = Maximum size of a single train as defined by the
;                  oxygen production rate in MM SCF/hr of O2.
;      REAL(53)  = Minimum size of a single train as defined by the
;                  oxygen production rate in MM SCF/hr of O2.
;      REAL(54)  = Constant A in the plant ISBL field cost equation.
;      REAL(55)  = Constant B in the plant ISBL field cost equation.
;      REAL(56)  = Constant E in the plant ISBL field cost equation.
;      REAL(57)  = Constant F in the plant ISBL field cost equation.
;      REAL(58)  = Number of spare trains.
;      REAL(59) -
;       REAL(70) = Future use.
;
;     NOTES:
;       1.  This model does not consider Argon as a separate element.
;           Hence, argon is lumped with nitrogen.
;       2.  MM SCF/hr of O2 means the oxygen production rate in
;           MM SCF/hr of O2 in the product oxygen stream and NOT
;           the total flow rate of the product oxygen stream.
;
```

```
;          %O2 in O2    %N2 in N2   Future Use (8 items)
      REAL 99.5003      100.0       0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Future Use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 18143.97       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.0           0.0 0.0       &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 0.0            0.0 0.0           0.0 0.0       &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           4.0           0.0                 &
;          Ref Flow     Max Flow     Min Flow
           1.763605     1.875        1.0     &
;          Plant cost equation costants.
;          A       B       E       F      Spares   Future use (2 items)
           0.0     38.2    0.7028  1.0    0.0      0.0   0.0    &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR10.
   FLASH-SPECS STRM = 10S01   KODE=2   TEMP =   80.0   PRES = 350.0  /
               STRM = 10S02   KODE=2   TEMP = -275.0   PRES = 164.7
;
; Plant 11 - Sulfur Recovery Plant, Use the User Fortran Model USR11.
BLOCK P11 USER
   SUBROUTINE MODEL = USR11   REPORT = USR11
   DESCRIPTION 'PLANT 11 - THE SULFUR RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the
;                    normal ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL11.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimun number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
```

```
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;     The following 70 real parameters are:
;     REAL(1)    = Fractional sulfur recovery; fraction of sulfur in
;                  the entering H2S and COS that is recovered in the
;                  product liquid sulfur stream.  All entering liquid
;                  sulfur entering in the feed stream is assumed to
;                  be recovered in the liquid sulfur product stream.
;     REAL(2) -
;      REAL(20) = Future use.
;     REAL(21)   = Constant factor for the power consumption, kw.
;     REAL(22)   = Power consumption per Mlbs/hr of product sulfur,
;                  kw/(Mlbs/hr).
;     REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;     REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                  product sulfur, (Mlbs/hr)/(Mlbs/hr).
;     REAL(25)   = Constant factor for the 900 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                  product sulfur, (Mlbs/hr)/(Mlbs/hr).
;     REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                  consumption, Mlbs/hr.
;     REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                  product sulfur, (Mlbs/hr)/(Mlbs/hr).
;     REAL(29)   = Constant factor for the 600 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                  product sulfur, (Mlbs/hr)/(Mlbs/hr).
;     REAL(31)   = Constant factor for the 150 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                  product sulfur, (Mlbs/hr)/(Mlbs/hr).
;     REAL(33)   = Constant factor for the 50 psig saturated steam
;                  consumption, Mlbs/hr.
;     REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                  product sulfur, (Mlbs/hr)/(Mlbs/hr).
;     REAL(35)   = Constant factor for the plant fuel consumption,
;                  MM BTU/hr.
;     REAL(36)   = Plant fuel consumption per Mlbs/hr of product sulfur,
;                  (MM BTU/hr)/(Mlbs/hr).
;     REAL(37)   = Constant factor for the cooling water consumption,
;                  Mgal/hr.
;     REAL(38)   = Cooling water consumption per Mlbs/hr of product
;                  sulfur (Mgal/hr)/(Mlbs/hr).
;     REAL(39)   = Constant factor for the process water consumption,
;                  Mgal/hr.
;     REAL(40)   = Process water consumption per Mlbs/hr of product
;                  sulfur, (Mgal/hr)/(Mlbs/hr).
```

```
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrigen consumption per Mlbs/hr of product sulfur,
;                   (MM SCF/hr of N2)/(Mlbs/hr).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per train,
;                   (operators/day)/train.
;       REAL(51)  = Reference product sulfur flow rate of a single train
;                   in Mlbs/hr of S for the calculation of the ISBL field
;                   cost of a single train as a function of capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   product sulfur flow rate in Mlbs/hr of S.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   product sulfur flow rate in Mlbs/hr of S.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
;       REAL(58)  = Number of spare trains.
;       REAL(59) -
;        REAL(70) = Future use.
;
;          S recovery
     REAL 0.998482    &
;          Future Use (19 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0       &
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;          Power              900/750 F steam   900 satd steam
           0.0 49.60954       0.0 0.0           0.0 0.0       &
;          600/720 F steam    600 satd steam    150 satd steam
           0.0 0.0            0.0 0.971388      0.0 -3.022277 &
;          50 satd steam      Plant fuel        Cooling  H2O
           0.0 0.882473       0.0 1.117916      0.0 7.89929   &
;          Process H2O        Nitrogen
           0.0 0.0            0.0 0.0         &
;          Future Use (6 items)
           0.0  0.0  0.0  0.0  0.0  0.0      &
;          Opers/day     (Opers/day)/train
           0.0           5.0                &
;          Ref Flow     Max Flow     Min Flow
           15.4305      16.5         5.0      &
;          Plant cost equation costants.
;          A       B        E      F      Spares   Future use (3 items)
           0.0     11.675   0.7823 1.0    0.0      0.0   0.0    &
;          Future use (10 items)
           0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR01.
   FLASH-SPECS STRM = 11S-FGAS  KODE=2   TEMP = 80.0   PRES = 14.7  /
               STRM = 11S-LIQS  KODE=2   TEMP = 80.0   PRES = 14.7
;
```

```
; Plant 31 - The Utilities plant - user Fortran block USR31.
BLOCK P31 USER
   SUBROUTINE MODEL = USR31   REPORT = USR31
   DESCRIPTION 'PLANTS 31 - THE UTILITIES PLANT'
   PARAM  NINT = 20   NREAL = 20
;      The following 20 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Not used.
;               2 => Not used.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCLO2.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each train does not exceed the maximum train
;                 capacity specified by variable REAL(2).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
;      INT(5) = Future use.
;      INT(6) -  Switches to select which fuels are burned in the steam
;       INT(10)  boiler to produce steam and/or electric power to
;                satisfy the steam demand.  The fuel specified in
;                INT(6) is used until it is all consumed, the steam
;                demand is satisfied, or the capacity to use this fuel
;                is reached.  Then the INT(7) fuel is used, etc.
;                The fuel codes are
;                  1 = Coal
;                  2 = ROSE-SR unit bottoms
;                  3 = Coke
;                  4 = Natural gas
;                  5 = Plant fuel
;      INT(11) - Switches to select which fuels are burned to satisfy
;       INT(16)  the electric power demand.  The fuel specified in
;                INT(11) is used until it is all consumed, the power
;                demand is satisfied, or the capacity to use this fuel
;                is reached.  Then the INT(12) fuel is used, etc.
;                The fuel codes are
;                  1 = Coal
;                  2 = ROSE-SR unit bottoms
;                  3 = Coke
;                  4 = Natural gas
;                  5 = Plant fuel
```

```
;                    6 = Purchased electric power
;       INT(17) -
;        INT(20)  Future use.
     INT  0  1  0  1  0  4  1  2  3  5    &
          4  1  2  3  5  6  0  0  0  0
;
;       The following 20 real parameters are:
;       REAL(1)  = Reference electric power generation rate of a single
;                  train in MW.
;       REAL(2)  = Maximum size of a single train as defined by the
;                  electric power generation rate in MW.
;       REAL(3)  = Minimum size of a single train as defined by the
;                  electric power generation rate in MW.
;       REAL(4)  = Constant A in the plant costing equation.
;       REAL(5)  = Constant B in the plant costing equation.
;       REAL(6)  = Constant E in the plant costing equation.
;       REAL(7)  = Constant F in the plant costing equation.
;       REAL(8)  = Number of spare trains.
;       REAL(9)  = Future use
;       REAL(10) = Future use
;       REAL(11) = Constant factor for the number of operators per
;                  day, operators/day.
;       REAL(12) = Number of operators per day per train,
;                  (operators/day)/train.
;       REAL(13) -
;        REAL(20) = Future use.
;
;          Ref MW    Max size   Min size
     REAL 79.259    84.0       1.0        &
;          Plant cost equation constants.
;          A      B       E      F      Spares   Future use (2 items)
           0.0    87.466  0.7    1.0    0.0      0.0   0.0   &
;          Opers/day     (Opers/day)/train
           6.0           2.0                  &
;          Future use (8 items)
           0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
;
; Plants 31.1 and 31.4 - The Fluidized Bed Combustor and Steam Turbine
; Generator unit - user Fortran block USRA6.
BLOCK P314 USER
   SUBROUTINE MODEL = USRA6   REPORT = USRA6
   DESCRIPTION 'PLANTS 31.1 AND 31.4 - THE FLUIDIZED BED COMBUSTOR AND
   STEAM TURBINE GENERATOR UNIT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
```

```
;                1 => Write the user block summary report to a separate
;                     user block output report file on logical unit 62
;                     called DCLA6.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;                If INT(3) = 0, the minimum number of duplicate
;                  trains will be determined so that the capacity
;                  of each train does not exceed the maximum train
;                  capacity specified by variable REAL(52).
;                If INT(3) > 0, the number of duplicate plants.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Solids production expressed as fraction of URCOAL
;                   in feed ending up in solids.
;      REAL(2)-
;       REAL(20) = Future use.
;      REAL(21)   = Constant factor for the power consumption, kw.
;      REAL(22)   = Power consumption per Mlbs/hr of unit feed,
;                   kw/(Mlbs/hr of unit feed).
;      REAL(23)   = Constant factor for the 900 psig / 750 F steam
;                   consumption, Mlbs/hr.
;      REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(25)   = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(27)   = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;      REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(29)   = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(31)   = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(33)   = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;      REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr of
;                   unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(35)   = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;      REAL(36)   = Plant fuel consumption per Mlbs/hr of unit feed,
;                   (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(37)   = Constant factor for the cooling water consumption,
```

```
;                    Mgal/hr.
;      REAL(38)  = Cooling water consumption per Mlbs/hr of unit feed,
;                  (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(39)  = Constant factor for the process water consumption,
;                  Mgal/hr.
;      REAL(40)  = Process water consumption per Mlbs/hr of unit feed,
;                  (Mlbs/hr)/(Mlbs/hr of unit feed).
;      REAL(41)  = Constant factor for the nitrogen consumption,
;                  MM SCF/hr of N2
;      REAL(42)  = Nitrogen consumption per Mlbs/hr of unit feed,
;                  (MM SCF/hr of N2)/(Mlbs/hr of unit feed).
;      REAL(43) -
;       REAL(48) = Future use.
;      REAL(49)  = Constant factor for the number of operators per
;                  day, operators/day.
;      REAL(50)  = Number of operators per day per train,
;                  (operators/day)/train.
;      REAL(51)  = Reference feed rate to a single train in Mlbs/hr of
;                  unit feed for the calculation of the ISBL field cost
;                  of a single train as a function of train capacity.
;      REAL(52)  = Maximum size of a single train as defined by the
;                  unit feed rate in Mlbs/hr of unit feed.
;      REAL(53)  = Minimum size of a single train as defined by the
;                  unit feed rate in Mlbs/hr of unit feed.
;      REAL(54)  = Constant A in the plant ISBL field cost equation.
;      REAL(55)  = Constant B in the plant ISBL field cost equation.
;      REAL(56)  = Constant E in the plant ISBL field cost equation.
;      REAL(57)  = Constant F in the plant ISBL field cost equation.
;      REAL(58)  = Number of spare trains.
;      REAL(59) -
;       REAL(70) = Future use.
;
;  NOTE: The number of operators in this plant and Plant 91is set so
;            as to maintain the same total number of operators as used
;            for the baseline design.
;
;         Fraction of URCOAL in feed ending up in solids
   REAL   0.8500914  &
;         Future use (9 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0        &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0   &
;         Power              900/750 F steam    900 satd steam
          0.0 -552.6474      0.0 0.0            0.0 0.0       &
;         600/720 F steam    600 satd steam     150 satd steam
          0.0 0.0            0.0 0.0            0.0 0.0       &
;         50 satd steam      Plant fuel         Cooling H2O
          0.0 0.0            0.0 0.0            0.0 27.99327  &
;         Process H2O        Nitrogen
          0.0 0.06900667     0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0       &
;         Opers/day     (Opers/day)/train
          0.0           20.0                &
;         Ref Flow      Max Flow   Min Flow
```

```
          368.660      400.0      30.0      &
;         Plant cost equation constants.
;         A      B      E      F      Spares   Future use (2 items)
          0.0    0.0    0.75   1.0    0.0      0.0   0.0    &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;
;  Set the temperature and pressure of the outlet stream.  These
;  values will override the default values in subroutine USRA6.
   FLASH-SPECS STRM = SA6-01    KODE=2   TEMP = 130.0  PRES = 14.7
;
; Plant 38 - The Ammonia Recovery Plant - use user Fortran block USR38.
BLOCK P38 USER
   SUBROUTINE MODEL = USR38   REPORT = USR38
   DESCRIPTION 'PLANT 38 - THE AMMONIA RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL38.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
    INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)    = Ammonia recovery, percent.
;      REAL(2)    = Purity of ammonia product, wt %.
;      REAL(3) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of NH3 recovered,
;                  kw/(Mlbs/hr of NH3 recovered).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
```

```
;       REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(25)  = Constant factor for the 900 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                   consumption, Mlbs/hr.
;       REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(29)  = Constant factor for the 600 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(31)  = Constant factor for the 150 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(33)  = Constant factor for the 50 psig saturated steam
;                   consumption, Mlbs/hr.
;       REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                   NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(35)  = Constant factor for the plant fuel consumption,
;                   MM BTU/hr.
;       REAL(36)  = Plant fuel consumption per Mlbs/hr of NH3 recovered,
;                   (MM BTU/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(37)  = Constant factor for the cooling water consumption,
;                   Mgal/hr.
;       REAL(38)  = Cooling water consumption per Mlbs/hr of NH3
;                   recovered, (Mgal/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(39)  = Constant factor for the process water consumption,
;                   Mgal/hr.
;       REAL(40)  = Process water consumption per Mlbs/hr of NH3
;                   recovered, (Mgal/hr)/(Mlbs/hr of NH3 recovered).
;       REAL(41)  = Constant factor for the nitrogen consumption,
;                   MM SCF/hr of N2.
;       REAL(42)  = Nitrogen consumption per Mlbs/hr of NH3 recovered,
;                   (MM SCF/hr of N2)/(Mlbs/hr of NH3 recovered).
;       REAL(43) -
;        REAL(48) = Future use.
;       REAL(49)  = Constant factor for the number of operators per
;                   day, operators/day.
;       REAL(50)  = Number of operators per day per operating train,
;                   (operators/day)/train.
;       REAL(51)  = Reference NH3 recovery rate of a single train in
;                   Mlbs/hr for the calculation of the ISBL field cost
;                   of a single train as a function of train capacity.
;       REAL(52)  = Maximum size of a single train as defined by the
;                   NH3 recovery rate in Mlbs/hr of NH3 recovered.
;       REAL(53)  = Minimum size of a single train as defined by the
;                   NH3 recovery rate in Mlbs/hr of NH3 recovered.
;       REAL(54)  = Constant A in the plant ISBL field cost equation.
;       REAL(55)  = Constant B in the plant ISBL field cost equation.
;       REAL(56)  = Constant E in the plant ISBL field cost equation.
;       REAL(57)  = Constant F in the plant ISBL field cost equation.
```

```
;      REAL(58)  = Number of spare trains.
;      REAL(59) -
;       REAL(70) = Future use.
;
;         NH3 recovery, %     NH3 purity, wt%
    REAL 99.103              99.552              &
;         Future use (8 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 75.713367      0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0  0.0           0.0 16.124425     0.0 28.745809 &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 0.0            0.0 0.0           0.0 227.9442  &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0            &
;         Opers/day      (Opers/day)/train
          0.0            20.0                 &
;         Ref Flow   Max Flow   Min Flow
          20.221     100.0      5.0         &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future Use (3 items)
          0.0    40.1    0.7807 1.0    0.0      0.0   0.0   &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR38.
   FLASH-SPECS STRM = NH3-PROD  KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = 38S-OUT   KODE=2   TEMP = 80.   PRES = 14.7
;
;  Component splitter to generate the vapor and liquid streams
;  leaving Plant 38, the ammonia recovery plant.
BLOCK P38A SEP
   FRAC  SUBS = MIXED  STRM = 38AS-VAP                  &
   COMP = H2  N2  O2  H2S  CO  CO2  NH3                 &
          L-SULFUR H2O HCL COS CH4                      &
          C2H6 C3H8 IC4H10 NC4H10 IC5H12 NC5H12         &
          T125  T175  T225  T275  T325                  &
          T375  T425                                    &
          T475  T525  T575  T625  T675                  &
          P125  P175  P225  P275  P325  P375            &
          P425  P475  P525  P575  P625  P675            &
   FRAC = 1.0  1.0  1.0  0.9956  1.0  0.9985  0.07104   &
          0.0  0.002755  1.0  1.0  0.8888889            &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492     &
          0.9492 0.9492 0.9492 0.9492 0.9492            &
          0.9492 0.9492                                 &
          0.08481 0.08481 0.08481 0.08481 0.9492        &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492     &
          0.9492 0.9492 0.9492 0.9492 0.9492 0.9492
   FLASH-SPECS STRM = 38AS-VAP  TEMP=90.0  PRES=25.0  NPK=1  KPH=1 /
```

```
                STRM = 38AS-LIQ  TEMP=90.0  PRES=25.0  NPK=1  KPH=2
;
;  Flow splitter to generate the waste water stream going to the
;  gasifier, Plant 9, and the stream going to the phenol recovery
;  plant, Plant 39.
BLOCK P38B FSPLIT
   FRAC  WASTE  0.28595
   PARAM NPK=1  KPH=2
;
; Plant 39 - The PHENOL RECOVERY PLANT - Use user Fortran block USR39.
BLOCK P39 USER
   SUBROUTINE MODEL = USR39   REPORT = USR39
   DESCRIPTION 'PLANT 39 - THE PHENOL RECOVERY PLANT'
   PARAM  NINT = 4   NREAL = 70
;      The following 4 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the mormal
;                     ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL39.REP.
;      INT(3) = Number of operating duplicate trains, excluding spares.
;               If INT(3) = 0, the minimum number of duplicate
;                 trains will be determined so that the capacity
;                 of each plant does not exceed the maximum train
;                 capacity specified by variable REAL(52).
;               If INT(3) > 0, the number of duplicate trains.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
   INT  0  1  0  1
;      The following 70 real parameters are:
;      REAL(1)   = Phenol recovery, percent.
;      REAL(2)   = Purity of phenol product, wt %.
;      REAL(3) -
;       REAL(20) = Future use.
;      REAL(21)  = Constant factor for the power consumption, kw.
;      REAL(22)  = Power consumption per Mlbs/hr of phenol recovered,
;                  kw/(Mlbs/hr of phenol recovered).
;      REAL(23)  = Constant factor for the 900 psig / 750 F steam
;                  consumption, Mlbs/hr.
;      REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
;                  phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
```

```
;                 recovered).
;     REAL(25)  = Constant factor for the 900 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr of
;                 phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                 recovered).
;     REAL(27)  = Constant factor for the 600 psig / 720 F steam
;                 consumption, Mlbs/hr.
;     REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
;                 phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                 recovered).
;     REAL(29)  = Constant factor for the 600 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr of
;                 phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                 recovered).
;     REAL(31)  = Constant factor for the 150 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr of
;                 phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                 recovered).
;     REAL(33)  = Constant factor for the 50 psig saturated steam
;                 consumption, Mlbs/hr.
;     REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr of
;                 phenol recovered, (Mlbs/hr)/(Mlbs/hr of phenol
;                 recovered).
;     REAL(35)  = Constant factor for the plant fuel consumption,
;                 MM BTU/hr.
;     REAL(36)  = Plant fuel consumption per Mlbs/hr of phenol
;                 recovered,
;                 (MM BTU/hr)/(Mlbs/hr of phenol recovered).
;     REAL(37)  = Constant factor for the cooling water consumption,
;                 Mgal/hr.
;     REAL(39)  = Cooling water consumption per Mlbs/hr of phenol
;                 recovered, (Mgal/hr)/(Mlbs/hr of phenol recovered).
;     REAL(39)  = Constant factor for the process water consumption,
;                 Mgal/hr.
;     REAL(40)  = Process water consumption per Mlbs/hr of phenol
;                 recovered, (Mgal/hr)/(Mlbs/hr of phenol recovered).
;     REAL(41)  = Constant factor for the nitrogen consumption,
;                 MM SCF/hr of N2.
;     REAL(42)  = Nitrogen consumption per Mlbs/hr of phenol recovered,
;                 (MM SCF/hr of N2)/(Mlbs/hr of phenol recovered).
;     REAL(43) -
;      REAL(48) = Future use.
;     REAL(49)  = Constant factor for the number of operators per
;                 day, operators/day.
;     REAL(50)  = Number of operators per day per operating train,
;                 (operators/day)/train.
;     REAL(51)  = Reference phenol recovery rate of a single train in
;                 Mlbs/hr for the calculation of the IKSBL field cost
;                 of a single train as a function of train capacity.
;     REAL(52)  = Maximum size of a single train as defined by the
;                 phenol recovery rate in Mlbs/hr of phenol recovered.
;     REAL(53)  = Minimum size of a single train as defined by the
```

```
;                  phenol recovery rate in Mlbs/hr of phenol recovered.
;      REAL(54)  = Constant A in the plant ISBL field cost equation.
;      REAL(55)  = Constant B in the plant ISBL field cost equation.
;      REAL(56)  = Constant E in the plant ISBL field cost equation.
;      REAL(57)  = Constant F in the plant ISBL field cost equation.
;      REAL(58)  = Number of spare trains.
;      REAL(59) -
;       REAL(70) = Future use.
;
;    NOTE: In the above, phenol recovered means pure phenol recovered.
;
;         Phenol recovery, %     Phenol purity, wt%
     REAL 97.0089              89.62                &
;         Future use (8 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Future use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  &
;         Power              900/750 F steam   900 satd steam
          0.0 339.16667      0.0 0.0           0.0 0.0       &
;         600/720 F steam    600 satd steam    150 satd steam
          0.0  0.0           0.0 0.0           0.0 9.465     &
;         50 satd steam      Plant fuel        Cooling  H2O
          0.0 25.652917      0.0 0.0           0.0 111.775   &
;         Process H2O        Nitrogen
          0.0 0.0            0.0 0.0         &
;         Future Use (6 items)
          0.0  0.0  0.0  0.0  0.0  0.0      &
;         Opers/day     (Opers/day)/train
          0.0           0.0                 &
;         Ref Flow   Max Flow   Min Flow
          2.4        20.0       1.0        &
;         Plant cost equation constants.
;         A      B       E      F      Spares   Future Use (3 items)
          0.0    13.3    0.8056 1.0    0.0      0.0   0.0   &
;         Future Use (10 items)
          0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
;  Set the temperature and pressure of the outlet streams.  These
;  values will override the default values in subroutine USR39.
   FLASH-SPECS STRM = PHENOL   KODE=2   TEMP = 80.   PRES = 14.7  /
               STRM = WASTEH2O KODE=2   TEMP = 80.   PRES = 14.7
;
;  Plant SA6 separates the combined product stream from Plants 31.1
;  and 31.4 into two streams, one for flue gas and another for solids.
;  The separation is set to the URCOAL fraction in the solids stream.
BLOCK SA6 SEP
  FRAC  SUBS=NC    STREAM=FBC-SOL  COMP=URCOAL  FRAC=0.8500914   /
        SUBS=MIXED STREAM=FBC-SOL  COMP=T1000+  FRAC=1.0D-10
;
;  Splitter S1 - The Inlet Coal Splitter.  Used as a switch to divert
;  flow between the three different coal cleaning options, as represented
;  by the three different Coal Cleaning and Preparation Plants:
;  Base Case (1S01), Alternate Case 1 (1S11), and Alternate Case 2 (1S21).
BLOCK S1 FSPLIT
  DESCRIPTION 'INLET ROM COAL SPLITTER - COAL CLEANING SWITCH'
  FRAC  1S01 1.0 / 1S11 0.0 / 1S21 0.0
```

```
;
;  Splitter S2 - The Clean Coal Splitter.
BLOCK S2 FSPLIT
  DESCRIPTION 'CLEAN COAL SPLITTER'
  FRAC COALTO14 0.736227
;
;  Splitter S6-SH2O is a component splitter to generate a pseudo
;   sour-water stream from Plant 6 to get the NH3 to Plant 38, the
;   Ammonia Recovery Plant.
BLOCK S6-SH2O SEP
  DESCRIPTION 'SPLITTER TO GENERATE PSEUDO SOUR WATER FROM PLANT 6'
  FRAC  SUBS=MIXED  STREAM=6S-SH2O  COMP=NH3  FRAC=1.0
;
;  Splitter S7 - The Product Naphtha Splitter.  Used as a switch to
;  divert flow between the naphtha reformer, Plant 7 and output to
;  naphtha product.
BLOCK S7 FSPLIT
  DESCRIPTION 'HYDROTREATED NAPHTHA SPLITTER - REFORMER OPTION SWITCH'
;  ==================================================================
;  Use the following line to direct total flow to the reformer, or....
  FRAC  7-NAPH 1.0
;  Use the following line to direct total flow to the product stream.
;  FRAC PNAPHTHA 1.0
;
;  Splitter S8 - The Ash-Concentrate Splitter.  Used as a switch to
;  divert flow between the fluidized bed combustor, Plant 314 and the
;  coal gasification train; Plants M9C, P09, & P10.
BLOCK S8 FSPLIT
  DESCRIPTION 'ASH-CONCENTRATE SPLITTER - FBC OPTION 6 SWITCH'
;  Direct the ash-concentrate flow to coal gasification.
  FRAC  S8-ASHC 1.0
;
;  Splitter S9 - The dummy hydrogen splitter used to switch between
;  the two hydorgen production alternatives, Plant 9.0/10 - coal
;  gasification, or Plant 9.1 - steam reforming of methane.
BLOCK S9 FSPLIT
  DESCRIPTION 'DUMMY H2 SPLITTER - H2 GENERATION OPTION SWITCH'
;  Set an H2 target flow for Plant 9.0/10 - coal gasification.
  FRAC  H9NEED 1.0
  PARAM   NPK=1  KPH=1
;
; Stream Report Section
; ---------------------
;
STREAM-REPORT P1A
   STREAMS STRM = ROMCOAL 1S-CCOAL 9COAL COALTO14 COALTO2       &
                  14S-XMID 14S-REF 1S-XMID 1S-REFSE             &
                  ASH-CONC S8-ASHC COALTO9 9-FEED SLAG SOLVENT  &
                  2S-BOTTS FBC-FEED SA6-01 FBC-SOL FBC-GAS
   FLOW-FRAC SUBS=MIXED BASES=MASS / SUBS=NC BASES=MASS
   INTENSIVE-PROPS SUBS=MIXED BASES=MASS &
                   PROPS=TEMP PRES MW ENTH ENTR DENS HCAP /
                   SUBS=NC BASES=MASS &
                   PROPS=TEMP PRES MW ENTH DENS
   ATTRIBUTES SUBS=NC COMPONENT
```

```
;
STREAM-REPORT P1B
   STREAMS STRM = 1S-WATER 14S-WAT 2-H2OIN 2-H2IN H2MIX 2-H2MIX      &
                  SOLVENT ROSE-XTR 2S-GAS GASES 2S-SH2O              &
                  NAPHTHA GAS-OIL H2-RICH SOUR-GAS P61-GAS           &
                  H2-2RICH SOUR-2GS GAS-OUT NAPHTHA2 3-GAS           &
                  3S-SGAS 3S-FGAS 3S-PROP 3S-BUT 3S-OIL 3S-SH2O      &
                  4-FEED 4-H2IN 4-H2OIN 4S-GAS 4S-NAPH 4S-SH2O       &
                  5S-HPGAS 5S-LPGAS 5-H2IN 5-H2OIN                   &
                  5S-NAPH P350-450 P450-650 P650-850 5S-SH2O         &
                  PS-NAPH PNAPHTHA 7-NAPH 7S-H2 7S-GAS REFORMED      &
                  61-HYD 62-HYD M9H2 M9H4 M9H5 MHNEED                &
                  H9NEED H91NEED                                     &
                  10-AIRIN 10S01 10S02 9-O2IN 9-H2OIN 9-STEMIN       &
                  H2-GAS H2S-GAS VENT-GAS 9S-SH2O                    &
                  NAT-GAS STEAM H2-PROD FLUE-GAS                     &
                  6-SGAS 6S-SH2O 11-FEED 11S-FGAS 11S-LIQS 31S-01    &
                  38-FEED NH3-PROD 38S-OUT 38AS-VAP 38AS-LIQ         &
                  WASTE 39FEED PHENOL WASTEH2O
   FLOW-FRAC SUBS=MIXED BASES=MASS
   INTENSIVE-PROPS SUBS=MIXED BASES=MASS &
                   PROPS=TEMP PRES MW ENTH ENTR DENS HCAP
;
;  End of input file OPT7.INP
```

APPENDIX M

APPENDIX M

ASPEN/SP PROCESS SIMULATION MODEL

INPUT FILE FOR THE KINETIC REACTOR MODEL

ASPEN/SP PROCESS SIMULATION MODEL

INPUT FILE FOR THE KINETIC REACTOR MODEL

```
NEW
;
; File T2V2S.INP
;
TITLE 'T2V2S.INP - KINETIC MODEL SIMULATION OF PLANT 2 REACTORS'
;
DESCRIPTION &
 " ASPEN/SP INPUT FILE FOR SIMULATING THE COAL LIQUEFACTION REACTORS
   IN PLANT 2 WITH THE KINETIC MODEL FOR THE BASELINE DESIGN USING
   FIXED RECYCLE RATES."
;
;   Last revision - August 12, 1992.
;
;   Prepared under DOE contract no. DE-AC22 90PC89857.
;
IN-UNITS ENG
OUT-UNITS ENG
HISTORY-UNITS ENG
HISTORY
   MSG-LEVEL PROPERTIES=2
;
PROPERTIES SYSOP2/SYSOP4
;
COMPONENTS H2 H2 / N2 N2 / O2 O2 / H2S H2S / CO CO / CO2 CO2 / &
   NH3 H3N / L-SULFUR SULFUR / H2O H2O / HCL HCL / COS COS / &
   CH4 CH4 / C2H6 C2H6 / C3H8 C3H8 / IC4H10 C4H10-2 / &
   NC4H10 C4H10-1 / IC5H12 C5H12-2 / NC5H12 C5H12-1 / &
;  Pseudocomponents
   T125 / T175 / T225 / T275 / T325 / T375 / T425 / T475 / &
   T525 / T575 / T625 / T675 / T725 / T775 / T825 / T875 / &
   T925 / T975 / T1000+ / I1000+ / &
;  Non-conventional components
   COAL / URCOAL / SLAG
;
FORMULA  H2 H2 / N2 N2 / O2 O2 / H2S H2S / CO CO / CO2 CO2 / &
   NH3 H3N / L-SULFUR SULFUR / H2O H2O / HCL HCL / COS COS / &
   CH4 CH4 / C2H6 C2H6 / C3H8 C3H8 / IC4H10 C4H10-2 / &
   NC4H10 C4H10-1 / IC5H12 C5H12-2 / NC5H12 C5H12-1 / &
;
;  PHYSICAL PROPERTY DATA
;=======================
;
PSEUDO-COMPS
  METHOD METCCOAL
;  The following APIs and MWs are revised from the ASPEN/SP predictions.
   COMPONENT T125  TBP=324.82 <K>  API=67.91  MW= 82.27
   COMPONENT T175  TBP=352.59 <K>  API=61.99  MW= 92.77
   COMPONENT T225  TBP=380.37 <K>  API=56.21  MW=102.84
```

```
   COMPONENT T275  TBP=408.15 <K>  API=50.60  MW=112.50
   COMPONENT T325  TBP=435.93 <K>  API=45.18  MW=121.82
   COMPONENT T375  TBP=463.71 <K>  API=39.96  MW=130.86
   COMPONENT T425  TBP=491.48 <K>  API=34.96  MW=139.75
   COMPONENT T475  TBP=519.26 <K>  API=30.19  MW=148.60
   COMPONENT T525  TBP=547.04 <K>  API=25.66  MW=157.54
   COMPONENT T575  TBP=574.82 <K>  API=21.39  MW=166.69
   COMPONENT T625  TBP=602.59 <K>  API=17.38  MW=176.16
   COMPONENT T675  TBP=630.37 <K>  API=13.66  MW=186.05
   COMPONENT T725  TBP=658.15 <K>  API=10.23  MW=196.44
   COMPONENT T775  TBP=685.93 <K>  API= 7.09  MW=207.37
   COMPONENT T825  TBP=713.71 <K>  API= 4.27  MW=218.85
   COMPONENT T875  TBP=741.48 <K>  API= 1.78  MW=230.87
   COMPONENT T925  TBP=769.26 <K>  API=-0.39  MW=243.37
   COMPONENT T975  TBP=797.04 <K>  API=-2.22  MW=256.24
;  Component T1000+ is the 1000+ F material leaving the second coal
;    liquefaction reactor in Plant 2.
   COMPONENT T1000+ TBP=908.15 <K>  API=-5.94  MW=308.05
;  Component I1000+ is the 1000+ F intermediate material leaving the
;    first coal liquefaction reactor in Plant 2.
   COMPONENT I1000+ TBP=908.15<K>  API=-5.94  MW=308.05
;
;
; Load the liquid sulfur (L-SULFUR) physical properties as taken from
; DIPPR - MW adjusted to be consistent with ASPEN.
PROP-DATA  IN-UNITS SI
  PROP-LIST        MW     /    TC    /     PC     /    VC    /   ZC
  PVAL L-SULFUR   32.06 / 1313.0 / 1.8208E+7 / 0.15800 / 0.2640
  PROP-LIST       MUP    /  OMEGA /    TB     /   RGYR
  PVAL L-SULFUR   0.0    / 0.2624 /  717.82   /   0.0
  PROP-LIST         DELTA   /  DGFORM   /  DHFORM
  PVAL L-SULFUR   2.0245E+4 / 2.3825E+8 / 2.7880E+8
  PROP-LIST       CPIG
  PVAL L-SULFUR   2.5639E+4  -7.9870  4.7860E-3  -9.5700E-7  0.0  0.0  &
                  273.15  1500.0  0.0  87.113  1.0
; Load the solubility parameter for COS from the API Tech Data Book.
  PROP-LIST        DELTA
  PVAL COS         18179.
;
; Reset some component molecular weights to be consisitent with the
; following elemental atomic weights, where needed.
; H=1.0079, C=12.011,  O=15.9994,  N=14.0067, S=32.06 & Cl=35.453
;
  PROP-LIST        MW
  PVAL H2          2.0158
  PVAL N2         28.0134
  PVAL O2         31.9988
  PVAL H2S        34.0758
  PVAL CO         28.0104
  PVAL CO2        44.0098
  PVAL NH3        17.0304
  PVAL H2O        18.0152
  PVAL HCL        36.4609
  PVAL COS        60.0704
  PVAL CH4        16.0426
```

```
  PVAL C2H6        30.0694
  PVAL C3H8        44.0962
  PVAL IC4H10      58.1230
  PVAL NC4H10      58.1230
  PVAL IC5H12      72.1498
  PVAL NC5H12      72.1498
;
; Set the specific gravities of H2, NH3 and H2S to the values given
; in the API Technical Data Book - Petroleum Refining.
  PROP-LIST         SPGR
  PVAL H2          0.3000
  PVAL CO          0.3000
  PVAL CO2         0.8180
  PVAL NH3         0.6162
  PVAL H2S         0.8014
  PVAL N2          0.8094
  PVAL COS         1.02
;
ATTR-COMPS COAL   PROXANAL ULTANAL SULFANAL AOXANAL
ATTR-COMPS URCOAL PROXANAL ULTANAL SULFANAL AOXANAL
ATTR-COMPS SLAG   PROXANAL ULTANAL SULFANAL AOXANAL

NC-PROPS   COAL   ENTHALPY  HCJ1BOIE /
                  DENSITY   DCOALIGT
NC-PROPS   URCOAL ENTHALPY  HCJ1BOIE /
                  DENSITY   DCHARIGT
NC-PROPS   SLAG   ENTHALPY  HCJ1BOIE /
                  DENSITY   DCHARIGT
;
DEF-STREAMS MIXNC ALL
;
;  FLOWSHEET
;==========
;
FLOWSHEET MAIN
   BLOCK 2M-101A  IN=2SY1 2SY2              OUT=2SY
   BLOCK 2M-101   IN=1SX 2SY                OUT=2S1
   BLOCK 2M-102H  IN=9SX1 9SX2              OUT=9SX
   BLOCK 2C-103   IN=9SX                    OUT=2S45 2S46
   BLOCK 2M-104   IN=2S46 2S28A             OUT=2S28
   BLOCK 2M-102   IN=2S1 2S45               OUT=2S3
   BLOCK 2L-101   IN=2S3                    OUT=2S4
   BLOCK 2L-102   IN=2S28                   OUT=2S10
   BLOCK 2M-103   IN=2S10 2S4               OUT=2S5
   BLOCK P2RX1    IN=2S5                    OUT=2S6
   BLOCK 2M-107   IN=2S6 2S27               OUT=2S7
   BLOCK P2RX2    IN=2S7                    OUT=2S11
   BLOCK 2C-107   IN=2S11                   OUT=2S12 2S13
   BLOCK 2X107    IN=2S12                   OUT=2S14
   BLOCK 2C-110   IN=2S14                   OUT=2S15 2S16
   BLOCK 2X106    IN=2S15                   OUT=2S191
   BLOCK 2M-110   IN=2S191 2S17             OUT=2S19
   BLOCK 2C-113   IN=2S19                   OUT=2S50 2S21 2S22
   BLOCK 2C-115   IN=2S50                   OUT=2S20 2S51
   BLOCK 2C-108   IN=2S13                   OUT=2S271 2S281
```

```
   BLOCK 2X104     IN=2S271                    OUT=2S29
   BLOCK 2M-106    IN=2S29 2S16                OUT=2S30
   BLOCK 2C-111    IN=2S30                     OUT=2S31 2S32
   BLOCK 2X110     IN=2S31                     OUT=2S33
   BLOCK 2M-108    IN=2S33 2S21                OUT=2S34
   BLOCK 2C-114    IN=2S34                     OUT=2S35 2S36 2S37
   BLOCK 2C-109    IN=2S281                    OUT=2S38 2S39
   BLOCK 2X108     IN=2S38                     OUT=2S41
   BLOCK 2C-112    IN=2S41                     OUT=2S43 2S44 2S42
   BLOCK 2C-105    IN=2S39                     OUT=2S461 2S40
   BLOCK 2M-109    IN=2S36 2S44 2S40 2S32 2S51     OUT=2S451
   BLOCK 2X109     IN=2S451                    OUT=2S452
   BLOCK 2C-200    IN=2S452     OUT=2S200 2S201 2S202 2S203 2S204
   BLOCK 2C-201    IN=2S204                    OUT=2S205 2S206
   BLOCK 2C-202    IN=2S205     OUT=2S211 2S212 2S213 2S214 2S215 2S216
;
;  STREAMS
;=========
;
DEF-STREAMS MIXNC ALL
;
STREAM 2S17
   SUBSTREAM MIXED TEMP=70.0 <F> PRES=2980.0 <PSIA>
   MASS-FLOW H2O 219929.0 <LB/HR>
;
;  MAKE-UP H2
STREAM 9SX1
   SUBSTREAM MIXED TEMP=200.0 <F> PRES=3200.0 <PSIA>
   MASS-FLOW N2 2 <LB/HR> / H2 15759 <LB/HR> / H2O 1 <LB/HR> / &
            H2S 1 <LB/HR> / NH3 1 <LB/HR> / CO 1 <LB/HR> / &
            CO2 1 <LB/HR> / CH4 1 <LB/HR> / C2H6 1 <LB/HR> / &
            C3H8 1 <LB/HR> / NC4H10 1 <LB/HR> / &
            NC5H12 1 <LB/HR>
;
;  FIRST REACTOR (STAGE I) TREATED RECYCLE GAS
STREAM 9SX2
   SUBSTREAM MIXED TEMP=200.0 <F> PRES=3200.0 <PSIA>
   MASS-FLOW N2 2 <LB/HR> / H2 4037 <LB/HR> / H2O 1 <LB/HR> / &
            H2S 2 <LB/HR> / NH3 4 <LB/HR> / CO 1 <LB/HR> / &
            CO2 2 <LB/HR> / CH4 1261 <LB/HR> / C2H6 756 <LB/HR> / &
            C3H8 757 <LB/HR> / NC4H10 252 <LB/HR> / &
            NC5H12 2 <LB/HR>
;
; FIRST REACTOR (STAGE I) UNTREATED RECYCLE GAS
STREAM 2S28A
   SUBSTREAM MIXED TEMP=100.0 <F> PRES=3200.0 <PSIA>
   MASS-FLOW N2 2 <LB/HR> / H2 3528 <LB/HR> / H2O 1 <LB/HR> / &
            H2S 2241 <LB/HR> / NH3 475 <LB/HR> / CO 129 <LB/HR> / &
            CO2 205 <LB/HR> / CH4 5098 <LB/HR> / C2H6 2131 <LB/HR> / &
            C3H8 1410 <LB/HR> / NC4H10 398 <LB/HR> / &
            NC5H12 1130 <LB/HR>
;
; SECOND REACTOR (STAGE II) UNTREATED RECYCLE GAS
STREAM 2S27
   SUBSTREAM MIXED TEMP=100.0 <F> PRES=3200.0 <PSIA>
```

```
   MASS-FLOW N2 2 <LB/HR> / H2 23577 <LB/HR> / H2O 102 <LB/HR> / &
            H2S 14979 <LB/HR> / NH3 3179 <LB/HR> / CO 862 <LB/HR> / &
            CO2 1399 <LB/HR> / CH4 34067 <LB/HR> / C2H6 14240 <LB/HR> / &
            C3H8 9426 <LB/HR> / NC4H10 2664 <LB/HR> / &
            NC5H12 7556 <LB/HR>
;
STREAM 2SY1
   SUBSTREAM MIXED TEMP=400.0 <F> PRES=3200.0 <PSIA>
;  CONVENTIONAL COMPONENTS:
   MASS-FLOW H2O 3 <LB/HR> / NH3 3 <LB/HR> / C3H8 765 <LB/HR> /
         CH4 7 <LB/HR> / NC4H10 1 <LB/HR> / H2S 7 <LB/HR> /
         CO 1 <LB/HR> / IC4H10 252 <LB/HR> / NC5H12 0 <LB/HR> /
         CO2 3 <LB/HR> / IC5H12 448 <LB/HR> / H2 4 <LB/HR> /
         C2H6 4 <LB/HR> /
;  PSEUDOCOMPONENTS:
         T125 2 <LB/HR> / T175 2 <LB/HR> / T225 2 <LB/HR> /
         T275 2 <LB/HR> / T325 440 <LB/HR> / T375 235 <LB/HR> /
         T425 2 <LB/HR> / T475 4411 <LB/HR> / T525 4411 <LB/HR> /
         T575 4411 <LB/HR> / T625 4411 <LB/HR> / T675 23174 <LB/HR> /
         T725 23174 <LB/HR> / T775 23174 <LB/HR> / T825 23174 <LB/HR> /
         T875 41565 <LB/HR> / T925 41565 <LB/HR> / T975 41565 <LB/HR> /
         T1000+ 308956 <LB/HR>
;
STREAM 2SY2
;  NON-CONVENTIONAL COMPONENTS:
   SUBSTREAM NC TEMP=400.0 <F> PRES=3023.0 <PSIA>
   MASS-FLOW URCOAL 74917 <LB/HR>
   COMP-ATTR URCOAL PROXANAL (0.0 19.199 16.547 64.254) /
                    ULTANAL (64.254 28.688 1.938 0.577 0.0 1.292 3.250) /
                    SULFANAL (0.760 0.076 0.456) /
                    AOXANAL  (43.8 17.1 24.1 0.8 0.1 5.6 1.0 0.6 2.1 4.1)
   COMP-ATTR SLAG PROXANAL (0.0 10.0 0.0 90.0) /
                    ULTANAL (90.0 10.0 0.0 0.0 0.0 0.0 0.0 ) /
                    SULFANAL (0.0 0.0 0.0) /
                    AOXANAL  (42.0 17.0 23.0 1. 1. 6. 2. 1. 3. 4.)
;
STREAM 1SX
   SUBSTREAM MIXED TEMP=200.0 <F> PRES=3023.0 <PSIA>
   MASS-FLOW H2O 5817.
;  NON-CONVENTIONAL COMPONENTS:
   SUBSTREAM NC TEMP=200.0 <F> PRES=3023.0 <PSIA>
      MASS-FLOW  COAL  285035.
      COMP-ATTR COAL PROXANAL (0.0 47.55 40.99 11.47) /
                     ULTANAL (11.473 71.047 4.80 1.43 0.00 3.20 8.05) /
                     SULFANAL (1.88 0.19 1.13) /
                     AOXANAL (43.8 17.1 24.1 0.8 0.1 5.6 1.0 0.6 2.1 4.1)
;
FORTRAN SOLVENT
 DEFINE SOLV STREAM-VAR STREAM=2SY1 VARIABLE=MASS-FLOW
 DEFINE URC MASS-FLOW STREAM=2SY2 SUBSTREAM=NC COMPONENT=URCOAL
C     Set the weight ratio of unconverted coal (URCOAL) to solvent in
C     the solvent recycle stream.
F        URC = 0.137168*SOLV
   EXECUTE BEFORE 2M-101A
;
```

```
;  UNIT OPERATION BLOCKS
;=====================
;
BLOCK 2M-101A MIXER
  PROPERTIES SYSOP4
  PARAM PRES=-1.0
;
BLOCK 2M-101 MIXER
  PROPERTIES SYSOP4
  PARAM PRES=-1.0
;
BLOCK 2M-102H MIXER
  PROPERTIES SYSOP4
  PARAM PRES=-1.0
;
BLOCK 2C-103 FSPLIT
  PROPERTIES SYSOP4
  FRAC 2S45 0.05
;
BLOCK 2M-102 MIXER
  PROPERTIES SYSOP4
  PARAM PRES=-1.0
;
BLOCK 2M-104 MIXER
  PROPERTIES SYSOP4
  PARAM PRES=-1.0
;
BLOCK 2L-101 HEATER
  PROPERTIES SYSOP4
  PARAM TEMP=570 <F> PRES=3115.0 <PSIA>
;
BLOCK 2L-102 HEATER
  PROPERTIES SYSOP4
  PARAM TEMP=1050 <F> PRES=3070.0 <PSIA>
;
BLOCK 2M-103 MIXER
  PROPERTIES SYSOP4
  PARAM PRES=-5.0
;
;  Plant P2RX1 is the model for the first coal liquefaction reactor.
;    Stream 2S5 is the feed stream to the first Plant 2 coal
;      liquefaction reactor.
;    Stream 2S6 is the total reactor effluent from the first
;      Plant 2 coal liquefaction reactor.
;
; Plant 2 - The first coal liquefaction reactor - Fortran block USR2R.
BLOCK  P2RX1  USER
  PROPERTIES SYSOP4
   SUBROUTINE MODEL = USR2R   REPORT = USR2R
   DESCRIPTION 'PLANT 2 - COAL LIQUEFACTION REACTORS MODEL'
   PARAM  NINT = 5   NREAL = 20
;      The following 5 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
```

```
;                    report.
;                2 => Skip the capital cost and utilities portions
;                     of the summary report.
;                3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;                0 => Write the user block summary report to the normal
;                     ASPEN/SP output report file.
;                1 => Write the user block summary report to a separate
;                     user block output report file on logical unit 62
;                     called DCL02.REP.
;      INT(3) = Number of duplicate plants.  NOT APPLICABLE.
;      INT(4) = History file additional output control switch.
;                0 => Write no additional output to the history file.
;                1 => Write the only the subroutine entry and exit
;                     messages to the history file.
;                2 => Write some additional output to the history file.
;              3-5 => Write some more additional output to the history
;                     file.  Larger values generate more intermediate
;                     output.
;      INT(5) = Yields factor calculation switch
;                2 => Yields calculated in subroutine USR2R via a
;                     linear model for both coal liquefaction reactors.
;                3 => Called by subroutine USRR1
;                4 => Called by subroutine USRR2
;                5 => Yields calculated in subroutine USR2R via a
;                     kinetic model for both liquefaction reactors.
;                     Exact transfer of Lotus spreadsheet
;                6 => Yields calculated in subroutine USR2R via a
;                     kinetic model for first stage reactor system
;                     only.Call this model P2RX1.
;                7 => Yields calculated in subroutine USR2R via
;                     a kinetic model for second stage reactor.
;                     It is assumed that input to this are yields
;                     from P2RX1 plus recycle stream 2S27.
;                     Call this P2RX2.
   INT  0  1  0  4  6
;     The following 20 real parameters are:
;     REAL(1)   = Percent coal conversion based on fresh MAF coal
;                 entering the coal liquefaction reactors.
;     REAL(2)   = Future use.
;     REAL(3)   = RESID YIELD IN REACTOR I, %MAF
;     REAL(4)   = OVERALL UNCONVERTED COAL, %MAF
;     REAL(5)   = RESID LOSS IN ROSE, %MAF
;     REAL(6)   = COAL SV, LB MAF COAL/HR/LB CATALYST
;     REAL(7)   = FIXED CARBON, WT% MF
;     REAL(8)   = REACTOR ID STAGE I AND II, FEET
;     REAL(9)   = MAXIMUM REACTOR WEIGHT,1 322 SHORT TONS
;     REAL(10)  = REACTOR I, TEMP DEG F
;     REAL(11)  = REACTOR II, TEMP DEG F
;     REAL(12)  = STAGE I OUTLET PRESSURE, PSIA
;     REAL(13)  = STAGE II OUTLET PRESSURE, PSIA
;     REAL(14)  = MAXIMUM GAS VELOCITY, FPS
;     REAL(15)  = Unconverted coal, stage 1 % MAF
;     REAL(16)  -
;      REAL(20) = Future use.
```

```
;
     REAL 92.7901  &
;         Future use (4 items)
          0.0 26.80 7.54 8.13 1.12 50.68 15.0 1322.0 790.0  &
          760.0 3040.0 3010.0 0.197 10.2 0.0 0.0 0.0 0.0 0.0
;  Use the following FLASH-SPECS sentence to force ASPEN/SP to flash
;  the reactor effluent stream.
   FLASH-SPECS STRM = 2S6      KODE=2
;
;
BLOCK 2M-107 MIXER
  PROPERTIES SYSOP4
  PARAM PRES=-5.0
;
;
;  Plant P2RX2 is the model for the second coal liquefaction reactor.
;    Stream 2S7 is the feed stream to the second Plant 2 coal
;      liquefaction reactor.
;    Stream 2S11 is the total reactor effluent from the second
;      coal liquefaction reactor.
;
; Plant 2 - The second coal liquefaction reactor - Fortran block USR2R.
BLOCK  P2RX2  USER
  PROPERTIES SYSOP4
   SUBROUTINE MODEL = USR2R   REPORT = USR2R
   DESCRIPTION 'PLANT 2 - COAL LIQUEFACTION REACTORS MODEL'
   PARAM  NINT = 5   NREAL = 20
;      The following 5 integer parameters are:
;      INT(1) = User block summary report control switch.
;               0 => Write the complete user block summary report.
;               1 => Skip the capital cost portion of the summary
;                    report.
;               2 => Skip the capital cost and utilities portions
;                    of the summary report.
;               3 => Skip writing the entire user block summary report.
;      INT(2) = User block summary report destination control switch.
;               0 => Write the user block summary report to the normal
;                    ASPEN/SP output report file.
;               1 => Write the user block summary report to a separate
;                    user block output report file on logical unit 62
;                    called DCL02.REP.
;      INT(3) = Number of duplicate plants.  NOT APPLICABLE.
;      INT(4) = History file additional output control switch.
;               0 => Write no additional output to the history file.
;               1 => Write the only the subroutine entry and exit
;                    messages to the history file.
;               2 => Write some additional output to the history file.
;             3-5 => Write some more additional output to the history
;                    file.  Larger values generate more intermediate
;                    output.
;      INT(5) = Yields factor calculation switch
;               2 => Yields calculated in subroutine USR2R via a
;                    linear model for both coal liquefaction reactors.
;               3 => Called by subroutine USRR1
;               4 => Called by subroutine USRR2
```

```
;                5 => Yields calculated in subroutine USR2R via a
;                     kinetic model for both liquefaction reactors.
;                     Exact transfer of Lotus spreadsheet
;                6 => Yields calculated in subroutine USR2R via a
;                     kinetic model for first stage reactor system
;                     only.Call this model P2RX1.
;                7 => Yields calculated in subroutine USR2R via
;                     a kinetic model for second stage reactor.
;                     It is assumed that input to this are yields
;                     from P2RX1 plus recycle stream 2S27.
;                     Call this P2RX2.
    INT  0  1  0  4  7
;      The following 20 real parameters are:
;      REAL(1)    = Percent coal conversion based on fresh MAF coal
;                   entering the coal liquefaction reactors.
;      REAL(2)    = Future use.
;      REAL(3)    = RESID YIELD IN REACTOR I, %MAF
;      REAL(4)    = OVERALL UNCONVERTED COAL, %MAF
;      REAL(5)    = RESID LOSS IN ROSE, %MAF
;      REAL(6)    = COAL SV, LB MAF COAL/HR/LB CATALYST
;      REAL(7)    = FIXED CARBON, WT% MF
;      REAL(8)    = REACTOR ID STAGE I AND II, FEET
;      REAL(9)    = MAXIMUM REACTOR WEIGHT,1 322 SHORT TONS
;      REAL(10)   = REACTOR I, TEMP DEG F
;      REAL(11)   = REACTOR II, TEMP DEG F
;      REAL(12)   = STAGE I OUTLET PRESSURE, PSIA
;      REAL(13)   = STAGE II OUTLET PRESSURE, PSIA
;      REAL(14)   = MAXIMUM GAS VELOCITY, FPS
;      REAL(15)   = Unconverted coal, stage 1 % MAF
;      REAL(16)   -
;       REAL(20)  = Future use.
;
     REAL 92.7901  &
;         Future use (5 items)
          0.0 26.80 7.54 8.13 1.12 50.68 15.0 1322.0 790.0  &
          760.0 3040.0 3010.0 0.197 10.2 0.0 0.0 0.0 0.0 0.0
;  Use the following FLASH-SPECS sentence to force ASPEN/SP to flash
;  the reactor effluent stream.
   FLASH-SPECS STRM = 2S11      KODE=2
;
BLOCK 2C-107 FLASH2
   PROPERTIES SYSOP4
   PARAM TEMP=760. <F> PRES=3015. <PSIA>
;
BLOCK 2X107 HEATER
   PARAM TEMP=550. <F> PRES=-10.0
;
BLOCK 2C-110 FLASH2
   PARAM TEMP=400. <F> PRES=3015. <PSIA>
;
BLOCK 2X106 HEATER
   PARAM TEMP=130. <F>  PRES=2995.0 <PSIA>
;
BLOCK 2C-113 FLASH3
   PROPERTIES SYSOP4
```

```
   PARAM TEMP=130. <F> PRES=2985. <PSIA>
;
BLOCK 2C-115 SEP
   FLASH-SPECS  STRM=2S51 TEMP=130.0 <F> PRES=2985.0 <PSIA>  /
                STRM=2S20 TEMP=130.0 <F> PRES=2985.0 <PSIA>
   FRAC SUBS=MIXED STRM=2S20                                          &
        COMP=H2      N2         O2       H2S      CO       CO2       &
             NH3     L-SULFUR   H2O      HCL      COS      CH4       &
             C2H6    C3H8       IC4H10   NC4H10   IC5H12   NC5H12    &
;  Pseudocomponents
             T125    T175       T225     T275     T325     T375      &
             T425    T475       T525     T575     T625     T675      &
             T725    T775       T825     T875     T925     T1000+    &
             I1000+                                                   &
        FRAC=1.0     1.0        1.0      1.0      1.0      1.0       &
             1.0     1.0        0.30     0.05     1.0      1.0       &
             1.0     1.0        0.5      0.8      0.3      0.3       &
;  Pseudocomponents
             0.0     0.0        0.0      0.0      0.0      0.0       &
             0.0     0.0        0.0      0.0      0.0      0.0       &
             0.0     0.0        0.0      0.0      0.0      0.0       &
             0.0                                                     /
        STRM=2S51                                                    &
        COMP=H2      N2         O2       H2S      CO       CO2       &
             NH3     L-SULFUR   H2O      HCL      COS      CH4       &
             C2H6    C3H8       IC4H10   NC4H10   IC5H12   NC5H12    &
;  Pseudocomponents
             T125    T175       T225     T275     T325     T375      &
             T425    T475       T525     T575     T625     T675      &
             T725    T775       T825     T875     T925     T1000+    &
             I1000+                                                   &
        FRAC=0.0     0.0        0.0      0.0      0.0      0.0       &
             0.0     0.0        0.70     0.95     0.0      0.0       &
             0.0     0.0        0.5      0.2      0.7      0.7       &
;  Pseudocomponents
             1.0     1.0        1.0      1.0      1.0      1.0       &
             1.0     1.0        1.0      1.0      1.0      1.0       &
             1.0     1.0        1.0      1.0      1.0      1.0       &
             1.0
;
BLOCK 2C-108 FLASH2
  PARAM TEMP=745. <F> PRES=115. <PSIA>
;
BLOCK 2X104 HEATER
   PARAM TEMP=550. <F> PRES=105.0 <PSIA>
;
BLOCK 2M-106 MIXER
  PARAM PRES=-1.0
;
BLOCK 2C-111 FLASH2
   PROPERTIES SYSOP4
  PARAM TEMP=550. <F> PRES=80. <PSIA>
;
BLOCK 2X110 HEATER
  PARAM TEMP=130. <F> PRES=70.0 <PSIA>
```

```
;
BLOCK 2M-109 MIXER
  PARAM PRES=-1.0
;
BLOCK 2M-108 MIXER
  PARAM PRES=-1.0
;
BLOCK 2C-114 FLASH3
   PROPERTIES SYSOP4
  PARAM TEMP=125. <F> PRES=65. <PSIA>
;
BLOCK 2C-109 FLASH2
 PARAM TEMP=743. <F> PRES=35. <PSIA>
;
BLOCK 2X108 HEATER
  PARAM TEMP=130. <F> PRES=25.0 <PSIA>
;
BLOCK 2C-112 FLASH3
  PARAM TEMP=130. <F> PRES=25. <PSIA>
;
BLOCK 2C-105 FSPLIT
   FRAC 2S461 0.43
;
BLOCK 2M-110 MIXER
  PARAM PRES=-1.0
;
BLOCK 2X109 HEATER
  PARAM TEMP=748.0 <F> PRES=115.0 <PSIA>
;
BLOCK 2C-200 SEP
   FLASH-SPECS  STRM=2S200 TEMP=140.0 <F> PRES=16.0 <PSIA>  /
                STRM=2S201 TEMP=140.0 <F> PRES=16.0 <PSIA>  /
                STRM=2S202 TEMP=140.0 <F> PRES=16.0 <PSIA>  /
                STRM=2S203 TEMP=140.0 <F> PRES=28.0 <PSIA>  /
                STRM=2S204 TEMP=695.0 <F> PRES=28.0 <PSIA>
   FRAC SUBS=MIXED STRM=2S200                                          &
        COMP=H2      N2        O2      H2S       CO      CO2          &
             NH3     L-SULFUR  H2O     HCL       COS     CH4          &
             C2H6    C3H8      IC4H10  NC4H10    IC5H12  NC5H12       &
;  Pseudocomponents
             T125    T175      T225    T275      T325    T375         &
             T425    T475      T525    T575      T625    T675         &
             T725    T775      T825    T875      T925    T975         &
             T1000+  I1000+                                            &
        FRAC=1.0     1.0       1.0     0.0       1.0     1.0          &
             0.1     0.0       0.05    0.0       1.0     0.0          &
             0.0     0.0       0.0     0.0       0.0     0.0          &
;  Pseudocomponents
             0.0     0.0       0.0     0.0       0.0     0.0          &
             0.0     0.0       0.0     0.0       0.0     0.0          &
             0.0     0.0       0.0     0.0       0.0     0.0          &
             0.0     0.0                                              /
        STRM=2S201                                                    &
        COMP=H2      N2        O2      H2S       CO      CO2          &
             NH3     L-SULFUR  H2O     HCL       COS     CH4          &
```

```
            C2H6     C3H8      IC4H10   NC4H10    IC5H12   NC5H12    &
;  Pseudocomponents
            T125     T175      T225     T275      T325     T375      &
            T425     T475      T525     T575      T625     T675      &
            T725     T775      T825     T875      T925     T975      &
            T1000+   I1000+                                           &
       FRAC=1.0      1.0       1.0      0.1       1.0      1.0       &
            0.9      1.0       0.95     1.0       1.0      1.0       &
            0.0      0.0       0.0      0.0       0.0      0.0       &
;  Pseudocomponents
            0.0      0.0       0.0      0.0       0.0      0.0       &
            0.0      0.0       0.0      0.0       0.0      0.0       &
            0.0      0.0       0.0      0.0       0.0      0.0       &
            0.0      0.0                                             /
       STRM=2S202                                                   &
       COMP=H2       N2        O2       H2S       CO       CO2       &
            NH3      L-SULFUR  H2O      HCL       COS      CH4       &
            C2H6     C3H8      IC4H10   NC4H10    IC5H12   NC5H12    &
;  Pseudocomponents
            T125     T175      T225     T275      T325     T375      &
            T425     T475      T525     T575      T625     T675      &
            T725     T775      T825     T875      T925     T975      &
            T1000+   I1000+                                           &
       FRAC=0.0      0.0       0.0      0.9       0.0      0.0       &
            0.0      0.0       0.0      0.0       0.0      1.0       &
            1.0      1.0       1.0      1.0       1.0      1.0       &
;  Pseudocomponents
            0.94     0.94      0.94     0.94      0.94     0.035     &
            0.035    0.0       0.0      0.0       0.0      0.0       &
            0.0      0.0       0.0      0.0       0.0      0.0       &
            0.0      0.0                                             /
       STRM=2S203                                                   &
       COMP=H2       N2        O2       H2S       CO       CO2       &
            NH3      L-SULFUR  H2O      HCL       COS      CH4       &
            C2H6     C3H8      IC4H10   NC4H10    IC5H12   NC5H12    &
;  Pseudocomponents
            T125     T175      T225     T275      T325     T375      &
            T425     T475      T525     T575      T625     T675      &
            T725     T775      T825     T875      T925     T975      &
            T1000+   I1000+                                           &
       FRAC=0.0      0.0       0.0      0.0       0.0      0.0       &
            0.0      0.0       0.0      0.0       0.0      0.0       &
            0.0      0.0       0.0      0.0       0.0      0.0       &
;  Pseudocomponents
            0.034    0.034     0.034    0.034     0.034    0.815     &
            0.815    0.404     0.404    0.404     0.404    0.096     &
            0.096    0.096     0.096    0.007     0.007    0.007     &
            0.0      0.0                                             /
       STRM=2S204                                                   &
       COMP=H2       N2        O2       H2S       CO       CO2       &
            NH3      L-SULFUR  H2O      HCL       COS      CH4       &
            C2H6     C3H8      IC4H10   NC4H10    IC5H12   NC5H12    &
;  Pseudocomponents
            T125     T175      T225     T275      T325     T375      &
            T425     T475      T525     T575      T625     T675      &
```

```
            T725     T775      T825     T875      T925     T975        &
            T1000+   I1000+                                             &
        FRAC=0.0     0.0       0.0      0.0       0.0      0.0         &
            0.0      0.0       0.0      0.0       0.0      0.0         &
            0.0      0.0       0.0      0.0       0.0      0.0         &
;   Pseudocomponents
            0.026    0.026     0.026    0.026     0.026    0.150       &
            0.150    0.596     0.596    0.596     0.596    0.904       &
            0.904    0.904     0.904    0.993     0.993    0.993       &
            1.0      1.0
;   Non-conventional components
    FRAC SUBS=NC STRM=2S200                                             &
        COMP=COAL   URCOAL    SLAG                                      &
        FRAC=0.0     0.0       0.0                                      /
        STRM=2S201                                                      &
        COMP=COAL   URCOAL    SLAG                                      &
        FRAC=0.0     0.0       0.0                                      /
        STRM=2S202                                                      &
        COMP=COAL   URCOAL    SLAG                                      &
        FRAC=0.0     0.0       0.0                                      /
        STRM=2S203                                                      &
        COMP=COAL   URCOAL    SLAG                                      &
        FRAC=0.0     0.0       0.0                                      /
        STRM=2S204                                                      &
        COMP=COAL   URCOAL    SLAG                                      &
        FRAC=1.0     1.0       1.0
;
BLOCK 2C-201 FSPLIT
   FRAC 2S205 0.72
;
BLOCK 2C-202 SEP
   FLASH-SPECS  STRM=2S211 TEMP=110.0 <F> PRES=16.7 <PSIA>  /
                STRM=2S212 TEMP=110.0 <F> PRES=16.7 <PSIA>  /
                STRM=2S213 TEMP=110.0 <F> PRES=16.7 <PSIA>  /
                STRM=2S214 TEMP=266.0 <F> PRES=16.7 <PSIA>  /
                STRM=2S215 TEMP=400.0 <F> PRES=16.7 <PSIA>  /
                STRM=2S216 TEMP=688.0 <F> PRES=50.0 <PSIA>
   FRAC SUBS=MIXED STRM=2S211                                           &
        COMP=H2     N2        O2       H2S       CO       CO2         &
            NH3     L-SULFUR  H2O      HCL       COS      CH4         &
            C2H6    C3H8      IC4H10   NC4H10    IC5H12   NC5H12      &
;   Pseudocomponents
            T125     T175      T225     T275      T325     T375        &
            T425     T475      T525     T575      T625     T675        &
            T725     T775      T825     T875      T925     T975        &
            T1000+   I1000+                                             &
        FRAC=1.0     1.0       1.0      0.9       1.0      1.0         &
            0.1      0.0       0.05     0.0       1.0      1.0         &
            1.0      1.0       1.0      1.0       0.0      0.0         &
;   Pseudocomponents
            0.0      0.0       0.0      0.0       0.0      0.0         &
            0.0      0.0       0.0      0.0       0.0      0.0         &
            0.0      0.0       0.0      0.0       0.0      0.0         &
            0.0      0.0                                                /
        STRM=2S212                                                      &
```

```
        COMP=H2       N2         O2       H2S       CO       CO2        &
             NH3      L-SULFUR   H2O      HCL       COS      CH4        &
             C2H6     C3H8       IC4H10   NC4H10    IC5H12   NC5H12     &
;  Pseudocomponents
             T125     T175       T225     T275      T325     T375       &
             T425     T475       T525     T575      T625     T675       &
             T725     T775       T825     T875      T925     T975       &
             T1000+   I1000+                                            &
        FRAC=0.0      0.0        0.0      0.1       0.0      0.0        &
             0.9      0.0        0.95     0.0       0.0      0.0        &
             0.0      0.0        0.0      0.0       0.0      0.0        &
;  Pseudocomponents
             0.0      0.0        0.0      0.0       0.0      0.0        &
             0.0      0.0        0.0      0.0       0.0      0.0        &
             0.0      0.0        0.0      0.0       0.0      0.0        &
             0.0      0.0                                               /
        STRM=2S213                                                     &
        COMP=H2       N2         O2       H2S       CO       CO2        &
             NH3      L-SULFUR   H2O      HCL       COS      CH4        &
             C2H6     C3H8       IC4H10   NC4H10    IC5H12   NC5H12     &
;  Pseudocomponents
             T125     T175       T225     T275      T325     T375       &
             T425     T475       T525     T575      T625     T675       &
             T725     T775       T825     T875      T925     T975       &
             T1000+   I1000+                                            &
        FRAC=0.0      0.0        0.0      0.0       0.0      0.0        &
             0.0      0.0        0.0      0.0       0.0      0.0        &
             0.0      0.0        0.0      0.0       1.0      1.0        &
;  Pseudocomponents
             0.545    0.545      0.545    0.545     0.545    0.068      &
             0.068    0.0        0.0      0.0       0.0      0.0        &
             0.0      0.0        0.0      0.0       0.0      0.0        &
             0.0      0.0                                               /
        STRM=2S214                                                     &
        COMP=H2       N2         O2       H2S       CO       CO2        &
             NH3      L-SULFUR   H2O      HCL       COS      CH4        &
             C2H6     C3H8       IC4H10   NC4H10    IC5H12   NC5H12     &
;  Pseudocomponents
             T125     T175       T225     T275      T325     T375       &
             T425     T475       T525     T575      T625     T675       &
             T725     T775       T825     T875      T925     T975       &
             T1000+   I1000+                                            &
        FRAC=0.0      0.0        0.0      0.0       0.0      0.0        &
             0.0      0.0        0.0      0.0       0.0      0.0        &
             0.0      0.0        0.0      0.0       0.0      0.0        &
;  Pseudocomponents
             0.455    0.455      0.455    0.455     0.455    0.932      &
             0.932    1.0        1.0      1.0       1.0      0.883      &
             0.883    0.883      0.883    0.026     0.026    0.026      &
             0.0      0.0                                               /
        STRM=2S215                                                     &
        COMP=H2       N2         O2       H2S       CO       CO2        &
             NH3      L-SULFUR   H2O      HCL       COS      CH4        &
             C2H6     C3H8       IC4H10   NC4H10    IC5H12   NC5H12     &
;  Pseudocomponents
```

```
            T125     T175     T225     T275     T325     T375     &
            T425     T475     T525     T575     T625     T675     &
            T725     T775     T825     T875     T925     T975     &
            T1000+   I1000+                                         &
        FRAC=0.0     0.0      0.0      0.0      0.0      0.0      &
            0.0      0.0      0.0      0.0      0.0      0.0      &
            0.0      0.0      0.0      0.0      0.0      0.0      &
;   Pseudocomponents
            0.0      0.0      0.0      0.0      0.0      0.0      &
            0.0      0.0      0.0      0.0      0.0      0.08     &
            0.08     0.08     0.08     0.533    0.533    0.533    &
            0.0136   0.0                                           /
        STRM=2S216                                                &
        COMP=H2      N2       O2       H2S      CO       CO2      &
            NH3      L-SULFUR H2O      HCL      COS      CH4      &
            C2H6     C3H8     IC4H10   NC4H10   IC5H12   NC5H12   &
;   Pseudocomponents
            T125     T175     T225     T275     T325     T375     &
            T425     T475     T525     T575     T625     T675     &
            T725     T775     T825     T875     T925     T975     &
            T1000+   I1000+                                         &
        FRAC=0.0     0.0      0.0      0.0      0.0      0.0      &
            0.0      0.0      0.0      0.0      0.0      0.0      &
            0.0      0.0      0.0      0.0      0.0      0.0      &
;   Pseudocomponents
            0.0      0.0      0.0      0.0      0.0      0.0      &
            0.0      0.0      0.0      0.0      0.0      0.037    &
            0.037    0.037    0.037    0.441    0.441    0.441    &
            0.9864   0.0
;   Non-conventional components
    FRAC SUBS=NC STRM=2S211                                       &
        COMP=COAL    URCOAL   SLAG                                &
        FRAC=0.0     0.0      0.0                                 /
        STRM=2S212                                                &
        COMP=COAL    URCOAL   SLAG                                &
        FRAC=0.0     0.0      0.0                                 /
        STRM=2S213                                                &
        COMP=COAL    URCOAL   SLAG                                &
        FRAC=0.0     0.0      0.0                                 /
        STRM=2S214                                                &
        COMP=COAL    URCOAL   SLAG                                &
        FRAC=0.0     0.0      0.0                                 /
        STRM=2S215                                                &
        COMP=COAL    URCOAL   SLAG                                &
        FRAC=0.0     0.0      0.0                                 /
        STRM=2S216                                                &
        COMP=COAL    URCOAL   SLAG                                &
        FRAC=1.0     1.0      1.0
;
;
STREAM-REPORT P2
   STREAMS STRM=ALL
   FLOW-FRAC SUBS=MIXED BASES=MASS / SUBS=NC BASES=MASS
   INTENSIVE-PROPS SUBS=MIXED BASES=MASS &
                   PROPS=TEMP PRES MW ENTH ENTR DENS HCAP/
```

```
                    SUBS=NC BASES=MASS &
                    PROPS=TEMP PRES ENTH DENS HCAP
;
; End of input file T2V2S.INP
```

APPENDIX N

APPENDIX N

ASPEN/SP FORTRAN USER BLOCK MODELS

FOR THE KINETIC REACTOR MODEL

ASPEN/SP FORTRAN USER BLOCK MODELS

FOR THE KINETIC REACTOR MODEL

<u>Editorial Note</u>
In the following listing, whenever TOF occurs between single quote marks (') in a FORMAT statement, it represents the IBM PC top of form character (ASCII character 012).

```
C  File USR2G.FOR
C
C     This file contains the following subroutines:
C       USR2R    Main routine for both Plant 2 coal liquefaction
C                reactors.
C       USR2BD   Block data routine for initializing some variables
C                in COMMON /USR12L/.
C       USR02A   Subroutine to load the pure component properties in
C                the CPROP array in named COMMON /USR02M/.
C       USR02B   Subroutine to write the reactor elemental balance to
C                the history file.
C       USR02R   Subroutine to calculate the net coal liquefaction
C                reactor yields and the reactor outlet stream.
C       USR2RS   Subroutine to load the coal liquefaction reactor outlet
C                stream into the reactor effluent stream vector.
C       USR2RZ   Subroutine to write any warning messages to the
C                summary report.
C       USR02C   Subroutine to calculate frequently used quantities
C                utilized in several different subroutines.
C       USR02F   Subroutine to calculate fluid dynamic properties of
C                ebullated bed reactor.
C       USR02K   Subroutine to calculate various kinetic parameters
C                for the eb-bed reactors.
C       USR2S1   Subroutine to calculate catalyst addition rate when
C                the first stage resid yield is given.
C       USR2RC   Subroutine to calculate resid concentration for both
C                reactor effluent streams, using accurate phase
C                equilibria.
C       USR2S2   Subroutine to calculate catalyst addition rate for
C                the second stage.
C       USR2YF   Subroutine to calculate product yields for reactor
C                stages I and II.
C       USR2FL   Subroutine to calculate equilibrium flash gas and
C                liquid phase compositions.
C       USR2KV   Subroutine returning temperature dependent equilibrium
C                K-values for a given reactor mixture.
C       USR02E   Subroutine to calculate the required fresh reactor
C                inlet stream temperature Tprh that will provide the
C                desired average bed temperature.
C       USR2EI   Subroutine to conducte a simple energy balance at the
C                'invisible' mixer at the reactor bottom, merging the
C                cool fresh feed with the hot internal recycle to the
C                single reactor net inlet stream.
```

```
C       USR2EB   Subroutine to evaluate temperature of the reactor
C                effluent stream, by an overall energy balance with
C                iterative convergence.
C       USR2CP   Subroutine to evaluate heat capacities of pure
C                substances.
C       USR2C1   Subroutine to evaluate conventional liquid heat
C                capacities.
C       USR2C2   Subroutine to evaluate conventional gases (ideal) heat
C                capacities.
C       USR2C3   Subroutine to evaluate petroleum liquid fractions heat
C                capacities.
C       USR2C4   Subroutine to evaluateing petroleum gas fractions heat
C                capacities.
C       USR2C5   Subroutine to evaluate solid carbon heat capacity
C                (graphite).
C       USR2LH   Subroutine to evaluate latent heats of pure compounds,
C                as functions of equilibrium temperature.
C       USR2L1   Subroutine to evaluate latent heats of vaporization of
C                pure conventional compounds.
C       USR2L2   Subroutine to evaluate latent heats of vaporization of
C                petroleum pseudo-components.
C
C     NOTE:  This model contains some USR02 subroutines and uses named
C            common blocks COMMON /USR02M/ and /USR12L/.
C
C     The above subroutines require the following non-standard ASPEN/SP
C     subroutines which are not included in this file.
C       USRCCN   Subroutine for locating the relative conventional
C                component number.
C       USRUCO   Subroutine for calculating, saving and reporting the
C                utilities, capital and operating costs for the plant.
C       GETSTR   Subroutine for finding the stream bead information.
C       USR31T   Subroutine to summarize the plant utilities. -- This
C                routine totals all the utilites and prints a summary
C                table for all plants.
C       USRBD1   User BLOCK DATA routine to initialize the items in
C                named COMMON /USRCO1/.
C
C     NOTE:  Changes are required in subroutines USR2S2 and USR2YF when
C            switching between the original baseline design case and
C            the improved baseline design (high space velocity) case.
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C$ USR2R
      SUBROUTINE USR2R (NSIN,NINFI,SIN1,SIN2,SIN3,SIN4, SINFI,NSOUT,
     1 NINFO,SOUT1,SOUT2,SOUT3,SOUT4,SINFO,NSUBS,IDXSUB,ITYPE,NINT,
     2 INT,NREAL,REAL,IDS,NPO,NBOPST,NIW,IW,NW,W,NSIZE,SIZE)
C
C  ASPEN USER UNIT OPERATION BLOCK:  USR2R
C
C  BLOCK DESCRIPTION:  Plant 2, Both DOE Coal Liquefaction Reactors
C
C          Both Plant 2 Coal Liquefaction Reactors Block Model
C
C                        ----------------------
```

```
C                        |                      |
C                        |       Plant 2        |
C                        |                      |
C     Reactor Feed---->  |     Both Coal        |-----> Reactor Effluent
C                        |    Liquefaction      |
C                        |      Reactors        |
C                        |                      |
C                        ------------------------
C
C
C  Prepared under DOE contract no. DE-AC22 90PC89857.
C
C  FUNCTION (MODEL, REPORT, OR BOTH):  Both
C
C  Last revision - January 20, 1992.
C
C  ASSUMPTIONS, SPECIAL FEATURES AND LIMITATIONS:
C     1.  The single inlet stream is the Total Reactor Feed Stream.
C     2.  The single outlet stream is the Reactor Effluent Stream.
C     3.  This user block model will work with any number of
C         conventional components, but requires three non-conventional
C         coal-type components which must be supplied in the following
C         order, COAL, URCOAL and SLAG.
C     4.  This user block Fortran model requires that all inupt and
C         output streams are of the ASPEN/SP stream class of MIXNC or
C         MIXNCPSD.
C     5.  The order of the items in the ATTR-COMPS statement must be
C         PROXANAL, ULTANAL, SULFANAL AND AOXANAL because it is in this
C         order that ASPEN/SP stores these items, and this subroutine
C         assumes this order.  Therefore, the three ATTR-COMPS
C         statements in the input file must be:
C           ATTR-COMPS COAL   PROXANAL ULTANAL SULFANAL AOXANAL
C           ATTR-COMPS URCOAL PROXANAL ULTANAL SULFANAL AOXANAL
C           ATTR-COMPS SLAG   PROXANAL ULTANAL SULFANAL AOXANAL
C     6.  Any fresh coal (COAL) present in the input stream may be
C         liquefied.  Any unreacted COAL leaves as URCOAL.  Any URCOAL
C         or SLAG present in the input stream leaves unchanged in the
C         reactor effluent stream.
C     7.  The 4 integer parameters are:
C         INT(1)  = User block summary report control switch.
C                   0 => Write the complete user block summary report.
C                   1 => Skip the capital cost portion of the summary
C                        report.
C                   2 => Skip the capital cost and utilities portions
C                        of the summary report.
C                   3 => Skip writing the entire user block summary
C                        report.
C         INT(2)  = User block summary report destination control
C                   switch.
C                   0 => Write the user block summary report to the
C                        normal ASPEN/SP output report file.
C                   1 => Write the user block summary report to a
C                        separate user block output report file on
C                        logical unit 62 called DCL2R.REP.
C         INT(3)  = Number of duplicate plants.  NOT AVAILABLE.
```

```
C          INT(4)  = History file additional output control switch.
C                    0 => Write no additional output to the history
C                         file.
C                    1 => Write only the subroutine entry and exit
C                         messages to the history file.
C                    2 => Write some additional output to the history
C                         file.
C                  3-5 => Write some more additional output to the
C                         history file.  Larger values generate more
C                         intermediate output.
C          INT(5)   = Yields factor calculation switch.
C                     2 => Yields calculated in subroutine USR2R
C                          via a linear model for both stages 1 and 2
C                          coal liquefaction reactors.
C                     3 => Called by subroutine USRR1.
C                     4 => Called by subroutine USRR2.
C                     5 => Yields calculated in subroutine USR2R via a
C                          kinetic model for both stages 1 and 2
C                          liquefaction reactors.
C                     6 => Yields calculated in subroutine USR2R via a
C                          kinetic model for first liquefaction reactor.
C                     7 => Yields calculated in subroutine USR2R via a
C                          kinetic model for second stage liquefaction
C                          reactor, assuming that yields from stage I
C                          reactor have alraedy been calculated.
C     8.  The 20 real parameters are:
C         REAL(1)   = Percent coal conversion based on fresh MAF coal
C                     entering the coal liquefaction reactors.
C         REAL(2)   = Future use.
C         REAL(3)   = RESID YIELD IN REACTOR I, % MAF
C         REAL(4)   = OVERALL UNCONVERTED COAL, %MAF
C         REAL(5)   = RESID LOSS IN ROSE, %MAF
C         REAL(6)   = COAL SV, LB MAF/HR/LB CATALYST
C         REAL(7)   = FIXED CARBON, WT% MF
C         REAL(8)   = REACTOR ID STAGE I AND II, FEET
C         REAL(9)   = MAXIMUM REACTOR WEIGHT, SHORT TONS
C         REAL(10)  = REACTOR STAGE I TEMPERATURE, DEG F
C         REAL(11)  = REACTOR STAGE II TEMPERATURE, DEG F
C         REAL(12)  = REACTOR STAGE I PRESSURE, PSIA
C         REAL(13)  = REACTOR STAGE II PRESSURE, PSIA
C         REAL(14)  = MAXIMUM GAS VELOCITY, FPS
C         REAL(15)  = UNCONVERTED COAL REACTOR I EFFLUENT, %MAF
C         REAL(16) -
C          REAL(20) = Future use.
C
C
C     Required user Fortran unit operation block declarations.
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
      DIMENSION SIN1(1),SIN2(1),SIN3(1),SIN4(1),SINFI(1),SOUT1(1),
     1 SOUT2(1),SOUT3(1),SOUT4(1),SINFO(1),IDXSUB(NSUBS),ITYPE(NSUBS),
     2 INT(NINT),REAL(NREAL),IDS(2,13),NBOPST(3,NPO),IW(NIW),W(NW),
     3 SIZE(NSIZE)
      COMMON/USER/RMISS,IMISS,NGBAL,IPASS,IRESTR,ICONVG,LMSG,
     1 LPMSG,KFLAG,NHSTRY,NRPT,NTRMNL,ISIZE
      COMMON/NCOMP/NCC,NNCC,NC,NAC,NACC,NVCP,NVNCP,NVACC,NVAVCC
```

```
      COMMON/IDSCC/IDSCC(2,1)
      COMMON/IDSNCC/IDSNCC(2,1)
      COMMON/IDXCC/IDXCC(1)
      COMMON/IDXNCC/IDXNCC(1)
      COMMON/RPTGLB/IREPFL,ISUB(10)
      COMMON/MW/XMW(1)
      COMMON/ASPGLB/RACC(200),IACC(200)
C
C      Component ordering in the various vectors.
C      No.  Component    Description
C       1.  H2           Hydrogen
C       2.  N2           Nitrogen
C       3.  O2           Oxygen
C       4.  H2S          Hydrogen sulfide
C       5.  CO           Carbon monoxide
C       6.  CO2          Carbon dioxide
C       7.  NH3          Ammonia
C       8.  H2O          Water
C       9.  HCL          Hydrochloric acid
C      10.  COS          Carbonyl sulfide
C      11.  CH4          Methane
C      12.  C2H6         Ethane
C      13.  C3H8         Propane
C      14.  IC4H10       Iso-butane
C      15.  NC4H10       Normal butane
C      16.  IC5H12       Iso-pentane
C      17.  NC5H12       Normal pentane
C      18.  T125         100 - 150 F boiling range fraction
C      19.  T175         150 - 200 F boiling range fraction
C      20.  T225         200 - 250 F boiling range fraction
C      21.  T275         250 - 300 F boiling range fraction
C      22.  T325         300 - 350 F boiling range fraction
C      23.  T375         350 - 400 F boiling range fraction
C      24.  T425         400 - 450 F boiling range fraction
C      25.  T475         450 - 500 F boiling range fraction
C      26.  T525         500 - 550 F boiling range fraction
C      27.  T575         550 - 600 F boiling range fraction
C      28.  T625         600 - 650 F boiling range fraction
C      29.  T675         650 - 700 F boiling range fraction
C      30.  T725         700 - 750 F boiling range fraction
C      31.  T775         750 - 800 F boiling range fraction
C      32.  T825         800 - 850 F boiling range fraction
C      33.  T875         850 - 900 F boiling range fraction
C      34.  T925         900 - 950 F boiling range fraction
C      35.  T975         950 - 1000 F boiling range fraction
C      36.  T1000+       1000+ F boiling range material leaving the
C                        second coal liquefaction reactor.
C      37.  I1000+       1000+ F boiling range intermediate material
C                        leaving the first coal liquefaction reactor.
C      38.  blank        Future use
C      39.  blank        Future use
C      40.  blank        Future use
C      41.  blank        Future use
C      42.  blank        Future use
C      43.  blank        Future use
```

```
C       44.  blank        Future use
C       45.  blank        Future use
C       46.  COAL         Fresh MAF coal that reacts to form conventional
C                         components and unreacted coal (URCOAL).
C       47.  URCOAL       Unreacted coal which leaving the reactors.
C       48.  SLAG         Slag, (i.e., gasifier solid bottoms product).
C       49.  blank        Future use
C       50.  OTHERS       Other components not listed above.
C
      COMMON/USR12L/C(50),F(50),Z(400)
C
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5), OPROP(20,5)
C
C     In COMMON /USR02M/
C       CIN(J) contains the component flow rates entering the coal
C         liquefaction reactors in lbs/hr.
C       COUT(J) contains the component flow rates leaving the coal
C         liquefaction reactors in lbs/hr.
C       CPROP(J,K) contains the conventional component properties
C         where J designates the component number and
C         K = 1 => Molecular weight
C             2 => Density, lbs/bbl
C             3 => Carbon content, wt%
C             4 => Hydrogen content, wt%
C             5 => Sulfur content, wt%
C             6 => Nitrogen content, wt%
C             7 => Oxygen content, wt%
C       ICNUMB(J) contains the relative component numbers.
C       ST1(J,K) and ST2(J,K) contain the properties of up to 5 inlet
C         and 6 outlet streams, in order, where J designates the stream
C         and
C         K = 1 => Total stream flow rate in Mlbs/hr.
C             2 => Stream temperature in degrees Fahrenheit.
C             3 => Stream pressure in PSIA.
C             4 => Stream flow rate in MMSCF/hr.
C             5 => Future use.
C       OPROP(J,K) contains the outlet petroleum fractions % elemental
C         contents, necessary for exact elemental balance. This had to
C         be added, because some petroleum fractions exist at inlet,
C         especially for stage II calculations in mode 7. This contains
C         the % elements in petroleum fractions (ID no. GE 18) in the
C         same order as in CPROP.
C         ASPEN/SP PRESERVES COMMONed VARIABLES CONTENTS BETWEEN
C         SUBSEQUENT CALLS. THUS, WE DON'T NEED TO PLACE CIN(46) IN THE
C         REAL VECTOR FOR MODE 7, WE WILL JUST SAVE THE MODE 6 VALUE AND
C         RE-USE IT FOR MODE 7.  THE SAME TRICK MAY BE USED FOR ANY
C         OTHER VARIABLE THAT NEEDS TO BE PRESERVED.
      COMMON /USR2SV/ SAVE46,SAVZ46,SAVZ49
C
C     Local variable declaration statements.
      DIMENSION ICN(2), ICNAME(100)
C
      DIMENSION OXIN1(10), OXIN1N(10), UIN1(7), UIN2(7), UIN3(7),
     1  UIN1N(7), UIN2N(7), UIN3N(7), ULTOUT(7), WTUC(7), WTUCC(7)
```

```
C
      CHARACTER * 4  BLANK4, ICN, ICNAME
      CHARACTER * 6  PNAME
C
C     Initialize the component identifications.
      DATA KMAXC / 50 /
      DATA KOMPS / 37 /
      DATA BLANK4 / '    ' /
      DATA ICNAME / 'H2  ', '    ', 'N2  ', '    ', 'O2  ', '    ',
     1  'H2S ', '    ', 'CO  ', '    ', 'CO2 ', '    ', 'NH3 ', '    ',
     2  'H2O ', '    ', 'HCL ', '    ', 'COS ', '    ', 'CH4 ', '    ',
     3  'C2H6', '    ', 'C3H8', '    ', 'IC4H', '10  ', 'NC4H', '10  ',
     4  'IC5H', '12  ', 'NC5H', '12  ', 'T125', '    ', 'T175', '    ',
     5  'T225', '    ', 'T275', '    ', 'T325', '    ', 'T375', '    ',
     6  'T425', '    ', 'T475', '    ', 'T525', '    ', 'T575', '    ',
     7  'T625', '    ', 'T675', '    ', 'T725', '    ', 'T775', '    ',
     8  'T825', '    ', 'T875', '    ', 'T925', '    ', 'T975', '    ',
     9  'T100', '0+  ', 'I100', '0+  ', '    ', '    ', '    ', '    ',
     A  '    ', '    ', '    ', '    ', '    ', '    ', '    ', '    ',
     B  '    ', '    ', '    ', '    ', 'COAL', '    ', 'URCO', 'AL  ',
     C  'SLAG', '    ', '    ', '    ', 'OTHE', 'RS  ' /
C
      DATA PNAME / 'RX 2  ' /
C
C
C     PARAMETER INITIALIZATION SECTION
C     -------------------------------
C
C     Load the KTEST switch which controls the optional printing to the
C     History file (0 => No printing  and  1 or more, print some results
C     to the History file.
      KTEST = INT(4)
      MODE = INT(5)
C
C     If requested, write the subroutine heading to the history file.
      IF ( KTEST .GE. 1 )  THEN
        WRITE (NHSTRY, 501) IPASS
  501   FORMAT ( // 1X, 'Plant 2 - Supplementary data from ',
     1    'subroutine USR2R' /
     2    2X, 'Coal Liquefaction Reactors', 20X, 'IPASS =', I3 )
      ENDIF
C
C     Check to insure that there is exactly 1 inlet stream, and if
C     not, print an error message and terminate execution.
      IF ( NSIN .NE. 1 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 502)  NSIN
  502   FORMAT ( / 1X, '* ERROR * - The Plant 2 reactors require ',
     1    'only one inlet stream.' /
     2    3X, 'It currently has', I4, ' inlet streams.' //
     3    3X, 'Please correct this problem and try again.' //
     4    3X, 'EXECUTION IS BEING TERMINATED.' / )
        STOP
      ENDIF
C
```

```
C     Check to insure that there is exactly 1 outlet stream, and if
C     not, print an error message and terminate execution.
      IF ( NSOUT .NE. 1 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501) IPASS
        WRITE (NHSTRY, 503)  NSOUT
  503   FORMAT ( / 1X, '* ERROR * - The Plant 2 reactors require ',
     1    'only one outlet stream.' /
     2    3X, 'It currently has', I4, ' outlet streams.' //
     3    3X, 'Please correct this problem and try again.' //
     4    3X, 'EXECUTION IS BEING TERMINATED.' / )
        STOP
      ENDIF
C
C     Check to insure that all inlet streams are of the ASPEN/SP
C     stream class MIXNC or MIXNCPSD, and if not, write an error
C     message to the History file and terminate execution.
      IF ( NSUBS .NE. 2 .OR. ITYPE(2) .NE. 3 )  THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 504)
  504   FORMAT ( / 1X, '* ERROR * - The input stream to the Plant 2 ',
     1    'coal liquefaction reactors is' /
     2    3X, 'not of stream class MIXNC or MIXNCPSD.  This model ',
     3    'will not work.  Please' /
     4    3X, 'set all input streams to one of these stream ',
     5    'classes and try again.' //
     6    3X, 'EXECUTION IS BEING TERMINATED.' / )
        STOP
      ENDIF
C
C     Set the stream class code to indicate the ASPEN/SP stream class
C     of the inlet and outlet streams, where
C       KLASS = 1  => MIXED
C             = 2  => MIXNC
C             = 3  => MIXNCPSD
      KLASS = 2
C
C     Check for a substream PSD attribute on the second substream of the
C     first inlet stream.
      CALL GETSTR (IDS(1,4), NB, LB, NBD, LBD)
      NUMATT = NPAT (LBD, 2)
      NUMPSD = 0
      IF ( NUMATT .GT. 0 )   THEN
        NUMPSD = NAVAR (LBD, 2, 1)
        KLASS = 3
      ENDIF
C
C     Set the offset variable for the conventional substream.
      NCONV = (NCC + 9)
C     Set the offset variable for the conventional substream and the
C     nonconventional substream.
      NCCONV = NCONV + (NNCC + 9)
C
C     Set NITEMS to the number of items in the component attributes for
C     each of the non conventional components.
C     NITEMS = PROXANAL + ULTANAL + SULFANAL + AOXANAL
```

```
      NITEMS =    4     +    7    +    3     +   10
C     Find the number of items in the whole inlet stream vector.
      ITEMS = NCCONV + NNCC * NITEMS + NUMPSD
C
C     Calculate the total inlet flow in lbs/hr.
C     CF is the conversion factor from Kg/sec to lbs/hr.
      CF = 3600.0D0 / 0.45359237D0
      J = NCC + 1
      K = NCC + 9
      X = SIN1(J)*SIN1(K)
      J = NCC + 9 + NNCC + 1
      FLOWIN = CF * (X + SIN1(J))
C
      IF ( FLOWIN .LE. 1.0D0 )   THEN
C       Skip all remaing calculations if this plant has no flow.
        IF ( KTEST .GE. 1 )  WRITE (NHSTRY, 505)
  505   FORMAT ( / ' There is no material entering the Plant 2 ',
     1    'coal liquefaction reactors.' )
        GO TO 999
C       ---------
      ENDIF
C
C     Check to insure that there are 3 non-conventional components, and
C     if not, write an error message to the History file and terminate
C     execution.
      IF ( NNCC .NE. 3 )  THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 506)
  506   FORMAT ( / 1X, '* ERROR * - The input stream to the Plant 2 ',
     1    'coal liquefaction reactors' /
     2    3X, 'must allow for three non-conventional components, ',
     3    'COAL, URCOAL and SLAG.' /
     4    3X, 'Please adjust your component list to contain them in ',
     5    'the above order and try again.' //
     6    3X, 'EXECUTION IS BEING TERMINATED.' / )
        STOP
      ENDIF
C
C     Find the relative component numbers of the required conventional
C     components, and save then in the ICNUMB vector.
      DO 20 J = 1, KOMPS
        K = 2 * J - 1
        ICN(1) = ICNAME(K)
        ICN(2) = ICNAME(K+1)
        ICNUMB(J) = 0
        CALL USRCCN (ICN, ICNUMB(J))
        IF ( ICNUMB(J) .EQ. 0 ) THEN
          IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
          WRITE (NHSTRY, 507)  ICN(1), ICN(2)
  507     FORMAT ( / 1X, '* ERROR * - The following component is ',
     1      'missing from your component list' / 5X, 2A4 /
     2      3X, 'The coal liquefaction plant requires this ',
     3      'component.  Please add' /
     4      3X, 'it to your component list and try again.' //
     5      3X, 'EXECUTION IS BEING TERMINATED.' / )
```

```
          STOP
        ENDIF
   20 CONTINUE
C
C
C     INPUT SECTION
C     -------------
C     User specified parameters.
C     Set up the logical unit number for writing the output report in
C     variable NOUT.
      NOUT = NRPT
      IF ( INT(2) .GE. 1 )   NOUT = 62
C
C     Load the percent coal conversion based on fresh MAF coal entering
C     the reactors.
C
      CONMAF = REAL(1)
C     REAL(15) was originally set to 10.2. Now, stage I unconverted coal
C     is reduced (i.e., first stage coal conversion increased) to
C     1.05*(stage II UC coal) (=8.0)
      REAL(15)=1.05*REAL(4)
C     Decide overall conversion based on MODE
C     ONCE CORRECT CONMAF IS SET, WEIGHTS ARE PROPERLY CALCULATED.
      IF (MODE .EQ. 5 .OR. MODE .EQ. 7) THEN
        CONMAF=100.0-REAL(4)
      ELSE IF (MODE .EQ. 6) THEN
        CONMAF=100.0-REAL(15)
      ENDIF
      WRITE (NHSTRY,26)
   26 FORMAT ( /'TABULATION OF REAL VECTOR'/)
C     SHOW ALL REAL ELEMENTS, EVEN EMPTY ONES
      WRITE (NHSTRY,28) (J,REAL(J),J=1,NREAL)
   28 FORMAT ( /4 (I2, 2X, F10.2, 2X))
C
C     Check the supplied fresh coal conversion to be sure that it a
C     realistic value has been supplied.
      IF ( CONMAF .LE. 10.0D0 .OR. CONMAF .GE. 99.9D0 )   THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 508)  CONMAF
  508   FORMAT ( / 1X, '* WARNING * - The supplied coal ',
     1    'converion based on fresh MAF coal to the plant' /
     2    3X, '2 reactors has an invalid value of', F10.3, '.  A ',
     3    'converion per pass of 92.5%' /
     4    3X, 'will be assumed, and execution will continue using ',
     5    'this conversion per pass.' )
        CONMAF = 92.5D0
      ENDIF
C
C     Call subroutine USR02A to load the pure component properties into
C     the CPROP array in named COMMON /USR02M/.
      CALL USR02A (KTEST, NCC, NHSTRY, MODE)
C
C     If requested, write the items of interest in the inlet
C     stream vector to the history file.
      IF ( KTEST .GE. 5 )  THEN
```

```
        WRITE (NHSTRY, 509)
  509   FORMAT ( / '  The inlet stream vector:'/
     1    3X, 'Item', 8X, 'SIN1' )
        DO 30 J = 1, ITEMS
          WRITE (NHSTRY, 510) J, SIN1(J)
  510     FORMAT ( 1X, I6, 1X, 1PE15.5 )
   30   CONTINUE
      ENDIF
C
C     Load the total entering component flow rates in the CIN vector.
C     First, zero the CIN vector.
      DO 40 J = 1, KMAXC
        CIN(J) = 0.0D0
   40 CONTINUE
C
C     Conventional components - Load the flow rate and component MWs.
C     CF is the conversion factor from Kg/sec to lbs/hr.
      DO 44 J = 1, NCC
        DO 42 K = 1, KOMPS
        IF ( J .EQ. ICNUMB(K) )  THEN
          CIN(K) = CF * XMW(J) * SIN1(J)
          GO TO 44
        ENDIF
   42   CONTINUE
        CIN(50) = CIN(50) + CF * XMW(J) * SIN1(J)
   44 CONTINUE
C
C     Non-conventional components.
      CIN(46) = CF * SIN1(NCONV+1)
      CIN(47) = CF * SIN1(NCONV+2)
      CIN(48) = CF * SIN1(NCONV+3)
C
      IER1 = 0
      IF ( CIN(50) .GE. 1.0D0 ) THEN
        IER1 = 1
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 511)  CIN(50)
  511   FORMAT ( / 1X, '* WARNING * - The feed to the plant 2 coal ',
     1    'liquefaction reactors' /
     2    3X, 'contains one or more components that this model ',
     3    'cannot handle.  It' /
     4    3X, 'contains', F10.1, ' lbs/hr of these components.  ',
     5    'These components will' /
     6    3X, 'be lost in the process.  The plant 2 reactors will not ',
     7    'be in mass balance.' /
     8    3X, 'Please remove these component(s) from the feed stream.'//
     9    3X, 'Execution is continuing.' / )
      ENDIF
C
      IF ( KTEST .GE. 4 )  THEN
        SUM = 0.0D0
        WRITE (NHSTRY, 513)
  513   FORMAT ( / ' Component properties:' /
     1    1X, 'No.', 2X, 'Name', 8X, 'lbs/hr', 5X, 'MW', 6X, 'lbs/bbl',
     2    4X, 'Wt% C', 4X, 'Wt% H', 4X, 'Wt% S', 4X, 'Wt% N',
```

```
     3    4X, 'Wt% O', 3X, 'ID' )
        DO 46 J = 1, KMAXC
          K = 2 * J - 1
          IF ( ICNAME(K) .NE. BLANK4 )  THEN
            SUM = SUM + CIN(J)
            IF ( J .LE. 40 )   THEN
                WRITE (NHSTRY, 514) J, ICNAME(K), ICNAME(K+1), CIN(J),
     1            (CPROP(J,K), K = 1, 7), ICNUMB(J)
   514          FORMAT ( 1X, I3, 2X, 2A4, F10.1, F10.4, F10.3, 5F9.4,
     1            I5 )
              ELSE
                WRITE (NHSTRY, 515) J, ICNAME(K), ICNAME(K+1), CIN(J),
     1            ICNUMB(J)
   515          FORMAT ( 1X, I3, 2X, 2A4, F10.1, I70 )
            ENDIF
          ENDIF
    46  CONTINUE
        WRITE (NHSTRY, 516) SUM
   516  FORMAT ( 6X, 'Total', F13.1 )
      ENDIF
C
C     IF THIS IS MODE 6, SAVE THE CIN(46) VALUE FOR MODE 7. IF THIS IS
C     MODE 7, USE THE PREVIOUSLY SAVED VALUE AS A PHANTOM CIN(46).
      IF (MODE .EQ. 6) THEN
        SAVE46=CIN(46)
      ELSE IF (MODE .EQ. 7) THEN
        CIN(46)=SAVE46
      ENDIF
C
C     Load the Ultimate analyses of the fresh inlet coal (COAL),
C     unreacted coal (URCOAL) and slag, and normalize to 100 wt%.
      N1 = NCCONV + 4
      N2 = N1 + 24
      N3 = N2 + 24
      SUMIN1 = 0.0D0
      SUMIN2 = 0.0D0
      SUMIN3 = 0.0D0
      DO 50 J = 1, 7
        UIN1(J) = SIN1(J+N1)
        UIN2(J) = SIN1(J+N2)
        UIN3(J) = SIN1(J+N3)
        SUMIN1 = SUMIN1 + UIN1(J)
        SUMIN2 = SUMIN2 + UIN2(J)
        SUMIN3 = SUMIN3 + UIN3(J)
   50 CONTINUE
      SUM1 = 0.0D0
      SUM2 = 0.0D0
      SUM3 = 0.0D0
      DO 52 J = 1, 7
        UIN1N(J) =  100.0D0 * UIN1(J) / SUMIN1
        UIN2N(J) =  100.0D0 * UIN2(J) / SUMIN2
        UIN3N(J) =  100.0D0 * UIN3(J) / SUMIN3
        SUM1 = SUM1 + UIN1N(J)
        SUM2 = SUM2 + UIN2N(J)
        SUM3 = SUM3 + UIN3N(J)
```

```
   52 CONTINUE
C
      IF (KTEST .GE. 3)  THEN
C       Write the supplied and normalized Ultimate analyses.
        WRITE (NHSTRY, 517)
  517   FORMAT ( / ' Supplied non-conventional component Ultimate ',
     1    'analyses:')
        WRITE (NHSTRY, 518)  (UIN1(J), UIN2(J), UIN3(J), J = 1, 7)
  518   FORMAT ( ' Component', 9X, 'Coal', 7X, 'URCOAL', 9X, 'SLAG' /
     1    2X, 'Ash     ', 3F13.2 /
     2    2X, 'Carbon  ', 3F13.2 /
     3    2X, 'Hydrogen', 3F13.2 /
     4    2X, 'Nitrogen', 3F13.2 /
     5    2X, 'Chlorine', 3F13.2 /
     6    2X, 'Sulfur  ', 3F13.2 /
     7   2X, 'Oxygen  ', 3F13.2 )
        WRITE (NHSTRY, 519)  SUMIN1, SUMIN2, SUMIN3
  519   FORMAT ( 2X, 'Total   ', 3F13.2 )
C
        WRITE (NHSTRY, 520)
  520   FORMAT ( / ' Normalized non-conventional component Ultimate ',
     1    'analyses:')
        WRITE (NHSTRY, 518)  (UIN1N(J), UIN2N(J), UIN3N(J), J = 1, 7)
        WRITE (NHSTRY, 519)  SUM1, SUM2, SUM3
      ENDIF
C
C     Load the ash oxide (AOXANAL) analyses of the fresh inlet coal and
C     normalize to 100%.
C     THIS IS FOR DISPLAY PURPOSES ONLY; NEITHER THE OXIN1 OR OXIN1N
C     VECTORS ARE USED ANYWHERE ELSE IN PROGRAM EXCEPT FOR THE
C     FOLLOWING WRITE STATEMENTS.
      N1 = NCCONV + 14
      SUM = 0.0D0
      DO 60 J = 1, 10
        OXIN1(J) = SIN1(J+N1)
        SUM = SUM + OXIN1(J)
   60 CONTINUE
      SUM1 = 0.0D0
      DO 62 J = 1, 10
        OXIN1N(J) = 100.0D0 * OXIN1(J) / SUM
        SUM1 = SUM1 + OXIN1N(J)
   62 CONTINUE
C
      IF (KTEST .GE. 3)  THEN
C       Write the supplied and normalized ash oxide (AOXANAL) analyses.
        WRITE (NHSTRY, 521)
  521   FORMAT ( / ' Supplied and normalized ash oxide (AOXANAL) ',
     1    'analyses of the fresh coal:')
        WRITE (NHSTRY, 522)  (OXIN1(J), OXIN1N(J), J = 1, 10)
  522   FORMAT ( ' Component', 4X, 'Supplied', 4X, 'Normalized' /
     1    2X, 'SiO2    ', 2F13.2 /
     2    2X, 'Al2O3   ', 2F13.2 /
     3    2X, 'FeOx    ', 2F13.2 /
     4    2X, 'TiO2    ', 2F13.2 /
     5    2X, 'P2O5    ', 2F13.2 /
```

```
     6    2X, 'CaO     ', 2F13.2 /
     7    2X, 'MgO     ', 2F13.2 /
     8    2X, 'Na2O    ', 2F13.2 /
     9    2X, 'K2O     ', 2F13.2 /
     A    2X, 'SO3     ', 2F13.2 )
        WRITE (NHSTRY, 519)  SUM, SUM1
      ENDIF
C
C     Calculate the lbs/hr of the Ultimate analyses components in the
C     feed stream entering the reactors (WTUCC) and the total lbs/hr of
C     all Ultimate analysis components entering the reactors (WTUC).
      N1 = NCCONV + 4
      N2 = N1 + 24
      N3 = N2 + 24
      DO 70 J = 1, 7
        WTUCC(J) = 0.01D0 * CIN(46) * UIN1N(J)
C       FOR MODE 7, THERE IS NO REAL COAL FEED. MODIFY TOTAL ELEMENTAL
C       FLOWS FOR THIS CASE, SUBTRACTING THE FICTIOUS COAL BASED
C       QUANTITY
        WTUC(J) = 0.01D0 * (CIN(47)*UIN2N(J) + CIN(48)*UIN3N(J))
     1    + WTUCC(J)
        IF (MODE .EQ. 7) WTUC(J)=WTUC(J)-WTUCC(J)
   70 CONTINUE
      TSOLID = CIN(46) + CIN(47) + CIN(48)
C     THIS TSOLID VARIABLE IS USED ONLY FOR FOLLOWING TABULATION.
C     IT IS ALSO USED FOR THE CALCULATION OF CONVSN.  MAKE IT
C     CONSISTENT FOR MODE 7.
      IF (MODE .EQ. 7)  TSOLID = TSOLID - CIN(46)
C
      IF ( KTEST .GE. 2 )  THEN
        WRITE (NHSTRY, 523)  (WTUCC(J), WTUC(J), J = 1, 7), CIN(46),
     1    TSOLID
  523   FORMAT ( / ' Amount of entering Ultimate analysis components,',
     1    ' lbs/hr.' / 13X, 'Fresh Coal', 8X, 'Total' /
     2    2X, 'Ash     ', 2F13.1 /
     3    2X, 'Carbon  ', 2F13.1 /
     4    2X, 'Hydrogen', 2F13.1 /
     5    2X, 'Nitrogen', 2F13.1 /
     6    2X, 'Chlorine', 2F13.1 /
     7    2X, 'Sulfur  ', 2F13.1 /
     8    2X, 'Oxygen  ', 2F13.1 /
     9    2X, 'Total   ', 2F13.1 )
      ENDIF
C
C     Calculate the required coal conversion/pass based of total MAF
C     coal entering the reactors to give the specified coal conversion
C     based on fresh MAF coal.
C     THIS CONVERSION PER PASS IS NEVER USED.  ITS VALUE IS NOT CORRECT
C     FOR MODE 7.
      CONVSN = CONMAF * (CIN(46) - WTUCC(1)) / (TSOLID - WTUC(1))
C
      IF ( KTEST .GE. 3 )  WRITE (NHSTRY, 524) CONMAF, CONVSN
  524 FORMAT ( / 2X, 'Specified fresh MAF coal conversion, % =', F10.4 /
     1  2X, 'Equivalent conversion/pass, %          =', F10.4 )
C
```

```
C     Set the reactor effluent stream temperature and pressure.
      TOUT = 800.0D00
      POUT=REAL(12)
      IF (MODE .EQ. 7) POUT=REAL(13)
C
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 2 )  THEN
C       If this user block summary report is to be written to the
C       normal ASPEN/SP report file, the ASPEN/SP system needs to know
C       the number of lines which will be written.  Thus, calculate the
C       number of lines which will be written.  Otherwise, open the
C       separate output file and skip to the top of a new page.
        IF ( INT(2) .EQ. 0 )   THEN
C           Calculate the number of lines in the first page.
            LINES = 54
            ISUM = IER1 + IER2 + IER3 + IER4
            IF ( ISUM .GE. 1 )   LINES = LINES + 1
C           Call subroutine RPTHDR to tell ASPEN/SP system the number
C           of lines that will be written.
            CALL RPTHDR (LINES, 0, 3, ISUB)
        ELSE
C           Open the separate output file called DCL2R.REP to contain
C           this user block summary report.
C     SET UP A DIFFERENT OUTPUT REPORT FOR MODE 7.  OTHERWISE, THE
C     REPORT WILL OVERWRITE THE ONE GENERATED IN THE OTHER MODES.
            IF (MODE .EQ. 7) THEN
              OPEN (UNIT=62, FILE='DCL2R_M7.REP', STATUS='UNKNOWN',
     1              ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2              BUFFERED='BUFFERED')
            ELSE
C            OPEN THE NORMAL SUMMARY REPORT FILE FOR EVERY OTHER CASE.
             OPEN (UNIT=62, FILE='DCL2R.REP', STATUS='UNKNOWN',
     1             ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2             BUFFERED='BUFFERED')
            ENDIF
            WRITE (NOUT, 800)
C           FORMAT statement 800 will print across a page on a PC
C           because it contains the PC top-of-form character (ASCII
C           character 012) between two quote marks ( i.e., 'TOF').
  800       FORMAT ( 'TOF' )
C           Depending on MODE, write the appropriate .REP file heading.
C
            IF ( MODE .EQ. 0)  WRITE (NOUT, 801)
  801       FORMAT ( / 22X, 'PLANT2 2, 6 AND 8 - SUMMARY REPORT' /
     1        17X, 'COAL LIQUEFACTION PLANT AND THE ROSE-SR UNIT')
C
            IF ( MODE .EQ. 1 )  WRITE (NOUT, 802)
  802       FORMAT ( / 27X, 'PLANT 2 - SUMMARY REPORT' /
     1        28X, 'COAL LIQUEFACTION PLANT')
C
            IF ( MODE .EQ. 2 .OR. MODE .EQ. 5)  WRITE (NOUT, 803)
  803       FORMAT (/15X,'COAL LIQUEFACTION REACTORS - SUMMARY REPORT')
C
            IF ( MODE .EQ. 3 )  WRITE (NOUT, 804)
  804       FORMAT ( / 24X, 'FIRST COAL LIQUEFACTION REACTOR' /
     1        32X, 'SUMMARY REPORT' )
```

```
C
            IF ( MODE .EQ. 6 )  WRITE (NOUT, 8804)
 8804       FORMAT ( / 24X, 'FIRST COAL LIQUEFACTION REACTOR' /
     1        32X, 'SUMMARY REPORT' )

            IF ( MODE .EQ. 7 )  WRITE (NOUT, 8888)
 8888       FORMAT ( / 24X, 'SECOND COAL LIQUEFACTION REACTOR' /
     1        32X, 'SUMMARY REPORT' )
C
            IF ( MODE .EQ. 4 )  WRITE (NOUT, 805)
  805       FORMAT ( / 23X, 'SECOND COAL LIQUEFACTION REACTOR' /
     1        31X, 'SUMMARY REPORT' )
C
            IF ( MODE .LE. 1 )  WRITE (NOUT, 811)
  811       FORMAT ( / ' LIQUEFACTION REACTOR SECTION')
        ENDIF
      ENDIF
C
C     Set MODE to 2 to tell subroutine USR02R that it is being called
C     by subroutine USR2R.
C     MODE = 2
C
C     Load the inlet and outlet stream temperatures (in degrees
C     Fahrenheit) and stream pressures (in PSIA) in the ST1 and ST2
C     arrays for printing in subroutine USR02R.
      X = 1.8D0
      X1 = 459.67D0
      ST1(1,2) = X * SIN1(NCC+2) - X1
C     FOR MODES 6 AND 7, THE OUTLET TEMPERATURE IS CALCULATED BY AN
C     OVERALL ENERGY BALANCE.   THUS, IF THIS IS MODE 6 OR 7, ST2(1,2)
C     WILL BE RECALCULATED LATER.
      ST2(1,2) = TOUT
      X = 1.0D0 / 6.8947573D+3
      ST1(1,3) = X * SIN1(NCC+3)
      ST2(1,3) = POUT
C     BEFORE ANY CALLS ARE MADE, CALL INITIALISATION ROUTINE.
      CALL USR02C(REAL,NREAL,WTUCC)
C     CALL SUBROUTINE USR02F TO CALCULATE THE FLUIDIZATION PROPERTIES.
      CALL USR02F(MODE,KOMPS,NHSTRY,NREAL,REAL,IPASS,NOUT)
C     Call Subroutine USR02R to calculate the net yields from the
C     coal liquefaction reactor.
      CALL USR02R (CONMAF, CONVSN, ICNAME, IER1, IER2, IER3, IER4,
     1  INT(1), IPASS, KMAXC, KOMPS, KTEST, MODE, NHSTRY, NOUT,
     2  NREAL,REAL,UIN1N, ULTOUT, UIN2N)
C
C     PERFORM ENERGY BALANCE
C     INLET TEMPERATURE, DEG F
      UTIN=ST1(1,2)
C
C     FOR ALL CASES, VIEW BOTH REACTORS AS A UNIT AND CALCULATE THE
C     TEMPERATURE OF THE STREAM LEAVING THE 2ND REACTOR, BASED ON THE
C     FRESH FEED TO THE 1ST REACTOR AND OVERALL H2 CONVERSION.
C     This is meaningful only for single reactor systems (MODEs 6 & 7).
      CALL USR2EB(UTIN,TOUT,KOMPS,NHSTRY)
      ST2(1,2)=TOUT
```

```
C     Write the energy balance results to report file
      IF (IPASS .EQ. 4 .AND. INT(1) .LE. 2 .AND. MODE .GE. 2) THEN
C       Energy balance in separate page.
        WRITE (NOUT, 842)
  842   FORMAT ( 'TOF' / 27X,'ENERGY BALANCE SECTION'///
     1          23X,'INLET',6X,'OUTLET'/)
        WRITE (NOUT, 841) ST1(1,2), ST2(1,2),
     1    ST1(1,3), ST2(1,3)
  841   FORMAT ( / 4X, 'TEMPERATURE, F', F10.1, F12.1 /
     1    4X, 'PRESSURE, PSIA', F10.1, F12.1/)
      ENDIF
C
C     Calculate correct fresh feed temperature that is required to
C     provide the desired average bed temperature. This can be performed
C     only for single reactors, using the calculated internal recycle
C     flow. Since this calculation is 'academic' as far as ASPEN is
C     concerned, restrict this call for quite large values of KTEST.
C     Also only during the report pass is this allowed to execute,
C     don't bother with it during recycle loops.
      IF (MODE .GT. 5 .AND. KTEST .GE. 3 .AND. IPASS .EQ. 4) THEN
C       SEPARATE REACTOR CALCULATIONS ENABLE MORE DETAILED EQUILIBRIA.
C       IN USR02E, THE REQUIRED INLET TEMPERATURE FOR ACHIEVING THE
C       DESIRED T-AVERAGE IN EVERY STAGE IS CALCULATED.
        IF (MODE .EQ. 6) THEN
          UTAVG=REAL(10)
        ELSE
          UTAVG=REAL(11)
        ENDIF
        CALL USR02E(UTAVG,KOMPS,NHSTRY,NOUT)
C       Results from the above call went to Z vector.
      ENDIF
C
C     CALL USR02K TO DO THE REACTOR KINETIC CALCULATIONS.
      CALL USR02K(MODE,ICNAME,KOMPS,KTEST,NHSTRY,NOUT,
     1            NREAL,REAL,IPASS,WTUCC,WTUC)
C
C     DISPLAY THE CURRENT (FINAL) VALUES IN THE BASIC VECTORS.
      IF (KTEST .GE. 2) THEN
        WRITE (NHSTRY,12)
  12    FORMAT ( /'TABULATION OF REAL,C, F, AND Z VECTORS'/)
        WRITE (NHSTRY,13)
  13    FORMAT ( /'TABULATION OF REAL VECTOR'/)
C       SHOW ALL REAL ELEMENTS, EVEN EMPTY ONES.
        WRITE (NHSTRY,15) (J,REAL(J),J=1,NREAL)
  15    FORMAT (/ 4(I2, 2X, F10.2, 2X) )
        WRITE (NHSTRY,14)
  14    FORMAT ( /'TABULATION OF C VECTOR'/)
        WRITE (NHSTRY,16) (J,C(J),J=1,50)
  16    FORMAT (/ 4(I2, 2X, F10.2, 2X) )
        WRITE (NHSTRY,18)
  18    FORMAT ( /'TABULATION OF F VECTOR'/)
        WRITE (NHSTRY,17) (J,F(J),J=1,50)
  17    FORMAT (/ 4(I2, 2X, F10.2, 2X) )
        WRITE (NHSTRY,22)
  22    FORMAT (/ 'TABULATION OF Z VECTOR'/)
```

```
          WRITE (NHSTRY,24) (J,Z(J),J=1,400)
   24     FORMAT (/ 4(I3, 2X, D12.6, 2X) )
        ENDIF
C
C       If requested, call subroutine USR02B to write the reactor
C       elemental balance to the history file.
        IF ( KTEST .GE. 3 )  THEN
          CALL USR02B (ICNAME, KMAXC, KOMPS, NHSTRY, ULTOUT, WTUC)
        ENDIF
C
C       Call Subroutine USR2RS to load the reactor effluent into the
C       single product stream.
        CALL USR2RS (ICNAME, IPASS, ITEMS, KOMPS, KTEST,
     1  NCC, NCCONV, NCONV, NHSTRY, NNCC, SIN1, SOUT1, ULTOUT)
C
C       If this is the report pass, the plant sumamry report is being
C       written, and any warning messages are needed, set up to write
C       them.
        ISUM = IER1 + IER2 + IER3 + IER4
        IF ( ISUM .GE. 1 .AND. IPASS .EQ. 4 .AND. INT(1) .LE. 2 )  THEN
          IF ( INT(2) .EQ. 0 )  THEN
C           Calculate the number of lines in second page.
            LSTRM = 3
            IF ( IER1 .GE. 1 )  LSTRM = LSTRM + 4
            IF ( IER2 .GE. 1 )  LSTRM = LSTRM + 4
            IF ( IER3 .GE. 1 )  LSTRM = LSTRM + 3
            IF ( IER4 .GE. 1 )  LSTRM = LSTRM + 4
            LINES = LSTRM
C           Call subroutine RPTHDR to tell ASPEN/SP system the number
C           of lines that will be written in this user block summary
C           report.
            CALL RPTHDR (LINES, 0, 3, ISUB)
          ELSE
            WRITE (NOUT, 800)
        ENDIF
C
C       Call Subroutine USR2RZ to write any warning messages to the
C       summary report.
        CALL USR2RZ (IER1, IER2, IER3, IER4, INT(1), IPASS, NOUT)
C
      ENDIF
C
C     If the summary report for this user block is has been sent to a
C     separate output file on logical unit 62, then close this file.
      IF ( IPASS .EQ. 4 .AND. INT(2) .GE. 1 )
     1  CLOSE ( UNIT=62, STATUS='KEEP' )
C
  999 IF ( KTEST .GE. 1 )  WRITE (NHSTRY, 540)
  540 FORMAT ( / ' Leaving subroutine USR2R' )
C
C
      RETURN
      END
C
C$ USR2BD
```

```
C
      BLOCKDATA USR2BD
C
C     This BLOCK DATA routine initalizes some varaables in COMMON
C     /USR12L/.   See subroutine USR2C for a definition of these
C     variables.
C
C     Last revision - July 23, 1992.
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON/USR12L/C(50),F(50),Z(400)
C
C     SOME OF THESE INITIALIZED VALUES ARE RECALCULATED IN THE PROGRAM.
C
C     INITIALIZE THE C VECTOR CONTAINING LIQUID AND PARTICLE PROPERTIES.
      DATA C /
C RULER ...1.....2.....3......4.....5....6....7......8......9....0
C     C(1) PATCHED TO LBM/FT3
     1 50.56, 0.3 ,  4.0,  1.11, 1.64,34.0, 0.8, 0.083, 0.240, 0.1354,
     2  0.64, 0.8 ,  2.4,379.5 ,15.0 ,85.0, 4.0,19.7  ,35.0  ,0.0 ,
     3  0.0 , 0.0 ,  0.0,  0.0 , 0.0 , 0.0, 0.0, 0.0  , 0.0  ,0.0 ,
     4  0.0 , 0.0 ,  0.0,  0.0 , 0.0 , 0.0, 0.0, 0.0  , 0.0  ,0.0 ,
     5  6.0 ,16.95,489.2,  0.0 , 0.0 , 0.0, 0.0, 0.0  , 0.0  ,0.0  /
C
C     INITIALIZE THE F VECTOR.
      DATA F /
C RULER ....1.....2.....3.....4.....5.....6.....7.....8.....9.....0
     1   0.0 , 0.0 , 0.8 ,12.5 , 0.0 , 0.0 , 0.0 , 2.3 , 0.0 , 0.0 ,
     2   0.0 , 0.0 , 0.0 , 0.0 , 0.66, 0.0 , 0.0 , 1.6 , 6.64, 1.6 ,
     3   0.5 , 0.3 , 0.3 , 0.1 ,21.06,30.43,12.72, 8.42, 2.38, 6.75,
     4   0.77, 1.25, 2.84,13.38, 0.0 , 0.1 , 7.5 ,14.5 ,24.9 ,44.8 ,
     5   8.2 , 0.0 , 0.0 , 0.0 , 0.0 , 0.0 , 0.0 , 0.0 , 0.0 , 0.0  /
C
      END
C
C$ USRO2A
      SUBROUTINE USRO2A (KTEST, NCC, NHSTRY, MODE)
C
C     This subroutine loads the conventional component molecular
C     weights, densities and elemental compositions in the CPROP(J,K)
C     array.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - July 21, 1992.
C
C     Calling arguments:
C     KTEST    = Switch for controlling the printing to the history
C                file.
C     NCC      = Number of conventional components.
C     NHSTRY   = Logical unit number of the history file.
C
C      The conventional components order follows.
C      No.  Component    Description
```

```
C        1.  H2          Hydrogen
C        2.  N2          Nitrogen
C        3.  O2          Oxygen
C        4.  H2S         Hydrogen sulfide
C        5.  CO          Carbon monoxide
C        6.  CO2         Carbon dioxide
C        7.  NH3         Ammonia
C        8.  H2O         Water
C        9.  HCL         Hydrochloric acid
C       10.  COS         Carbonyl sulfide
C       11.  CH4         Methane
C       12.  C2H6        Ethane
C       13.  C3H8        Propane
C       14.  IC4H10      Iso-butane
C       15.  NC4H10      Normal butane
C       16.  IC5H12      Iso-pentane
C       17.  NC5H12      Normal pentane
C       18.  T125        100 - 150 F boiling range fraction
C       19.  T175        150 - 200 F boiling range fraction
C       20.  T225        200 - 250 F boiling range fraction
C       21.  T275        250 - 300 F boiling range fraction
C       22.  T325        300 - 350 F boiling range fraction
C       23.  T375        350 - 400 F boiling range fraction
C       24.  T425        400 - 450 F boiling range fraction
C       25.  T475        450 - 500 F boiling range fraction
C       26.  T525        500 - 550 F boiling range fraction
C       27.  T575        550 - 600 F boiling range fraction
C       28.  T625        600 - 650 F boiling range fraction
C       29.  T675        650 - 700 F boiling range fraction
C       30.  T725        700 - 750 F boiling range fraction
C       31.  T775        750 - 800 F boiling range fraction
C       32.  T825        800 - 850 F boiling range fraction
C       33.  T875        850 - 900 F boiling range fraction
C       34.  T925        900 - 950 F boiling range fraction
C       35.  T975        950 - 1000 F boiling range fraction
C       36.  T1000+      1000+ F boiling range material leaving the
C                        second coal liquefaction reactor.
C       37.  I1000+      1000+ F boiling range intermediate material
C                        leaving the first coal liquefaction reactor.
C       38.  blank       Future use
C       39.  blank       Future use
C       40.  blank       Future use
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON/MW/XMW(1)
C
      COMMON /USRO2M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5), OPROP(20,5)
C
C     In COMMON /USRO2M/
C       CPROP(J,K) contains the conventional component properties
C         where J designates the component number and
C         K = 1 => Molecular weight
```

```
C             2 => Density, lbs/bbl
C             3 => Carbon content, wt%
C             4 => Hydrogen content, wt%
C             5 => Sulfur content, wt%
C             6 => Nitrogen content, wt%
C             7 => Oxygen content, wt%
C       ICNUMB(J) contains the relative component numbers.
C
C
C     Initialize all component properties to either 1.0 or zero.
      DO 10 J = 1, 40
        CPROP(J,1) = 1.0D0
        CPROP(J,2) = 1.0D0
        DO 8 K = 3, 7
          CPROP(J,K) = 0.0D0
    8   CONTINUE
   10 CONTINUE
C
C     Calculate the conversion factor for converting the component
C     standard volumes from m**3/Kg-mole to densities in lbs/bbl.
C         Kg --> lbs    m**3 --> ft**3         ft**3 --> bbls
      X = 2.2046226D0 * ((0.3048D0)**3) * (42.0D0*231.0D0/1728.0D0)
C
C     Conventional components - Load the component molecular weights
C     and densities in lbs/bbl as calculated from the standard volumes
C     in m**3/Kg.
      DO 20 J = 1, NCC
        DO 18 K = 1, 40
        IF ( J .EQ. ICNUMB(K) )  THEN
          CPROP(K,1) = XMW(J)
C         The component volumes are stored in the XMW vector following
C         the molecular weights; i.e., they are offset by NCC items.
          STDVOL = XMW(J+NCC)
          CPROP(K,2) = X * XMW(J) / STDVOL
        ENDIF
   18   CONTINUE
   20 CONTINUE
C
C
C     Load the molecular weights of atomic carbon, hydrogen, sulfur,
C     nitrogen and oxygen.
      XMWH = 0.5D0 * CPROP(1,1)
      XMWC = CPROP(11,1) - 2.0D0 * CPROP(1,1)
      XMWS = CPROP(4,1) - CPROP(1,1)
      XMWN = 0.5D0 * CPROP(2,1)
      XMWO = 0.5D0 * CPROP(3,1)
C
C
C     Load the pure component carbon, hydrogen, sulfur, nitrogen and
C     oxygen contents in wt%.
C     Hydrogen.
      CPROP(1,4) = 100.0D0
C     Nitrogen.
      CPROP(2,6) = 100.0D0
C     Oxygen.
```

```
      CPROP(3,7) = 100.0D0
C     Hydrogen sulfide.
      CPROP(4,4) = 100.0D0 * 2.0D0 * XMWH / CPROP(4,1)
      CPROP(4,5) = 100.0D0 * XMWS / CPROP(4,1)
C     Carbon monoxide.
      CPROP(5,3) = 100.0D0 * XMWC / CPROP(5,1)
      CPROP(5,7) = 100.0D0 * XMWO / CPROP(5,1)
C     Carbon dioxide.
      CPROP(6,3) = 100.0D0 * XMWC / CPROP(6,1)
      CPROP(6,7) = 100.0D0 * 2.0D0 * XMWO / CPROP(6,1)
C     Ammonia.
      CPROP(7,4) = 100.0D0 * 3.0D0 * XMWH / CPROP(7,1)
      CPROP(7,6) = 100.0D0 * XMWN / CPROP(7,1)
C     Water.
      CPROP(8,4) = 100.0D0 * 2.0D0 * XMWH / CPROP(8,1)
      CPROP(8,7) = 100.0D0 * XMWO / CPROP(8,1)
C     Hydrochloric acid.
      CPROP(9,4) = 100.0D0 * XMWH / CPROP(9,1)
C     COS - Carbonyl sulfide.
      CPROP(10,3) = 100.0D0 * XMWC / CPROP(10,1)
      CPROP(10,5) = 100.0D0 * XMWS / CPROP(10,1)
      CPROP(10,7) = 100.0D0 * XMWO / CPROP(10,1)
C     Methane.
      CPROP(11,3) = 100.0D0 * XMWC / CPROP(11,1)
      CPROP(11,4) = 100.0D0 * 4.0D0 * XMWH / CPROP(11,1)
C     Ethane.
      CPROP(12,3) = 100.0D0 * 2.0D0 * XMWC / CPROP(12,1)
      CPROP(12,4) = 100.0D0 * 6.0D0 * XMWH / CPROP(12,1)
C     Propane.
      CPROP(13,3) = 100.0D0 * 3.0D0 * XMWC / CPROP(13,1)
      CPROP(13,4) = 100.0D0 * 8.0D0 * XMWH / CPROP(13,1)
C     Butanes.
      CPROP(14,3) = 100.0D0 * 4.0D0 * XMWC / CPROP(14,1)
      CPROP(14,4) = 100.0D0 * 10.0D0 * XMWH / CPROP(14,1)
      CPROP(15,3) = CPROP(14,3)
      CPROP(15,4) = CPROP(14,4)
C     Pentanes.
      CPROP(16,3) = 100.0D0 * 5.0D0 * XMWC / CPROP(16,1)
      CPROP(16,4) = 100.0D0 * 12.0D0 * XMWH / CPROP(16,1)
      CPROP(17,3) = CPROP(16,3)
      CPROP(17,4) = CPROP(16,4)
C
C     IF THIS IS MODE 7, INSTEAD OF FOLLOWING VALUES, USE THOSE
C     CALCULATED AND SAVED FOR US AT STAGE I OUTLET.
      IF (MODE .NE. 7) THEN
C     USE THE NORMAL PROCEDURE FOR COMPOSITIONS.
C       Load the C6+ component sulfur contents in wt%.
        CPROP(18,5) = 0.01
        CPROP(19,5) = 0.01
        CPROP(20,5) = 0.01
        CPROP(21,5) = 0.01
        CPROP(22,5) = 0.01
        CPROP(23,5) = 0.01
        CPROP(24,5) = 0.01
        CPROP(25,5) = 0.02
```

```
      CPROP(26,5) = 0.02
      CPROP(27,5) = 0.02
      CPROP(28,5) = 0.02
      CPROP(29,5) = 0.06
      CPROP(30,5) = 0.06
      CPROP(31,5) = 0.06
      CPROP(32,5) = 0.06
      CPROP(33,5) = 0.10
      CPROP(34,5) = 0.15
      CPROP(35,5) = 0.20
      CPROP(36,5) = 0.50
      CPROP(37,5) = 0.50
C
C     Load the C6+ component nitrogen contents in wt%.
      CPROP(18,6) = 0.17D0
      CPROP(19,6) = 0.17D0
      CPROP(20,6) = 0.17D0
      CPROP(21,6) = 0.17D0
      CPROP(22,6) = 0.17D0
      CPROP(23,6) = 0.22D0
      CPROP(24,6) = 0.22D0
      CPROP(25,6) = 0.24D0
      CPROP(26,6) = 0.24D0
      CPROP(27,6) = 0.24D0
      CPROP(28,6) = 0.24D0
      CPROP(29,6) = 0.28D0
      CPROP(30,6) = 0.28D0
      CPROP(31,6) = 0.28D0
      CPROP(32,6) = 0.28D0
      CPROP(33,6) = 0.35D0
      CPROP(34,6) = 0.40D0
      CPROP(35,6) = 0.45D0
      CPROP(36,6) = 0.50D0
      CPROP(37,6) = 0.50D0
C
C     Load the C6+ component oxygen contents in wt%.
      CPROP(18,7) = 0.50D0
      CPROP(19,7) = 0.50D0
      CPROP(20,7) = 0.50D0
      CPROP(21,7) = 0.50D0
      CPROP(22,7) = 0.50D0
      CPROP(23,7) = 0.70D0
      CPROP(24,7) = 0.70D0
      CPROP(25,7) = 0.60D0
      CPROP(26,7) = 0.60D0
      CPROP(27,7) = 0.60D0
      CPROP(28,7) = 0.60D0
      CPROP(29,7) = 0.67D0
      CPROP(30,7) = 0.67D0
      CPROP(31,7) = 0.67D0
      CPROP(32,7) = 0.67D0
      CPROP(33,7) = 0.70D0
      CPROP(34,7) = 0.71D0
      CPROP(35,7) = 0.72D0
      CPROP(36,7) = 0.75D0
```

```
          CPROP(37,7) = 0.75D0
C
C         Load the C6+ component hydrogen contents in wt%.
          CPROP(18,4) = 14.21D0
          CPROP(19,4) = 14.21D0
          CPROP(20,4) = 14.21D0
          CPROP(21,4) = 14.21D0
          CPROP(22,4) = 14.21D0
          CPROP(23,4) = 12.16D0
          CPROP(24,4) = 12.16D0
          CPROP(25,4) = 10.95D0
          CPROP(26,4) = 10.95D0
          CPROP(27,4) = 10.95D0
          CPROP(28,4) = 10.95D0
          CPROP(29,4) = 9.97D0
          CPROP(30,4) = 9.97D0
          CPROP(31,4) = 9.97D0
          CPROP(32,4) = 9.97D0
          CPROP(33,4) = 9.90D0
          CPROP(34,4) = 9.80D0
          CPROP(35,4) = 9.70D0
          CPROP(36,4) = 9.00D0
          CPROP(37,4) = 5.50D0
C
C         Calculate the C6+ component carbon contents in wt% by
C         difference.
          DO 30 J = 18, 37
            CPROP(J,3) = 100.0D0 - CPROP(J,4) - CPROP(J,5) - CPROP(J,6)
     1        - CPROP(J,7)
   30     CONTINUE
        ELSE
C       FOR MODE 7, USE PREVIOUSLY SAVED COMPOSITIONS (i.e., OUTLET
C       COMPOSITION OF STAGE I BECOMES INLET COMPOSITION FOR STAGE II).
          DO 50,J=18,37
            DO 40, K=1,5
              CPROP(J,K+2)=OPROP(J-17,K)
   40       CONTINUE
   50     CONTINUE
        ENDIF
C
C
        RETURN
        END
C
C$ USR02B
C
        SUBROUTINE USR02B (ICNAME, KMAXC, KOMPS, NHSTRY, ULTOUT, WTUC)
C
C       This subroutine calculates and reports a reactor elemental
C       balance.  In this elemental balance, chlorine is considered as
C       carbon.
C
C       Prepared under DOE contract no. DE-AC22 90PC89857.
C
C       Last revision - July 21, 1992.
```

```
C
C     Calling arguments:
C     ICNAME() = Vector of component identifications (CHARACTER * 4)
C     KMAXC    = Total number of componets (conventional and non-
C                conventional) in the component vectors.
C     KOMPS    = Number of conventional components used in the coal
C     NHSTRY   = Logical unit number of the history file.
C     ULTOUT() = Ultimate analysis of the URCOAL (unconverted coal and
C                ash) leaving the ROSE-SR unit.
C     WTUC()   = Totatl weight of entering Ultimate analysis components,
C                lbs/hr.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON /USRO2M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5), OPROP(20,5)
C
      DIMENSION ICNAME(*), ULTOUT(*), WTUC(*)
C
C     Local variable declarations.
C
      DIMENSION EINC(7), EINS(7), EINT(7), EOUTC(7), EOUTS(7), EOUTT(7),
     1  ENAME(7)
C
C     EINC are the element weights in lbs/hr entering the reactor in the
C       conventional components in the order given in the UNAME vector.
C     EINS are the element weights in lbs/hr entering the reactor in the
C       non-conventional (solid) components in the order given in the
C       UNAME vector.
C     EINT are the total element weights in lbs/hr entering the reactor
C       of all components in the order given in the UNAME vector.
C     EOUTC, EOUTS and EOUTT are equivalent to the EIN? vectors for the
C       elements leaving the coal liquefaction reactors.
C
C
      CHARACTER * 4  BLANK4, ICNAME
      CHARACTER * 8  ENAME
C
      DATA BLANK4 / '    ' /
C
      DATA ENAME / 'Carbon  ', 'Hydrogen', 'Sulfur  ', 'Nitrogen',
     1             'Oxygen  ', 'Ash     ', 'Total   ' /
C
C
C     Zero all the elemntal vectors.
      DO 10 J = 1, 7
        EINC(J) = 0.0D0
        EINS(J) = 0.0D0
        EINT(J) = 0.0D0
        EOUTC(J) = 0.0D0
        EOUTS(J) = 0.0D0
        EOUTT(J) = 0.0D0
   10 CONTINUE
C
```

```
C     Calculate the lbs/hr of each element entering and leaving the
C     coal liquefaction reactors in the conventional components.
      DO 30 K = 1, 5
        L = K + 2
        DO 28 J = 1, KOMPS
C     HERE THE REASON BECOMES EVIDENT FOR RECALCULATION OF CPROPs
C     FOR PETROLEUM FRACTIONS AT THE END OF USR02R. BUT FOR MODE 7,
C     THE STAGE I CPROPs FOR FRACTIONS SHOULD BE SAVED, IN ORDER TO
C     PERFORM RIGHT BALANCES.
          EINC(K)  = EINC(K)  + CIN(J)  * CPROP(J,L)
C         DISTINGUISH % COMPOSITION FOR OIL FRACTIONS.
          IF (J .LT. 18) THEN
            COMPOS=CPROP(J,L)
          ELSE
            COMPOS=OPROP(J-17,K)
          ENDIF
          EOUTC(K) = EOUTC(K) + COUT(J) * COMPOS
   28   CONTINUE
   30 CONTINUE
C
C     Convert to lbs/hr from % times lbs/hr.
      DO 40 K = 1, 5
        EINC(K)  = 0.01D0 * EINC(K)
        EOUTC(K) = 0.01D0 * EOUTC(K)
   40 CONTINUE
C
C     Elements entering in the non-conventional components.
      EINS(1) = WTUC(2) + WTUC(5)
      EINS(2) = WTUC(3)
      EINS(3) = WTUC(6)
      EINS(4) = WTUC(4)
      EINS(5) = WTUC(7)
      EINS(6) = WTUC(1)
C
C     Elements leaving in the non-conventional components.
      EOUTS(1) = 0.01D0 * COUT(47) * (ULTOUT(2) + ULTOUT(5))
      EOUTS(2) = 0.01D0 * COUT(47) * ULTOUT(3)
      EOUTS(3) = 0.01D0 * COUT(47) * ULTOUT(6)
      EOUTS(4) = 0.01D0 * COUT(47) * ULTOUT(4)
      EOUTS(5) = 0.01D0 * COUT(47) * ULTOUT(7)
      EOUTS(6) = 0.01D0 * COUT(47) * ULTOUT(1)
C
C     Calculate the totals.
      DO 50 K = 1, 6
        EINC(7)  = EINC(7) + EINC(K)
        EINS(7)  = EINS(7) + EINS(K)
        EOUTC(7) = EOUTC(7) + EOUTC(K)
        EOUTS(7) = EOUTS(7) + EOUTS(K)
   50 CONTINUE
      DO 60 K = 1, 7
        EINT(K)  = EINC(K) + EINS(K)
        EOUTT(K) = EOUTC(K) + EOUTS(K)
   60 CONTINUE
C
C     Write the reactor elemental balance.
```

```
      WRITE (NHSTRY, 701)
  701 FORMAT ( / ' Reactor elemental balance in lbs/hr.' /
     1  2X, 'In this balance, chlorine is included in the carbon.' /
     2  3X, 'Element', 7X, 'in fluids', 6X, 'in solids', 10X, 'Total' )
C
      WRITE (NHSTRY, 702)
  702 FORMAT ( '  Reactor feed' )
C
      WRITE (NHSTRY, 703) (ENAME(J), EINC(J), EINS(J), EINT(J), J= 1, 7)
  703 FORMAT ( 3X, A8, F15.1, F15.1, F15.1 )
C
      WRITE (NHSTRY, 704)
  704 FORMAT ( '  Reactor effluent' )
C
      WRITE (NHSTRY, 703) (ENAME(J), EOUTC(J), EOUTS(J), EOUTT(J),
     1  J = 1, 7)
C
C
      RETURN
      END
C
C$ USRO2C
C
C     SUBROUTINE USRO2C CALCULATES FEQUENTLY USED QUANTITIES UTILIZED
C     IN SEVERAL DIFFERENT SUBROUTINES. THIS MAKES THE DIFFERENT
C     MODES INDEPENDENT, NO MATTER WHICH SUBROUTINE EXECUTES FIRST OR
C     DOES NOT EXECUTE AT ALL.
C
C     THE FOLLOWING DEFINITIONS ARE USED:
C     C(1) LIQUID DENSITY (LBM/FT3)
C     C(2) LIQUID VISCOCITY (CP)
C     C(3) LIQUID SURFACE TENSION (DYN/CC)
C     C(4) DENSITY OF DRY CATALYST PARTICLES (GM/CC)
C     C(5) DENSITY OF SOAKED CATALYST PARTICLES (GM/CC)
C     C(6) SETTLED DRY CATALYST BULK DENSITY (LB/FT3)
C     C(7) SPHERICITY OF CATALYST PARTICLES (DIMENSIONLESS)
C     C(8) AVERAGE DIAMETER OF CATALYST PARTICLE (INC)
C     C(9) AVERAGE LENGTH OF CATALYST PARTICLE (INC)
C     C(10) SPHERE EQUIVALENT DIAMETER OF CATALYST PARTICLE (IN)
C     C(11) PORE VOLUME OF FRESH DRY CATALYST (CC/GR)
C     C(12) DENSITY OF COKE ON CATALYST (GR/CC)
C     C(13) DENSITY OF METALS SULFIDES ON CATALYST (GM/CC)
C     C(14) FT3 PER LBMOL = 379.5
C     C(15) H-COAL REACTOR INTERNAL DIAMETER, FT; USE 15 FT
C     C(16) H-COAL REACTOR HEIGHT; USE 85. FT
C     C(17) RATIO OF RECYCLE TO FRESH FEED
C     C(18) EXPANDED BED DENSITY, LB/FT3
C     C(19) SETTLED BED DENSITY, LB/FT3
C     C(20) TO C(40) KEEP SPARE FOR FLUID DYNAMIC CALCULATIONS
C     C(41) REFRACTORY THICKNESS, INCHES
C     C(42) REACTOR OD, FT
C     C(43) REACTOR STEEL WEIGHT CONSTANT, 489.2 LBS/FT3
C     F(1) Future use.
C     F(2) Future use.
C     F(3) Ni,V AND S ON CATALYST (WT% OF FRESH)
```

```
C     F(4) C AND H ON CATALYST (WT% OF FRESH)
C     F(5) SOLVENT/MF COAL
C     F(6) ASH, % MAF
C     F(7) MAF COAL LB/HR/TRAIN
C     F(8) WATER IN COAL, % MAF
C     F(9) MF COAL LB/HR/TRAIN
C     F(10) RESID IN RECYCLE SOLVENT, % MAF
C     F(11) C5 TO 1000F+F IN RECYCLE SOLVENT
C     F(12) ASH IN RECYCLE SOLVENT, LB/HR
C     F(13) UNCONVERTED COAL IN RECYCLE SOLVENT, LB/HR
C     F(14) UC COAL REACTOR I % MAF
C     F(15) DISTILLATE LOSS % MAF
C     F(16) ASH IN SOLVENT , % MAF COAL
C     F(17) TOTAL SOLVENT LB/HR
C     F(18) RECYCLE GAS FROM H2 PURIFIER, WT% MAF COAL
C     F(19) UNTREATED RECYCLE GAS TO STAGE I, WT% MAF
C     F(20) H2 IN RECYCLE PURIFIED GAS, WT% MAF
C     F(21) C1 IN RECYCLE PURIFIED GAS, WT% MAF
C     F(22) C2 IN RECYCLE PURIFIED GAS, WT% MAF
C     F(23) C3 IN RECYCLE PURIFIED GAS, WT% MAF
C     F(24) C4 IN RECYCLE PURIFIED GAS, WT% MAF
C     F(25) UNTREATED RECYCLE GAS H2 WT%
C     F(26) UNTREATED RECYCLE GAS C1 WT%
C     F(27) UNTREATED RECYCLE GAS C2 WT%
C     F(28) UNTREATED RECYCLE GAS C3 WT%
C     F(29) UNTREATED RECYCLE GAS C4 WT%
C     F(30) UNTREATED RECYCLE GAS C5+ WT%
C     F(31) UNTREATED RECYCLE GAS CO WT%
C     F(32) UNTREATED RECYCLE GAS CO2 WT%
C     F(33) UNTREATED RECYCLE GAS NH3 WT%
C     F(34) UNTREATED RECYCLE GAS H2S WT%
C     F(35) C5-350 F WT% IN 1000 F- SOLVENT
C     F(36) 350-450 F WT% IN 1000 F- SOLVENT
C     F(37) 450-650 F WT% IN 1000 F- SOLVENT
C     F(38) 650-750 F WT% IN 1000 F- SOLVENT
C     F(39) 750-850 F WT% IN 1000 F- SOLVENT
C     F(40) 850-950 F WT% IN 1000 F- SOLVENT
C     F(41) 950-1000 F WT% IN 1000 F- SOLVENT
C     Z(1) SUPERFICIAL VELOCITY OF FEED LIQUID (FPS)
C     Z(2) SUPERFICIAL VELOCITY OF RECYCLE LIQUID (FPS)
C     Z(3) SUPERFICIAL VELOCITY OF LIQUID IN CATALYST BED (FPS)
C     Z(3)=Z(1)+Z(2)
C     Z(4) SUPERFICIAL VELOCITY OF FEED GAS (FPS)
C     Z(5) SUPERFICIAL VELOCITY OF RECYCLE GAS (FPS)
C     Z(6) SUPERFICIAL VELOCITY OF GAS IN CATALYST BED (FPS)
C     Z(6)=Z(4)+Z(5)
C     Z(7) TERMINAL VELOCITY OF CATALYST PARTICLES (FPS)
C     Z(8) TERMINAL VELOCITY OF BUBBLES (FPS)
C     Z(9) MINIMUM FLUIDIZATION VELOCITY WITHOUT GAS (FPS)
C     Z(10) MINIMUM FLUIDIZATION VELOCITY WITH GAS (FPS)
C     Z(11) SPHERE EQUIVALENT BUBBLE DIAMETER (CM)
C     Z(12) POROSITY OF TAPPED SETTLED BED ((VOL.FR. BED)
C     Z(13) POROSITY AT MINIMUM FLUIDIZATION VELOCITY (VOL. FR. BED)
C     Z(14) GAS HOLDUP IN CATALYST BED (VOL  FRACTION OF TOTAL BED)
C     Z(16) CATALYST PARTICLE HOLDUP IN BED (VOL. FRACTION OF BED)
```

```
C     Z(15) LIQUID HOLDUP IN BED (VOL. FR. OF BED)
C     Z(17) BED POROSITY (VOL. FR. BED)
C     Z(18) AVERAGE BED DENSITY (LB/FT3)
C     Z(19) AVERAGE FREEBOARG DENSITY (LB/FT3)
C     Z(20) VAPOR DENSITY (LB/FT3)
C
C     Z(22) BED INITIAL HEIGHT (FT)
C     Z(23) BED EXPANDED HEIGHT (FT)
C     Z(24) BED EXPANSION (% OF SETTLED BED HEIGHT)
C     Z(25) BED EXPANSION WITHOUT GAS (% OF SETTLED BED HEIGHT)
C     Z(26) LBMOLS/HR OF GASEOUS COMPONENTS ENTERING THE REACTOR
C     Z(27) LBS/HR OF LIQUID COMPONENTS ENTERING THE REACTOR
C     Z(28) LBS/HR OF LIQUID COMPONENTS WITH RECYCLE STREAM
C     Z(29) LBMOLS/HR OF GASEOUS COMPONENTS WITH RECYCLE STREAM
C     Z(30) SCFM OF VAPOR FEED AT REACTOR INLET
C     Z(31) SCFM OF RECYCLE VAPOR
C     Z(32) GPM OF LIQUID FEED
C     Z(33) GPM OF RECYCLE LIQUID
C     Z(34) REACTOR CROSS SECTION, FT**2
C     Z(35) CATALYST WEIGHT EACH REACTOR, LBS
C     Z(36) EXPANDED BED VOLUME, FT3
C     Z(37) EFFECTIVE REACTOR ID, FT
C     Z(38) EXPANDED HEIGHT, FT
C     Z(39) REACTOR HEIGHT, FT
C     Z(40) SETTLED CATALYST VOLUME, FT3
C     Z(41) REACTOR SHELL WEIGHT, LBS
C     Z(42) REACTOR HEADS WEIGHT, LBS
C     Z(43) REACTOR NOZZLES AND SKIRS WEIGHT, LBS
C     Z(44) MISCELLANEOUS ADDITION TO REACTOR WEIGHT, 7% OF Z(41)
C     Z(45) REACTOR WEIGHT IN SHORT TONS
C
      SUBROUTINE USR02C(REAL,NREAL,WTUCC)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C     COMMON STORAGE: the main connection to main program.
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5), OPROP(20,5)
C     FIRST DECLARATION OF THIS COMMON.
C     DATA IS INITIALIZED IN BLOCK DATA ROUTINE USR2BD.
      COMMON/USR12L/C(50),F(50),Z(400)
C     FORMAL ARGS DECLARATION
      DIMENSION REAL(NREAL),WTUCC(*)
C
C     Note:  the C and F vectors are initialized in BLOCKDATA USR2BD.
C
C     ZERO THE Z VECTOR--CONTAINING CALCULATED RESULTS.
      DO 5 I=1,400
        Z(I)=0.0
  5   CONTINUE
C
C     STAGE I INPUT DATA: REST OF VALUES ARE CONTAINED IN REAL VECTOR.
C     CALCULATE MAF COAL LB/HR/TRAIN, MOVED FROM 02F.
      F(7)=CIN(46)-WTUCC(1)
C     CALCULATE ASH IN COAL, % MAF, MOVED FROM 02F.
      F(6)=WTUCC(1)*100./F(7)
C
```

```
C     STAGE II INPUT DATA: REST OF VALUES ARE CONTAINED IN REAL VECTOR
C     OR IN THE ABOVE INITIALIZED F VECTOR OR SHARED WITH THE STAGE I
C     DATA.
C
C     STAGE II PREREQUISITES: SET 2S2/2Y2 PATH INDEPENDENT OF 2S1/2Y1
C     PATH.  REMEMBER THAT MODE 7 STILL HAS TO PASS THROUGH 2S1/2Y1
C     PATH TO GET THE STAGE I YIELDS [Z(69)-Z(83)].
C     SET UC COAL REACTOR I % MAF.
      F(14)=REAL(15)
C     CATALYST WEIGHT EACH REACTOR, LB.
      Z(35)=F(7)/REAL(6)
C     Z(66) DISTILLATE AND RESID LOSS, % MAF.
      Z(66)=(3./7.)*(F(6)+REAL(4))
C     Z(67) RESID LOSS % MAF.
      Z(67)=Z(66)-F(15)
C     Z(68) OVERALL COAL CONVERSION TO 1000-F %MAF.
      Z(68)=100.0-REAL(4)-Z(67)
C
C     FINAL GENERAL PURPOSE PATCHES.
C
C     EQUILIVANCE THE STAGE I CONVERSION WITH Z(68) (OVERALL
C     CONVERSION), WHICH IS ALSO EVALUATED IN HERE.
C     Z(65) 1000+F CONV REACTOR I, % MAF.
      Z(65)=100.0-REAL(3)-REAL(15)
C
C     F(18) RECYCLE GAS FROM PURIFIER, WT% MAF COAL.
      F(18)=F(20)+F(21)+F(22)+F(23)+F(24)
C
      RETURN
      END
C
C$ USR02R
C
      SUBROUTINE USR02R (CONMAF, CONVSN, ICNAME, IER1, IER2, IER3, IER4,
     1  INT1, IPASS, KMAXC, KOMPS, KTEST, MODE, NHSTRY, NOUT,
     2  NREAL,REAL,UFCOAL, ULTOUT, UURC)
C
C     This subroutine calculates the net coal liquefaction reactor
C     yields and the total reactor outlet stream.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - July 21, 1992.
C
C     Method of calculation:
C       1.  The entering non-ash solids are converted to the net
C           yields from the coal liquefaction reactor by the yield
C           distribution factors loaded in the CYF vector.
C       2.  The unconverted coal and mineral matter (called ash) is
C           the URCOAL.
C       3.  The Ultimate analysis of the unreacted coal URCOAL is
C           calculated by an elemental balance
C       4.  The net yields are loaded in the COUT vector.
C
C     Calling arguments:
```

```
C     CONMAF    = Percent coal conversion based on fresh MAF coal
C                 entering the reactors.
C     CONVSN    = Percent coal conversion per pass based on total MAF
C                 coal entering the reactors.
C     ICNAME()  = Vector of component identifications (CHARACTER * 4)
C     IER1      = Switch to indicate whether the OTHERS warning message
C                 should be written.
C                   0 => Do not write the warning message.
C                   1 => Write the warning message.
C     IER2      = Switch to indicate whether the insufficient hydrogen
C                 supplied warning message should be written.
C                   0 => Do not write the warning message.
C                   1 => Write the warning message.
C     IER3      = Switch to indicate whether the conversion was changed
C                 to balance the elements in the URCOAL warning message
C                 should be written.
C                   0 => Do not write the warning message.
C                   1 => Write the warning message.
C     IER4      = Switch to indicate whether the liquefaction reactor
C                 element inbalance warning message should be written.
C                   0 => Do not write the warning message.
C                   1 => Write the warning message.
C     INT1      = User block output report control switch.
C                   0 => Write the complete user block summary report.
C                   1 => Skip the capital cost section of the report.
C                   2 => Skip the capital cost and utilities sections of
C                        the report.
C                   3 => Skip writing the entire user block summary report.
C     IPASS     = The results pass flag.
C     KMAXC     = Total number of componets (conventional and non-
C                 conventional) in the component vectors.
C     KOMPS     = Number of conventional components used in the coal
C                 liquefaction reactor model.
C     KTEST     = Switch for controlling the printing to the history
C                 file.
C     MODE      = Switch to indicate which model and/or subroutine
C                 has called this subroutine.
C                   0 => Called by subroutine USR28, the combined model for
C                        plants 2, 6 and 8.
C                   1 => Called by subroutine USR02, the block model for
C                        plant 2.
C                   2 => Called by subroutine USR2R, the detailed model for
C                        both plant 2 coal liquefaction reactors.
C                   3 => Called by subroutine USRR1, the detailed model for
C                        the first plant 2 coal liquefaction reactor.
C                   4 => Called by subroutine USRR2, the detailed model for
C                        the second plant 2 coal liquefaction reactor.
C     NHSTRY    = Logical unit number of the history file.
C     NOUT      = Logical unit number of the plant output report file.
C                 liquefaction reactor model.
C     UFCOAL()  = Ultimate analysis of the fresh coal entering the
C                 reactors.
C     ULTOUT()  = Ultimate analysis of the URCOAL (unconverted coal
C                 and ash) leaving the reactors.
C     UURC(7)   = Ultimate analysis of the URCOAL that enters the
```

```
C                 reactors.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5), OPROP(20,5)
C
      COMMON/USR12L/C(50),F(50),Z(400)
C
C
      DIMENSION ICNAME(*), ULTOUT(*), UFCOAL(*), UURC(*)
C
C     Local variable declarations.
C
C     YFC(J), YFH(J), YFS(J), YFN(J) and YFO(J) are the fractional
C     yields of carbon, hydrogen, sulfur, nitrogen and oxygen going to
C     component J produced by the reaction of one pound of fresh MAF
C     coal.
C     * For the two reactor yields model, the YFCO(J), YFHO(J),
C       YFSO(J), YFNO(J) and YFOO(J) factors were developed from data
C       at 92.79 conversion and adjusted to 100% fresh MAF coal
C       conversion.
C     * For the first reactor yields model, the YFC1(J), YFH1(J),
C       YFS1(J), YFN1(J) and YFO1(J) factors were developed from data
C       at 89.80 conversion and adjusted to 100% fresh MAF coal
C       conversion.
C
C     YFUC(5) contains the fractional yields of C, H, S, N and O in
C     the unconverted coal (URCOAL) for the above base case.
C     * For the two reactor yields model, the YFUCO(J) factors
C       were developed from data at 92.79 fresh MAF coal conversion.
C     * For the first reactor yields model, the YFUC1(J) factors
C       were developed from data at 89.80 fresh MAF coal conversion.
C
      DIMENSION YFC(50), YFH(50), YFN(50), YFO(50), YFS(50), YFUC(5),
     1  YFCO(50), YFHO(50), YFNO(50), YFOO(50), YFSO(50), YFUCO(5),
     2  YFC1(50), YFH1(50), YFN1(50), YFO1(50), YFS1(50), YFUC1(5)
C
      DIMENSION CPROD(50), ENAME(5), EYLD(50,5), SUME(5), UANAME(8),
     1  WTEIN(5), WTUOUT(7), XYF(20,5),REAL(NREAL)
C
      DIMENSION YYFC(50),YYFH(50),YYFS(50),YYFN(50),YYFO(50)
C
      CHARACTER * 4  BLANK4, ICNAME
      CHARACTER * 8  ENAME, UANAME
C
      DATA BLANK4 / '    ' /
C
C     Define new yield factors based on kinetic model
      EQUIVALENCE (YFC(1),YYFC(1)),(YFH(1),YYFH(1)),(YFS(1),YYFS(1)),
     1  (YFN(1),YYFN(1)),(YFO(1),YYFO(1))
C
C     Initialize the reactor element yield distribution factors in
C     lbs/lb of fresh MAF coal converted.
```

```
C
C     OVERALL TWO REACTOR ELEMENTAL YIELD FACTORS.
C     ---------------------------------------------
C     The iC5/NC5 split was assumed to be the same as the IC4/NC4 split.
C     The properties of the 850+ F material were estimated based on the
C     data in the letters.
C
C     Carbon.
C     Wt fraction to  H2      N2          O2          H2S         CO
      DATA YFCO /    0.0 , 0.000000 , 0.000000 , 0.0000000, 0.0003466,
C       CO2         NH3         H2O         HCL         COS
     1  0.0005148, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       CH4         C2H6        C3H8        IC4H10      N C4H10
     2  0.0185601, 0.0153915, 0.0167342, 0.0013364, 0.0074615,
C       IC5H12      N C5H12     T125        T175        T225
     3  0.0002555, 0.0014266, 0.0366256, 0.0366256, 0.0366256,
C       T275        T325        T375        T425        T475
     4  0.0366256, 0.0366256, 0.0439693, 0.0439693, 0.0754803,
C       T525        T575        T625        T675        T725
     5  0.0754803, 0.0754803, 0.0754803, 0.0640470, 0.0640470,
C       T775        T825        T875        T925        T975
     6  0.0640470, 0.0640470, 0.0026366, 0.0026363, 0.0026360,
C       T1000+      I1000+      Future      Future      Future
     7  0.1008881, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       Future      Future      Future      Future      Future
     8  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       Coal        URCOAL      Slag        Future      OTHERS
     9  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000 /
C
C     Hydrogen.
C     Wt fraction to  H2      N2          O2          H2S         CO
      DATA YFHO /-0.066818, 0.000000 , 0.000000 , 0.0146041, 0.0000000,
C       CO2         NH3         H2O         HCL         COS
     1  0.0000000, 0.0213052, 0.0918606, 0.0000000, 0.0000000,
C       CH4         C2H6        C3H8        IC4H10      N C4H10
     2  0.0399181, 0.0248274, 0.0239940, 0.0017964, 0.0100299,
C       IC5H12      N C5H12     T125        T175        T225
     3  0.0003297, 0.0018410, 0.0391783, 0.0391783, 0.0391783,
C       T275        T325        T375        T425        T475
     4  0.0391783, 0.0391783, 0.0394149, 0.0394149, 0.0600448,
C       T525        T575        T625        T675        T725
     5  0.0600448, 0.0600448, 0.0600448, 0.0459572, 0.0459572,
C       T775        T825        T875        T925        T975
     6  0.0459572, 0.0459572, 0.0018801, 0.0018611, 0.0018421,
C       T1000+      I1000+      Future      Future      Future
     7  0.0651810, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       Future      Future      Future      Future      Future
     8  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       Coal        URCOAL      Slag        Future      OTHERS
     9  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000 /
C
C     Sulfur.
C     Wt fraction to  H2      N2          O2          H2S         CO
      DATA YFSO / 0.000000, 0.000000 , 0.000000 , 0.9770567, 0.0000000,
C       CO2         NH3         H2O         HCL         COS
```

```
     1  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       CH4        C2H6       C3H8       IC4H10     N C4H10
     2  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       IC5H12     N C5H12    T125       T175       T225
     3  0.0000000, 0.0000000, 0.0001160, 0.0001160, 0.0001160,
C       T275       T325       T375       T425       T475
     4  0.0001160, 0.0001160, 0.0001363, 0.0001363, 0.0004613,
C       T525       T575       T625       T675       T725
     5  0.0004613, 0.0004613, 0.0004613, 0.0011634, 0.0011634,
C       T775       T825       T875       T925       T975
     6  0.0011634, 0.0011634, 0.0000799, 0.0001198, 0.0001598,
C       T1000+     I1000+     Future     Future     Future
     7  0.0152324, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       Future     Future     Future     Future     Future
     8  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       Coal       URCOAL     Slag       Future     OTHERS
     9  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000 /
C
C     Nitrogen.
C     Wt fraction to  H2     N2         O2         H2S        CO
      DATA YFNO / 0.000000, 0.000000 , 0.000000 , 0.0000000, 0.0000000,
C       CO2        NH3        H2O        HCL        COS
     1  0.0000000, 0.8454024, 0.0000000, 0.0000000, 0.0000000,
C       CH4        C2H6       C3H8       IC4H10     N C4H10
     2  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       IC5H12     N C5H12    T125       T175       T225
     3  0.0000000, 0.0000000, 0.0040154, 0.0040154, 0.0040154,
C       T275       T325       T375       T425       T475
     4  0.0040154, 0.0040154, 0.0061092, 0.0061092, 0.0112746,
C       T525       T575       T625       T675       T725
     5  0.0112746, 0.0112746, 0.0112746, 0.0110572, 0.0110572,
C       T775       T825       T875       T925       T975
     6  0.0110572, 0.0110572, 0.0005694, 0.0006508, 0.0007321,
C       T1000+     I1000+     Future     Future     Future
     7  0.0310227, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       Future     Future     Future     Future     Future
     8  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       Coal       URCOAL     Slag       Future     OTHERS
     9  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000 /
C
C     Oxygen.
C     Wt fraction to  H2     N2         O2         H2S        CO
      DATA YFOO / 0.000000, 0.000000 , 0.000000 , 0.0000000, 0.0037755,
C       CO2        NH3        H2O        HCL        COS
     1  0.0112137, 0.0000000, 0.9304138, 0.0000000, 0.0000000,
C       CH4        C2H6       C3H8       IC4H10     N C4H10
     2  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       IC5H12     N C5H12    T125       T175       T225
     3  0.0000000, 0.0000000, 0.0017593, 0.0017593, 0.0017593,
C       T275       T325       T375       T425       T475
     4  0.0017593, 0.0017593, 0.0028956, 0.0028956, 0.0041988,
C       T525       T575       T625       T675       T725
     5  0.0041988, 0.0041988, 0.0041988, 0.0039414, 0.0039414,
C       T775       T825       T875       T925       T975
     6  0.0039414, 0.0039414, 0.0001697, 0.0001721, 0.0001745,
```

```
C       T1000+     I1000+     Future     Future     Future
      7 0.0069322, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       Future     Future     Future     Future     Future
      8 0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       Coal       URCOAL     Slag       Future     OTHERS
      9 0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000 /
C
C      Unconverted coal (URCOAL) at 92.79 conversion.
C      Weight fraction of element in the fresh MAF coal going to URCOAL
C      (unconverted coal) for the base MAF coal at 92.79 conversion.
C                      C          H          S          N
       DATA YFUCO  / 0.0751810, 0.0032037, 0.2380879, 0.1628409,
C                      O
      1               0.0017012 /
C
C      FIRST REACTOR ELEMENTAL YIELD FACTORS.
C      --------------------------------------
C      The iC5/NC5 split was assumed to be the same as the IC4/NC4 split.
C      The properties of the 850+ F material were estimated based on the
C      data in the letters.
C
C      Carbon.
C      Wt fraction to  H2      N2          O2          H2S         CO
       DATA YFC1 /     0.0 , 0.000000 , 0.000000 , 0.0000000, 0.0002304,
C       CO2        NH3        H2O        HCL        COS
      1 0.0003300, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       CH4        C2H6       C3H8       IC4H10     N C4H10
      2 0.0091525, 0.0079417, 0.0093307, 0.0006747, 0.0037670,
C       IC5H12     N C5H12    T125       T175       T225
      3 0.0001359, 0.0007587, 0.0181109, 0.0181109, 0.0181109,
C       T275       T325       T375       T425       T475
      4 0.0181109, 0.0181109, 0.0286048, 0.0286048, 0.0207329,
C       T525       T575       T625       T675       T725
      5 0.0207329, 0.0207329, 0.0207329, 0.0454438, 0.0454438,
C       T775       T825       T875       T925       T975
      6 0.0454438, 0.0454438, 0.0737284, 0.0737201, 0.0738313,
C       T1000+     I1000+     Future     Future     Future
      7 0.0000000, 0.3339277, 0.0000000, 0.0000000, 0.0000000,
C       Future     Future     Future     Future     Future
      8 0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       Coal       URCOAL     Slag       Future     OTHERS
      9 0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000 /
C
C      Hydrogen.
C      Wt fraction to  H2      N2          O2          H2S         CO
       DATA YFH1 /-0.041203, 0.000000 , 0.000000 , 0.0131610, 0.0000000,
C       CO2        NH3        H2O        HCL        COS
      1 0.0000000, 0.0187649, 0.0883811, 0.0000000, 0.0000000,
C       CH4        C2H6       C3H8       IC4H10     N C4H10
      2 0.0254416, 0.0165569, 0.0172914, 0.0011722, 0.0065446,
C       IC5H12     N C5H12    T125       T175       T225
      3 0.0002266, 0.0012653, 0.0250391, 0.0250391, 0.0250391,
C       T275       T325       T375       T425       T475
      4 0.0250391, 0.0250391, 0.0331412, 0.0331412, 0.0213167,
C       T525       T575       T625       T675       T725
```

```
     5  0.0213167, 0.0213167, 0.0213167, 0.0421451, 0.0421451,
C       T775       T825       T875       T925       T975
     6  0.0421451, 0.0421451, 0.0679499, 0.0672636, 0.0666851,
C       T1000+     I1000+     Future     Future     Future
     7  0.0000000, 0.1639707, 0.0000000, 0.0000000, 0.0000000,
C       Future     Future     Future     Future     Future
     8  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       Coal       URCOAL     Slag       Future     OTHERS
     9  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000 /
C
C     Sulfur.
C     Wt fraction to  H2      N2          O2          H2S         CO
      DATA YFS1 / 0.000000, 0.000000 , 0.000000 , 0.9155408, 0.0000000,
C       CO2        NH3        H2O        HCL        COS
     1  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       CH4        C2H6       C3H8       IC4H10     N C4H10
     2  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       IC5H12     N C5H12    T125       T175       T225
     3  0.0000000, 0.0000000, 0.0000771, 0.0000771, 0.0000771,
C       T275       T325       T375       T425       T475
     4  0.0000771, 0.0000771, 0.0001192, 0.0001192, 0.0001703,
C       T525       T575       T625       T675       T725
     5  0.0001703, 0.0001703, 0.0001703, 0.0011093, 0.0011093,
C       T775       T825       T875       T925       T975
     6  0.0011093, 0.0011093, 0.0030020, 0.0045030, 0.0060138,
C       T1000+     I1000+     Future     Future     Future
     7  0.0000000, 0.0651981, 0.0000000, 0.0000000, 0.0000000,
C       Future     Future     Future     Future     Future
     8  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       Coal       URCOAL     Slag       Future     OTHERS
     9  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000 /
C
C     Nitrogen.
C     Wt fraction to  H2      N2          O2          H2S         CO
      DATA YFN1 / 0.000000, 0.000000 , 0.000000 , 0.0000000, 0.0000000,
C       CO2        NH3        H2O        HCL        COS
     1  0.0000000, 0.7281565, 0.0000000, 0.0000000, 0.0000000,
C       CH4        C2H6       C3H8       IC4H10     N C4H10
     2  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       IC5H12     N C5H12    T125       T175       T225
     3  0.0000000, 0.0000000, 0.0025096, 0.0025096, 0.0025096,
C       T275       T325       T375       T425       T475
     4  0.0025096, 0.0025096, 0.0050233, 0.0050233, 0.0039142,
C       T525       T575       T625       T675       T725
     5  0.0039142, 0.0039142, 0.0039142, 0.0099161, 0.0099161,
C       T775       T825       T875       T925       T975
     6  0.0099161, 0.0099161, 0.0201258, 0.0230009, 0.0259179,
C       T1000+     I1000+     Future     Future     Future
     7  0.0000000, 0.1248831, 0.0000000, 0.0000000, 0.0000000,
C       Future     Future     Future     Future     Future
     8  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       Coal       URCOAL     Slag       Future     OTHERS
     9  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000 /
C
C     Oxygen.
```

```
C     Wt fraction to  H2      N2          O2          H2S         CO
      DATA YFO1 / 0.000000, 0.000000 , 0.000000 , 0.0000000, 0.0032903,
C       CO2         NH3         H2O         HCL         COS
     1  0.0094237, 0.0000000, 0.9080477, 0.0000000, 0.0000000,
C       CH4         C2H6        C3H8        IC4H10      N C4H10
     2  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       IC5H12      N C5H12     T125        T175        T225
     3  0.0000000, 0.0000000, 0.0011405, 0.0011405, 0.0011405,
C       T275        T325        T375        T425        T475
     4  0.0011405, 0.0011405, 0.0024697, 0.0024697, 0.0015121,
C       T525        T575        T625        T675        T725
     5  0.0015121, 0.0015121, 0.0015121, 0.0036665, 0.0036665,
C       T775        T825        T875        T925        T975
     6  0.0036665, 0.0036665, 0.0062197, 0.0063086, 0.0064078,
C       T1000+      I1000+      Future      Future      Future
     7  0.0000000, 0.0289459, 0.0000000, 0.0000000, 0.0000000,
C       Future      Future      Future      Future      Future
     8  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       Coal        URCOAL      Slag        Future      OTHERS
     9  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000 /
C
C     Unconverted coal (URCOAL) at 89.80 conversion.
C     Weight fraction of element in the fresh MAF coal going to URCOAL
C     (unconverted coal) for the base MAF coal at 89.80 conversion.
C                    C           H           S           N
      DATA YFUC1  / 0.0724812, 0.0145230, 0.4313947, 0.3357133,
C                    O
     1              0.2363297 /
C
C
      DATA UANAME / 'Ash     ', 'Carbon  ', 'Hydrogen', 'Nitrogen',
     1              'Chlorine', 'Sulfur  ', 'Oxygen  ', 'Total   ' /
C
      DATA ENAME  / 'Carbon  ', 'Hydrogen', 'Sulfur  ', 'Nitrogen',
     1  'Oxygen  ' /
C
C
      IF ( KTEST .GE. 2 )  WRITE (NHSTRY, 501)  MODE
  501 FORMAT ( / ' Starting the coal liquefaction plant reactor ',
     1  'calculations in Subroutine USRO2R.' /
     2  3X, 'MODE =', I3 )
C
C     Load the appropriate element yield distribution factors into the
C     working element yield distribution factors loacations.
C
      IF ( MODE .EQ. 3 )   THEN
C       Load the First Reactor Factors.
        DO 4 J = 1, 50
          YFC(J) = YFC1(J)
          YFH(J) = YFH1(J)
          YFS(J) = YFS1(J)
          YFN(J) = YFN1(J)
          YFO(J) = YFO1(J)
    4   CONTINUE
        DO 5 J = 1, 5
```

```
          YFUC(J) = YFUC1(J)
    5   CONTINUE
      ENDIF
C
      IF ( MODE .EQ. 2 )   THEN
C       Load the Overall Two Reactor Factors.
        DO 14 J = 1, 50
          YFC(J) = YFCO(J)
          YFH(J) = YFHO(J)
          YFS(J) = YFSO(J)
          YFN(J) = YFNO(J)
          YFO(J) = YFOO(J)
   14   CONTINUE
         DO 15 J = 1, 5
           YFUC(J) = YFUCO(J)
   15   CONTINUE
      ENDIF
C
C     Zero the component flow rates in the reactor outlet stream and
C     the elemental yields of each component.
      DO 26 J = 1, KMAXC
        CPROD(J) = 0.0D0
        DO 24 K = 1, 5
          EYLD(J,K) = 0.0D0
   24   CONTINUE
   26 CONTINUE
C
C     Calculate the amount of MAF solids entering the coal liquefaction
C     reactors and put them in the WTEIN vector in the order of C, H, S
C     N an O.  Include the chlorine with the carbon.
      WTEIN(1) = 0.01D0 * CIN(46) * (UFCOAL(2) + UFCOAL(5))
      WTEIN(2) = 0.01D0 * CIN(46) * UFCOAL(3)
      WTEIN(3) = 0.01D0 * CIN(46) * UFCOAL(6)
      WTEIN(4) = 0.01D0 * CIN(46) * UFCOAL(4)
      WTEIN(5) = 0.01D0 * CIN(46) * UFCOAL(7)
C     Calculate the total amount of entering fresh MAF coal.
      TOTMAF = WTEIN(1) + WTEIN(2) + WTEIN(3) + WTEIN(4) + WTEIN(5)
C
      IF ( KTEST .GE. 3 )   THEN
        WRITE (NHSTRY, 506) (ENAME(J), WTEIN(J), J = 1, 5), UANAME(8),
     1    TOTMAF
  506   FORMAT ( / ' Entering elemental weights in the fresh MAF coal,',
     1    ' lbs/hr.', 6( / 2X, A8, F12.1 ))
      ENDIF
C
C     Calculate the weights of fresh MAF coal that is converted and the
C     amount that remains unconverted.
C     ADJUST CONVERTED AND UNCONVERTED FRACTIONS FOR MODES >=5.
C
C     NEXT 2 VARIABLES HOLD THE CONVERTED AND UNCONVERTED AMOUNTS BASED
C     ON THE FRESH MAF AT STAGE I.  THEY PROBABLY HAVE NO MEANING FOR
C     MODE 7.
      WTCONV = 0.01 * CONMAF * TOTMAF
      WTUC = TOTMAF - WTCONV
C
```

```
C     DEFINE A NEW SWITCH TO CALCULATE REFERENCE CASE YIELDS
C        MODE > or = 5 YIELDS BASED ON THE REFERENCE CASE MODEL -
C                        TWO STAGE REACTORS
C
C     CALL SUBROUTINE TO CALCULATE YIELD FACTORS BASED ON THE REFERENCE
C     CASE MODEL ONLY FOR MODE 5.
      IF (MODE .GE. 5) THEN
        CALL USR2YF(MODE,KTEST,NHSTRY,NREAL,REAL,
     1              YYFC,YYFH,YYFS,YYFN,YYFO)
      ENDIF
C     NEXT DO LOOP HOLDS FOR ALL MODES?
C     THAT'S WHY FOR MODES 5 AND 6 WE GET THE SAME AMOUNT OF URCOAL OUT,
C     BECAUSE WE ALWAYS USE THE YIELD FACTORS FOR THE 2-STAGE SYSTEM.
C     DETERMINE UCOAL YIELD FACTORS FOR MODES >= 5.
      IF (MODE .GE. 5) THEN
C     THE YFUCs FOR URCOAL ARE GIVEN FOR 2 BASE CONVERSIONS, BASED ON
C     THE MAF ELEMENTS ENTERING THE REACTORS SYSTEM. LINEARLY
C     INTERPOLATE TO GET THE FACTORS FOR ANY CONVERSION. NOTE THAT THOSE
C     FACTORS ARE INVERSLY PROPORTIONAL TO THE COAL CONVERSION. THEN,
C     FOR ALL MODES (EXCEPT 7?), THOSE FACTORS SHOULD BE ADJUSTED TO
C     THE TOTAL UNCONVERTED AMOUNT, USING THE CORRECT UNCONVERTED
C     QUANTITY. HOW WILL THE INVERSE PROPORTIONALITY HANDELED HERE?
C     MAYBE A CHANGE OF SIGN.
        DO 115, J=1,5
          YFUC(J)=YFUC1(J)-(YFUCO(J)-YFUC1(J))/(92.79-89.8)*
     1            (CONMAF-89.8)
  115   CONTINUE
C     FOR MODE 7 WE WANT THE DIFFERENCE OF THESE FACTORS.
        IF (MODE .EQ. 7) THEN
          DO 116, J=1,5
C           CALCULATE THE APPROPRIATE STAGE I FACTOR, USING STAGE I
C           CONVERSION.
            XYFUC=YFUC1(J)-(YFUCO(J)-YFUC1(J))/(92.79-89.8)*
     1            ((100.0-REAL(15))-89.8)
C           USE THE DIFFERENCE AS THE CORRECT YIELD FACTOR
C           YFUC(J) CURRENTLY CONTAINS OVERALL FACTOR
            YFUC(J)=YFUC(J)-XYFUC
  116     CONTINUE
C         GET THE CORRECT AMOUNT CONVERTED FOR STAGE II ONLY
C         THIS QUANTITY WILL PROBABLY BE NEGATIVE! ALL YFUCs ARE EITHER
C         POSITIVE OR NEGATIVE.
          WTUC=WTUC-0.01*TOTMAF*REAL(15)
        ENDIF
      ENDIF
C
      IF ( KTEST .GE. 2 )   THEN
        WRITE (NHSTRY, 502)
  502   FORMAT ( / ' The elemental yield distribution factors' /
     1    '   No.', 5X, 'Name   ', 13X, 'C', 10X, 'H', 10X, 'S', 10X,
     2    'N', 10X, 'O' )
C     ONLY POSITIVE YIELD FACTORS ARE NORMALISED AND USED FOR SUMs.
        SUME(1) = 0.0
        SUME(2) = 0.0
        SUME(3) = 0.0
        SUME(4) = 0.0
```

```
      SUME(5) = 0.0
      DO 20 J = 1, KOMPS
        K = 2 * J - 1
        WRITE (NHSTRY, 503)  J, ICNAME(K), ICNAME(K+1), YFC(J),
     1    YFH(J), YFS(J), YFN(J), YFO(J)
  503   FORMAT ( 1X, I5, 5X, 2A4, 5X, 5F11.7 )
        IF (YFC(J) .GT. 0.0) SUME(1) = SUME(1) + YFC(J)
        IF (YFH(J) .GT. 0.0) SUME(2) = SUME(2) + YFH(J)
        IF (YFS(J) .GT. 0.0) SUME(3) = SUME(3) + YFS(J)
        IF (YFN(J) .GT. 0.0) SUME(4) = SUME(4) + YFN(J)
        IF (YFO(J) .GT. 0.0) SUME(5) = SUME(5) + YFO(J)
   20 CONTINUE
      WRITE (NHSTRY, 504)  (SUME(J), J = 1, 5)
  504 FORMAT ( 11X, 'Total', 8X, 5F11.7 )
C
      WRITE (NHSTRY, 505)  (YFUC(J), J = 1, 5)
  505 FORMAT ( / ' Overall fractions to URCOAL at the reference ',
     1  'conversion.' /
     2  11X, 'URCOAL', 7X, 5F11.7 )
    ENDIF
    IF ( KTEST .GE. 4 )  WRITE (NHSTRY, 507) WTCONV, WTUC
  507 FORMAT ( / ' Weight of fresh MAF coal converted = ', F16.1 /
     1  ' Weight of fresh MAF coal not converted = ', F12.1 )
C
C     Add the hydrogen consumed to that in the coal.
C     FOR MODES GE 5, THE YFH(1) IS BASED ON MAF QUANTITY IN STAGE I.
      IF (MODE .GE. 5) THEN
        WTEIN(2) = WTEIN(2) - TOTMAF * YFH(1)
      ELSE
C       FOR PREVIOUS MODES, USE FACTORS BASED ON CONVERTED QUANTITY.
        WTEIN(2) = WTEIN(2) - WTCONV * YFH(1)
      ENDIF
C
      IF ( KTEST .GE. 4 )   THEN
        SUM = TOTMAF - WTCONV * YFH(1)
        WRITE (NHSTRY, 508) (ENAME(J), WTEIN(J), J = 1, 5), UANAME(8),
     1    SUM
  508 FORMAT ( / ' Total elemental weights going to all the ',
     1  'products, lbs/hr.', 6( / 2X, A8, F12.1 ))
      ENDIF
C
C     Calculate the weight of the elements going to the unconverted coal
C     (URCOAL) at the reference conversion.
      SUM = 0.0
      DO 30 J = 1, 5
        EYLD(47,J) = WTEIN(J) * YFUC(J)
        SUM = SUM + EYLD(47,J)
   30 CONTINUE
C
C     Adjust this total to match the total amount that is unconverted.
      CPROD(47) = 0.0D0
      DO 32 J = 1, 5
        EYLD(47,J) = WTUC * EYLD(47,J) / SUM
        CPROD(47) = CPROD(47) + EYLD(47,J)
   32 CONTINUE
```

```
C
      IF ( KTEST .GE. 4 )  WRITE (NHSTRY, 509) (EYLD(47,J), J = 1, 5),
     1  CPROD(47)
  509 FORMAT ( / ' Weights of unconverted fresh MAF coal, lbs/hr.' /
     1  1X, 6F12.1 )
C
C     Calculate the weight of the elements to be distributed among the
C     conventional component products.
      DO 34 J = 1, 5
        WTEIN(J) = WTEIN(J) - EYLD(47,J)
   34 CONTINUE
C
      IER3 = 0
      DO 36 J = 1, 5
      IF ( WTEIN(J) .LT. 0 .0D0 )  THEN
        IER3 = 1
        X = - WTEIN(J)
        WTEIN(J) = 0.0D0
        EYLD(47,J) = EYLD(47,J) - X
        CPROD(47) = CPROD(47) - X
        CONMAF = 100.0D0 * (TOTMAF - CPROD(47)) / TOTMAF
        X1 = 0.01D0 * CIN(47) * (100.0D0 - UURC(1))
        CONVSN = 100.0D0 * (TOTMAF - CPROD(47)) / (TOTMAF + X1)
        IF ( KTEST .GE. 0 )  WRITE (NHSTRY, 531) IPASS
  531   FORMAT ( // 1X, 'Plant 2 - Supplementary data from ',
     1    'subroutine USR02' /
     2    2X, 'Coal Liquefaction Plant', 20X, 'IPASS =', I3 )
        WRITE (NHSTRY, 532)  ENAME(J), X, ENAME(J), ENAME(J), CONMAF
  532   FORMAT ( / ' * WARNING * - The coal liquefaction reactors are',
     1    ' not in elemental balance for'/
     2    3X, A8, '.  The URCOAL (unconverted coal) should contain',
     3    F8.1, ' lbs/hr more' /
     4    3X, A8, ' than is entering the reactors.  The Ultimate ',
     5    'analysis of the URCOAL' /
     6    3X, 'for ', A8, ' is being adjusted.  This adjustment ',
     7    'will cause a small change' /
     8    3X, 'in the conversion.  The new fresh MAF coal ',
     9    'conversion is ', F8.3, ' wt%.' /
     A    3X, 'Execution is continuing.')
        ENDIF
   36 CONTINUE
C
C     IN ORDER TO MAINTAIN THE ORIGINAL CONTEXT OF YYs, FOR MODE 7
C     WE NEED THE ELEMENTAL QUANTITIES PRODUCED SOLELY AT STAGE II.
C     THESE CONSIST OF THE ELEMENTS CONVERTED AT STAGE II, ie. URCOAL,
C     H2 AND T875 AND UP FRACTIONS. TO BE MORE GENERAL, EVERY COMPOUND
C     WITH NEGATIVE YYs (ie. CONVERTED) MUST BE INCLUDED AS ELEMENT
C     SOURCE, AND AFTER THAT EXCLUDED FROM THE DISTRIBUTION TO PRODUCTS.
C     THE CONVERTED AMOUNTS CAN BE OBTAINED FROM THE NON-NORMALISED YYs
C     BASED ON THE OVERALL MAF QUANTITY.  HANDLE H2 AND URCOAL A BIT
C     DIFFERENTLY.
      IF (MODE .EQ. 7) THEN
C       ZERO ALL ELEMENTS AVAILABLE FOR CONVERSION; NOTE THAT TILL NOW,
C       WE NEEDED THE ORIGINAL WTEINs FOR CORRECT URCOAL CALCULATIONS.
        DO 300, J=1,5
```

```
          WTEIN(J)=0.0
  300   CONTINUE
C       SCAN YIELD FACTORS FOR NEGATIVE ELEMENTS.  FOR EACH COMPOUND
C       EITHER ALL FACTORS ARE NEGATIVE OR POSITIVE.  SOME MAY BE
C       NIL (NOTE THAT H2 *IS* INCLUDED HERE).
        DO 302, J=1,KOMPS
          IF (YFC(J) .LT. 0.0 .OR. YFH(J) .LT. 0.0 .OR.
     1        YFS(J) .LT. 0.0 .OR. YFN(J) .LT. 0.0 .OR.
     2        YFO(J) .LT. 0.0) THEN
C           ADD THIS PRODUCTs CONTRIBUTION TO CONVERSION; NOTE THAT
C           BOTH EYLDs AND CORRECT WTEINs ARE CALCULATED IN ONE STROKE.
            EYLD(J,1) = TOTMAF * YFC(J)
            EYLD(J,2) = TOTMAF * YFH(J)
            EYLD(J,3) = TOTMAF * YFS(J)
            EYLD(J,4) = TOTMAF * YFN(J)
            EYLD(J,5) = TOTMAF * YFO(J)
            DO 304, I=1,5
C             THESE EYLDs ARE NEGATIVE,  SUBTRACT TO CHANGE SIGN.
              WTEIN(I) = WTEIN(I) - EYLD(J,I)
  304       CONTINUE
          ENDIF
  302   CONTINUE
C       FINALLY, ADD ELEMENTS DUE TO URCOAL CONVERSION AT STAGE II.
        DO 306, I=1,5
          WTEIN(I)=WTEIN(I)-EYLD(47,I)
  306   CONTINUE
      ENDIF
C
C     Distribute this amount of material among the pure conventional
C     component products, the first 17 components, but ignore hydrogen
C     since that will be handled separately later.
      DO 40 J = 2, 17
        EYLD(J,1) = WTEIN(1) * YFC(J)
        EYLD(J,2) = WTEIN(2) * YFH(J)
        EYLD(J,3) = WTEIN(3) * YFS(J)
        EYLD(J,4) = WTEIN(4) * YFN(J)
        EYLD(J,5) = WTEIN(5) * YFO(J)
   40 CONTINUE
C
C     Calculate the molecular weights of atomic H, C, S, N and O.
      XMWH = 0.5D0 * CPROP(1,1)
      XMWC = CPROP(11,1) - 4.0D0 * XMWH
      XMWS = CPROP(4,1) - 2.0D0 * XMWH
      XMWN = 0.5D0 * CPROP(2,1)
      XMWO = 0.5D0 * CPROP(3,1)
C
C     THIS ADJUSTMENT MEANS THAT FOR MODE 7, NONE OF THESE IS PERMITTED
C     TO BE A REACTANT (ie. CONVERTED) AT STAGE II.
C     Adjust the carbon and hydrogen weights as necessary in the pure
C     components to maintain the correct proportions for the compound.
C     H2S - Component no. 4.
      EYLD(4,2) = 2.0D0 * XMWH * EYLD(4,3) / XMWS
C     CO - Component no. 5.
      EYLD(5,1) = XMWC * EYLD(5,5) / XMWO
C     CO2- Component no. 6.
```

```
      EYLD(6,1) = XMWC * EYLD(6,5) / (2.0D0 * XMWO)
C     NH3 - Component no. 7.
      EYLD(7,2) = 3.0D0 * XMWH * EYLD(7,4) / XMWN
C     H2O - Component no. 8.
      EYLD(8,2) = 2.0D0 * XMWH * EYLD(8,5) / XMWO
C     HCL - Component no. 9. - Ignore chlorine since is lumped with
C     carbon in the pure component yields calculations.
C     COS - Component no. 10. - Ignore the minor corrections to the
C     carbon and oxygen yields for the slight change to maintain the
C     correct proportions with respect to sulfur.
      EYLD(10,1) = XMWC * EYLD(10,3) / XMWS
      EYLD(10,5) = XMWO * EYLD(10,3) / XMWS
C     CH4 - Component no. 11.
      EYLD(11,2) = 4.0D0 * XMWH * EYLD(11,1) / XMWC
C     C2H6 - Component no. 12.
      EYLD(12,2) = 6.0D0 * XMWH * EYLD(12,1) / (2.0D0 * XMWC)
C     C3H8 - Component no. 13.
      EYLD(13,2) = 8.0D0 * XMWH * EYLD(13,1) / (3.0D0 * XMWC)
C     iC4H10 and NC4H10 - Component nos. 14 and 15.
      EYLD(14,2) = 10.0D0 * XMWH * EYLD(14,1) / (4.0D0 * XMWC)
      EYLD(15,2) = 10.0D0 * XMWH * EYLD(15,1) / (4.0D0 * XMWC)
C     iC5H12 and NC5H11 - Component nos. 16 and 17.
      EYLD(16,2) = 12.0D0 * XMWH * EYLD(16,1) / (5.0D0 * XMWC)
      EYLD(17,2) = 12.0D0 * XMWH * EYLD(17,1) / (5.0D0 * XMWC)
C
C     Calculate the remaing amount of the elments to be distributed
C     among the pure components.
      DO 50 J = 2, 17
       DO 48 K = 1, 5
          WTEIN(K) = WTEIN(K) - EYLD(J,K)
   48   CONTINUE
   50 CONTINUE
C
      IER4 = 0
      DO 52 J = 1, 5
      IF ( WTEIN(J) .LT. 0 .0D0 )  THEN
        IER4 = 1
        X = - WTEIN(J)
        WTEIN(J) = 0.0D0
        L = 0
        IF ( WTEIN(1) .GE. X )  THEN
          L = 1
          WTEIN(1) = WTEIN(1) - X
        ENDIF
        IF ( KTEST .GE. 0 )  WRITE (NHSTRY, 531) IPASS
        WRITE (NHSTRY, 534)  ENAME(J), X, ENAME(J), ENAME(J)
  534   FORMAT ( / ' * WARNING * - The coal liquefaction reactors are',
     1    ' not in elemental balance for'/
     2    3X, A8, '.  The pure conventional components contain',
     3    F8.1, ' lbs/hr more' /
     4    3X, A8, ' than is available for them.  The reactors are ',
     5    'in effect, generating' /
     6    3X, 'this amount of ', A8, '.' )
        IF ( L .EQ. 0 )  WRITE (NHSTRY, 535)
  535   FORMAT ( 3X, 'No adjustments are being made.  Please check ',
```

```
     1    'the pure component yield' /
     2    3X, 'factors.  The plant 2 reactors are not in mass ',
     3    'and elemental balance.' /
     4    3X, 'Execution is continuing.')
        IF ( L .GE. 1 )  WRITE (NHSTRY, 536)
  536   FORMAT ( 3X, 'The carbon is being adjusted to maintain the ',
     1    'mass balance.  Please check the' /
     2    3X, 'pure component yield factors.  The plant 2 reactors ',
     3    'are not in elemental' /
     4    3X, 'balance.   Execution is continuing.')
        ENDIF
   52 CONTINUE
C
      IF ( KTEST .GE. 4 )  WRITE (NHSTRY, 510) (WTEIN(J), J = 1, 5)
  510 FORMAT ( / ' Element weights to be distributed in the ',
     1  'pseudo-components, lbs/hr.' /
     2  1X, 6F12.1 )
C
C     Renormalize the elemental yield factors for the pseudo-components
C     to 1.0 to distribute the remaining material, and save these
C     factors in the XYF(20,5) array, where the first subscript
C     designates the component number less 17 and the second subscript
C     designates, c, H, S, N and O, respectively.
      DO 60 K = 1, 5
        SUME(K) = 0.0
   60 CONTINUE
      DO 64 J = 18, KOMPS
        XYF(J-17,1) = YFC(J)
        XYF(J-17,2) = YFH(J)
        XYF(J-17,3) = YFS(J)
        XYF(J-17,4) = YFN(J)
        XYF(J-17,5) = YFO(J)
C     SECOND STAGE NORMALISATION MUST UNDERGO THE SAME APPROACH. THAT
C     IS, DO NOT ACCOUNT FOR NEGATIVE YF?s.
        DO 62 K = 1, 5
          IF (XYF(J-17,K) .GT. 0.0) SUME(K) = SUME(K) + XYF(J-17,K)
   62   CONTINUE
   64 CONTINUE
      DO 68 J = 18, KOMPS
        DO 66 K = 1, 5
          XYF(J-17,K) = XYF(J-17,K) / SUME(K)
   66   CONTINUE
   68 CONTINUE
C
C     Distribute this amount of material among the pseudo-components,
C     components 18-36.
      DO 72 J = 18, KOMPS
        DO 70 K = 1, 5
          IF (XYF(J-17,K) .GT. 0.0) EYLD(J,K) = WTEIN(K) * XYF(J-17,K)
   70   CONTINUE
   72 CONTINUE
C
C     Calculate the amount of material remaining to be distributed.
      DO 82 J = 18, KOMPS
        DO 80 K = 1, 5
```

```
          IF (EYLD(J,K) .GT. 0.0) WTEIN(K) = WTEIN(K) - EYLD(J,K)
   80   CONTINUE
   82 CONTINUE
C
      IF ( KTEST .GE. 4 )  THEN
        SUM = 0.0D0
        DO 84 J = 1, 5
          SUM = SUM + WTEIN(J)
   84   CONTINUE
        IF ( SUM .GE. 0.5D0 )  WRITE (NHSTRY, 511) (WTEIN(J), J = 1, 5)
  511   FORMAT ( / ' * WARNING * - All but the following elements ',
     1    'have been distributed, lbs/hr.' /
     2    3X, 'Something is wrong in the yield calculations.' /
     3    1X, 6F12.3 )
      ENDIF
C
      IF ( KTEST .GE. 3 )   THEN
        WRITE (NHSTRY, 512)
  512   FORMAT ( / ' Elemental yields, lbs/hr.' /
     1    '   No.', 2X, 'Name   ', 8X, 'C', 9X, 'H', 9X, 'S', 9X,
     2    'N', 9X, 'O', 7X, 'Total' )
        DO 102 L = 1, 5
          SUME(L) = 0.0D0
  102   CONTINUE
        DO 106 J = 2, KMAXC
          K = 2 * J - 1
          IF ( ICNAME(K) .NE. BLANK4 )  THEN
            SUM = EYLD(J,1) + EYLD(J,2) + EYLD(J,3) + EYLD(J,4)
     1        + EYLD(J,5)
            WRITE (NHSTRY, 513)  J, ICNAME(K), ICNAME(K+1),
     1        (EYLD(J,K), K = 1, 5), SUM
  513       FORMAT ( 1X, I5, 2X, 2A4, 6F10.1 )
            DO 104 L = 1, 5
              SUME(L) = SUME(L) + EYLD(J,L)
  104       CONTINUE
          ENDIF
  106   CONTINUE
        SUM = 0.0D0
        DO 108 L = 1, 5
          SUM = SUM + SUME(L)
  108   CONTINUE
        WRITE (NHSTRY, 514)  (SUME(J), J = 1, 5), SUM
  514   FORMAT ( 8X, 'Total', 3X, 6F10.1 )
      ENDIF
C
C     Load the total conventional component flows in the CPROD vector.
C     INTERMEDIATE HYDROGEN ADDITION IS HANDLED BASED ON THE
C     DIFFERENCE OF THE BASE OF H2 YIELD FACTOR PATCHED.
      IF (MODE .GE. 5) THEN
        CPROD(1) = TOTMAF * YFH(1)
      ELSE
        CPROD(1) = WTCONV * YFH(1)
      ENDIF
      DO 110 J = 2, KOMPS
        CPROD(J) = EYLD(J,1) + EYLD(J,2) + EYLD(J,3) + EYLD(J,4)
```

```
     1    + EYLD(J,5)
  110 CONTINUE
C
C     Account for the fresh coal.
      CPROD(46) = - CIN(46)
C
C     Add the ash in the fresh coal to the URCOAL product.
C     DO NOT ADD ASH AT STAGE II; THIS HAPPENED AT STAGE I ALREADY.
      IF (MODE .NE. 7)  CPROD(47) = CPROD(47) + 0.01D0 *
     1                              CIN(46) * UFCOAL(1)
C
C     Calculate the Ultimate analysis of the solid URCOAL that is
C     produced by the reaction of the fresh coal.
C     FOR STAGE II IN MODE 7, NEGATIVE EYLD(47,*) WILL CAUSE A MESS.
C     THERE IS NO SENSE IN TABULATING THE 'PRODUCED' URCOAL FOR 2ND
C     STAGE.  ALSO REMEMBER TO BLOCK OUT THE ASH HERE.
      IF (MODE .NE. 7) THEN
        WTUOUT(1) = 0.01D0 * CIN(46) * UFCOAL(1)
      ELSE
        WTUOUT(1) = 0.0
      ENDIF
      WTUOUT(2) = EYLD(47,1)
      WTUOUT(3) = EYLD(47,2)
      WTUOUT(4) = EYLD(47,4)
      WTUOUT(5) = 0.0D0
      WTUOUT(6) = EYLD(47,3)
      WTUOUT(7) = EYLD(47,5)
C
C     Separate the chlorine which previously was lumped with the
C     carbon.  Assume it distributes in the same proportion as the
C     carbon.
      WTUOUT(5) = WTUOUT(2) * UFCOAL(5) / UFCOAL(2)
      WTUOUT(2) = WTUOUT(2) - WTUOUT(5)
C
      IF (MODE .NE. 7) THEN
        SUM = 0.0D0
        DO 120 J = 1, 7
          SUM = SUM + WTUOUT(J)
  120   CONTINUE
        DO 122 J = 1, 7
          ULTOUT(J) = 100.0D0 * WTUOUT(J) / SUM
  122   CONTINUE
C
        IF ( KTEST .GE. 4 )  WRITE (NHSTRY, 517)
     1    (UANAME(J), ULTOUT(J), WTUOUT(J), J = 1, 7), UANAME(8), SUM
  517   FORMAT (/' Ultimate analysis of the URCOAL (unconverted coal)',
     1    ' that is produced.'  /   16X, 'Wt %', 5X, 'lbs/hr' /
     2    7(3X, A8, F9.2, F11.1 / ),
     3    3X, A8, F20.1 )
      ENDIF
C
C     Calculate the Ultimate analysis of the total URCAOL that is
C     leaving the reactors.  That is, combine the URCOAL that is
C     produced with the URCOAL entering the reactors.
      SUM = 0.0D0
```

```
      DO 130 J = 1, 7
        WTUOUT(J) = WTUOUT(J) + 0.01D0 * CIN(47) * UURC(J)
        SUM = SUM + WTUOUT(J)
  130 CONTINUE
      DO 132 J = 1, 7
        ULTOUT(J) = 100.0D0 * WTUOUT(J) / SUM
  132 CONTINUE
C
      IF ( KTEST .GE. 4 )  WRITE (NHSTRY, 518)
     1  (UANAME(J), ULTOUT(J), WTUOUT(J), J = 1, 7), UANAME(8), SUM
  518 FORMAT ( / ' Ultimate analysis of the total URCOAL (unconverted',
     1  ' coal) leaving the reactors.'  /   16X, 'Wt %', 5X, 'lbs/hr' /
     2  7(3X, A8, F9.2, F11.1 / ),
     3  3X, A8, F20.1 )
C
C
C     Calculate the total component flows leaving the coal
C     liquefaction reactor in lbs/hr.
      DO 160 J = 1, KMAXC
        COUT(J) = CIN(J) + CPROD(J)
  160 CONTINUE
C
C     If the hydrogen flow leaving the reactor section is negative,
C     then insufficient hydrogen has been supplied.  Set the net
C     hydrogen in the total product to zero and write a warning
C     message.  When this is done, the coal liquefaction section
C     will not be in mass balance.
      IER2 = 0
      IF ( COUT(1) .LT. 0.001D0 )  THEN
        IER2 = 1
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 521)  IPASS
  521   FORMAT ( // 1X, 'Plant 2 - Supplementary data from ',
     1    'subroutine USR02' /
     2    2X, 'Coal Liquefaction Plant', 20X, 'IPASS =', I3 /)
        X = - COUT(1)
        COUT(1) = 0.0D0
        WRITE (NHSTRY, 522)  X
  522   FORMAT ( / 1X, '* WARNING * - Insufficient hydrogen has been ',
     1    'supplied to plant 2, the' /
     2    3X, 'coal liquefaction plant.  The unit is short ', F10.3,
     3    ' lbs/hr of hydrogen.' /
     4    3X, 'Execution will continue assuming just the correct ',
     5    'amount of hydrogen has' /
     6    3X, 'been supplied.  No excess hydrogen will be in the ',
     7    'outlet gas stream.' /
     8    3X, 'Plant 2 will not be in mass balance.'
     9    // 3X, 'Execution is continuing.' / )
      ENDIF
C
C     ALL CIN(46) BASED CALCULATIONS ARE NOW OVER.  NOW SET CIN(46)
C     TO ITS REAL VALUE OF ZERO TO PRODUCE A VALID PRINTOUT.
      IF (MODE .EQ. 7) THEN
        CIN(46)=0.0
        CPROD(46)=0.0
      ENDIF
```

```
C
      IF ( KTEST .GE. 3 )   THEN
        WRITE (NHSTRY, 523)
  523   FORMAT ( / ' Plant 2 reactor flow rates, lbs/hr.' /
     1    '   No.', 5X, 'Name', 13X, 'Inlet', 3X, 'Production',
     2    7X, 'Outlet' )
        SUME(1) = 0.0D0
        SUME(2) = 0.0D0
        SUME(3) = 0.0D0
        DO 170 J = 1, KMAXC
          K = 2 * J - 1
          IF ( ICNAME(K) .NE. BLANK4 )  THEN
            WRITE (NHSTRY, 524)  J, ICNAME(K), ICNAME(K+1), CIN(J),
     1        CPROD(J),  COUT(J)
  524       FORMAT ( 1X, I5, 1X, 2A4, 5X, 3F13.2)
            SUME(1) = SUME(1) + CIN(J)
            SUME(2) = SUME(2) + CPROD(J)
            SUME(3) = SUME(3) + COUT(J)
          ENDIF
  170   CONTINUE
        WRITE (NHSTRY, 525)  SUME(1), SUME(2), SUME(3)
  525   FORMAT ( 11X, 'Total', F17.2, 2F13.2 )
      ENDIF
C
C     Calculate the pseudo-component *OUTLET* properties.
C     WARMING: THIS APPROACH IGNORES ANY PREVIOUSLY KNOWN ELEMENTAL
C     COMPOSITIONS FOR THESE ELEMENTS!!  ONCE THIS CPROP VECTOR ISN'T
C     USED BY ASPEN, NOR CONSERVES ITS CONTENTS BETWEEN SUBSEQUENT
C     CALLS!  PATCHED TO INCLUDE PREVIOUS CONTENTS AND COPE FOR
C     CONSUMPTION.
      DO 182 J = 18, KOMPS
        SUM=CIN(J)+EYLD(J,1)+EYLD(J,2)+EYLD(J,3)+EYLD(J,4)+EYLD(J,5)
        DO 180 K = 1, 5
        IF (SUM .GE. 1.0D-20) THEN
          OPROP(J-17,K)=100.0*(EYLD(J,K)+0.01*CIN(J)*CPROP(J,K+2))/SUM
        ELSE
          OPROP(J-17,K) = 0.0D0
      ENDIF
  180   CONTINUE
  182 CONTINUE
C
C     NOW THAT THE REASON FOR RE-EVALUATION OF FRACTION'S COMPOSITIONS
C     HAS BEEN REALIZED, SAVE THESE FRESHLY CALCULATED AT STAGE I
C     OUTLET FOR SHORTCOMING STAGE II. THERE, THE CPROPs WILL BE FILLED
C     BY THESE SAVED VALUES. OPROP common'ed array will preserve it's
C     contents till used in mode 7 run for new inlet properties.
C
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 526)
  526   FORMAT ( / ' Calculated component properties:' /
     1    1X, 'No.', 2X, 'Name', 8X, 'Wt% C', 5X, 'Wt% H', 5X, 'Wt% S',
     2    5X, 'Wt% N', 5X, 'Wt% O', 5X, 'Total' )
        DO 190  J = 18, KOMPS
          K = 2 * J - 1
          IF ( ICNAME(K) .NE. BLANK4 )  THEN
```

```
            SUM = OPROP(J-17,1) + OPROP(J-17,2) + OPROP(J-17,3) +
     1        OPROP(J-17,4) + OPROP(J-17,5)
            IF ( J .LE. 40 )   THEN
               WRITE (NHSTRY, 527) J, ICNAME(K), ICNAME(K+1),
     1           (OPROP(J-17,K), K = 1, 5), SUM
  527          FORMAT ( 1X, I3, 2X, 2A4, 6F10.4 )
            ELSE
            ENDIF
          ENDIF
  190   CONTINUE
      ENDIF
C
      IF ( IPASS .EQ. 4 .AND. INT1 .LE. 2 )  THEN
C
C       Write the reactor portion of the output report.
C       ==============================================
        WRITE (NOUT, 800)
  800   FORMAT (/ 30X, 'MASS BALANCE REPORT')
C
C       Convert the total flow rates to Mlbs/hr.
        TOTIN = 0.001D0 * TOTIN
        SUM = 0.001D0 * SUM
C
        WRITE (NOUT, 812) CONMAF
  812   FORMAT ( / '  FRESH MAF COAL CONVERSION, %       ', F10.3 )
C
        IF ( MODE .LE. 2 )  WRITE (NOUT, 813) CONVSN
  813   FORMAT ( '  OVERALL COAL CONVERSION PER PASS, %', F10.3 )
C
        IF ( MODE .LE. 1 )  WRITE (NOUT, 821)
  821   FORMAT ( / '  REACTOR COMPONENT FLOW RATES, MLBS/HR' /
     1    4X, 'COMPONENT', 8X, 'INLET', 6X, 'OUTLET' )
C
        IF ( MODE .EQ. 2 .OR. MODE .EQ. 5)  WRITE (NOUT, 822)
  822   FORMAT ( / 21X, 'FLOW RATES, MLBS/HR' /
     1    22X, '1ST RX', 6X, '2ND RX' /
     2    4X, 'COMPONENT', 10X, 'INLET', 6X, 'OUTLET' )
C
        IF ( MODE .EQ. 3 )  WRITE (NOUT, 823)
  823   FORMAT ( / 21X, 'FLOW RATES, MLBS/HR' /
     1    22X, '1ST RX', 6X, '1ST RX' /
     2    4X, 'COMPONENT', 10X, 'INLET', 6X, 'OUTLET' )
C
        IF ( MODE .EQ. 6 )  WRITE (NOUT, 8823)
 8823   FORMAT ( / 21X, 'FLOW RATES, MLBS/HR' /
     1    22X, '1ST RX', 6X, '1ST RX' /
     2    4X, 'COMPONENT', 10X, 'INLET', 6X, 'OUTLET' )
C
        IF ( MODE .EQ. 7 )  WRITE (NOUT, 8824)
 8824   FORMAT ( / 21X, 'FLOW RATES, MLBS/HR' /
     1    22X, '2ND RX', 6X, '2ND RX' /
     2    4X, 'COMPONENT', 10X, 'INLET', 6X, 'OUTLET' )
C
        IF ( MODE .EQ. 4 )  WRITE (NOUT, 824)
  824   FORMAT ( / 21X, 'FLOW RATES, MLBS/HR' /
```

```
     1    22X, '2ND RX', 6X, '2ND RX' /
     2    4X, 'COMPONENT', 10X, 'INLET', 6X, 'OUTLET' )
C
C       Write the liquefaction reactor component flow rates in Mlbs/hr.
        SUME(1) = 0.0D0
        SUME(2) = 0.0D0
        DO 210 J = 1, KMAXC
          K = 2 * J - 1
          IF ( ICNAME(K) .NE. BLANK4 )  THEN
            X = 0.001D0 * CIN(J)
            X1= 0.001D0 * COUT(J)
            WRITE (NOUT, 831) ICNAME(K), ICNAME(K+1), X, X1
  831       FORMAT ( 4X, 2A4, F16.3, F12.3 )
            SUME(1) = SUME(1) + X
            SUME(2) = SUME(2) + X1
          ENDIF
  210   CONTINUE
        WRITE (NOUT, 832) SUME(1), SUME(2)
  832   FORMAT ( 4X, 'TOTAL', 3X, F16.3, F12.3 )
C
C       ON A NEW PAGE, REPORT KINETIC MODEL ASSUMED WT% YIELDS.
C       THIS INVOLVES USE OF COMPONENT RANGES, CALCULATED IN USR2YF.
        IF (MODE .GT. 5) THEN
          IF(MODE .GT. 6) GO TO 601
          WRITE (NOUT, 600)
  600     FORMAT ('TOF'/ 23X,'KINETIC MODEL WT% YIELDS (MAF BASED)'///
     1           2X,'COMPONENT',11X,'WT% YIELD')
C         USE XYF(*,1) AS SLAVE STORAGE SPACE, NOW USELESS.
C         LOOP CONTAINS ALL COMPONENTS BUT RESID & UC (FOR STAGE I).
C         IDs IDENTICAL TO THE ELEMENT ORDER CALCULATED IN USR2YF.
 601      CONTINUE
          DO 603, I=1,15
            XYF(I,1)=Z(68+I)
  603     CONTINUE
C         RESID STAGE I YIELD
          XYF(16,1)=REAL(3)
C         UC STAGE I YIELD
          XYF(17,1)=REAL(15)
C         REPORT SINGLE STAGE YIELDS FOR SECOND STAGE, NOT TOTALS.
          IF (MODE .EQ. 7) THEN
          WRITE (NOUT, 6000)
 6000 FORMAT ('TOF'/ 13X,'KINETIC MODEL OVERALL WT% YIELDS (MAF BASED)'///
     1           2X,'COMPONENT',11X,'WT% YIELD')
C           TO FIND STAGE SPECIFIC YIELDS, SUBTRACT STAGE I YIELDS
C           FROM TOTALS.
            DO 606, I=1,15
C             XYF(I,1)=Z(178+I)-XYF(I,1)
              XYF(I,1)=Z(178+I)
  606       CONTINUE
C           RESID STAGE II YIELD
C           XYF(16,1)=Z(67)-REAL(3)
            XYF(16,1)=Z(67)
C           UC STAGE II YIELD
C           XYF(17,1)=REAL(4)-REAL(15)
            XYF(17,1)=REAL(4)
```

```
          ENDIF
C         GIVE H2 THE PROPER SIGN (CONVERTED)
          XYF(1,1)=-XYF(1,1)
          WRITE (NOUT, 609) XYF(6,1)
  609     FORMAT (2X,'CO',T20,F10.3)
          WRITE (NOUT, 612) XYF(7,1)
  612     FORMAT (2X,'CO2',T20,F10.3)
          WRITE (NOUT, 615) XYF(10,1)
  615     FORMAT (2X,'H2O',T20,F10.3)
          WRITE (NOUT, 618) XYF(9,1)
  618     FORMAT (2X,'H2S',T20,F10.3)
          WRITE (NOUT, 621) XYF(8,1)
  621     FORMAT (2X,'NH3',T20,F10.3)
          WRITE (NOUT, 624) XYF(2,1)
  624     FORMAT (2X,'C1',T20,F10.3)
          WRITE (NOUT, 627) XYF(3,1)
  627     FORMAT (2X,'C2',T20,F10.3)
          WRITE (NOUT, 630) XYF(4,1)
  630     FORMAT (2X,'C3',T20,F10.3)
          WRITE (NOUT, 633) XYF(5,1)
  633     FORMAT (2X,'C4',T20,F10.3)
          WRITE (NOUT, 636) XYF(11,1)
  636     FORMAT (2X,'C5-C350',T20,F10.3)
          WRITE (NOUT, 639) XYF(12,1)
  639     FORMAT (2X,'C350-C450',T20,F10.3)
          WRITE (NOUT, 642) XYF(13,1)
  642     FORMAT (2X,'C450-C650',T20,F10.3)
          WRITE (NOUT, 645) XYF(14,1)
  645     FORMAT (2X, 'C650-C850',T20,F10.3)
          WRITE (NOUT, 648) XYF(15,1)
  648     FORMAT (2X,'C850-C1000',T20,F10.3)
          WRITE (NOUT, 651) XYF(16,1)
  651     FORMAT (2X, 'RESID',T20,F10.3)
          WRITE (NOUT, 654) XYF(17,1)
  654     FORMAT (2X, 'UC',T20,F10.3)
          WRITE (NOUT, 657) XYF(1,1)
  657     FORMAT (2X,'H2',T20,F10.3)
C         REPORT SUM, TOO
C     Note that this SUM will be 100.0 for first stage, where MAF coal
C     is actually converted, and 0.0 for second stage where all
C     conversion flows internally among the components is included in
C     the summation.  If we included the MAF coal yield in this list,
C     the SUM should evidently be 0.0 for both stages.
          SUM=0.0
          DO 660, I=1,17
            SUM=SUM+XYF(I,1)
  660     CONTINUE
          WRITE (NOUT,663) SUM
  663     FORMAT (/ 2X, 'TOTAL', T20, F10.3)
        ENDIF
C
C
        ISUM = IER1 + IER2 + IER3 + IER4
C
        IF ( MODE .LE. 1 .AND. ISUM .GE. 1 )   WRITE (NOUT, 851)
```

```
  851   FORMAT ( / 25X, '- CONTINUED ON NEXT PAGE -' )
C
        IF ( MODE .GE. 1 .AND. ISUM .GE. 1 )   WRITE (NOUT, 852)
  852   FORMAT ( 25X, '- CONTINUED ON NEXT PAGE -' )
C
      ENDIF
C
C
  999 RETURN
      END
C
C$ USR2RS
C
      SUBROUTINE USR2RS (ICNAME, IPASS, ITEMS, KOMPS, KTEST,
     1  NCC, NCCONV, NCONV, NHSTRY, NNCC, SIN1, SOUT1, ULTOUT)
C
C     This subroutine loads the coal liquefaction reactor outlet stream
C     into the reactor effluent stream vector, the SOUT1 vector.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - July 21, 1992.
C
C     Calling arguments:
C     ICNAME() = Vector of component identifications (CHARACTER * 4)
C     IPASS    = The results pass flag.
C     ITEMS    = Total number of items in the SOUT1 vector.
C     KOMPS    = Number of conventional components used in the coal
C                liquefaction reactor model.
C     KTEST    = Switch for controlling the printing to the history
C                file.
C     NCC      = Number of conventional components.
C     NCCONV   = Offset for the non-conventional component substream.
C     NCONV    = Offset for the conventional component substream.
C     NHSTRY   = Logical unit number of the history file.
C     NNCC     = Number of non-conventional components.
C     SIN1()   = ASPEN/SP stream vector for reactor inlet stream.
C     SOUT1()  = ASPEN/SP stream vector for reactor effluent stream.
C     ULTOUT() = Ultimate analysis of the URCOAL (unconverted coal and
C                ash) leaving the ROSE-SR unit.
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5), OPROP(20,5)
C
      COMMON /USRC02/ IDX(100), XPACK(100)
C     Vectors IDX and XPACK are required for the calculation of the
C     stream average molecular weight using subroutine CPACK and
C     function AVEMW initialization.  They are placed in COMMON /USRC02/
C     only to save space since all block models use these variables.
C
      DIMENSION ICNAME(*), ULTOUT(*), SIN1(*), SOUT1(*)
C
C     Local variable declarations.
```

```
      CHARACTER * 4  BLANK4, ICNAME
C
      DATA BLANK4 / '    ' /
C
C     Set up the properties of the product streams.
C     ---------------------------------------------
      IF ( IPASS .NE. 4 )   THEN
C       First, zero all the base items in the product stream vector.
        DO 200 J = 1, NCCONV
          SOUT1(J) = 0.0D0
  200   CONTINUE
C
C       CF is the conversion factor from Kg/sec to lbs/hr.
        CF = 3600.0D0 / 0.45359237D0
C
C       Set the molar flow rates of the conventional components.
        SUM1 = 0.0D0
        DO 210 J = 1, NCC
          DO 208 K = 1, KOMPS
            IF ( J .EQ. ICNUMB(K) )  THEN
              SOUT1(J) = COUT(K) / (CF * CPROP(K,1))
              SUM1 = SUM1 + SOUT1(J)
              GO TO 210
            ENDIF
  208     CONTINUE
  210   CONTINUE
C
C       Set the total molar flow rate of the conventional components.
        SOUT1(NCC+1) = SUM1
C
C       Set the mass flow rates of the non-conventional components.
        SUM1 = 0.0D0
        DO 220 J = 1, 3
          SOUT1(NCONV+J) = COUT(J+45) / CF
          SUM1 = SUM1 + SOUT1(NCONV+J)
  220   CONTINUE
C
C       Set the total mass flow rates of the non-conventionals.
        SOUT1(NCONV+NNCC+1) = SUM1
C
C       Set the temperature and pressure of the reactor effluent stream
C       to the values which were loaded in the ST2 array.  Return these
C       values to ASPEN/SP in Kelvins and Pascals.
C       NOTE:  These default values can be overriden by the FLASH-SPECS
C              sentence in the ASPEN/SP input file.
        SOUT1(NCC+2) = (ST2(1,2) - 32.0D0)/1.8D0 + 273.15D0
        SOUT1(NCC+3) = ST2(1,3) * 6.8947573D+3
        SOUT1(NCONV+NNCC+2) = SOUT1(NCC+2)
        SOUT1(NCONV+NNCC+3) = SOUT1(NCC+3)
C
        SOUT1(NCONV+NNCC+9) = 1.0D0
C
C     IF MODE=6, SHOULD THIS ULTIMATE ANALYSIS PASS BACK TO ASPEN,
C     SO THAT THE FORTHCOMING MODE 7 WILL HAVE THE RIGHT ANALYSIS TO
C     WORK WITH? OR ONLY AFTER MODE 7 HAS RUN SHOULD THIS ANALYSIS BE
```

```
C     PERMITTED TO PASS BACK TO ASPEN/SP.
C       Set the Ultiminate analysis of the unconverted coal (URCOAL) to
C       that calculated in subroutine USR02R.
C
C       Load the first outlet stream.
        DO 230 J = 1, 7
          N1 = NCCONV + 24 + 4
          SOUT1(J + N1) = ULTOUT(J)
  230   CONTINUE
C
C       Set the PROXANAL of the unconverted coal (URCOAL).
C       Set the moisture to zero.
        SOUT1(NCCONV+25) = 0.0D0
C       Set the ash to that of the Ultimate analysis.
        SOUT1(NCCONV+28) = SOUT1(NCCONV+29)
C       Distribute the fixed carbon and volatile matter in the
C       same proportions as that of the entering coal.
        X = (100.0D0 - SOUT1(NCCONV+29)) * SIN1(NCCONV+2) /
     1    (SIN1(NCCONV+2) + SIN1(NCCONV+3))
        X1 = 100.0D0 - SOUT1(NCCONV+29) - X
        SOUT1(NCCONV+26) = X
        SOUT1(NCCONV+27) = X1
C
C       Calculate and load the SULFANAL of the unconverted coal (URCOAL)
C       in the same proportions as the feed coal, but adjust the total
C       to match the sulfur in the Ultimate analysis.
        X = SIN1(NCCONV+12) + SIN1(NCCONV+13) + SIN1(NCCONV+14)
        X1 = SOUT1(NCCONV+34) * SIN1(NCCONV+12) / X
        X2 = SOUT1(NCCONV+34) * SIN1(NCCONV+13) / X
        X3 = SOUT1(NCCONV+34) * SIN1(NCCONV+14) / X
        SOUT1(NCCONV+36) = X1
        SOUT1(NCCONV+37) = X2
        SOUT1(NCCONV+38) = X3
C
C       Load the AOXANAL of the unconverted coal (URCOAL) to be the same
C       as that of the feed coal.
        DO 240 J = 1, 10
          N1 = NCCONV + 24 + 14
          N2 = NCCONV + 14
          SOUT1(J + N1) = SIN1(J + N2)
  240   CONTINUE
C
C       Call subroutine CPACK and funcion AVEMW to calculate the
C       average molecular weight of the conventional components in all
C       the product streams.
        CALL CPACK (SOUT1, NCP, IDX, XPACK, TMASS)
        SOUT1(NCC+9) = AVEMW (NCP, IDX, XPACK)
C
C       If requested, write the items of interest in the outlet stream
C       vector to the history file.
        IF ( KTEST .GE. 5 )  THEN
          WRITE (NHSTRY, 531)
  531     FORMAT ( // ' The outlet stream vector' /
     1      14X, 'SOUT1' )
          DO 290 J = 1, ITEMS
```

```
            WRITE (NHSTRY, 532) J, SOUT1(J)
  532       FORMAT ( 2X, I5, 6(1PE15.5) )
  290     CONTINUE
        ENDIF
C
      ENDIF
C
      RETURN
      END
C
C$ USR2RZ
      SUBROUTINE USR2RZ (IER1, IER2, IER3, IER4, INT1, IPASS, NOUT)
C
C     This subroutine writes any warning messages to the summary report.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - July 21, 1992.
C
C     Calling arguments:
C     IER1      = Switch to indicate whether the OTHERS warning message
C                 should be written.
C                 0 => Do not write the warning message.
C                 1 => Write the warning message.
C     IER2      = Switch to indicate whether the insufficient hydrogen
C                 supplied warning message should be written.
C                 0 => Do not write the warning message.
C                 1 => Write the warning message.
C     IER3      = Switch to indicate whether the conversion was changed
C                 to balance the elements in the URCOAL warning message
C                 should be written.
C                 0 => Do not write the warning message.
C                 1 => Write the warning message.
C     IER4      = Switch to indicate whether the liquefaction reactor
C                 element inbalance warning message should be written.
C                 0 => Do not write the warning message.
C                 1 => Write the warning message.
C     INT1      = User block output report control switch.
C                 0 => Write the complete user block summary report.
C                 1 => Skip the capital cost section of the report.
C                 2 => Skip the capital cost and utilities sections of
C                      the report.
C                 3 => Skip writing the entire user block summary report.
C     IPASS     = The results pass flag.
C     NOUT      = Logical unit number of the plant output report file.
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      IF ( IPASS .EQ. 4 .AND. INT1 .LE. 0 )  THEN
C
        WRITE (NOUT, 801)
  801   FORMAT ( / 15X, 'COAL LIQUEFACTION REACTORS - SUMMARY REPORT' /
     1    30X, '(CONTINUED)' )
C
        IF ( IER1 .GE. 1 )  WRITE (NOUT, 811)
```

```
  811     FORMAT (/ 1X, '*WARNING* THE FEED TO THIS PLANT CONTAINS ',
     1      'SOME COMPONENT(S) UNKNOWN TO' /
     2      2X, 'THIS MODEL.  THEY ARE BEING IGNORED.  THEREFORE, ',
     3      'PLANT 2 IS NOT IN' /
     4      2X, 'MASS BALANCE.  PLEASE REMOVE THE EXTRA ',
     5      'COMPONENT(S) FROM THE FEED.' )
C
        IF ( IER2 .GE. 1 )  WRITE (NOUT, 812)
  812     FORMAT (/ 1X, '*WARNING* INSUFFICIENT HYDROGEN HAS BEEN ',
     1      'SUPPLIED.  THE ABOVE RESULTS' /
     2      2X, 'ASSUME JUST THE CORRECT AMOUNT OF HYDROGEN WAS ',
     3      'SUPPLIED.  PLANT 2 IS' /
     4      2X, 'NOT IN MASS BAANCE.  PLEASE PROVIDE SOME ',
     5      'MORE HYDROGEN.' )
C
        IF ( IER3 .GE. 1 )  WRITE (NOUT, 813)
  813     FORMAT (/ 1X, '*WARNING* THE MAF COAL CONVERSION HAS BEEN ',
     1      'CHANGED TO MAINTAIN THE ' /
     2      2X, 'ELEMENTAL BALANCE.  SEE THE HISTORY FILE FOR MORE ',
     3      'INFORMATION.' )
C
        IF ( IER4 .GE. 1 )  WRITE (NOUT, 814)
  814     FORMAT (/ 1X, '*WARNING* THE COAL LIQUEFACTION REACTORS ',
     1      'ARE NOT IN ELEMENTAL BALANCE' /
     2      2X, 'AND MAY NOT BE IN MASS BALANCE ALSO.  SEE THE ',
     3      'HISTORY FILE FOR MORE' /
     4      2X, 'INFORMATION.' )
C
      ENDIF
C
      RETURN
      END
C
C$ USR02F
C
      SUBROUTINE USR02F(MODE,KOMPS,NHSTRY,NREAL,REAL,IPASS,NOUT)
C
C     SUBROUTINE TO CALCULATE THE FLUID DYNAMIC PROPERTIES OF THE
C     EBULLATED BED REACTORS.
C
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      COMMON/USR02M/CIN(50),COUT(50),CPROP(40,7),ICNUMB(50),
     1 ST1(5,5),ST2(6,5), OPROP(20,5)
C     THIS COMMON NOW JUST SERVES AS A REFERENCE FOR INCLUDED DATA.
      COMMON/USR12L/C(50),F(50),Z(400)
C     THIS IS THE MAIN FLASH COMMON STORAGE.
      COMMON /USR02V/ FIN(40),VOUT(40),XLOUT(40)
C     FORMAL ARGS DECLARATION
      DIMENSION REAL(NREAL)
C
      PVAVL = C(11) - F(4)/100.0/C(12) - F(3)/100.0/C(13)
      IF (PVAVL .LT. 0.0)  PVAVL = 0.0
      COKE = 0.0
      C(5) = C(4)*(1.0+F(3)/100.0 + COKE/100.0 + PVAVL*C(1)/62.42)
      PI = 3.14159
```

```
      VOL = C(9)*PI*(C(8)**2)/4.0
      C(10)= (6.*VOL/PI)**0.3333
      AREAS = PI*(C(10)**2)
      AREAP = PI*C(9)*C(8)+2.*PI*(C(8)**2)/4.
      C(7) = AREAS/AREAP
C
      DIMP=2.54*C(8)
      XLEN=2.54*C(9)
      DENL=C(1)/62.42
      VISL=C(2)/100.
      GA=(DIMP**3)*981.*(DENL)*(C(5)-DENL)/(VISL**2)
      A=3.1456*GA/2.
      IF (A .LT. 1.D3 ) THEN
        RET=0.2441*(A**0.6642)
      ELSEIF (A .LT. 1.D4 ) THEN
        RET=0.3993*(A**0.5930)
      ELSEIF (A .LT. 1.D5 ) THEN
        RET=0.7946*(A**0.5182)
      ELSE
        RET=0.8875*(A**0.5086)
      ENDIF
      Z(7)=RET*VISL/DENL/DIMP
      Z(7)=Z(7)/30.48
      Z(13)=0.44
      DIMSP=2.54*C(10)
      G=981.
      GA=G*(DIMSP**3)*DENL*(C(5)-DENL)/VISL/VISL
      CI=2.53-0.615*DEXP(1.27*C(7))
      A=CI
      B=24.0
      C1=-GA*(Z(13)**4.94)/1.21/(C(7)**1.35)
      REM=(-B+DSQRT(B*B-4.*A*C1))/2./A
      UMINLI=REM*VISL/DIMSP/DENL
      Z(9)=UMINLI/30.48
C
C     SET REACTOR TEMPERATURE, DEG F.
      IF (MODE .EQ. 7) THEN
C       USE SECOND REACTOR TEMPERATURE.
        TRXN=REAL(11)
        PRXN=REAL(13)
      ELSE
C       FOR ANY OTHER CASE, USE FIRST REACTOR TEMPERATURE.
        TRXN=REAL(10)
        PRXN=REAL(12)
      ENDIF
C
C     FLASH CALCULATIONS.
      DO 123, J=1,KOMPS
        FIN(J)=CIN(J)
  123 CONTINUE
      CALL USR2FL(TRXN,KOMPS,TOTGAS,TOTLIQ,NHSTRY)
      Z(26)=TOTGAS
      Z(27)=TOTLIQ
      Z(32)=0.0
      DO 10 J=1,KOMPS
```

```
        DEBUG=CPROP(J,2)
        IF (DEBUG .LT. 0.001) DEBUG=100.0
        Z(32)=Z(32)+XLOUT(J)*42./DEBUG/60.
   10 CONTINUE
      Z(29)=0.1*Z(26)
      Z(30)=Z(26)*C(14)/60.
      Z(31)=Z(29)*C(14)/60

      Z(37)=REAL(8)-2.*C(41)/12.0
      Z(34)=0.754*Z(37)**2
      Z(4)=Z(30)*(14.7/PRXN)*(460.+TRXN)/537./60./Z(34)
      Z(5)=Z(31)*(14.7/PRXN)*(460.+TRXN)/537./60./Z(34)
      Z(6)=Z(4)+Z(5)
      Z(1)=Z(32)/7.48/60./Z(34)
C
      UGB=Z(6)*30.48
      DENSP=C(5)
      RATIO=1.-(UGB**.436)*(VISL**.227)*(DIMSP**.598)
     1   /((DENSP-DENL)**0.305)
      ULMG=RATIO*Z(9)
      Z(10)=ULMG
C
      Z(39)=C(16)
      Z(38)=Z(39)-8.0
      Z(36)=Z(38)*Z(34)
      C(18)=Z(35)/Z(36)
      Z(17)=1.0-C(18)/(62.42*C(4))
      RELG=Z(6)*30.48*DENL*DIMSP/VISL
      ELWOG=Z(17)/(1.0+0.07*RELG**0.34)
      GA=(DIMSP**3)*981.*(DENL)*(C(5)-DENL)/(VISL**2)
      CI=2.53-0.615*DEXP(1.27*C(7))
      QUAD=GA/(ELWOG**(-4.94)*0.75*1.61*C(7)**1.35)
      DET=24.0**2.0-4.0*CI*(-QUAD)
      DET=DSQRT(DET)
      REF=(-24.0+DET)/(2.0*CI)
      Z(3)=(REF*VISL)/(30.38*DENL*DIMSP)
      Z(2)=Z(3)-Z(1)
      Z(33)=Z(2)*7.48*60.0*Z(34)
      C(17)=Z(33)/Z(32)
      Z(309)=C(17)*TOTLIQ
C
C     VARIOUS BED CALULATIONS.
C     BED INPUT (MAX ALLOWED) HEIGHT, FT
C     I WONDER WHY WE USE SEPARATE VARIABLES FOR THIS METRIC.
      Z(21)=F(2)
C     BED SETTLED VOLUME, Z(40)==FT3 (SAME AS CATALYST VOL)
      Z(40)=Z(35)/C(19)
C     BED INITIAL (SETTLED) HEIGHT, FT
      Z(22)=Z(40)/Z(34)
C     CALCULATE EXPANDED BED HEIGHT, FT
C     Z(38) CONTAINS THE SAME HEIGHT
      Z(23)=Z(38)
C     CALCULATE BED EXPANSION, % OF INITIAL BED HEIGHT.
      Z(24)=Z(23)/Z(22)*100.0
C
```

```
C     CALCULATE SHELL WEIGHT, LBS
      Z(41)=PI*(C(42)/2.+REAL(8)/2.)*(C(42)/2.-REAL(8)/2.)
     1      * C(43)*Z(39)
C     CALCULATE HEADS WEIGHT, LBS
      Z(42)=0.4189D1*((C(42)/2.)**3-(REAL(8)/2.)**3)*C(43)
C     SET WEIGHT FOR NOZZLES AND SKIRS, LBS
      Z(43)=30000.
C     CALCULATE MISCELLANEOUS ADDITIONS TO WEIGHT, LBS
      Z(44)=7.0D-2*Z(41)
C     CALCULATE REACTOR WEIGHT IN SHORT TONS.
      Z(45)=(Z(41)+Z(42)+Z(43)+Z(44))/2000.
C
C     WARN IF SUPPLIED LIQUID SUPERFICIAL VELOCITY IS LOWER THAN MINIMUM
C     FLUIDIZATION VELOCITY WITH GAS.
      IF (Z(3) .LT. Z(10)) THEN
        WRITE (NHSTRY, 966) Z(3),Z(10)
  966   FORMAT ('* WARNING * Liquid superficial velocity in bed is'/
     1          'smaller then the minimum required for fluidization!'/
     2          'Current liquid velocity ',F10.3,' FPS'/
     3          'Minimum required        ',F10.3,' FPS')
      ENDIF

C     REPORT FLUID DYNAMICS
      IF (IPASS .EQ. 4) THEN
        WRITE (NOUT, 853)
  853   FORMAT (/ 15X, 'FLUID DYMAMICS REACTOR - SUMMARY REPORT' )
        WRITE (NOUT,881)
  881   FORMAT ('REACTOR GEOMETRY')
        WRITE (NOUT,861) C(17)
  861   FORMAT (4X,'RATIO OF RECYCLE TO FRESH FEED',T60,F10.3)
        WRITE (NOUT,859) C(15)
  859   FORMAT (4X,'H-COAL INTERNAL DIAMETER, FT',T60,F10.3)
        WRITE (NOUT,860) C(16)
  860   FORMAT (4X,'H-COAL REACTOR MAX ALLOWED HEIGHT, FT',T60,F10.3)
        WRITE (NOUT,864) C(42)
  864   FORMAT (4X,'REACTOR OD, FT',T60,F10.3)
        WRITE (NOUT,879) Z(39)
  879   FORMAT (4X,'REACTOR HEIGHT, FT',T60,F10.3)
        WRITE (NOUT,880) Z(45)
  880   FORMAT (4X,'REACTOR WEIGHT, SHORT TONS',T60,F10.3)
C
C       GAS, LIQUID AND SOLID PROPERTIES
        WRITE (NOUT,882)
  882   FORMAT ('GAS, LIQUID AND SOLID PROPERTIES')
        WRITE (NOUT,854) C(1)
  854   FORMAT (4X,'LIQUID DENSITY, LBM/FT3',T60,F10.3)
        WRITE (NOUT,857) C(8)
  857   FORMAT (4X,'AVERAGE DIAMETER OF CATALYST PARTICLE, INC',T60,
     1  F10.3)
        WRITE (NOUT,858) C(9)
  858   FORMAT (4X,'AVERAGE LENGTH OF CATALYST PARTICLE, INC',T60,F10.3)
        WRITE (NOUT,855) C(4)
  855   FORMAT (4X,'DENSITY OF DRY CATALYST PARTICLES, GM/CC',T60,F10.3)
        WRITE (NOUT,884) C(5)
  884   FORMAT (4X,'DENSITY OF SOAKED CATALYST PARTICLES, GM/CC',T60,
```

```
     1  F10.3)
        WRITE (NOUT,856) C(6)
  856   FORMAT (4X,'SETTLED DRY CATALYST BULK DENSITY, LBM/FT3',T60,
     1  F10.3)
C
C       FLUID DYNAMICS DATA
        WRITE (NOUT,883)
  883   FORMAT ('FLUID DYNAMICS DATA')
C       PHASE VELOCITIES
        WRITE (NOUT,869) Z(4)
  869   FORMAT (4X,'SUPERFICIAL VELOCITY OF FEED GAS, FPS',T60,F10.3)
        WRITE (NOUT,870) Z(5)
  870   FORMAT (4X,'SUPERFICIAL VELOCITY OF RECYCLE GAS, FPS',T60,F10.3)
        WRITE (NOUT,871) Z(6)
  871   FORMAT (4X,'SUPERFICIAL VELOCITY OF GAS IN CATALYST BED, FPS',
     1  T60,F10.3)
        WRITE (NOUT,866) Z(1)
  866   FORMAT (4X,'SUPERFICIAL VELOCITY OF FEED LIQUID, FPS',T60,F10.3)
        WRITE (NOUT,867) Z(2)
  867   FORMAT (4X,'SUPERFICIAL VELOCITY OF RECYCLE LIQUID, FPS',T60,
     1  F10.3)
        WRITE (NOUT,868) Z(3)
  868   FORMAT (4X,'SUPERFICIAL VELOCITY OF LIQUID IN CATALYST BED, FPS'
     1  ,T60,F10.3)
        WRITE (NOUT,890) Z(7)
  890   FORMAT (4X,'PARTICLE TERMINAL VELOCITY, FPS',T60,F10.3)
        WRITE (NOUT,872) Z(9)
  872   FORMAT (4X,'MINIMUM FLUIDIZATION VELOCITY WITHOUT GAS, FPS',T60,
     1  F10.3)
        WRITE (NOUT,873) Z(10)
  873   FORMAT (4X,'MINIMUM FLUIDIZATION VELOCITY WITH GAS, FPS',T60,
     1  F10.3)
C
C       BED PRROPERTIES
        WRITE (NOUT,877) Z(22)
  877   FORMAT (4X,'BED INITIAL HEIGHT, FT',T60,F10.3)
        WRITE (NOUT,878) Z(23)
  878   FORMAT (4X,'BED EXPANDED HEIGHT, FT',T60,F10.3)
        WRITE (NOUT,863) C(19)
  863   FORMAT (4X,'SETTLED BED DENSITY, LBM/FT3',T60,F10.3)
        WRITE (NOUT,862) C(18)
  862   FORMAT (4X,'EXPANDED BED DENSITY, LBM/FT3',T60,F10.3)
        WRITE (NOUT,874) Z(17)
  874   FORMAT (4X,'BED POROSITY (VOL. FR. BED)',T60,F10.3)
        WRITE (NOUT,875) Z(24)
  875   FORMAT (4X,'BED EXPANSION (% OF SETTLED BED)',T60,F10.3)
C
C       FORCE NEW PAGE HERE.
        WRITE (NOUT, 800)
  800   FORMAT ( 'TOF' )
C
      ENDIF
C
      RETURN
      END
```

```
C
C$ USRO2K
C
C     SUBROUTINE USRO2K, CALCULATING VARIOUS KINETIC PARAMETERS FOR
C     EB-BED REACTORS. THE MAIN VARIABLE CALCULATED IS THE CATALYST
C     ADDITION RATE.
C
      SUBROUTINE USRO2K(MODE,ICNAME,KOMPS,KTEST,NHSTRY,NOUT,
     1                  NREAL,REAL,IPASS,WTUCC,WTUC)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C     COMMON STORAGE
      COMMON/USR12L/C(50),F(50),Z(400)
      COMMON /USRO2M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5), OPROP(20,5)
      COMMON /USR2SV/ SAVE46,SAVZ46,SAVZ49
C     FORMAL ARGS DECLARATION
      DIMENSION ICNAME(*)
      DIMENSION REAL(NREAL),WTUCC(*),WTUC(*)
      CHARACTER *4 ICNAME
C
C     Older coal flow property calculations were restricted in using
C     REAL vector data. Many of them may be more accurately calculated,
C     using the mass balance data, already calculated. Note for MODE 7,
C     that CIN(46) has been restored to zero before this subroutine is
C     called.
C     CALCULATE MF COAL, LB/HR/TRAIN.
      F(9) = F(7) + WTUCC(1)
C     CALCULATE RESID IN RECYCLE SOLVENT, %MAF, MOVED FROM O2F
C     For 2nd stage this is bigger!
      F(10)=CIN(36)*100./F(7)
C     CALCULATE C5 TO 1000F- IN SOLVENT, MOVED FROM O2F
      SUM=0.0
      DO 4 I=16,35
        SUM=SUM+CIN(I)
  4   CONTINUE
      F(11)=SUM
C     CALCULATE SOLVENT/MAF COAL, MOVED FROM O2F
      F(5)=(F(11)+CIN(36)+CIN(37)+CIN(47))/F(7)
C     F(17) TOTAL SOLVENT,LB/HR/TRAIN, MOVED FROM O2F
C     For 2nd stage this is quite bigger!
      F(17)=F(7)*F(5)
C     CALCULATE ASH IN RECYCLE SOLVENT LB/HR
      F(12)=WTUC(1)-WTUCC(1)
      IF (MODE .EQ. 7) F(12)=WTUC(1)
C     CALCULATE UNCONVERTED COAL IN RECYCLE SOLVENT, LB/HR
      F(13)=CIN(47)-F(12)
C     UC IN SOLVENT,%MAF
      F(42)=F(13)*100.0/F(7)
C     ASH IN SOLVENT, % MAF COAL.
      F(16)=F(12)*100.0/F(7)
C
      IF (MODE .NE. 7) THEN
C       Accurately evaluate previously assumed REAL values.
C       UC in solvent, %MAF.
        REAL2=100.0*F(13)/F(7)
```

```
C       Resid yield in reactor 1, %MAF
        REAL3=100.0*(COUT(36)-CIN(36))/F(7)
C       Z(46) RESID+UC OUT OF REACTOR 1 PER 100 LBS OF MAF COAL,
C       FROM 2S1
        Z(46)=F(10)+REAL2+REAL3+REAL(15)
C       Z(49) SLURRY FEED TO REACTOR I, LB/HR/TRAIN.
        Z(49)=F(9)+F(7)*F(8)*0.01+F(5)*F(7)
C       Save these values for MODE 7.
        SAVZ46=Z(46)
        SAVZ49=Z(49)
      ELSE
C       Use previously saved values.
        Z(46)=SAVZ46
        Z(49)=SAVZ49
      ENDIF
C     Z(50) SLURRY FEED /LB CATALYST (REACTOR I).
      Z(50)=Z(49)/Z(35)
C     Z(51) FC CONVERSION, LB/HR.
      Z(51)=(0.01*F(9)*REAL(7))-(0.01*F(7)*REAL(4))
C     Z(52) REACTOR I RESID B TOTAL CONV% FC.
      Z(52)=(Z(51)-F(7)*REAL(3)*0.01)*100./Z(51)
C     Z(53) RESID B CONV,LB/HR/TRAIN REACTOR I.
      Z(53)=0.01*Z(51)*Z(52)
C
      IF (MODE .EQ. 6) THEN
C       CALL SUBROUTINE USR2S1 TO CARRY OUT STAGE I REACTOR CALCULATIONS
        CALL USR2S1(ICNAME,KOMPS,KTEST,NHSTRY,NREAL,REAL)
      ELSE
C       THIS 'ELSE' INCLUDES ALL REST CASES, THAT IS MODES 2, 7, AND
C       ALL OTHERS, USING SECOND STAGE REASONING FOR THE CATALYST
C       ADDITION RATES.
C       CALL SUBROUTINE USR2S2 TO CARRY OUT STAGE II REACTOR
C       CALCULATIONS.
        CALL USR2S2(ICNAME,KOMPS,KTEST,NHSTRY,NREAL,REAL)
      ENDIF
C
C     REPORT HERE.
C     NOTE THAT NOUT STREAM IS VALID ONLY IF IPASS=4.
C
      IF (IPASS .EQ. 4) THEN
        WRITE (NOUT, 10)
   10   FORMAT ( 'TOF', 30X,' REACTOR KINETICS' /)
C     SINCE DIFFERENT MODES STORE THE SAME RESULTS IN DIFFERENT SPOTS,
C     USE DIFFERENT WRITE COMMANDS WITH THE SAME FORMAT SPECIFICATIONS.
        IF (MODE .EQ. 6) THEN
          WRITE (NOUT, 60)  F(9)
          WRITE (NOUT, 62)  F(7)
          WRITE (NOUT, 22)  REAL(6)
          WRITE (NOUT, 23)  F(5)
          WRITE (NOUT, 20)  REAL(15)
          WRITE (NOUT, 30)  REAL(7)
          WRITE (NOUT, 40)  REAL(3)
          WRITE (NOUT, 50)  REAL(10)
          WRITE (NOUT, 70)  F(10)
C         WRITE (NOUT, 75)  REAL(2)
```

```
          WRITE (NOUT, 75)  F(42)
          WRITE (NOUT,76) F(16)
C         WRITE (NOUT, 80)  Z(46)
          WRITE (NOUT, 90)  Z(48)
          WRITE (NOUT, 100) Z(49)
          WRITE (NOUT, 110) Z(50)
          WRITE (NOUT, 120) Z(52)
          WRITE (NOUT, 130) Z(53)
          WRITE (NOUT, 140) Z(54)
          WRITE (NOUT, 150) Z(55)
          WRITE (NOUT, 160) Z(56)
          WRITE (NOUT, 170) Z(57)
          WRITE (NOUT, 180) Z(58)
          WRITE (NOUT, 190) Z(59)
          WRITE (NOUT, 200) Z(60)
          WRITE (NOUT, 210) Z(61)
          WRITE (NOUT, 220) Z(62)
          WRITE (NOUT, 230) Z(63)
          WRITE (NOUT, 240) Z(64)
          WRITE (NOUT, 242) Z(327)
C         H2 PARTIAL PRESSURE REPORT FOR 1ST REACTOR.
          WRITE (NOUT, 250) Z(295)*REAL(12)
        ELSE
C         NO MATCH TO FORMAT STATEMENTS 160, 170 AND 210.
          WRITE (NOUT, 60)  F(9)
          WRITE (NOUT, 62)  F(7)
          WRITE (NOUT, 22)  REAL(6)
C         WRITE (NOUT, 23)  F(5)
          WRITE (NOUT, 20)  REAL(4)
          WRITE (NOUT, 30)  REAL(7)
          WRITE (NOUT, 40)  Z(67)
          WRITE (NOUT, 50)  REAL(11)
C         WRITE (NOUT, 70)  F(10)
C         WRITE (NOUT, 75)  F(42)
C         WRITE (NOUT, 76) F(13)
C         WRITE (NOUT, 80)  Z(165)
          WRITE (NOUT, 90)  Z(166)
          WRITE (NOUT, 100) Z(49)
          WRITE (NOUT, 110) Z(50)
          WRITE (NOUT, 120) Z(167)
          WRITE (NOUT, 130) Z(168)
          WRITE (NOUT, 140) Z(169)
          WRITE (NOUT, 150) Z(170)
          WRITE (NOUT, 180) Z(173)
          WRITE (NOUT, 190) Z(174)
          WRITE (NOUT, 200) Z(175)
          WRITE (NOUT, 220) Z(177)
          WRITE (NOUT, 230) Z(178)
          WRITE (NOUT, 240) Z(172)
          WRITE (NOUT, 242) Z(327)
          WRITE (NOUT, 250) Z(295)*REAL(13)
        ENDIF
      ENDIF
C
   20 FORMAT (2X,'UNCONVERTED COAL, WT% MAF',          T60,F12.3)
```

```
   22 FORMAT (2X,'COAL SV LB MAF COAL/HR/LB CATALYST',T60,F12.3)
   23 FORMAT (2X,'SOLVENT/MAF COAL',                  T60,F12.3)
   30 FORMAT (2X,'FIXED CARBON, WT% MAF',             T60,F12.3)
   40 FORMAT (2X,'RESID YIELD, WT% MAF',              T60,F12.3)
   50 FORMAT (2X,'REACTOR AVERAGE TEMPERATURE, DEG F',T60,F12.3)
   60 FORMAT (2X,'MF COAL, LBM/HR',                   T60,F12.3)
   62 FORMAT (2X,'MAF COAL, LBM/HR',                  T60,F12.3)
   70 FORMAT (2X,'RESID IN RECYCLE SOLVENT, %MAF',    T60,F12.3)
   75 FORMAT (2X,'UC IN SOLVENT, %MAF',               T60,F12.3)
   76 FORMAT (2X,'ASH IN SOLVENT, %MAF',              T60,F12.3)
C  80 FORMAT (2X,'RESID+UC AT REACTOR EFFLUENT, %MAF',T60,F12.3)
   90 FORMAT (2X,'RESID+UC CONVERSION, %FEED R+UC',   T60,F12.3)
  100 FORMAT (2X,'SLURRY FEED, LBM/HR',               T60,F12.3)
  110 FORMAT (2X,'SLURRY FEED PER LB CATALYST',       T60,F12.3)
  120 FORMAT (2X,'RESID B CONVERSION, %FC',           T60,F12.3)
  130 FORMAT (2X,'RESID B CONVERSION, LBM/HR',        T60,F12.3)
  140 FORMAT (2X,'K THERMAL',                         T60,F12.3)
  150 FORMAT (2X,'RESID+UC CONVERSION',               T60,F12.3)
  160 FORMAT (2X,'THERMAL RX',                        T60,F12.3)
  170 FORMAT (2X,'RESID B CATAL CONVERSION, %FC',     T60,F12.3)
  180 FORMAT (2X,'K REACTOR',                         T60,F12.3)
  190 FORMAT (2X,'FREQUENCY FACTOR A',                T60,D12.6)
  200 FORMAT (2X,'1/R',                               T60,F12.3)
  210 FORMAT (2X,'CATALYST REPLACEMENT FACTOR',       T60,D12.6)
  220 FORMAT (2X,'CATALYST REPLACEMENT, LBM/HR',      T60,F12.3)
  230 FORMAT (2X,'CATALYST ADDITION, LBM/TON MF',     T60,F12.3)
  240 FORMAT (2X,'RESID OUTLET CONCENTRATION',        T60,F12.3)
  242 FORMAT (2X,'VAPOR WEIGHT % REACTOR OUTLET',     T60,F12.3)
  250 FORMAT (2X,'H2 OUTLET PARTIAL PRESSURE',        T60,F12.3)
C
      RETURN
      END
C
C$ USR2S1
C
      SUBROUTINE USR2S1 (ICNAME,KOMPS,KTEST,NHSTRY,NREAL,REAL)
C     THIS SUBROUTINE CALCULATES THE CATALYST ADDITION RATE WHEN
C     THE FIRST STAGE RESID YIELD IS GIVEN.
C
C     Last revision - December 22, 1992.
C
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      COMMON/USR12L/C(50),F(50),Z(400)
      DIMENSION ICNAME(*)
      DIMENSION REAL(NREAL)
      CHARACTER *4 ICNAME
C
C     Z(47) RESID+UC IN INLET TO REACTOR I PER 100 LBS OF MAF COAL.
      Z(47)=100.0+F(10)+F(13)*100.0/F(7)
C     Z(48) STAGE I R+UC CONV% - FEED R+UC
      Z(48)=(Z(47)-Z(46))*100./Z(47)
C     Z(54) STAGE I, THERMAL K.
      Z(54)=0.58*(DEXP(37.33-47307.0/(REAL(10)+460.0)))
C     Z(55) RESID + UC CONVERSION
      Z(55)=Z(54)/(Z(54)+Z(50))
```

```
C     Z(56) THERMAL RX, STAGE I
      Z(56)=Z(55)*100.0/Z(48)
C     Z(57) REACTOR I RESID B CATAL CONV, % FC
      Z(57)=Z(52)*(1.-Z(56))
C
C     CALCULATE RESID CONCENTRATION IN REACTOR I EFFLUENT.
      CALL USR2RC(REAL(10),ICNAME,KOMPS,KTEST,NHSTRY)
C     Z(64) RESID CONCENTRATION IN REACTOR I EFFLUENT
C     Z(64) CALCULATED IN USR2RC NOW.
C     Z(58) K,REACTOR I
      Z(58)=Z(53)*Z(57)/(Z(35)*Z(64)*Z(52)*0.01)
C     Z(59) FREQUENCY FACTOR A
      Z(59)=Z(58)*DEXP(40000./(1.985*(273.2+((REAL(10)-32.)/1.8))))
C     The following equation for Z(60) is valid for both the original
C     and improved baseline (high space velocity) design cases.
C     Z(60) = 1/R
      Z(60) = 3.6312D+15/Z(59) - 2000.0
C     Z(61) CATALYST REPLACEMENT FACTOR BED FRACTION/HR
      Z(61)=1.0/Z(60)
C     Z(62) CATALYST REPLACEMENT LB/HR/TRAIN
      Z(62)=Z(61)*Z(35)
C     Z(63) CATALYST ADDITION LB/TON MF I STAGE
      Z(63)=Z(62)/(F(9)/2000.)
C
      RETURN
      END
C
C$ USR2RC
C
C     SUBROUTINE USR2RC, CALCULATING RESID CONCENTRATION FOR BOTH
C     REACTOR EFFLUENT STREAMS, USING ACCURATE PHASE EQUILIBRIA.
C
      SUBROUTINE USR2RC(TAVG,ICNAME,KOMPS,KTEST,NHSTRY)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      COMMON/USR02M/CIN(50),COUT(50),CPROP(40,7),ICNUMB(50),
     1 ST1(5,5),ST2(6,5), OPROP(20,5)
      COMMON/USR12L/C(50),F(50),Z(400)
C     COMMON STORAGE FOR INTERFACING TO USR2FL, WHICH PERFORMS FLASH.
C     CALCULATIONS.
      COMMON /USR02V/ FIN(40),VOUT(40),XLOUT(40)
C     ARGS DECLARATION AND LOCAL VARIABLES DEFINITION.
      DIMENSION ICNAME(*)
      CHARACTER *4 ICNAME,BLANK4
C
C     INITIALISE DUMMY STRING FOR REPORT PRINTOUT.
      DATA BLANK4 /'    '/
C
C     PREPARE OUTLET FLASH, FILLING FIN VECTOR WITH ALREADY CALCULATED.
C     COUTs.
      DO 10, J=1,KOMPS
        FIN(J)=COUT(J)
   10 CONTINUE
C
C     FLASH SHOULD BE PERFORMED AT EXIT TEMPERATURE, BUT TO REDUCE
C     CALLING OVERHEAD, APPROXIMATE OUTLET TEMPERATURE WITH THE AVERAGE
```

```
C     ONE IN REAL VECTOR.
C     THIS TEMPERATURE IS PASSED AS THE TAVG FORMAL ARG IN HERE,
C     SINCE THIS SUBROUTINE IS CALLED FOR BOTH STAGES I AND II.
C
C     FLASH OUTLET STREAM; TOTGAS IS TOTAL GAS FLOW IN LB-MOL/HR, AND
C     TOTLIQ IS TOTAL LIQUID FLOW IN LBM/HR.
C     Z327 TOTAL LIQUID FLOW IN LB-MOL/HR
      CALL USR2FL(TAVG,KOMPS,TOTGAS,TOTLIQ,NHSTRY)
C
C     CALCULATE WT% RESID IN LIQUID.
      Z(64)=100.0*(XLOUT(36)+XLOUT(37))/TOTLIQ
C
C     CALCULATE OUTLET VAPOR H2 MOLE FRACTION.
      Z(295)=VOUT(1)/TOTGAS
C     PARTIAL PRESSURE CALCULATED BY CALLER.
C
C     REPORT EQUILIBRIA HERE.
      IF (KTEST .GE. 2) THEN
        WRITE (NHSTRY, 100)
  100   FORMAT ( / 23X,'REACTOR EFFLUENT PHASE EQUILIBRIA' /
     1          2X,'  #',2X,'COMP    ',2X,' LIQUID FLOW',2X,
     2          '    GAS FLOW',2X,'    GAS FLOW',2X,'     WT% GAS' /
     3          17X,'    (LBM/HR)',2X,' (LB-MOL/HR)',2X,'    (LBM/HR)')
C
        SUM = 0.0
C       SOLIDS (ID GT 37) LEFT OUT FROM PHASE REPORT.
        DO 20, J = 1, KOMPS
          K = 2*J - 1
          IF (ICNAME(K) .NE. BLANK4) THEN
C           INCLUDE WT% IN GAS PHASE IN REPORT
            WTGAS=VOUT(J)*CPROP(J,1)
            SUM=SUM+WTGAS
C           CATCH THOSE NASTY DIVISION BY ZERO ERRORS
            PCGAS=XLOUT(J)+WTGAS
            IF (PCGAS .GT. 0.0) PCGAS=100.0*WTGAS/PCGAS
C           OTHERWISE PCGAS IS ALREADY ZERO
            WRITE (NHSTRY,200) J, ICNAME(K), ICNAME(K+1), XLOUT(J),
     1        VOUT(J), WTGAS, PCGAS
  200       FORMAT (2X, I3, 2X, 2A4, 4(2X, F12.3) )
          ENDIF
   20   CONTINUE
C
        WRITE (NHSTRY, 300) TOTLIQ, TOTGAS, SUM
  300   FORMAT (2X, 'TOTALS:', 6X, 3(2X, F12.3) )
      ENDIF
C
C     Calculate weight % gas in reactor outlet (will be reported in
C     USR02K).
      Z(327)=100.0*SUM/(SUM+TOTLIQ)
C
      RETURN
      END
C
C$ USR2S2
C
```

```
      SUBROUTINE USR2S2(ICNAME,KOMPS,KTEST,NHSTRY,NREAL,REAL)
C     THIS SUBROUTINE CALCULATES THE CATALYST ADDITION RATE FOR
C     THE SECOND STAGE.
C
C     Last revision - December 22, 1992.
C
C     NOTE:  For the improved baseline (high space velocity) design
C            remove the C% from the begining of the equation that
C            calculates Z(175), the reciprocal of the second reactor
C            rate constant.
C
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      COMMON/USR12L/C(50),F(50),Z(400)
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5), OPROP(20,5)
C     FORMAL ARGS DECLARATIONS
      DIMENSION ICNAME(*)
      DIMENSION REAL(NREAL)
      CHARACTER *4 ICNAME
C
C     Z(165) RESID+UC OUT OF REACTOR 2 PER 100 LBS OF MAF COAL.
      Z(165)=100.0*(COUT(36)+COUT(47)-F(12))/F(7)
C     Z(166) STAGE II R+UC CONV% FEED R+UC.
      Z(166)=(Z(46)-Z(165))*100./Z(46)
C     Z(167) OVERALL B TOTAL CONV, % FC
      Z(167)=(Z(51)-F(7)*Z(67)*0.01)*100./Z(51)
C     Z(168) RESID B CONV REACTOR II, LB/HR/TRAIN
      Z(168)=Z(51)*Z(167)*0.01-Z(53)
C     Z(169) STAGE II, THERMAL K
      Z(169)=0.58*(DEXP(37.33-47307.0/(REAL(11)+460.0)))
C     Z(170) E,RESID + UC CONV, STAGE II
      Z(170)=Z(169)/(Z(169)+Z(50))
C     Z(171) STAGE II T FRACTION
      Z(171)=Z(170)*100./Z(166)
C
C     CALCULATE RESID CONCENTRATION IN REACTOR II EFFLUENT.
      CALL USR2RC(REAL(11),ICNAME,KOMPS,KTEST,NHSTRY)
C     Z(172) RESID CONCENTRATION IN REACTOR II EFFLUENT.
C     Z(172) CALCULATED IN USR2RC (MAIN RESULT).
      Z(172)=Z(64)
C     Z(173) K FOR REACTOR II.
      Z(173)=Z(168)*(1.-Z(171))/(Z(35)*Z(172)*0.01)
C     Z(174) FREQUENCY FACTOR A,REACTOR II
      Z(174)=Z(173)*DEXP(40000./(1.985*(273.2+((REAL(11)-32.)/1.8))))
C     Z(175) = 1/R FOR REACTOR II
C     NOTE:  The following equation is valid for the original baseline
C            design case.
        Z(175) = (1.0/Z(174)-1.0/2.5871D+12)*2.5871D+12/5.0D-05
C     NOTE:  The following equation is valid for the improved baseline
C            (high space velocity) design case.
C%     Z(175) = (1.0/Z(174)-1.0/5.5426D+12)*5.5426D+12/5.0D-05
C     Z(176) = R FOR REACTOR II.
      Z(176)=1./Z(175)
C     Z(177) REACTOR II REPLACEMENT RATE, LB/HR/TRAIN
      Z(177)=Z(35)*Z(176)
```

```
C     Z(178) CATALYST ADDITION RATE IN LB/TON MF FOR STAGE II.
      Z(178)=Z(177)/(F(9)/2000.)
C
      RETURN
      END
C
C$ USR2YF
C
      SUBROUTINE USR2YF (MODE, KTEST, NHSTRY, NREAL, REAL,
     1  YYFC, YYFH, YYFS, YYFN, YYFO)
C
C     Last revision - December 22, 1992.
C
C     NOTE:  For the improved baseline (high space velocity) design
C            case, remove the C% in front of the DATA statements for
C            the A and B vectors and comment out the other set of
C            DATA statements for the A and B vectors that are for the
C            original baseline design case.
C
C     THIS SUBROUTINE CALCULATES THE PRODUCT YIELDS FOR REACTOR STAGES
C     I AND II THAT ARE BASED ON CORRELATIONS  WHICH HAVE THE FORM
C              Y = A * X - B
C     WHERE:  Y IS THE YIELD WT% ON MAF COAL,
C             X IS THE 1000+F CONVERSION IN REACTOR I, % MAF COAL.
C     THIS SUBROUTINE OVERRIDES THE YIELD FACTORS OF THE STANDARD
C     SET IN SUBROUTINE USR20R.
C     VECTORS YFC,YFH,YFS,YFN,YFO, etc. ARE DEFINED IN SUBROUTINE
C     USR02R.
C
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C     THIS COMMON IS NEEDED FOR CPROP PROPERTIES VECTOR.
      COMMON/USR02M/CIN(50),COUT(50),CPROP(40,7),ICNUMB(50),
     1 ST1(5,5),ST2(6,5), OPROP(20,5)
      COMMON/USR12L/C(50),F(50),Z(400)
      DIMENSION V0(50),V1(50),V(50),SUME(5)
C     ARGS DECLARATION AND LOCAL VARIABLES DEFINITION.
      DIMENSION REAL(NREAL)
      DIMENSION YYFC(*),YYFH(*),YYFS(*),YYFN(*),YYFO(*)
      DIMENSION A(50),B(50)
C
C     INITIALIZE VECTOR A
C     Set the yields for the original baseline design case.
      DATA A /
C     RULER  .........1.........2.........3..........4..........5
     $       13.1230D-2,  8.480D-2,  8.480D-2,   8.480D-2, 1.82240D-2,
     $        9.3458D-4,  2.336D-3,  2.086D-2,   4.021D-2, 1.12617D-1,
     1       3.79439D-1, 1.2196D-1, 8.6028D-1, 2.87851D-1,  13.123D-2,
     1          4.25D-2, 8.3458D-1,       0.0,        0.0,        0.0,
     2              0.0,       0.0,       0.0,        0.0,        0.0,
     2              0.0,       0.0,       0.0,        0.0,        0.0,
     3              0.0,       0.0,       0.0,        0.0,        0.0,
     3              0.0,       0.0,       0.0,        0.0,        0.0,
     4              6.0,     16.95,     489.2,        0.0,        0.0,
     4              0.0,       0.0,       0.0,        0.0,        0.0 /
C     Set the yields for the improved baseline (high space velocity)
```

```
C     design case.
C%    DATA A /
C     RULER  .........1.........2.........3..........4..........5
C%   $       13.1230D-2,  8.260D-2,  8.470D-2,   8.470D-2, 2.72900D-2,
C%   $        9.3458D-4,  2.800D-3,  2.081D-2,   4.021D-2, 1.31200D-1,
C%   1       5.47890D-1, 2.8916D-1, 1.44372D0, 5.83050D-1,  13.123D-2,
C%   1          4.33D-2, 8.3458D-1,       0.0,        0.0,        0.0,
C%   2              0.0,       0.0,       0.0,        0.0,        0.0,
C%   2              0.0,       0.0,       0.0,        0.0,        0.0,
C%   3              0.0,       0.0,       0.0,        0.0,        0.0,
C%   3              0.0,       0.0,       0.0,        0.0,        0.0,
C%   4              6.0,     16.95,     489.2,        0.0,        0.0,
C%   4              0.0,       0.0,       0.0,        0.0,        0.0 /
C
C     INITIALIZE VECTOR B
C     Set the yields for the original baseline design case.
      DATA B /
C     RULER  ......1...........2..........3...........4..........5
     $    4.86710D+0,     6.46D+1,    6.46D+1,     6.46D+1, 0.74813D+0,
     $    1.88785D-2,   5.7158D-2, 3.45526D-1,    5.329D-1,  5.1402D-3,
     1   1.590467D+1,  2.78365D+0, 4.71977D+1, 2.934579D+0,  4.8671D+0,
     1       2.97D+1, 7.109854D+1,       0.0,        0.0,        0.0,
     2           0.0,        0.0,       0.0,        0.0,        0.0,
     2           0.0,        0.0,       0.0,        0.0,        0.0,
     3           0.0,        0.0,       0.0,        0.0,        0.0,
     3           0.0,        0.0,       0.0,        0.0,        0.0,
     4           0.0,        6.0,     16.95,      489.2,        0.0,
     4           0.0,        0.0,       0.0,        0.0,        0.0 /
C     Set the yields for the improved baseline (high space velocity)
C     design case.
C%    DATA B /
C     RULER  ......1...........2..........3...........4..........5
C%   $    4.86710D+0,     6.46D+1,    6.46D+1,     6.46D+1, 1.31965D+0,
C%   $    1.88785D-2,   5.7160D-2, 3.75000D-1,    5.329D-1,  1.8920D+0,
C%   1   3.177045D+1,  17.2789D+0, 8.84158D+1, 3.570923D+1,  4.8671D+0,
C%   1       2.97D+1, 7.109854D+1,       0.0,        0.0,        0.0,
C%   2           0.0,        0.0,       0.0,        0.0,        0.0,
C%   2           0.0,        0.0,       0.0,        0.0,        0.0,
C%   3           0.0,        0.0,       0.0,        0.0,        0.0,
C%   3           0.0,        0.0,       0.0,        0.0,        0.0,
C%   4           0.0,        6.0,     16.95,      489.2,        0.0,
C%   4           0.0,        0.0,       0.0,        0.0,        0.0 /
C
C     FOR ALL MODES, CALCULATE STAGE I YIELDS
      AG72=Z(65)
C     CALCULATE STAGE I H2 CONSUMPTION, % MAF
      Z(69)=A(1)*AG72-B(1)
C     CALCULATE STAGE I C1 YIELD, WT% MAF
      Z(70)=(A(2)*REAL(10)-B(2))*3.6145D-1
C     CALCULATE STAGE I C2 YIELD, WT% MAF
      Z(71)=(A(3)*REAL(10)-B(3))*2.9719D-1
C     CALCULATE STAGE I C3 YIELD, WT% MAF
      Z(72)=(A(4)*REAL(10)-B(4))*3.4136D-1
C     CALCULATE STAGE I C4 YIELD, WT% MAF
      Z(73)=A(5)*AG72-B(5)
```

```
C     CALCULATE STAGE I CO YIELD, WT% MAF
      Z(74)=A(6)*AG72-B(6)
C     CALCULATE STAGE I CO2 YIELD, 4WT% MAF
      Z(75)=A(7)*AG72-B(7)
C     CALCULATE STAGE I NH3 YIELD, WT% MAF
      Z(76)=A(8)*AG72-B(8)
C     CALCULATE STAGE I H2S YIELD, WT% MAF
      Z(77)=A(9)*AG72-B(9)
C     CALCULATE STAGE I H2O YIELD, WT% MAF
      Z(78)=A(10)*AG72-B(10)
C     CALCULATE STAGE I C5-350 F YIELD, WT% MAF
      Z(79)=A(11)*AG72-B(11)
C     CALCULATE STAGE I 350-450 F YIELD, WT% MAF
      Z(80)=A(12)*AG72-B(12)
C     CALCULATE STAGE I 450-650 F YIELD, WT% MAF
      Z(81)=A(13)*AG72-B(13)
C     CALCULATE STAGE I 650-850 F YIELD, WT% MAF
      Z(82)=A(14)*AG72-B(14)
C     CALCULATE SUM OF C1 TO 650/850 YIELDS
      SUM=0.0
      DO 4 I=70,82
        SUM=SUM+Z(I)
    4 CONTINUE
C     CALCULATE STAGE I 850-1000 F YIELD, WT% MAF
      Z(83)=(100.+Z(69))-(REAL(15)+REAL(3)+SUM)
C
C     FOR MODE 7, CALCULATE THE STAGE II YIELDS.
      IF (MODE .EQ. 7) THEN
        AG72=Z(68)
C       CALCULATE TOTAL H2 CONSUMPTION, % MAF
        Z(179)=A(1)*AG72-B(1)
C       CALCULATE TOTAL C1 YIELD, WT% MAF
        Z(180)=((A(2)*REAL(10)-B(2))+(A(16)*REAL(11)-B(16)))*3.8413D-1
C       CALCULATE TOTAL C2 YIELD, WT% MAF
        Z(181)=((A(2)*REAL(10)-B(2))+(A(16)*REAL(11)-B(16)))*2.9854D-1
C       CALCULATE TOTAL C3 YIELD, WT% MAF
        Z(182)=((A(2)*REAL(10)-B(2))+(A(16)*REAL(11)-B(16)))*3.1733D-1
C       CALCULATE TOTAL C4 YIELD, WT% MAF
        Z(183)=A(5)*AG72-B(5)
C       CALCULATE TOTAL CO YIELD, WT% MAF
        Z(184)=A(6)*AG72-B(6)
C       CALCULATE TOTAL CO2 YIELD, WT% MAF
        Z(185)=A(7)*AG72-B(7)
C       CALCULATE TOTAL NH3 YIELD, WT% MAF
        Z(186)=A(8)*AG72-B(8)
C       CALCULATE TOTAL H2S YIELD, WT% MAF
        Z(187)=A(9)*AG72-B(9)
C       CALCULATE TOTAL H2O YIELD, WT% MAF
        Z(188)=A(10)*AG72-B(10)
C       CALCULATE TOTAL C5-350 F YIELD, WT% MAF
        Z(189)=A(11)*AG72-B(11)
C       CALCULATE TOTAL 350-450 F YIELD, WT% MAF
        Z(190)=A(12)*AG72-B(12)
C       CALCULATE TOTAL 450-650 F YIELD, WT% MAF
        Z(191)=A(13)*AG72-B(13)
```

```
C       CALCULATE TOTAL 650-850 F YIELD, WT% MAF
        Z(192)=A(14)*AG72-B(14)
C       CALCULATE C1 TO 650/850 YIELDS
        SUM=0.0
        DO 5 I=180,192
          SUM=SUM+Z(I)
    5   CONTINUE
C       CALCULATE TOTAL 850-1000 F YIELD,WT% MAF
        Z(193)=(100.+Z(179))-(SUM+Z(67)+REAL(4))
      ENDIF
C
C     V0(J) CONTAINS THE PRODUCT YIELDS FROM THE TWO REACTOR MODEL
C     V1(J) CONTAINS THE PRODUCT YIELDS FROM THE FIRST REACTOR
C     V(J) CONTAINS THE FINAL PRODUCT YIELDS, WT% MAF COAL
C
      DO 10 J=1,50
        V0(J)=0.0
        V1(J)=0.0
        V(J)=0.0
   10 CONTINUE
C
C     FOR MODE 7, JUST THE STAGE II YIELDS BASED ON THE FRESH MAF COAL
C     ENTERING THE STAGE I REACTOR ARE NEEDED.  THESE ARE THE DIFFERENCE
C     BETWEEN THE TOTAL YIELDS MINUS STAGE I YIELDS.  THIS MEANS THAT
C     FOR MODE 7, ALL YIELDS MUST BE CALCULATED.  STILL, NO NEW VECTORS
C     ARE INTRODUCED FOR THIS SPECIAL CASE, SINCE THE RESULTS ARE PLACED
C     IN THE V VECTOR, WHICH THEN FILLS THE VARIOUS YYF* VECTORS.
C
      IF (MODE .EQ. 5 .OR. MODE .EQ. 7) THEN
C       CALCULATE V0(J), WT% YIELD MAF IN COMPONENT J, TWO STAGE SYSTEM
C       NUMBER SEQUENCE IS THE SAME AS SUBROUTINE USR2R.
        V0(1)=Z(179)
        V0(4)=Z(187)
        V0(5)=Z(184)
        V0(6)=Z(185)
        V0(7)=Z(186)
        V0(8)=Z(188)
        V0(11)=Z(180)
        V0(12)=Z(181)
        V0(13)=Z(182)
C       SPLIT IC4/NC4 ACCORDING TO THE RATIO SHOWN IN THE YFCO.
C       VECTOR IN SUBROUTINE USR02R
        V0(14)=(1.3364D-3/8.7979D-3)*Z(183)
        V0(15)=Z(183)-V0(14)
C       SPLIT IC5/NC5 ACCORDING TO THE RATIO SHOWN IN THE YFCO
C       VECTOR IN SUBROUTINE USR02R
        V0(16)=(2.555D-4/1.6821D-3)*(1.6821D-3/1.848102D-1)*Z(189)
        V0(17)=(1.4266D-3/1.6821D-3)*(1.6821D-3/1.848102D-1)*Z(189)
C       CALCULATE PSEUDOCOMPONENT YIELDS ASSUMING EQUAL DISTRIBUTION
C       IN EACH BOILING RANGE
        V0(18)=(Z(189)-V0(16)-V0(17))/5.0
        V0(19)=(Z(189)-V0(16)-V0(17))/5.0
        V0(20)=(Z(189)-V0(16)-V0(17))/5.0
        V0(21)=(Z(189)-V0(16)-V0(17))/5.0
        V0(22)=(Z(189)-V0(16)-V0(17))/5.0
```

```
          V0(23)=Z(190)/2.0
          V0(24)=Z(190)/2.0
          V0(25)=Z(191)/4.0
          V0(26)=Z(191)/4.0
          V0(27)=Z(191)/4.0
          V0(28)=Z(191)/4.0
          V0(29)=Z(192)/4.0
          V0(30)=Z(192)/4.0
          V0(31)=Z(192)/4.0
          V0(32)=Z(192)/4.0
          V0(33)=Z(193)/3.0
          V0(34)=Z(193)/3.0
          V0(35)=Z(193)/3.0
          V0(36)=Z(67)
        ENDIF
        IF (MODE .EQ. 6 .OR. MODE .EQ. 7) THEN
C         CALCULATE V1(J), WT% YIELD MAF IN COMPONENT J, ONE STAGE SYSTEM
C         NUMBER SEQUENCE IS THE SAME AS SUBROUTINE USR2R.
          V1(1)=Z(69)
          V1(4)=Z(77)
          V1(5)=Z(74)
          V1(6)=Z(75)
          V1(7)=Z(76)
          V1(8)=Z(78)
          V1(11)=Z(70)
          V1(12)=Z(71)
          V1(13)=Z(72)
C         SPLIT IC4/NC4 ACCORDING TO THE RATIO SHOWN IN THE YFCO
C         VECTOR IN SUBROUTINE USR02R.
          V1(14)=(1.3364D-3/8.7979D-3)*Z(73)
          V1(15)=Z(73)-V1(14)
C         SPLIT IC5/NC5 ACCORDING TO THE RATIO SHOWN IN THE YFCO
C         VECTOR IN SUBROUTINE USR02R.
          V1(16)=(2.555D-4/1.6821D-3)*(1.6821D-3/1.848102D-1)*Z(79)
          V1(17)=(1.4266D-3/1.6821D-3)*(1.6821D-3/1.848102D-1)*Z(79)
C         CALCULATE PSEUDOCOMPONENT YIELDS ASSUMING EQUAL DISTRIBUTION
C         IN EACH BOILING RANGE.
          V1(18)=(Z(79)-V1(16)-V1(17))/5.0
          V1(19)=(Z(79)-V1(16)-V1(17))/5.0
          V1(20)=(Z(79)-V1(16)-V1(17))/5.0
          V1(21)=(Z(79)-V1(16)-V1(17))/5.0
          V1(22)=(Z(79)-V1(16)-V1(17))/5.0
          V1(23)=Z(80)/2.0
          V1(24)=Z(80)/2.0
          V1(25)=Z(81)/4.0
          V1(26)=Z(81)/4.0
          V1(27)=Z(81)/4.0
          V1(28)=Z(81)/4.0
          V1(29)=Z(82)/4.0
          V1(30)=Z(82)/4.0
          V1(31)=Z(82)/4.0
          V1(32)=Z(82)/4.0
          V1(33)=Z(83)/3.0
          V1(34)=Z(83)/3.0
          V1(35)=Z(83)/3.0
```

```
        V1(36)=REAL(3)
      ENDIF
      IF (MODE .EQ. 5) THEN
        DO 20 J=1,50
          V(J)=V0(J)
   20   CONTINUE
      ENDIF
      IF (MODE .EQ. 6) THEN
        DO 30 J=1,50
          V(J)=V1(J)
   30   CONTINUE
      ENDIF
C     SPECIAL MODE 7 FACTORS.
      IF (MODE .EQ. 7) THEN
        DO 31 J=1,50
          V(J)=V0(J)-V1(J)
   31   CONTINUE
      ENDIF
C
C     THESE ELEMENTAL YIELD FACTORS WERE ORIGINALLY THE WT FRACTION
C     (NOT PERCENT) OF THE PRODUCED ELEMENTS THAT WAS DUE TO THE
C     COMPOUND FORMATION, i.e., YYFC(2) WAS THE WT FRACTION OF THE TOTAL
C     ELEMENTAL CARBON PRODUCED THAT WAS DUE TO COMPOUND NO 2 FORMATION.
C     NOTICE THAT H2 (ID 1) IS OMITTED FROM THIS CONTEXT, SINCE IT
C     IS CONVERTED AND NOT FORMED, FOR ALL STAGES.  WHEN MODE 7 COMES
C     INTO PLAY, SOME COMPOUNDS (i.e., FRACTIONS 875 & UP) ARE CONVERTED
C     AT STAGE II, IN CONTRAST TO STAGE I FORMATION OF THE SAME
C     COMPOUNDS.  NEGATIVE ELEMENTAL YIELD FACTORS ARE CATASTROPHIC
C     IN THE ORIGINAL CONTEXT.  THE PROPOSED PROCEDURE IS TO
C     NORMALIZE ALL YIELD FACTORS CONCERNING ELEMENTS THAT ARE PRODUCED
C     IN ANY STAGE, AND LEAVE OUT ALL FACTORS OF COMPOUNDS BEING
C     CONVERTED.  THE TYPE 1 FACTORS RETAIN THE ORIGINAL IDEA,
C     WHILE TYPE 2 FACTORS ARE NOT NORMALIZED AND SIMILAR TO ORIGINAL
C     H2 FACTOR, i.e., BASED ON THE TOTAL MAF QUANTITY (WATCH IT:
C     NOT ELEMENTAL QUANTITY THAT WAS ENTERED AT THE FIRST REACTOR).
C
C     Z(304) LBS OF C IN GASEOUS AND LIQUID PRODUCTS PER LB MAF COAL.
      SUMC=0.0
      DO 100 J=1,37
C     OMIT FROM SUM NEGATIVE V(J)s
        IF (V(J) .GT. 0.0) SUMC=SUMC+0.01*0.01*V(J)*CPROP(J,3)
  100 CONTINUE
      Z(304)=SUMC
C     CALCULATE YIELD FACTORS,LB OF C IN COMPONENT J PER LB OF MAF COAL
      DO 110 J=1,37
        YYFC(J)=0.01*0.01*V(J)*CPROP(J,3)
C     NORMALIZE ONLY POSITIVE V(J)s
        IF (V(J) .GT. 0.0) YYFC(J)=YYFC(J)/SUMC
  110 CONTINUE
C     Z(305) LBS OF H IN GASEOUS AND LIQUID PRODUCTS PER LB MAF COAL.
C     CALCULATE LB OF H CONSUMED PER LB OF MAF COAL.
C     NOTICE THE DIFFERENT WAY THIS YIELD FACTOR IS EVALUATED; H2 IS
C     CONSUMED, SO THIS MUST BE NEGATIVE. STILL, THERE IS NO MATCH
C     BETWEEN THIS AND THE REST YYFH(J) FACTORS WHICH ARE 'NORMALIZED'.
C     SO IN STAGE II, WHERE MANY PRODUCTS THAT WERE PRODUCED IN STAGE I
```

```
C     AND ARE CONSUMED IN STAGE II, MUST UNDERGO A SIMILAR PROCEDURE.
C     LEAVE OUT H2, COS ITS V(J) IS POSITIVE ALTHOUGH IT IS CONVERTED.
      YYFH(1)=-0.01*0.01*V(1)*CPROP(1,4)
      SUMH=0.0
      DO 120 J=2,37
C     OMIT FROM SUM NEGATIVE V(J)s.
        IF (V(J) .GT. 0.0) SUMH=SUMH+0.01*0.01*V(J)*CPROP(J,4)
  120 CONTINUE
      Z(305)=SUMH
C     CALCULATE YIELD FACTORS, LB OF H IN COMPONENT J PER LB OF MAF COAL
      DO 130 J=2,37
        YYFH(J)=0.01*0.01*V(J)*CPROP(J,4)
C     NORMALISE ONLY POSITIVE V(J)s.
        IF (V(J) .GT. 0.0) YYFH(J)=YYFH(J)/SUMH
  130 CONTINUE
C     Z(306) LBS OF S IN GASEOUS AND LIQUID PRODUCTS PER LB MAF COAL.
      SUMS=0.0
      DO 140 J=1,37
C     OMIT FROM SUM NEGATIVE V(J)s
        IF (V(J) .GT. 0.0) SUMS=SUMS+0.01*0.01*V(J)*CPROP(J,5)
  140 CONTINUE
      Z(306)=SUMS
C     CALCULATE YIELD FACTORS, LB OF S IN COMPONENT J PER LB OF MAF COAL
      DO 150 J=1,37
        YYFS(J)=0.01*0.01*V(J)*CPROP(J,5)
C     NORMALIZE ONLY POSITIVE V(J)s.
        IF (V(J) .GT. 0.0) YYFS(J)=YYFS(J)/SUMS
  150 CONTINUE
C     Z(307) LBS OF N IN GASEOUS AND LIQUID PRODUCTS PER LB MAF COAL
      SUMN=0.0
      DO 160 J=1,37
C     OMIT FROM SUM NEGATIVE V(J)s
        IF (V(J) .GT. 0.0) SUMN=SUMN+0.01*0.01*V(J)*CPROP(J,6)
  160 CONTINUE
      Z(307)=SUMN
C     CALCULATE YIELD FACTORS, LB OF N IN COMPONENT J PER LB OF MAF COAL
      DO 170 J=1,37
        YYFN(J)=0.01*0.01*V(J)*CPROP(J,6)
C     NORMALIZE ONLY POSITIVE V(J)s.
        IF (V(J) .GT. 0.0) YYFN(J)=YYFN(J)/SUMN
  170 CONTINUE
C     Z(308) LBS OF O IN GASEOUS AND LIQUID PRODUCTS PER LB MAF COAL
      SUMO=0.0
      DO 180 J=1,37
C     OMIT FROM SUM NEGATIVE V(J)s.
        IF (V(J) .GT. 0.0) SUMO=SUMO+0.01*0.01*V(J)*CPROP(J,7)
  180 CONTINUE
      Z(308)=SUMO
C     CALCULATE YIELD FACTORS, LB OF O IN COMPONENT J PER LB OF MAF COAL
      DO 190 J=1,37
        YYFO(J)=0.01*0.01*V(J)*CPROP(J,7)
C     NORMALIZE ONLY POSITIVE V(J)s.
        IF (V(J) .GT. 0.0) YYFO(J)=YYFO(J)/SUMO
  190 CONTINUE
C
```

```
      IF (KTEST .GE. 2) THEN
        WRITE (NHSTRY,12)
   12   FORMAT ( /'TABULATION OF V0,V1,V  VECTORS'/)
        WRITE (NHSTRY,26)
   26   FORMAT ( /'TABULATION OF V0  VECTOR'/)
        WRITE (NHSTRY,14) (J,V0(J),J=1,50)
   14   FORMAT (/ 4(I3, 2X, D12.6, 2X) )
        WRITE (NHSTRY,24)
   24   FORMAT (/ 'TABULATION OF V1  VECTOR'/)
        WRITE (NHSTRY,16) (J,V1(J), J = 1, 50)
   16   FORMAT (/ 4(I3, 2X, D12.6, 2X) )
        WRITE (NHSTRY,22)
   22   FORMAT (/ 'TABULATION OF V  VECTOR'/)
        WRITE (NHSTRY,18) (J,V(J), J = 1, 50)
   18   FORMAT (/ 4(I3, 2X, D12.6, 2X))
      ENDIF
C
      RETURN
      END
C
C$ USR2FL
C
C SUBROUTINE USR2FL, CALCULATING EQUILIBRIUM FLASH GAS AND LIQUID PHASE
C COMPOSITIONS, BASED ON OPERATING TEMPERATURE AND PRESSURE, GIVEN THE
C OVERALL INPUT COMPOSITION.  STANDARD FLASH CALCULATIONS ARE INCLUDED,
C USING EXPERIMENTALLY DERIVED K-VALUES FOR THE MIXTURE COMPONENTS.
C
C FORMAL ARGS
C -----------
C TF......FLASH TEMPERATURE, F.
C KOMPS...NUMBER OF MIXTURE COMPONENTS INVOLVED IN PHASE EQUILIBRIA.
C TFG.....TOTAL GAS FLOW, LB-MOL/HR  (FILLED HERE)
C TFL.....TOTAL LIQUID FLOW, LBM/HR  (FILLED HERE)
C NHSTRY..HISTORY FILE UNIT NUMBER, USED FOR TROUBLE REPORT. IF FLASH
C         CALCULATIONS DO NOT CONVERGE, AN ERROR MESSAGE IS PRINTED AND
C         EXECUTION IS HALTED.
C
C PHASE COMPOSITIONS ARE PASSED THROUGH COMMON /USR02V/.
C THIS COMMON CONSISTS OF THE FOLLOWING VECTORS:
C   FIN(I)....OVERALL FEED COMPOSITION, LBM/HR. CALLER MUST FILL THIS
C             VECTOR BEFORE CALLING HERE. WATCH THAT THIS ONE IS
C             PRESERVED HERE, SO CALLER NEEDN'T REFILL IT (I.E., IN
C             ITERATIVE SOLUTIONS).
C   VOUT(I)...GAS PHASE COMPOSITION, LB-MOL/HR (FILLED HERE)
C   XLOUT(I)..LIQUID PHASE COMPOSITION, LBM/HR (FILLED HERE)
C THE VALUES IN THIS COMMON ARE VALID TILL ANOTHER CALL TO USR2FL IS
C PERFORMED. IN BETWEEN, THE V/L DISTRIBUTION VALUES MAY BE USED FREELY.
C
C MOLECULAR WEIGHTS FOR MASS BASIS CONVERSIONS ARE PASSED THROUGH THE
C COMMONed PROPERTIES' MATRIX CPROP(I,J).  IT IS ASSUMED THAT FOR
C PETROLEUM PSEUDO-COMPONENTS, THE GAS AND LIQUID PHASES HAVE THE SAME
C MOLECULAR WEIGHT.
C
C FLASH PRESSURE IS IGNORED, ASSUMED 3015 PSIA.
C
```

```
      SUBROUTINE USR2FL (TF,KOMPS,TFG,TFL,NHSTRY)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      COMMON/USR12L/C(50),F(50),Z(400)
C     THIS CONTAINS PROPERTIES' MATRIX.
      COMMON/USR02M/CIN(50),COUT(50),CPROP(40,7),ICNUMB(50),
     1 ST1(5,5),ST2(6,5), OPROP(20,5)
C     THIS IS THE MAIN FLASH COMMON STORAGE.
      COMMON /USR02V/ FIN(40),VOUT(40),XLOUT(40)
C     LOCAL VARIABLES (MAX 40 COMPONENTS)
C     SLAVE VECTOR FOR INPUT COMPOSITION PRESERVATION.
      DIMENSION ZIN(40)
C     CONSTANT TEMPERATURE, K's NEED ONLY BE EVALUATED ONCE.
      DIMENSION XK(40)
C
C     NO NEED TO ZERO FILLED VECTORS.
C
C     CONVERT FEED COMPOSITION FROM LBM->LB-MOLES TO SLAVE VECTOR.
C     CONCURRENTLY GET TOTAL MOLAR FEED RATE.
      FTOT=0.0
      DO 20, I=1,KOMPS
C       BE SURE THAT THE FIN VECTOR IS PRESERVED.
        ZIN(I)=FIN(I)/CPROP(I,1)
        FTOT=FTOT+ZIN(I)
   20 CONTINUE
C     GET MOLAR FEED CONCENTRATION (MOLAR FRACTIONS).
      DO 30, I=1,KOMPS
        ZIN(I)=ZIN(I)/FTOT
   30 CONTINUE
C     EVALUATE EQUILIBRIUM K-VALUES AT FLASH TEMPERATURE.
      DO 40, I=1,KOMPS
        CALL USR2KV(I,TF,XK(I))
   40 CONTINUE
C     CALCULATE WITH BASE 1 LB-MOL TOTAL FEED.
C
C     GET TOTAL VAPOR PHASE FRACTION VFT, USING NEWTON-RAPHSON METHOD.
C     SOLUTION TOLERANCE.
      TOLRNC=1.0D-5
C     MAX LIMIT FOR CONVERGENCE.
      MAXITR=100
      ITCNT=0
C     INITIAL GUESS FOR VAPOR FRACTION IN [0,1].
      VFT=0.9
C     ITERATIONS ENTRY POINT.
   50   ITCNT=ITCNT+1
C       STD FLASH CALCULATIONS USED.
        FNV=0.0
        DO 60, I=1,KOMPS
          FNV=FNV+(ZIN(I)*(XK(I)-1.0))/(1.0+VFT*(XK(I)-1.0))
   60   CONTINUE
C       DERIVATIVE EXACTLY KNOWN, NO NEED FOR APPROXIMATIONS.
        DFNV=0.0
        DO 70, I=1,KOMPS
          DFNV=DFNV-(ZIN(I)*((XK(I)-1.0)**2.0))/
     1              ((1.0+VFT*(XK(I)-1.0))**2.0)
   70   CONTINUE
```

```
C       DERIVATIVE SHOULD NOT BE ZERO NOW.
        IF (DABS(DFNV) .LT. 1.0D-50) THEN
C         INDICATE DERIVATIVE ZERO ERROR AND BREAK LOOP.
          IERR=1
          GOTO 100
        ENDIF
        VFTNEW=VFT-FNV/DFNV
C       CHECK FOR CONVERGENCE.
        IF (DABS(VFTNEW-VFT) .LE. TOLRNC) THEN
C         INDICATE NORMAL EXIT AND BREAK LOOP.
          IERR=0
          VFT=VFTNEW
          GOTO 100
        ELSE
C         HOW ABOUT MAX ITERATION OVERCOME???
          IF (ITCNT .GT. MAXITR) THEN
C           INDICATE TOO MANY ITERATIONS ERROR AND BREAK LOOP.
            IERR=2
            GOTO 100
          ENDIF
C         CONTINUE ITERATIONS WITH FRESHLY CALCULATED VALUE.
          VFT=VFTNEW
        ENDIF
C     LOOP BACK FOR NEXT ITERATION.
      GOTO 50
C     END OF ITERATION LOOP.
C
C CHECK TO ENSURE THAT THE CALCULATIONS CONVERGED NORMALLY.  IF NOT,
C PRINT AN ERROR MESSAGE AND TERMINATE EXECUTION.
  100 IF (IERR .GT. 0) THEN
        WRITE (NHSTRY, 990)
  990   FORMAT (/ 1X,'*** ERROR *** in flash calculations')
C       SHOW THE KIND OF TROUBLE ENCOUNTERED
        IF (IERR .EQ. 1)  WRITE (NHSTRY,991) ITCNT
        IF (IERR .EQ. 2)  WRITE (NHSTRY,992) MAXITR
  991   FORMAT (3X, 'Derivative is zero at iteration No.', I4)
  992   FORMAT (3X, 'Failed to converge after ',I4,' iterations')
        WRITE (NHSTRY, 999)
  999   FORMAT (1X, 'EXECUTION IS BEING TERMINATED'//)
        STOP
      ENDIF
C
C     EVALUATE PHASE COMPOSITIONS; EACH FRACTION MUST BE NON-NEGATIVE.
      DO 110, I=1,KOMPS
        XLOUT(I)=ZIN(I)/(1.0+VFT*(XK(I)-1.0))
        VOUT(I) =XLOUT(I)*XK(I)
  110 CONTINUE
C     OUTPUT STREAM VECTORS NOW CONTAIN MOLAR CONCENTRATIONS.
C     CONVERT TO DESIRED OUTPUT UNITS.
C     FIRST REVERT TO ACTUAL FLOW RATES, LB-MOL/HR.
      VFT=VFT*FTOT
C     LIQUID PHASE FLOW RATE, LB-MOL/HR
      XLFT=FTOT-VFT
C     TFL ALREADY EVALUATED.
C     LIQUID PHASE FLOW RATE IN LBM/HR, TO BE EVALUATED.
```

```
      TFL=0.0
      DO 120, I=1,KOMPS
C       LIQUID OUTFLOW IN LB-MOL/HR.
        XLOUT(I)=XLOUT(I)*XLFT*CPROP(I,1)
        TFL=TFL+XLOUT(I)
C       VAPOR OUTFLOW IN LB-MOL/HR
        VOUT(I)=VOUT(I)*VFT
  120 CONTINUE
C     PASS BACK TOTAL GAS AND LIQUID FLOWS.
      TFG=VFT
C     TFL HAS ALREADY BEEN EVALUATED.
C
      RETURN
      END
C
C$ USR2KV
C
C SUBROUTINE USR2KV, RETURNS TEMPERATURE DEPENDENT EQUILIBRIUM
C K-VALUES FOR GIVEN REACTOR MIXTURE.  DUE TO STRUCTURE SIMILARITIES
C BETWEEN COMPOUNDS, CONCENTRATION DEPENDENCE ON K-VALUES IS IGNORED.
C FORMAL ARGS
C -----------
C   ID....SUBSTANCE ID, AS DESCRIBED IN COMPOUND TABLE REFERENCE.
C   TF....EQUILIBRIOUM TEMPERATURE, F.
C   XKVAL.CALCULATED K-VALUE RETURNED TO CALLER.
C
      SUBROUTINE USR2KV(ID,TF,XKVAL)
C     DECLARATION REQUIRED BY ASPEN LINKER.
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C     VECTOR TO HOLD QUADRATIC COEFFICIENTS. CONTAINED VALUES ARE
C     OBTAINED FROM EXPERIMENTAL POINTS FOR 3016 PSIA.
      DIMENSION QDRC(37,3)
C
C     INITIALISE QUADRATIC COEFFICIENT MATRIX IN C-STYLE.
C     PURE GASES HAVE A K-VALUE APPROACHING POSITIVE INFINITY.
C     APPROXIMATE {+oo} WITH A HUGE VALUE.
      DATA ((QDRC(I,J), J=1,3), I=1,37) /
C           A        B        C            A        B        C
C                  H2                          N2(ASSUMED GAS)
     1  +5.00537,-0.87126,+0.04587,    +6.00841,-1.01848,+0.00377,
C            O2(ASSUMED GAS)                      H2S
     2  +1.0D003,+0.00000,+0.00000,    +1.82016,+0.24297,-0.07473,
C                  CO                           CO2
     3  +5.91984,-0.96431,-0.00877,    +2.98101,+0.15222,-0.12699,
C                  NH3                          H2O
     4  +1.85336,+0.30818,-0.08773,    +0.81384,+0.28503,-0.02240,
C            HCL(ASSUMED GAS)                COS(ASSUMED GAS)
     5  +1.0D003,+0.00000,+0.00000,    +1.0D003,+0.00000,+0.00000,
C                  CH4                          C2H6
     6  +3.98225,-0.26869,-0.07791,    +2.58080,+0.12330,-0.09136,
C                  C3H8                         IC4H10
     7  +1.94535,+0.23441,-0.07782,    +1.61922,+0.20520,+0.00000,
C                 NC4H10                        IC5H12
     8  +1.46280,+0.22677,+0.00000,    +1.21610,+0.28011,-0.04351,
C                 NC5H12                        T125
```

```
     9  +1.16740,+0.28982,-0.04144,    +1.23587,+0.15151,+0.00000,
C                   T175                          T225
     $  +0.94279,+0.17790,+0.00000,    +0.73249,+0.19783,+0.00000,
C                   T275                          T325
     1  +0.52288,+0.18992,+0.00000,    +0.34751,+0.16065,+0.00000,
C                   T375                          T425
     2  +0.23014,+0.13274,+0.00000,    +0.18662,+0.13460,+0.00000,
C                   T475                          T525
     3  +0.12646,+0.10913,+0.00000,    +0.08661,+0.07079,+0.01733,
C                   T575                          T625
     4  +0.05914,+0.05243,+0.01602,    +0.04095,+0.03887,+0.01428,
C                   T675                          T725
     5  +0.02862,+0.02895,+0.01250,    +0.01998,+0.02155,+0.01088,
C                   T775                          T825
     6  +0.01369,+0.01583,+0.00941,    +0.00903,+0.01129,+0.00806,
C                   T875                          T925
     7  +0.00563,+0.00764,+0.00675,    +0.00328,+0.00482,+0.00546,
C                   T975                         T1000+
     8  +0.00178,+0.00279,+0.00423,    +0.00015,+0.00003,+0.00135,
C         I1000+(SAME AS T1000+)
     9  +0.00015,+0.00003,+0.00135  /
C
C     IN ALL EUATIONS, TERM (T-700)/150 APPEARS WHEREVER T APPEARS.
      T=(TF-700.0)/150.0
C     INVENTORY IS LIMITED TO EQUATIONS FOR FIRST 37 COMPOUNDS.
C     ASSUME ALL THE OTHER COMPONENTS ARE LIQUIDS (K=0).
      IF (ID .GT. 37) THEN
        XKVAL=0
      ELSE
        XKVAL=QDRC(ID,1)+QDRC(ID,2)*T+QDRC(ID,3)*T*T
C       THE EQUATION FOR CO2 IS OF SPECIAL EXPONENTIAL TYPE.
C       IF (ID .EQ. 6) XKVAL=10.0**XKVAL
      ENDIF
C
      RETURN
      END
C
C$ USR02E
C
C  ENERGY BALANCE SECTION
C  ----------------------
C
C Subroutine USR02E, calculates the required fresh reactor inlet stream
C temperature, Tprh, that will provide the desired average bed
C temperature.  The actual overall energy balance has already been
C conducted by USR2EB, which calculated the actual effluent temperature
C based on the inlet one supplied by ASPEN, and ST2(1,2) has been
C updated. This sub will calculate a temperature which has no meaning in
C the current run.  If the Tprh that shortly will be calculated is found
C to considerably differ from the one supplied by ASPEN, the input file
C should be modified upstream to provide the correct Tprh for the
C desired Tavg.  Note that this sub is meaningful only for separate
C reactor calculations, i.e., it should be called only for modes 6 & 7.
C Formal args:
C -----------
```

```
C TAVG.....Desired bed average temperature, deg F. This is either REAL10
C          or REAL11, depending on current mode.
C KOMPS....Number of fluid mixture components (=37).
C NHSTRY...History file to print any warning messages.
C NOUT.....Report file to print any warning messages.
C          Watch that this sub is called only at the report pass
C          (IPASS=4), so the NOUT handle is positively valid.
C All results (if any...) are stored in Z vector.
C
      SUBROUTINE USR02E(TAVG,KOMPS,NHSTRY,NOUT)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C     Common storage.
      COMMON/USR12L/C(50),F(50),Z(400)
C     This contains the actual inlet and outlet temperatures in ST?(1,2)
C     array.
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5), OPROP(20,5)
C     Some Z values are interesting.
C     Local storage. Save vector, see comments below.
      DIMENSION SAV(15)
C
C     Save the original values calculated by initial energy balance in
C     Z, since USR2EB will be called again from here, altering the
C     actual values. Restore those values before exiting this sub.
      DO 10, J=1,12
        SAV(J)=Z(J+309)
   10 CONTINUE
C
C     The only guaranteed method of correct fresh feed temperature
C     evaluation is to use the bounding Regula-Falsi procedure, since
C     trial and error has proven itself unacceptably slow to converge
C     (in fact it didn't converge at all unless the initial guess was
C     too close to optimal solution). The Regula-Falsi scheme requires
C     two pairs of initial values, which confine the optimal solution.
C     A low Tprh value will lead to a low Tout, thus low Tavg. This
C     means that Tprh and Tavg are directly proportional.
C
C     Define low and hi limits for Tprh and corresponding Tavg's.
C     The overall energy balance has provided the temperature rise from
C     fresh feed to outlet. If we assume that this rise will not
C     significantly vary with Tprh, then we have a means of hi and lo
C     limits guess: the min Tprh cannot be less than (Tavg-rise), since
C     the optimal Tout will be slightly above the desired Tavg. The max
C     limit for Tprh is of course Tavg itself.
      RISE=ST2(1,2)-ST1(1,2)
      TPRHLO=TAVG-RISE
      TPRHHI=TAVG
C     Get corresponding Tavg's for Tprh initial interval.
C     The correct procedure here would be to accurately calculate the
C     Tavg hi and lo limits corresponding to TPRHHI and TPRHLO. But this
C     would involve for each point a call to USR2EB and then USR2EI,
C     which is an unacceptable overhead for input guesses.  Use
C     reasonable values instead, which be improved during solution.
      TAVGLO=TPRHLO+0.5*RISE
C     Here we cannot use ST2(1,2) since in the general case this might
```

```
C     be smaller than the avarage.
      TAVGHI=TAVG+0.2*RISE
C
C     Initial guess for TIN net reactor inlet temperature, deg F.
C     Note that the effect of this assumption is minimal, since TIN is a
C     relatively unimportant variable in this scheme.
      TIN=TAVGLO
C
C     Initialise loop counter, max iterations limit and tolerance.
      ITCNT=0
      MAXITR=100
C     It is unwise to specify a very low tolerance here.
      TOLRNC=1.0D-1
C
C     Entering main iteration loop.
   20 ITCNT=ITCNT+1
C     Use Regula-Falsi derivative based algorithm to determine new Tprh.
C     Note that Regula-Falsi is much more efficient compared to a simple
C     bisection technique.
      TPRH=TPRHLO+(TPRHHI-TPRHLO)*(TAVG-TAVGLO)/(TAVGHI-TAVGLO)
C
C     Perform an overall energy balance to get corresponding outlet
C     temperature, by calling sub USR2EB.
      CALL USR2EB(TPRH,TOUT,KOMPS,NHSTRY)
C
C     Now get corresponding average bed temperature, performing an inlet
C     energy balance by calling USR2EI. TIN, the net inlet temperature
C     is mainly passed back for display purposes.
      CALL USR2EI(TPRH,TOUT,TIN,TAVNEW,KOMPS,NHSTRY)
C
C     If original TAVG limits were valid, TAVNEW must now lie inside the
C     [TAVGLO,TAVGHI] region.
C
C     Check for convergence on average bed temperature.
      IF (DABS(TAVG-TAVNEW) .LT. TOLRNC) THEN
        GOTO 100
      ELSE
C       Check if max iteration limit exceeded.  If yes, break loop.
        IF (ITCNT .GT. MAXITR) GOTO 100
C       Else prepare next iteration.  Either the lo or hi limits are to
C       be replaced by the freshly calculated pair (Tprh,Tavg).
        IF (TAVNEW .GT. TAVG) THEN
C         We have a new hi limit pair.
          TPRHHI=TPRH
          TAVGHI=TAVNEW
        ELSE
C         This must be the new lo limit.
          TPRHLO=TPRH
          TAVGLO=TAVNEW
        ENDIF
      ENDIF
C     Loop back for next iteration.
      GOTO 20
C     Leaving iteration loop.
C
```

```
C     Check for convergence; if failed, print a warning message to the
C     history file and RESUME execution.
  100 IF (ITCNT .GT. MAXITR) THEN
        WRITE (NHSTRY, 500) MAXITR
  500   FORMAT (/ ' * WARNING * Failed to bring outer energy balance'/
     1    ' to convergence after ',I4,' iterations.'/
     2    ' Resuming normal execution.'/)
      ELSE
C       Store fictious temperatures in Z vector.
C       Required fresh feed temperature, deg F
        Z(322)=TPRH
C       Corresponding net reactor inlet temperature, deg F
        Z(323)=TIN
C       Corresponding reactor outlet temperature, deg F
        Z(324)=TOUT
C
C       Since this sub but itself is just a computational overhead,
C       calculate the net inlet and bed average temperatures for the
C       ASPEN provided values.
        TPRH=ST1(1,2)
        TOUT=ST2(1,2)
        CALL USR2EI(TPRH,TOUT,TIN,TAVNEW,KOMPS,NHSTRY)
C       Store these values as well.
C       Actual net reactor inlet temperature, deg F
        Z(325)=TIN
C       Actual reactor bed average temperature, deg F
        Z(326)=TAVNEW
C
C       Post a warning message if the calculated Tprh significantly
C       differs from the current fresh inlet temperature.
        IF (DABS(ST1(1,2)-Z(322)) .GT. 1.0)
     1    WRITE (NOUT, 510) ST1(1,2), Z(325), Z(326), ST2(1,2),
     2    Z(322), Z(323), TAVG, Z(324)
  510     FORMAT (/'* WARNING * The supplied fresh feed temperature '/
     1      'cannot provide the desired average bed temperature.'/
     2      11X, '   Fresh', 2X, '   Inlet', 2X, ' Average', 2X,
     3      '  Outlet', 2X, '(deg F)' /
     4      'Supplied ', 4(2X,F8.3) /
     5      'Required ', 4(2X,F8.3) / )
      ENDIF
C
C     Restore actual effluent stream heat properties in any case.
      DO 110, J=1,12
        Z(J+309)=SAV(J)
  110 CONTINUE
C
      RETURN
      END
C
C$ USR2EI
C
C Subroutine USR2EI, does  a simple energy balance at the 'invisible'
C mixer at the reactor bottom, merging the cool fresh feed with the
C hot internal recycle to the single reactor net inlet stream.  the goal
C is to calculate the average bed temperature corresponding to a certain
```

```
C fresh inlet temperature and the corresponding outlet temperature, that
C already has been calculated by subroutine USR2EB.  First the net inlet
C temperature Tin of the reactor is calculated, and the average is
C obtained as the arithmetic mean of Tin and Tout.
C Formal args:
C -----------
C TPRH....Fresh inlet temperature, deg F
C TOUT....Effluent stream temperature, deg F
C TIN.....Net reactor inlet temperature, deg F (filled here)
C TAVG....Average bed temperature, deg F       (filled here)
C KOMPS...Number of fluid mixtite components.
C
      SUBROUTINE USR2EI(TPRH,TOUT,TIN,TAVG,KOMPS,NHSTRY)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C     Common storage
C     Flash interface
      COMMON /USR02V/ FIN(40),VOUT(40),XLOUT(40)
C     This contains the already calculated mass balance in and out.
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5), OPROP(20,5)
      COMMON /USR12L/ C(50), F(50), Z(400)
C
C     Local storage
C     Vector to hold latent heats at Tprh, Btu/lb-mol.
      DIMENSION DHVAP(40)
C     Vector to hold net inlet composition, lbm/hr of fluids.
      DIMENSION TOTIN(40)
C
C     Perform an energy balance at the inlet to obtain Tin, the net
C     inlet reactor temperature. This is a simple mixing balance, with
C     no reaction heat. Input streams are:
C       i. Fresh feed at Tprh; mixed gas, liquid and solid flows.
C      ii. Internal recycle at Tout; solely liquid flow. The internal
C          recycle is returned from the reactor top, and assuming
C          minimal heat losses during transfer the Tout temperature is
C          justified. It mainly consists of heavy fractions, that is why
C          it is considered solely liquid. Its total flow rate has
C          already been determined from the fluidization calculations in
C          the eb-bed, stored in Z(309), lbm/hr. The sole output stream
C          is the net reactor inlet stream, mixed flow at Tin.  Base
C          temperature for the energy balance is Tprh and liquid state.
C
C     Store internal recycle total flow, lbm/hr.
      RECYCL=Z(309)
C     The total recycle flow may be fixed, but the actual concentration
C     in heavy fractions is slightly dependent on outlet temperature.
C     Just before this sub is called, an overall energy balance has
C     provided the Tout outlet temperature. The responsible sub USR2EB,
C     was the last customer to the flash sub USR2FL, thus XLOUT contains
C     the liquid outlet composition, which is identical to internal
C     recycle composition, only watch that XLOUT refers to the outlet
C     total flow, which is smaller than the recycle flow. Adjust XLOUT
C     to reflect the recycle flow and calculate the net reactor inlet
C     overall detailed flows.  NOTE that the recycle is assumed to be
C     free from solids.
```

```
C     Get total outlet fluid flow, lbm/hr.
      SUM=0.0
      DO 10, J=1,KOMPS
        SUM=SUM+XLOUT(J)
   10 CONTINUE
      DO 20, J=1,KOMPS
C       Store net inlet flows to TOTIN vector, will be used in flashing.
        TOTIN(J)=CIN(J)+XLOUT(J)*RECYCL/SUM
   20 CONTINUE
C     The energy balance has also supplied the correct outlet liquid
C     specific heat, stored at Z(313), Btu/(lbm F).
      CPREC=Z(313)
C     Final element of inlet entalpy is the recycle cooling, Btu/hr.
      HINREC=RECYCL*CPREC*(TOUT-TPRH)
C
C     Get total solid net inlet flow, lbm/hr solely due to fresh feed.
      TOTSOL=CIN(46)+CIN(47)+CIN(48)
C
C     Flash fresh input to get corresponding vaporization enthalpy,
C     Btu/hr.
      DO 30, J=1,KOMPS
        FIN(J)=CIN(J)
   30 CONTINUE
C     Here we don't need the total gas and liquid flows, since both
C     gases and liquids are already at the base temperature.
      CALL USR2FL(TPRH,KOMPS,DUMMY1,DUMMY2,NHSTRY)
      HINVAP=0.0
      DO 40, J=1,KOMPS
C       Store individual latent heats, Btu/lb-mol, since they will be
C       used for fresh feed vaporization, too.
        CALL USR2LH(J,TPRH,DHVAP(J))
        HINVAP=HINVAP+VOUT(J)*DHVAP(J)
   40 CONTINUE
C
C     The net inlet (outlet for nrg balance) flash should be performed
C     at Tin, a temperaure that we are searching for. Thus iterations
C     are needed.
C
C     Initial guess for net inlet temperature, deg F.
      TIN=TPRH+5.0
C
C     Fill here once the TOTIN to the flash total stream FIN. It won't
C     have to be refilled during the iterative calculations that follow.
      DO 50, J=1,KOMPS
        FIN(J)=TOTIN(J)
   50 CONTINUE
C
C     Iterations counter, maximum number of iterations and tolerance.
      ITCNT=0
      MAXITR=100
      TOLRNC=1.0D-3
C
C     Entering iterations main loop.
  100 ITCNT=ITCNT+1
C     Flash net reactor inlet at current Tin to get detailed
```

```
C     vapor/liquid flows. TOTGAS is gas flow in lb-mol/hr, and TOTLIQ is
C     the liquid flow in lbm/hr.
      CALL USR2FL(TIN,KOMPS,TOTGAS,TOTLIQ,NHSTRY)
C     Calculate the net inlet stream enthalpy Btu/hr, due to
C     vaporization at Tprh.  Note that this is a portion of the outlet
C     enthalpy, as far as this specific energy balance is concerned.
C     Concurrently, get net inlet average gas and liquid specific heat
C     capacities, CPGAS is in Btu/(lb-mol F), and CPLIQ in Btu/(lbm F).
      HUTVAP=0.0
      CPGAS=0.0
      CPLIQ=0.0
      DO 110, J=1,KOMPS
C       Latent heats at Tprh already stored in DHVAP vector.
        HUTVAP=HUTVAP+VOUT(J)*DHVAP(J)
        CALL USR2CP(J,0,TPRH,TIN,CPTMP)
        CPLIQ=CPLIQ+CPTMP*XLOUT(J)/TOTLIQ
        CALL USR2CP(J,1,TPRH,TIN,CPTMP)
        CPGAS=CPGAS+CPTMP*VOUT(J)/TOTGAS
  110 CONTINUE
C
C     Get solid heat capacities, Btu/(lbm F), all considered coal (=46).
      CALL USR2CP(46,0,TPRH,TIN,CPSOL)
C
C     Calculate outlet enthalpy available for gas, liquid and solids
C     heating.
      HOUT=HINVAP+HINREC-HUTVAP
C
C     Calculate net inlet temperature, deg F.
      TINNEW=TPRH+HOUT/(TOTGAS*CPGAS+TOTLIQ*CPLIQ+TOTSOL*CPSOL)
C
C     Check for convergence.
      IF ( DABS(TINNEW-TIN) .LT. TOLRNC ) THEN
        TIN=TINNEW
        GOTO 200
      ELSE
C       If there are any iterations to spare, keep on searching.
        IF (ITCNT .GT. MAXITR) GOTO 200
        TIN=TINNEW
      ENDIF
C     Loop back for next iteration.
      GOTO 100
C
C     Leaving iterations loop, check for method failure.
  200 IF (ITCNT .GT. MAXITR) THEN
C       Post a warning message and continue with best accurate value.
        WRITE (NHSTRY, 500) MAXITR
  500   FORMAT (/'* WARNING * Inlet energy balance failed to converge'/
     1          'after ',I4,' iterations.'/
     2          'Resuming execution with currently best guess.'/)
      ENDIF
C
C     Average TIN and TOUT to get average bed temperature, deg F.
      TAVG = 0.5*(TIN+TOUT)
C
      RETURN
```

```
      END
C
C$ USR2EB
C
C SUBROUTINE USR2EB, EVALUATING TEMPERATURE OF THE REACTOR EFFLUENT
C STREAM, BY AN OVERALL ENERGY BALANCE WITH ITERATIVE CONVERGENCE.
C FORMAL ARGS:
C -----------
C TIN....INLET TEMPERATURE, DEG F
C TOUT...OUTLET TEMPERATURE, DEG F
C KOMPS..NUMBER OF CONVENTIONAL COMPONENTS (=37)
C        THREE NON-CONVENTIONAL COMPONENTS EXIST AT INDICES 46, 47 & 48,
C        WHICH ARE CONSIDERED SOLID CARBON IN ENERGY BALANCE CALCULATIONS.
C NHSTRY.HISTORY FILE UNIT NUMBER, FOR ERROR PRINTOUTS. THIS HAPPENS IF
C        THE METHOD FAILS TO CONVERGE AFTER A NUMBER OF ITERATIONS.
C
C INLET AND OUTLET OVERALL COMPOSITIONS ARE PASSED AS COMMON ARGS, KEPT
C IN VECTORS CIN() AND COUT(), LBM/HR, ALREADY CALCULATED.
C
      SUBROUTINE USR2EB(TIN,TOUT,KOMPS,NHSTRY)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C     COMMON HOLDING INLET AND OUTLET OVERALL RATES.
      COMMON/USR02M/CIN(50),COUT(50),CPROP(40,7),ICNUMB(50),
     1 ST1(5,5),ST2(6,5), OPROP(20,5)
C     THIS IS THE MAIN FLASH COMMON STORAGE.
      COMMON /USR02V/ FIN(40),VOUT(40),XLOUT(40)
C     THIS COMMON FOR STORING SOME INTERESTING VALUES IN Z VECTOR.
      COMMON/USR12L/C(50),F(50),Z(400)
C     LOCAL VARIABLES.
C     VECTOR TO HOLD CONVENTIONAL COMPONENTS' LATENT HEATS AT INLET
C     CONDITIONS, IN BTU/LB-MOL.
      DIMENSION DHVAP(40)
C
C     NRG BALANCE IS BASED ON INLET TEMPERATURE TIN, DEG F, AND LIQUID
C     PHASE AS STANDARDS. THUS INLET ENTHALPY IS ALREADY KNOWN. A HEAT
C     LOSS IS ASSUMED DUE TO INTERNAL RECYCLE STREAM. FINALLY, DHrxn OF
C     THE REACTION IS PER LB-MOL HYDROGEN CONVERTED.  ITS VALUE IS
C     TRADITIONALLY NEGATIVE FOR EXOTHERMIC REACTIONS LIKE THIS ONE.
C     DHrxn MUST BE FOR ALL REACTANTS AND PRODUCTS IN THE LIQUID STATE,
C     AND PROPERLY CONVERTED TO BASE TEMPERATURE OF ENERGY BALANCE
C     CALCULATIONS.
C
C     HEAT LOSS NOT RESSOLVED YET.
      QLOSS=0.0
C
C     DHrxn=-11000 BTU/LBM H2 CONSUMED, DHRXN IN BTU/HR
      DHRXN=-11000.0*(CIN(1)-COUT(1))
C     NRG CONSERVATION EQUATION:       Hin-DHrxn=Hout+Qloss
C     GET INLET STREAM ENTHALPY, BTU/HR. BECAUSE NRG BALANCE IS RELATIVE
C     TO INPUT TEMPERATURE, JUST ENTHALPIES OF VAPORIZATION SHOULD BE
C     CONSIDERED, AT INLET CONDITIONS. GET VAPOR AT INLET BY CALLING
C     USR2FL. NORMALLY, FLASH IS NOT ISOTHERMAL, SO THERE IS A SERIOUS
C     BUG IN THIS APPROACH... MOREOVER, FLASH CALCULATIONS FOR THE INLET
C     STREAM HAVE ALREADY BEEN PERFORMED IN REACTOR FLOW MODEL
C     CALCULATIONS IN USR02F. IN COMMON USR02V USED FOR FLASH INTERFACE,
```

```
C     THE VECTORS ARE:
C     FIN()....OVERALL FEEDS, LBM/HR
C     VOUT()...GAS PHASE RATES, LB-MOL/HR
C     XLOUT()..LIQUID PHASE RATES, LBM/HR
C
C     FILL OVERALL FEED FOR INLET FLASH.
      DO 10, I=1,KOMPS
        FIN(I)=CIN(I)
   10 CONTINUE
C     PERFORM FLASH CALCULATIONS; USR2FL ALSO RETURNS TOTAL GAS & LIQUID
C     PHASE RATES, WHICH ARE NOT NEEDED HERE, THUS DUMMIES ARE PASSED.
C     PREVAILING PRESSURE IS IGNORED IN FLASH CALCULATIONS.
      CALL USR2FL(TIN,KOMPS,DUM1,DUM2,NHSTRY)
C     CALCULATE INLET ENTHALPY DUE TO GAS PHASE EXISTANCE. NOTE THAT
C     NON-CONVENTIONAL STUFF ARE IGNORED HERE, LIKE LIQUIDS.
      HIN=0.0
C     ONLY CONVENTIONAL COMPONENTS MAY EXIST IN GAS STATE.
      DO 20, I=1,KOMPS
C       GET ENTHALPY OF VAPORIZATION FOR SPECIES I, AND STORE IT IN DHVAP
C       VECTOR. WATCH ONCE MORE THAT LATENT HEAT IS EVALUATED AT INLET
C       CONDITIONS.
        CALL USR2LH(I,TIN,DHVAP(I))
C       ADD EFFECT OF SPECIES I TO INPUT ENTHALPY.
        HIN=HIN+DHVAP(I)*VOUT(I)
   20 CONTINUE
C     THE ADOPTED PROCEDURE IS TO ASSUME AN EXIT TEMPERATURE, THUS
C     FIXING VAPOR AND LIQUID RATES AT OUTLET. ALSO MEAN TOTAL PHASE CPs
C     ARE EVALUATED FOR THIS ASSUMED TEMPERATURE AND A NEW EXIT
C     TEMPERATURE IS EVALUATED FROM THE NRG BALANCE, THUS CREATING AN
C     ITERATIVE SCHEME.
C     FILL FLASH EXIT TOTAL STREAM HERE ONCE; THIS IS PRESERVED IN USR2FL,
C     SO IT WON'T HAVE TO BE FILLED AGAIN.
      DO 30, I=1,KOMPS
        FIN(I)=COUT(I)
   30 CONTINUE
C     SOLIDS DO NOT ENTER PHASE EQUILIBRIA. CALCULATE HERE TOTAL SOLIDS
C     OUTFLOW IN LBM/HR.
      TOTSOL=COUT(46)+COUT(47)+COUT(48)
C     ITERATION COUNTER AND MAX ITERATIONS ALLOWED FOR CONVERGENCE.
      ITCNT=0
      MAXITR=100
C     SOLUTION TEMPERATURE TOLERANCE, DEG F.
      TOLRNC=1.0D-3
C     INITIAL TEMPERATURE GUESS, DEG F. SINCE REACTION IS EXOTHERMIC,
C     THIS WILL BE A BIT HIGHER THAN INLET TEMPERATURE.
      TOUT=TIN+5.0
C     ENTERING NRG BALANCE ITERATION LOOP.
C
   50 ITCNT=ITCNT+1
C     FLASH OUTLET TO GET VAPOR AND LIQUID PHASES. NOTE THAT THE TOTAL
C     GAS AND LIQUID FLOWS ARE INTERESTING.  TOTGAS IS IN LB-MOL/HR, AND
C     TOTLIQ IS IN LBM/HR.
      CALL USR2FL(TOUT,KOMPS,TOTGAS,TOTLIQ,NHSTRY)
C     CONVENTIONAL COMPOUNDS AREA: LIQUID AND GAS PHASES.
C     GET MEAN LIQUID PHASE CP IN BTU/(LBM F).
```

```
      CPLIQ=0.0
      DO 60, I=1,KOMPS
C       GET SPECIES I LIQUID HEAT CAPACITY CPI, BTU/(LBM F) FOR ASSUMED
C       TOUT. PRESSURE IS NOT NEEDED FOR LIQUIDS, SO NIL IS PASSED.
        CALL USR2CP(I,0,TIN,TOUT,CPI)
C       ADD EFFECT TO MEAN LIQUID CP VALUE.
        CPLIQ=CPLIQ+CPI*XLOUT(I)/TOTLIQ
   60 CONTINUE
C     GET MEAN GAS PHASE CP IN BTU/(LB-MOL F).
      CPGAS=0.0
      DO 70, I=1,KOMPS
C       GET SPECIES I GAS HEAT CAPACITY CPI, BTU/(LB-MOL F) FOR ASSUMED
C       TOUT. PRESSURE IS NEEDED FOR GASES, OUTLET PRESSURE IS NEEDED
C       HERE, ASSUMED 20 PSIA LESS THAN INLET.
        CALL USR2CP(I,1,TIN,TOUT,CPI)
C       ADD EFFECT TO MEAN GES CP VALUE.
        CPGAS=CPGAS+CPI*VOUT(I)/TOTGAS
   70 CONTINUE
C     NON-CONVENTIONAL COMPOUNDS AREA: PERMANENTLY IN SOLID STATE
C     SOLIDS CP IN BTU/(LBM F), ALL HAVE THE SAME, SO CALL ONLY ONCE.
      CALL USR2CP(46,0,TIN,TOUT,CPSOL)
C     EXIT ENTHALPY CONSISTS OF LIQUID, GAS AND SOLIDS HEATING FROM TIN
C     (BASE TEMPERATURE) TO TOUT, PLUS ENTHALPY OF EVAPORATION OF OUTLET
C     GASES AT BASE TEMPERATURE. THE LATTER CAN BE EVALUATED HERE, ONCE
C     GAS FLOW IS ALREADY KNOWN FROM FLASH EQUILIBRIA. NOTE THAT THIS IS
C     BASED ON A REACTION HEAT IN WHICH ALL REACTANTS/PRODUCTS ARE AT
C     LIQUID PHASE AND BASE TEMPERATURE.
C     CALCULATE OUTLET VAPORIZATION ENTHALPY, BTU/HR.
      HUTVAP=0.0
      DO 80, I=1,KOMPS
C       DHVAPs MUST BE POSITIVE VALUES.
        HUTVAP=HUTVAP+VOUT(I)*DHVAP(I)
   80 CONTINUE
C     EVALUATE THE NEW OUTLET TEMPERATURE, TNEW, IN DEG F...
C     Hout=Hout,vap+(Tout-Tbase)*SUM(CPi,out*FLOWi,out)
C     WHERE i IS LIQUID, GAS AND SOLID PHASES. EVALUATE TNEW BY
C     SUBSTITUTING Hout FROM THE ABOVE EQUATION IN OVERALL NRG BALANCE.
C     OUTLET ENTHALPY FROM NRG BALANCE, BTU/HR.
      HOUT=HIN-DHRXN-QLOSS
C     GET DESIRED OUTLET TEMPERATURE, DEG F.
      TNEW=TIN+(HOUT-HUTVAP)/(CPLIQ*TOTLIQ+CPGAS*TOTGAS+CPSOL*TOTSOL)
C     CHECK FOR CONVERGENCE.
      IF (DABS(TOUT-TNEW) .LT. TOLRNC) THEN
        TOUT=TNEW
        GOTO 500
      ELSE
C       CHECK IF MAX ITERATIONS HAVE BEEN EXCEEDED.
        IF (ITCNT .GT. MAXITR) GOTO 500
C       ELSE PREPARE NEXT ITERATION.
        TOUT=TNEW
      ENDIF
C     LOOP BACK FOR NEXT ITERATION.
      GOTO 50
C     LEAVING ITERATION LOOP; CHECK FOR METHOD FAILURE.
C
```

```
  500 IF (ITCNT .GT. MAXITR) THEN
C        PRINT ERROR MESSAGE AT REPORT FILE AND HALT EXECUTION.
         WRITE (NHSTRY,900) ITCNT
  900    FORMAT (/ 1X, '*** ERROR *** in energy balance calculations!'/
     1     4X, 'Method failed to converge after ',I4,' iterations'/
     2     1X, 'EXECUTION IS BEING TERMINATED.'//)
         STOP
       ENDIF
C      CALCULATED EXIT TEMPERATURE IN TOUT NOW, DEG F.
C
C      STORE INTERESTING VALUES IN END POSITIONS OF Z VECTOR.  ALSO,
C      DISTINGUISH THE MODE SINCE THERE IS NO SENSE IN NRG BALANCE FOR
C      MODE 5.
C      INLET TEMPERATURE, DEG F
       Z(310)=TIN
C      INLET TEMPERATURE, DEG F
       Z(311)=TOUT
C      NRG GENERATED FROM H2 CONVERSION, BTU/HR
       Z(312)=DHRXN
C      OUTLET LIQUID MEAN CP, BTU/(LBM F)
       Z(313)=CPLIQ
C      OUTLET GAS MEAN CP, BTU/(LB-MOL F)
       Z(314)=CPGAS
C      OUTLET SOLIDS CP, BTU/(LBM F)
       Z(315)=CPSOL
C      OUTLET LIQUID FLOW, LBM/HR
       Z(316)=TOTLIQ
C      OUTLET GAS FLOW, LB-MOL/HR
       Z(317)=TOTGAS
C      OUTLET SOLIDS FLOW, LBM/HR
       Z(318)=TOTSOL
C      TOTAL INLET ENTHALPY, BTU/HR
       Z(319)=HIN
C      TOTAL OUTLET ENTHALPY, BTU/HR
       Z(320)=HOUT
C      TOTAL OUTLET VAPORIZATION ENTHALPY, BTU/HR
       Z(321)=HUTVAP
C
       RETURN
       END
C
C$ USR2CP
C
C SUBROUTINE USR2CP, CALCULATES THE HEAT CAPACITIES OF PURE SUBSTANCES.
C CLASIFICATION IS BEING DONE INTERNALLY, SEPARATING CONVENTIONAL
C SUBSTANCES FROM PETROLEUM PSEUDO-COMPONENTS THROUGH CALLS TO SEPARATE
C SUBPROGRAMS. THIS WAY THE JARGON IS MINIMIZED; READABILITY AND SPEED
C ARE ATTAINED.  THE CP VALUES ARE TEMPERATURE DEPENDENT; TEMPERATURE
C RANGE IS PASSED HERE, AND CP IS RETURNED AS THE MEAN VALUE OVER THE
C SPECIFIED RANGE.
C FORMAL ARGS:
C -----------
C ID.....SUBSTANCE ID, AS DESCRIBED IN REFERENCE TABLE.
C IDPHS..PHASE ID FOR SUBSTANCE, AS FOLLOWS:
C        -> 0...LIQUID
```

```
C         -> 1...GAS
C TLOW...MIN TEMERATURE LIMIT, DEGREES F.
C TUP....MAX TEMERATURE LIMIT, DEGREES F.
C CP.....HEAT CAPACITY, WITH UNITS AS FOLLOWS:
C         -> LIQUID..BTU/(LBM F)    (SAME APPLIES TO SOLIDS)
C         -> GAS.....BTU/(LB-MOL F)
C THIS PHASE UNITS DISTINCTION IS CUSTOMISED FOR THE SPECIFIC PROBLEM;
C THE SUBROUTINES CALLED FROM HERE RETURN THE CP VALUES IN SAME UNITS AS
C FOUND IN TABULATIONS.
      SUBROUTINE USR2CP(ID,IDPHS,TLOW,TUP,CP)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C     ADD COMMON INCLUDING CPROP(I,J) FOR MOLECULAR WEIGHTS.
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5), OPROP(20,5)
C
C     DIRECT PROBLEM TO APPROPRIATE HANDLER; EACH ONE HANDLES
C     TEMPERATURE AND CP UNITS INDIVIDUALLY.  THUS NO PRELIMINARY UNIT
C     CONVERSIONS ARE BEING DONE AT THIS STAGE.  FIRST DISTINCTION IS
C     AMONG CONVENTIONAL COMPONENTS (ID<=17) AND PETROLEUM FRACTIONS.
      IF (ID .LE. 17) THEN
C       SECONDLY, DISTINGUISH THE PHASE.
        IF (IDPHS .EQ. 0) THEN
C         HANDLE CONVENTIONAL LIQUIDS (NO PHASE ID REQUIRED).
          CALL USR2C1(ID,TLOW,TUP,CP)
C         CONVERT UNITS J/(KG-MOL K) -> BTU/(LBM F)
          CP=CP/(4186.8*CPROP(ID,1))
        ELSE
C         HANDLE CONVENTIONAL GASES.
          CALL USR2C2(ID,TLOW,TUP,CP)
C         CONVERT UNITS J/(KG-MOL K) -> BTU/(LB-MOL F)
          CP=CP/4186.8
        ENDIF
      ELSE IF (ID .LE. 37) THEN
C       CALCULATE SPECIFIC GRAVITY OF FRACTION.  DIFFERENT FOR LIQUID AND
C       GAS PHASES.
C       CPROP(I,2) CONTAINS LIQUID DENSITIES IN LBS/BBL, CONVERT UNITS
        SG=CPROP(ID,2)*2.85301/1000.0
C       SECONDLY, DISTINGUISH THE PHASE.
C     IN PETROLEUM EVALUATIONS, WATCH THAT ID BEGINS WITH 18 AND UP.
        IF (IDPHS .EQ. 0) THEN
C         HANDLE PETROLEUM LIQUID FRACTIONS.
          CALL USR2C3(ID,TLOW,TUP,SG,CP)
C         CP ALREADY IN DESIRED UNITS, BTU/(LBM F).
        ELSE
C         HANDLE PETROLEUM GAS FRACTIONS.
C         CALL USRGSG TO CALCULATE GAS SPECIFIC GRAVITY, PASSING
C         TEMPERATURE, PRESSURE AND MOLECULAR WEIGHT. MW IS ASSUMED SAME
C         TO LIQUID'S. CALL USRGSG(CPROP(ID,1),PRESS,(TLOW+TUP)/2.0,SG).
          CALL USR2C4(ID,TLOW,TUP,SG,CP)
C         CP UNITS ALREADY IN BTU/(LB-MOL F).
        ENDIF
      ELSE
C       ALL NON-CONVENTIONAL COMPONENTS ARE TREATED AS SOLID CARBON.
C       THUS NO IDs NEED TO BE PASSED.  THIS IS VALID ONLY FOR
C       COMPONENT IDs 46, 47 AND 48.  IF USED FOR ANY OTHER IDs
```

```
C       (BLANKs),  UNPREDICTABLE RESULTS WILL OCCUR.
        CALL USR2C5(TLOW,TUP,CP)
C       CONVERT UNITS CAL/(MOL K) -> BTU/(LBM F)
C       USE PURE CARBON'S MOLECULAR WEIGHT.
        CP=CP/12.01
      ENDIF
C
      RETURN
      END
C
C$ USR2C1
C
C SUBROUTINE USR2C1, EVALUATING CONVENTIONAL LIQUID HEAT CAPACITIES.
C EXTENDED QUADRATIC EQUATIONS TAKEN FROM AIChE/DIPPR DATA COMPILATION
C (TABLES OF PROPERTIES OF PURE COMOUNDS)
C TEMPERATURE RANGE CHECK IS PERFORMED, TO ASSURE VALIDITY OF RESULTS.
C THIS IS COMPULSORY FOR LIQUID CP VALUES, SINCE MOST COMPOUNDS ARE
C GASES AT THE OPERATING TEMPERATURE, STILL THE FINITE K-VALUES MAY
C ALLOW A TINY AMOUNT OF LIQUID PHASE; IF A WILD CP VALUE IS EVALUATED
C FOR THIS SMALL AMOUNT OF LIQUID, UNPREDICTABLE RESULTS MAY OCCUR.
C FORMAL ARGS:
C -----------
C ID.....SUBSTANCE ID, AS DESCRIBED IN REFERENCE TABLE (1-17 FOR
C        CONVENTIONAL).
C TLOW...MIN TEMERATURE LIMIT, DEGREES F.
C TUP....MAX TEMERATURE LIMIT, DEGREES F.
C CP.....LIQUID HEAT CAPACITY, J/(KG-MOL K).
C
      SUBROUTINE USR2C1(ID,TLOW,TUP,CP)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C     MATRIX TO HOLD QUADRATIC EQUATION COEFFICIENTS. THE GENERAL
C     EQUATION FORM IS
C             CP = A + B*T + C*T**2 + D*T**3 + E*T**4
C     SOME SUBSTANCES MAY USE A REDUCED FORM OF THE ABOVE EQUATION.
      DIMENSION CFN(17,5)
C     MATRIX TO HOLD TEMPERATURE RANGE VALIDYTY OF EQUATION COEFFICIENTS
C     FOR EACH ELEMENT, A LOW AND  HIGH LIMIT IN KELVINS.
      DIMENSION TRNG(17,2)
C
C     INITIALIZE COEFFICIENTS VECTOR IN 'C' STYLE.
      DATA ((CFN(I,J), J=1,5), I=1,17) /
C           A            B            C            D            E
     1 +2.2560D+04, -1.9859D+03, +1.1547D+02, -1.2598D+00, +0.0000D+00,
     2 -3.3400D+04, +3.5070D+03, -4.6700D+01, +2.1270D-01, +0.0000D+00,
     3 +6.8337D+04, -6.1354D+02, +7.9280D+00, -3.1680D-02, +0.0000D+00,
     4 +3.7491D+06, -5.5411D+04, +2.7765D+02, -4.6310D-01, +0.0000D+00,
     5 +5.5140D+04, +7.0400D+01, +0.0000D+00, +0.0000D+00, +0.0000D+00,
     6 -8.3043D+06, +1.0437D+05, -4.3333D+02, +6.0052D-01, +0.0000D+00,
     7 +1.0827D+06, -1.5541D+04, +8.9011D+01, -2.2513D-01, +2.1336D-04,
     8 +5.2634D+04, +2.4119D+02, -8.5085D-01, +1.0000D-03, +0.0000D+00,
     9 +4.7300D+04, +9.0000D+01, +0.0000D+00, +0.0000D+00, +0.0000D+00,
     $ +2.5260D+05, -3.1304D+03, +2.0129D+01, -5.8185D-02, +6.5430D-05,
     1 +6.0714D+05, -1.8946D+04, +2.3842D+02, -1.3113D+00, +2.6842D-03,
     2 +1.8310D+05, -3.0830D+03, +2.9608D+01, -1.2133D-01, +1.8430D-04,
     3 +1.2220D+05, -9.9430D+02, +9.0810D+00, -3.3549D-02, +4.7384D-05,
```

```
     4 +2.2870D+05, -2.8505D+03, +2.1722D+01, -6.6330D-02, +7.4614D-05,
     5 +2.9060D+05, -3.0036D+03, +1.8266D+01, -4.7125D-02, +4.7040D-05,
     6 +1.0830D+05, +1.4600D+02, -2.9200D-01, +1.5100D-03, +0.0000D+00,
     7 +1.5016D+05, -1.1700D+02, +1.4490D-01, +1.4840D-03, +0.0000D+00 /
C
C     INITIALIZE RANGE VECTOR IN 'C' STYLE.
      DATA ((TRNG(I,J), J=1,2), I=1,17) /
C          TLOW,   TUP          TLOW,   TUP
     1     14.0,   32.0,        64.0,  120.0,
     2     54.3,  105.0,       191.5,  208.2,
     3     68.1,   90.0,       220.0,  290.0,
     4    195.4,  373.1,       303.1,  363.1,
     5    165.0,  185.0,       134.3,  378.8,
     6     90.7,  180.0,        90.3,  290.0,
     7     85.4,  350.0,       113.5,  390.0,
     8    134.9,  410.0,       113.2,  310.0,
     9    148.6,  302.9                      /
C
C     CP IS OBVIOUSLY NEEDED FOR ENTHALPY VARIATION EVALUATIONS OVER A
C     TEMPERATURE RANGE; CP's ARE NOT CONSTANT OVER THIS RANGE, SO AN
C     APPROXIMATION MUST BE DONE. ONE APPROACH IS TO EVALUATE CPs AT LOW
C     AND HIGH TEMPERATURE LIMITS AND THEN USE THE AVERAGE OF THE TWO
C     VALUES.  THE APPROACH UTILIZED HERE IS TO EVALUATE CP VALUE AT THE
C     TEMPERATURE IN THE MIDDLE OF DESIRED RANGE.
C     GET MID TEMPERATURE, F.
      TMID=(TLOW+TUP)/2.0
C     CONVERT THE TEMPERATURE TO KELVINS.
      TMID=5.0/9.0*(TMID-32.0)+273.15
C     CHECK TEMPERATURE RANGE; IF ATTEMPT TO EVALUATE CP IS MADE OUT OF
C     THE VALID RANGE, ERRONEOUS RESULTS MAY OCCUR. IN THIS CASE,
C     CALCULATE THE CP VALUE AT THE CLOSEST TEMPERATURE LIMIT.
      IF (TMID .LT. TRNG(ID,1)) THEN
        TMID=TRNG(ID,1)
      ELSE IF (TMID .GT. TRNG(ID,2)) THEN
        TMID=TRNG(ID,2)
      ENDIF
C     EVALUATE CP, J/(KG-MOL K)
      CP=CFN(ID,1)+CFN(ID,2)*TMID+CFN(ID,3)*TMID**2.0+
     1   CFN(ID,4)*TMID**3.0+CFN(ID,5)*TMID**4.0
C     CP CONVERSION TO DESIRED UNITS IS HANDLED BY CALLER.
C
      RETURN
      END
C
C$ USR2C2
C
C SUBROUTINE USR2C2, EVALUATING CONVENTIONAL GASES (IDEAL) HEAT
C CAPACITIES. EXPONENTIAL EQUATIONS TAKEN FROM AIChE/DIPPR DATA
C COMPILATION (TABLES OF PROPERTIES OF PURE COMOUNDS).
C FORMAL ARGS:
C -----------
C ID.....SUBSTANCE ID, AS DESCRIBED IN REFERENCE TABLE (1-17 FOR
C        CONVENTIONAL).
C TLOW...MIN TEMERATURE LIMIT, DEGREES F.
C TUP....MAX TEMERATURE LIMIT, DEGREES F.
```

```
C CP.....GAS HEAT CAPACITY, J/(KG-MOL K).

      SUBROUTINE USR2C2(ID,TLOW,TUP,CP)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C     MATRIX TO HOLD EXPONENTIAL EQUATION COEFFICIENTS. THE GENERAL
C     EQUATION FORM IS
C                        CP = A + B*DEXP(-C/T**D)
      DIMENSION CFN(17,4)
C     MATRIX TO HOLD TEMPERATURE RANGE VALIDYTY OF EQUATION COEFFICIENTS
C     FOR EACH ELEMENT, A LOW AND HIGH LIMIT IN KELVINS.
      DIMENSION TRNG(17,2)
C
C     INITIALIZE COEFFICIENTS VECTOR IN 'C' STYLE.
      DATA ((CFN(I,J), J=1,4), I=1,17) /
C            A            B            C            D
     1  +2.9158D+04,  +7.8952D+05,  +1.7069D+02,  +4.6970D-01,
     2  +2.9097D+04,  +9.4578D+03,  +8.5872D+04,  +1.6488D+00,
     3  +2.9095D+04,  +9.6530D+03,  +3.9556D+04,  +1.6287D+00,
     4  +3.3330D+04,  +4.1150D+04,  +1.0066D+03,  +9.7470D-01,
     5  +2.9123D+04,  +9.3780D+03,  +7.8460D+04,  +1.6569D+00,
     6  +2.8950D+04,  +3.9680D+04,  +6.0610D+02,  +1.0432D+00,
     7  +3.3190D+04,  +7.4230D+04,  +5.4040D+02,  +8.8950D-01,
     8  +3.3252D+04,  +6.0104D+04,  +4.1899D+02,  +7.7240D-01,
     9  +2.9130D+04,  +1.1150D+04,  +5.0140D+04,  +1.5086D+00,
     $  +2.8280D+04,  +3.8650D+04,  +4.3340D+02,  +1.0520D+00,
     1  +3.3106D+04,  +9.9975D+04,  +2.3380D+03,  +1.1347D+00,
     2  +3.8380D+04,  +1.7500D+05,  +8.4350D+02,  +1.0204D+00,
     3  +4.7497D+04,  +2.4670D+05,  +6.9858D+02,  +1.0074D+00,
     4  +4.8010D+04,  +3.5400D+05,  +3.0100D+02,  +8.8240D-01,
     5  +5.7380D+04,  +3.4240D+05,  +3.7050D+02,  +9.0700D-01,
     6  +7.1560D+04,  +3.9240D+05,  +6.3720D+02,  +1.0017D+00,
     7  +8.2707D+04,  +3.6653D+05,  +1.1194D+03,  +1.0873D+00 /
C
C     INITIALIZE RANGE VECTOR IN 'C' STYLE.
      DATA ((TRNG(I,J), J=1,2), I=1,17) /
C          TLOW,   TUP          TLOW,   TUP
     1    400.0,  1500.0,       50.0,  1500.0,
     2    100.0,  1500.0,      100.0,  1500.0,
     3    100.0,  1500.0,       50.0,  1500.0,
     4    100.0,  1500.0,      100.0,  1573.2,
     5     50.0,  1500.0,      100.0,  1500.0,
     6    100.0,  1500.0,      100.0,  1500.0,
     7    100.0,  1500.0,      100.0,  1500.0,
     8    100.0,  1500.0,      100.0,  1500.0,
     9    100.0,  1500.0                      /
C
C     USE THE SAME APPROACH AS IN CONVENTIONAL LIQUIDS.
C     GET THE TEMPERATURE AT THE MIDDLE OF THE RANGE, F.
      TMID=(TLOW+TUP)/2.0
C     CONVERT THE TEMPERATURES TO KELVINS.
      TMID=5.0/9.0*(TMID-32.0)+273.15
C     CHECK TEMPERATURE RANGE; IF ATTEMPT TO EVALUATE CP IS MADE OUT OF
C     THE VALID RANGE, ERRONEOUS RESULTS MAY OCCUR. IN THIS CASE,
C     CALCULATE THE CP VALUE AT THE CLOSEST TEMPERATURE LIMIT.
      IF (TMID .LT. TRNG(ID,1)) THEN
```

```
          TMID=TRNG(ID,1)
        ELSE IF (TMID .GT. TRNG(ID,2)) THEN
          TMID=TRNG(ID,2)
C       ELSE WE ARE IN RANGE, NO ADJUSTMENTS NECESSARY.
        ENDIF
C       EVALUATE CP, J/(KG-MOL K).
        CP=CFN(ID,1)+CFN(ID,2)*DEXP(-CFN(ID,3)/(TMID**CFN(ID,4)))
C       CP CONVERSION TO DESIRED UNITS IS HANDLED BY CALLER.
        RETURN
        END
C
C$ USR2C3
C
C SUBROUTINE USR2C3, EVALUATING PETROLEUM LIQUID FRACTIONS HEAT
C CAPACITIES.
C FORMAL ARGS:
C -----------
C ID.....SUBSTANCE ID, AS DESCRIBED IN REFERENCE TABLE (18-37 FOR
C        FRACTIONS).
C TLOW...MIN TEMERATURE LIMIT, DEGREES F.
C TUP....MAX TEMERATURE LIMIT, DEGREES F.
C SG.....SPECIFIC GRAVITY OF FRACTION.
C CP.....LIQUID HEAT CAPACITY, BTU/(LBM F).
C
      SUBROUTINE USR2C3(ID,TLOW,TUP,SG,CP)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C
C     USE THE SAME APPROACH AS FOR CONVENTIONAL LIQUIDS.
C     GET MID TEMPERATURE, F
      TMID=(TLOW+TUP)/2.0
C     NO RANGE CHECKING IS PERFORMED HERE; SINCE LIQUID CP DEPENDENCE ON
C     TEMPERATURE APPROXIMATES A STRAIGHT LINE, EVALUATION OF CP IS
C     EXPECTED TO BE IN VALID RANGE, EVEN ABOVE THIS FRACTION'S
C     PSEUDOCRITICAL TEMPERATURE.
C     GET API GRAVITY.
      API=141.5/SG-131.5
C     CP EVALUATION IS BASED ON NELSON'S DIAGRAMS; THE SUBSEQUENT
C     EQUATION IS THE MATHEMATICAL INTERPRATATION OF THE TABLE, USING
C     DOUBLE LINEARIZATION, BOTH TEMPERATURE AND API GRAVITY INCLUDED.
C     THE REASONING IN CALCULATIONS, LEADS TO OMISSION OF THIS
C     FRACTION'S TBP TEMPERATURE FROM CP EVALUATION; CP IS MAINLY
C     DEPENDANT ON API GRAVITY. THIS MEANS THAT 2 FRACTIONS WITH SAME
C     API GRAVITY, WILL HAVE THE SAME CP VALUE FOR A GIVEN TEMPERATURE
C     RANGE, DESPITE ANY POSSIBLE DIFFERENCE IN THEIR TBP VALUES.
C     EVALUATE CP, BTU/(LBM F), TEMPERATURE IN DEG F.
      CP=1.49583D-6*API*TMID+5.33475D-4*TMID+1.75683D-3*API+0.34701
C     CP CONVERSION TO DESIRED UNITS IS HANDLED BY CALLER.
C
      RETURN
      END
C
C$ USR2C4
C
C SUBROUTINE USR2C4, EVALUATING PETROLEUM GAS FRACTIONS HEAT CAPACITIES.
C METHOD ADOPTED FOLLOWS THE KESSLER CORRELATIONS, AS LISTED IN ASPEN/SP
```

```
C MANUALS. KESSLER CORRELATIONS HAVE PROVEN VERY STIFF IN VARIATION
C OF SPECIFIC GRAVITY.  NOW GAS CP IS BASED ON RIAZI'S CORRELATIONS.
C FORMAL ARGS:
C -----------
C ID.....SUBSTANCE ID, AS DESCRIBED IN REFERENCE TABLE (18-37 FOR
C        FRACTIONS).
C TLOW...MIN TEMERATURE LIMIT, DEGREES F.
C TUP....MAX TEMERATURE LIMIT, DEGREES F.
C SG.....SPECIFIC GRAVITY OF FRACTION.
C CP.....GAS HEAT CAPACITY, BTU/(LB-MOL F).
C        WHEN KESSLER CORRELATIONS WERE USED THESE UNITS WERE SI.
C
      SUBROUTINE USR2C4(ID,TLOW,TUP,SG,CP)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C     VECTOR HOLDING NORMAL BOILING POINTS OF FRACTIONS, K.
      DIMENSION TBP(20)
C
C     INITIALIZE NORMAL BOILING POINTS VECTOR, KELVINS.
C     DATA TAKEN FROM ASPEN LISTING 'T2V2.INP'.
      DATA TBP /
C                        5 ELEMENTS PER TABLE LINE
     1             324.82, 352.59, 380.37, 408.15, 435.93,
     2             463.71, 491.48, 519.26, 547.04, 574.82,
     3             602.59, 630.37, 658.15, 685.93, 713.71,
     4             741.48, 769.26, 797.04, 824.82, 825.00   /
C
C     RIAZI's APPROACH CALCULATES FIRST GAS SPECIFIC GRAVITY AT TWO BASE
C     TEMPERATURES (600 & 1200 F), USING FRACTION's SPECIFIC GRAVITY AND
C     TBP TEMPERATURE.  THEN, THE CP VALUE AT DESIRED TEMPERATURE COMES
C     FROM INTERPOLATION IN THIS REGION.  NOTE THAT THE REGION 600-1200F
C     IS QUITE SUFFICIENT FOR THE SPECIFIC PROBLEM DEFINITION.
C     CONVERT TBP TEMPERATURE FROM KELVINS TO DEG R.
      TBR=TBP(ID-17)*1.8
C     GET BASE CP VALUES, BTU/(LB-MOL F).
      CP6 =4.935D-6*(TBR**2.4219)*(SG**(-1.9436))
      CP12=8.352D-6*(TBR**2.3853)*(SG**(-1.9320))
C     GET MID DESIRED TEMPERATURE, F.
      TMID=(TLOW+TUP)/2.0
C     LINEARLY INTERPOLATE TO GET DESIRED VALUE, BTU/(LB-MOL F).
      CP=CP6+(CP12-CP6)/(1200.0-600.0)*(TMID-600.0)
C     CP CONVERSION TO DESIRED UNITS IS HANDLED BY CALLER.
C
      RETURN
      END
C
C$ USR2C5
C
C SUBROUTINE USR2C5, EVALUATING SOLID CARBON HEAT CAPACITY (GRAPHITE).
C EQUATION TAKEN FROM HIMMELBLAU CP TABLES.
C TEMPERATURE RANGE CHECK IS ALSO PERFORMED.
C FORMAL ARGS:
C -----------
C TLOW...MIN TEMERATURE LIMIT, DEGREES F.
C TUP....MAX TEMERATURE LIMIT, DEGREES F.
C CP.....SOLID CARBON HEAT CAPACITY, CAL/(MOL K).
```

```
C
      SUBROUTINE USR2C5(TLOW,TUP,CP)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C     GET MID TEMPERATURE, F.
      TMID=(TLOW+TUP)/2.0
C     CONVERT TEMPERATURE TO KELVINS.
      TMID=5.0/9.0*(TMID-32.0)+273.15
C     CHECK TEMPERATURE RANGE; IF ATTEMPT TO EVALUATE CP IS MADE OUT OF
C     THE VALID RANGE, ERRONEOUS RESULTS MAY OCCUR. IN THIS CASE,
C     CALCULATE THE CP VALUE AT THE CLOSEST TEMPERATURE LIMIT.
      IF (TMID .LT. 273.15) THEN
        TMID=273.15
      ELSE IF (TMID .GT. 1373.15) THEN
        TMID=1373.15
      ENDIF
C     EVALUATE CP, CAL/(MOL K).
      CP=2.673+0.2617D-2*TMID-1.169D5/(TMID**2.0)
C     CP CONVERSION TO DESIRED UNITS IS HANDLED BY CALLER.
C
      RETURN
      END
C
C$ USR2LH
C
C SUBROUTINE USR2LH, EVALUATING LATENT HEATS OF PURE COMPOUNDS AS
C FUNCTIONS OF EQUILIBRIUM TEMPERATURE.  CLASIFICATION IS BEING DONE
C INTERNALLY, SEPARATING CONVENTIONAL SUBSTANCES FROM PETROLEUM
C PSEUDO-COMPONENTS THROUGH CALLS TO SEPARATE SUBPROGRAMS. THIS WAY THE
C JARGON IS MINIMIZED, READABILITY AND SPEED ARE ATTAINED.
C FORMAL ARGS:
C -----------
C ID.....SUBSTANCE ID, AS DESCRIBED IN REFERENCE TABLE.
C TVAP...VAPORIZATION TEMERATURE, DEGREES F.
C DHVAP..ENTHALPY OF VAPORIZATION, BTU/LB-MOL (FILLED HERE)
C
C EFFECT OF PRESSURE IS IGNORED; THIS HAS NO MEANING FOR PURE COMPOUNDS,
C BUT IF MIXTURE VAPORIZATION HAPPENS THE PRESSURE MAY CAUSE ERRONEOUS
C RESULTS.
C
      SUBROUTINE USR2LH(ID,TVAP,DHVAP)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C     ADD COMMON INCLUDING CPROP(I,J) FOR MOLECULAR WEIGHTS.
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5), OPROP(20,5)
C
C     DIRECT PROBLEM TO APPROPRIATE HANDLER; EACH ONE HANDLES
C     TEMPERATURE AND DHVAP UNITS INDIVIDUALLY, THUS NO PRELIMINARY UNIT
C     CONVERSIONS ARE BEING DONE AT THIS STAGE.
C     DISTINCTION IS AMONG CONVENTIONAL (ID<=17) & PETROLEUM FRACTIONS.
      IF (ID .LE. 17) THEN
        CALL USR2L1(ID,TVAP,DHVAP)
C       CONVERT FROM J/KG-MOL -> BTU/LB-MOL
        DHVAP=DHVAP/2326.0
      ELSE IF (ID .LE. 37) THEN
C     IN PETROLEUM EVALUATIONS, WATCH THAT ID BEGINS WITH 18 AND UP.
```

```
C       CALCULATE SPECIFIC GRAVITY OF FRACTION.
C       CPROP(I,2) CONTAINS DENSITIES IN LBS/BBL, CONVERT UNITS.
C       THIS IS MOST PROBABLY THE LIQUID DENSITY.
        SG=CPROP(ID,2)*2.85301/1000.0
        CALL USR2L2(ID,TVAP,SG,DHVAP)
C       UNITS ALREADY BTU/LB-MOL.
      ELSE
C       FOR ALL OTHER IDs, DHvap=0.
        DHVAP=0.0
      ENDIF
C     RESULT IS KEPT IN 'DHVAP' VARIABLE NOW.
C
      RETURN
      END
C
C$ USR2L1
C
C SUBROUTINE USR2L1, EVALUATING LATENT HEATS OF VAPORIZATION OF PURE
C CONVENTIONAL COMPOUNDS. EXPONENTIAL EQUATIONS TAKEN FROM AIChE/DIPPR
C DATA COMPILATION (TABLES OF PROPERTIES OF PURE COMPOUNDS).
C RANGE CHECKING PERFORMED FOR CRITICAL TEMPERATURE OVERCOME.
C FORMAL ARGS:
C -----------
C ID.....SUBSTANCE ID, AS DESCRIBED IN REFERENCE TABLE (1-17 FOR
C        CONVENTIONAL).
C TVAP...VAPORIZATION TEMERATURE, DEGREES F.
C DHVAP..ENTHALPY OF VAPORIZATION, J/KG-MOL (FILLED HERE)
C
C EFFECT OF PRESSURE IS IGNORED; THIS HAS NO MEANING FOR PURE COMPOUNDS,
C BUT IF MIXTURE VAPORIZATION HAPPENS, THE PRESSURE MAY CAUSE ERRONEOUS
C RESULTS.
C
      SUBROUTINE USR2L1(ID,TVAP,DHVAP)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C     MATRIX TO HOLD EXPONENTIAL EQUATION COEFFICIENTS. THE GENERAL
C     EQUATION FORM IS:
C                DHVAP = A * (1 - Tr)**(B + C*Tr +D*Tr**2 + E*Tr**3)
C     WHERE Tr IS THE REDUCED TEMPERATURE.
C     SOME SUBSTANCES MAY USE A REDUCED FORM OF THE ABOVE EQUATION.
      DIMENSION CFN(17,4)
C     CRITICAL TEMPERATURE FOR CONVENTIONAL COMPOUNDS, KELVINS.
C     WATCH THAT ABOVE Tc, HEAT OF VAPORIZATION IS NIL.
      DIMENSION TCR(17)
C
C     INITIALISE COEFFICIENTS VECTOR IN 'C' STYLE.
      DATA ((CFN(I,J), J=1,4), I=1,17) /
C            A            B            C            D
     1  +1.5170D+06,  +2.2221D+00,  -4.1870D+00,  +2.4110D+00,
     2  +9.4300D+06,  +1.2010D+00,  -1.4811D+00,  +7.0850D-01,
     3  +8.0400D+06,  -9.8000D-02,  +5.9900D-01,  -1.8900D-01,
     4  +2.1230D+07,  -2.3400D-01,  +7.6400D-01,  -1.9300D-01,
     5  +8.0030D+06,  +3.1800D-01,  +0.0000D+00,  +0.0000D+00,
     6  +1.8260D+07,  +2.1460D-01,  -6.5900D-01,  +7.8260D-01,
     7  +3.1523D+07,  +3.9140D-01,  -2.2890D-01,  +2.3090D-01,
     8  +5.7608D+07,  +6.9640D-01,  -7.7970D-01,  +4.7678D-01,
```

```
     9  +3.0540D+07,  +1.6900D+00,  -2.2393D+00,  +1.0086D+00,
     $  +2.5850D+07,  +3.6300D-01,  +0.0000D+00,  +0.0000D+00,
     1  +1.0325D+07,  +3.1380D-01,  -2.3180D-01,  +2.5750D-01,
     2  +2.0903D+07,  +5.7200D-01,  -5.0610D-01,  +3.1330D-01,
     3  +2.6720D+07,  +3.8550D-01,  -8.6000D-02,  +6.8600D-02,
     4  +3.1944D+07,  +3.9170D-01,  +0.0000D+00,  +0.0000D+00,
     5  +3.3430D+07,  +4.1770D-01,  -7.5000D-02,  +4.0000D-02,
     6  +3.7700D+07,  +3.9520D-01,  +0.0000D+00,  +0.0000D+00,
     7  +3.9850D+07,  +3.9790D-01,  +0.0000D+00,  +0.0000D+00 /
C
C     INITIALIZE CRITICAL TEMPERATURES VECTOR, KELVINS.
C     VALUES TAKEN FROM AIChE/DIPPR DATA COMPILATION (TABLES OF
C     PROPERTIES OF PURE COMOUNDS).
      DATA TCR /
C                        5 ELEMENTS PER TABLE LINE
     1            33.25, 126.10, 154.58, 373.53, 132.92,
     2           304.19, 405.65, 647.29, 324.65, 378.80,
     3           190.58, 305.42, 369.82, 408.14, 425.18,
     4           460.43, 469.65                         /
C
C     CONVERT INPUT TEMPERATURE TO KELVINS.
      TCNV=5.0/9.0*(TVAP-32.0)+273.15
C     GET REDUCED TEMPERATURE, DIMENSIONLESS.
      TR=TCNV/TCR(ID)
C     CHECK TR; IF THE CRITICAL TEMPERATURE EXCEEDED (TR>1.), THEN THE
C     HEAT OF VAPORIZATION IS ZERO.
      IF (TR .LT. 1.0) THEN
C       CALCULATE LATENT HEAT, J/KG-MOL.
        DHVAP=CFN(ID,1)*(1.0-TR)**(CFN(ID,2)+CFN(ID,3)*TR+
     1        CFN(ID,4)*TR**2.0)
      ELSE
C       ABOVE CRITICAL TEMPERATURE, NO DISTINCTION BETWEEN GAS AND
C       LIQUID PHASES EXIST, THUS, DHVAP = 0.
        DHVAP=0.0
      ENDIF
C     CONVERSION TO DESIRED UNITS IS HANDLED BY CALLER.
      RETURN
      END
C
C$ USR2L2
C
C SUBROUTINE USR2L2, EVALUATING LATENT HEATS OF VAPORIZATION OF
C PETROLEUM PSEUDO-COMPONENTS. ASPEN/SP MANUALS OFFER TWO PATHS FOR SUCH
C AN EVALUATION:
C  A. USING GRAY's REGION MODEL; HERE DHVAP IS A SIMPLE FUNCTION OF THE
C     FRACTION'S BOILING POINT ONLY, WHICH IS THE TEMPERATURE THAT
C     CHARACTERISES THE FRACTION ITSELF.
C  B. USING RIAZI's PARAMETRIC MODEL FOR OIL PROPERTIES ESTIMATION; HERE
C     DHVAP FOLLOWS A POWER LAW CORRELATION, BASED ON BOILING POINT AND
C     SPECIFIC GRAVITY. THIS APPROACH IS USED IN THIS SUBROUTINE.
C NOTE THAT THE EFFECT OF PRESSURE IS NOT TAKEN INTO ACCOUNT IN BOTH
C METHODS, A FACT THAT MAY LEAD TO POOR VAPORIZATION HEATS ESTIMATES.
C FORMAL ARGS:
C -----------
C ID.....SUBSTANCE ID, AS DESCRIBED IN REFERENCE TABLE (18-37 FOR
```

```
C        FRACTALS).
C TVAP...VAPORIZATION TEMERATURE, DEGREES F.
C        NOTE: TVAP IS NOT THE SAME AS THE ONE CHARACTERIZING THE
C              FRACTION. SINCE THE APPLIED METHOD USES THE NORMAL
C              BOILING POINT, THIS VARIABLE IS OF NO USE FOR THE MOMENT,
C              UNLESS A WAY OF INTRODUCING PRESSURE EFFECT ON DHVAP IS
C              DEVISED.
C SG.....SPECIFIC GRAVITY OF FRACTION (LIQUID PHASE???).
C DHVAP..ENTHALPY OF VAPORIZATION, BTU/LB-MOL (FILLED HERE)
C
      SUBROUTINE USR2L2(ID,TVAP,SG,DHVAP)
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C     VECTOR HOLDING NORMAL BOILING POINTS OF FRACTIONS, K.
      DIMENSION TBP(20)
C
C     INITIALIZE NORMAL BOILING POINTS VECTOR, KELVINS.
      DATA TBP /
C                        5 ELEMENTS PER TABLE LINE
     1             324.82, 352.59, 380.37, 408.15, 435.93,
     2             463.71, 491.48, 519.26, 547.04, 574.82,
     3             602.59, 630.37, 658.15, 685.93, 713.71,
     4             741.48, 769.26, 797.04, 824.82, 825.00   /
C     REMEMBER THAT THE PSEUDOCOMPONENT IDS START AT 18 HERE.
C     CONVERT TBP AND TVAP TEMPERATURES TO DEGREES R.
      TCNV=TBP(ID-17)*1.8
      TVAR=TVAP+459.67
C     SPECIFIC GRAVITY IS PASSED AS AN ARGUMENT, DIMENSIONLESS.
C     AGAIN, CRITICAL TEMPERATURE MUST BE VERIFIED TO BE WELL ABOVE
C     TVAP, THE TEMPERATURE IN INTEREST HERE.
C     CALCULATE CRITICAL TEMPERATURE IN R, USING ANOTHER RIAZI's POWER
C     LAW.
      TC=24.2787*(TCNV**0.58848)*(SG**0.3596)
C     CHECK TC; IF CRITICAL TEMPERATURE EXCEEDED (TVAP>TC) THEN
C     ASSIGN NIL TO HEAT OF VAPORIZATION.
      IF (TVAR .LT. TC) THEN
C       CALCULATE LATENT HEAT AT NORMAL BOILING POINT, BTU/LB-MOL.
        DHVAP=8.48585*(TCNV**1.1347)*(SG**0.0214)
C       INTRODUCE TEMPERATURE EFFECT ON DHVAP.
C       GET REDUCED TEMPERATURE AND A REDUCED-TYPE ONE.
        TR=TVAR/TC
        TRNB=TCNV/TC
C       GET 'gamma' CORRECTION FACTOR DESCRIBED BY NELSON.
C       SUBSEQUENT EQUATION IS INTERPRATATION OF DIAGRAMM WITH DOUBLE
C       LINEARIZATION RELATIVE TO REDUCED TEMPERATURES DESCRIBED ABOVE.
        GF=-4.255*TR*TRNB+0.386*TR+5.312*TRNB-0.9092
C       GET CORRECTED DHVAP, BTU/LB-MOL.
        DHVAP=GF*DHVAP*TVAR/TCNV
      ELSE
C       ABOVE CRITICAL TEMPERATURE, NO DISTINCTION BETWEEN GAS AND
C       AND PHASES EXIST, THUS DHVAP = 0.
        DHVAP=0.0
      ENDIF
C     CONVERSION TO DESIRED UNITS IS HANDLED BY CALLER.
      RETURN
      END
```