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 I Appendices (A and B)

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 I

A. ASPEN/SP PROCESS SIMULATION MODEL INPUT FILE FOR THE BASELINE DESIGN . . . . . A-1

B. ASPEN/SP DIRECT COAL LIQUEFACTION PROCESS SIMULATION MODEL FORTRAN USER BLOCK MODELS . . . . . B-1

# APPENDIX A

# APPENDIX A

# ASPEN/SP PROCESS SIMULATION MODEL

# INPUT FILE FOR THE BASELINE DESIGN

## ASPEN/SP PROCESS SIMULATION MODEL

## INPUT FILE FOR THE BASELINE DESIGN

```
NEW
;
;   File: DCLN.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 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 = 0
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 = 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 USRO2.
BLOCK PO2 USER
   SUBROUTINE MODEL = USRO2   REPORT = USRO2
   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 DCLO2.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 DCLO2.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-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   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  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.            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 DCLN.INP
```

# APPENDIX B

# APPENDIX B

# ASPEN/SP DIRECT COAL LIQUEFACTION PROCESS SIMULATION MODEL FORTRAN USER BLOCK MODELS

## ASPEN/SP DIRECT COAL LIQUEFACTION PROCESS

## SIMULATION MODEL FORTRAN USER BLOCK MODELS

**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:  PLANTS.FOR
C
C     Last revised - December 11, 1992.
C
C     This file contains subroutines for the following plants:
C       Plant 1       USR01 and the required USR01? subroutines.
C       Plant 2       USR02 and the required USR02? subroutines.
C       Plant 3       USR03 and the required USR03? subroutines.
C       Plant 4       USR04 and the required USR04? subroutines.
C       Plant 5       USR05 and the required USR05? subroutines.
C       Plant 6.1     USR61 and the required USR61? subroutines.
C       Plant 6.2     USR62 and the required USR62? subroutines.
C       Plant 8.1     USR81 and the required USR81? subroutines.
C       Plant 8.2     USR82 and the required USR82? subroutines.
C       Plant 9.0     USR09 and the required USR09? subroutines.
C       Plant 9.1     USR91 and the required USR91? subroutines.
C       Plant 10      USR10 and the required USR10? subroutines.
C       Plant 11      USR11 and the required USR11? subroutines.
C       Plant 31      USR31 and the required USR31? subroutines.
C       Plant 38      USR38 and the required USR38? subroutines.
C       Plant 39      USR39 and the required USR39? subroutines.
C       Alternate 6   USRA6 and the required USRA6? subroutines.
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C$  Subroutine USR01
C
C     This file contains the following subroutine:
C       USR01    Main routine for Plants 1 and 1.4 - The coal cleaning
C                and preparation (drying and grinding) plants.
C
C     The above subroutine requires the following non-standard ASPEN/SP
C     subroutines which are not included in this file.
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       GETSTR   Subroutine for finding the stream bead information.
C
C
C$ USR01
      SUBROUTINE USR01 (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:  USR01
C
C  BLOCK DESCRIPTION:  DOE Coal Cleaning/Preparation Plant Fortran
C                      Block Model
C
C                     ----------------------
C                     |                    |-----> Clean Coal Product
C                     |      Plant 1       |
C                     |                    |-----> Middling Coal
C      Feed Coal ---->|   Coal Cleaning /  |
C                     |    Preparation     |-----> Refuse
C                     |       Plant        |
C                     |                    |-----> Waste Water
C                     ----------------------
C
C     This model can be used to simulate the following situations.
C     Input parameter INTEGER(5) distinguishes these oprions.
C     1.  Coal cleaning, drying and grinding (Plants 1 and 1.4 in
C         combination) with the product coal going to liquefaction.
C         In this case, the input parameter values are determined so
C         that they represent both plants in combination.  The baseline
C         design case has two plant 1.4 trains for each plant 1 train.
C         Therefore, each train of this combination represents one
C         train of plant 1 and two trains of plant 1.4.
C     2.  Coal cleaning (Plant 1 only) with the product coal going to
C         gasification.  In this case, the input parameter values are
C         determined so that they represent only plant 1.
C     3.  Coal grinding and drying only.
C
C  Prepared under DOE contract no. DE-AC22 90PC89857.
C
C  FUNCTION (MODEL, REPORT, OR BOTH):  Both
C
C  Last revision - June 2, 1992.
C
C  ASSUMPTIONS, SPECIAL FEATURES AND LIMITATIONS:
C     1.  The single inlet stream is:   Feed coal stream
C     2.  The four outlet streams are:  Clean coal product stream
C                                       Middling coal stream
C                                       Refuse stream
C                                       Waste water stream
C     3.  This user block model will work with any number of
C         conventional components and non-conventional components.
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.  Each non-conventional component must have the following
C         component attributes specified in the ATTR-COMPS statement
C         PROXANAL, ULTANAL, SULFANAL AND AOXANAL.  This subroutine
C         assumes that they are in the above order.  Therefore, the
C         ATTR-COMPS statement in the input file must be:
C           ATTR-COMPS COAL PROXANAL ULTANAL SULFANAL AOXANAL
C     6.  The coal to be cleaned must be the first non-conventional
C         component.
```

```
C     7.  KH2O is the relative conventional component number of water.
C     8.  All components other than water and coal that enter the coal
C         cleaning plant stream leave in the refuse stream.
C     9.  Important Variables:
C         COAL(J)   = Lbs of item J in the inlet coal.
C         CLEAN(J)  = Lbs of item J in the clean coal product stream.
C         XMID(J)   = Lbs of item J in the middling coal stream.
C         REFUSE(J) = Lbs of item J in the refuse stream.
C           For the above 4 vectors, subscript J designates
C             J = 1  =>  Carbon
C               = 2  =>  Hydrogen
C               = 3  =>  Nitrogen
C               = 4  =>  Chlorine
C               = 5  =>  Sulfur
C               = 6  =>  Oxygen
C               = 7  =>  Ash (mineral matter)
C               = 8  =>  Water
C               = 9  =>  Total weight, dry basis
C               = 10 =>  Total weight including water (i.e., wet basis)
C         UCOAL(J) = Ultimate analysis of the inlet coal, wt%.
C         UCLN(J)  = Ultimate analysis of the clean coal product, wt%.
C         UMID(J)  = Ultimate analysis of the middling coal, wt%.
C         UREF(J)  = Ultimate analysis of the refuse, wt%.
C           For the above 4 vectors, subscript J designates
C             J = 1  =>  Carbon
C               = 2  =>  Hydrogen
C               = 3  =>  Nitrogen
C               = 4  =>  Chlorine
C               = 5  =>  Sulfur
C               = 6  =>  Oxygen
C               = 7  =>  Ash (mineral matter)
C               = 8  =>  Total weight
C         FCLN(J) = Fraction of component J in the inlet coal stream
C                   leaving in the clean coal product stream.
C         FMID(J) = Fraction of component J in the inlet coal stream
C                   leaving in the middling coal stream.
C         PCWP = Moisture content of the clean product coal on a dry
C                basis, wt%.
C         PCWM = Moisture content of the middling coal on a dry
C                basis, wt%.
C         PCWR = Moisture content of the refuse on a dry basis, wt%.
C    10.  The 5 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 DCL01B.REP, DCL01A1.REP
C                       or DCL01A2.REP depending on the value of the
C                       coal cleaning option control switch, INT(5).
C         INT(3)  = Number of operating duplicate trains, excluding
C                   spares.
C                   If INT(3) = 0, the minimun number of duplicate
C                     plants will be determined so that the capacity
C                     each train does not exceed the maximum train
C                     capacity specified by variable REAL(52).
C                   If INT(3) > 0, this number of duplicate trains will
C                     be used.
C         INT(4)  = History file additional output control switch.
C                   0 => Write no additional output to the history 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                 3-4 => Write some more additional output to the
C                        history file.  Larger values generate more
C                        intermediate output.
C         INT(5)  = Coal cleaning, drying and grinding option control
C                   switch.  The name of the short plant report file
C                   written for each option is option dependent.
C                   0 => Base case - Coal cleaning by jigs for coal
C                        liquefaction in plant 2. (Report = DCL01B.REP)
C                   1 => Alternate case 1 - Coal cleaning by heavy media
C                        separation.  (Report = DCL01A1.REP)
C                   2 => Alternate case 2 - Coal cleaning by heavy media
C                        separation and spherical agglomeration.
C                        (Report = DCL01A2.REP)
C                   3 => Coal cleaning by jigs for coal gasification in
C                        plant 9.  (Report = DCL01G.REP)
C                   4 => Coal grinding and drying plant only, Plant 1.4.
C                        (Report = DCL01D.REP)
C                 NOTE: Values 0, 1 and 2 are used when this model
C                       cleans the coal going to the coal liquefaction
C                       plant; 3 is used only when this model cleans
C                       the coal going to the coal gasification plant;
C                       and 4 is for a coal grinding/drying plant only.
C    11.  The 70 real parameters are:
C         REAL(1)   = Fraction of carbon in the inlet coal leaving
C                     in the clean coal product stream.
C         REAL(2)   = Fraction of carbon in the inlet coal leaving
C                     in the middling coal stream.
C         REAL(3)   = Fraction of hydrogen in the inlet coal leaving
C                     in the clean coal product stream.
C         REAL(4)   = Fraction of hydrogen in the inlet coal leaving
C                     in the middling coal stream.
C         REAL(5)   = Fraction of nitrogen in the inlet coal leaving
C                     in the clean coal product stream.
C         REAL(6)   = Fraction of nitrogen in the inlet coal leaving
C                     in the middling coal stream.
C         REAL(7)   = Fraction of chlorine in the inlet coal leaving
C                     in the clean coal product stream.
```

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

```
C          REAL(37)  = Constant factor for the cooling water consumption,
C                      Mgal/hr.
C          REAL(38)  = Cooling water consumption per Mlbs/hr of dry clean
C                      coal, (Mgal/hr)/(Mlbs/hr).
C          REAL(39)  = Constant factor for the process water consumption,
C                      Mgal/hr.
C          REAL(40)  = Process water consumption per Mlbs/hr of dry clean
C                      coal, (Mgal/hr)/(Mlbs/hr).
C          REAL(41)  = Constant factor for the nitrogen consumption,
C                      MM SCF/hr of N2.
C          REAL(42)  = Nitrogen consumption per Mlbs/hr of dry clean
C                      coal, (MM SCF/hr of N2)/(Mlbs/hr).
C          REAL(43) -
C           REAL(48) = Future use.
C          REAL(49)  = Constant factor for the number of operators per
C                      day, operators/day.
C          REAL(50)  = Number of operators per day per train,
C                      (operators/day)/train.
C          REAL(51)  = Reference flow rate of the dry clean coal of a
C                      single train in  Mlbs/hr for the calculation of
C                      the ISBL field cost of a single train as a
C                      function of train capacity.
C          REAL(52)  = Maximum size of a single train as defined by the
C                      flow rate of the dry clean coal in Mlbs/hr.
C          REAL(53)  = Minimum size of a single train as defined by the
C                      flow rate of the dry clean coal in Mlbs/hr.
C          REAL(54)  = Constant A in the plant ISBL field cost equation.
C          REAL(55)  = Constant B in the plant ISBL field cost equation.
C          REAL(56)  = Constant E in the plant ISBL field cost equation.
C          REAL(57)  = Constant F in the plant ISBL field cost equation.
C          REAL(58)  = Number of spare trains.
C          REAL(59) -
C           REAL(70) = Future use.
C
C       NOTES:
C         1.  If both the sulfur distribution factors, REAL(9) and
C             REAL(10), are zero and a SULFANAL has been supplied, the
C             sulfur will be distributed among the products as follows.
C             a. The ORGANIC sulfur will be distributed in the same
C                proportions as the carbon is distributed.
C             b. The PYRITIC and SULFATE sulfur will be distributed in
C                the same proportions as the ash is distributed.
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
      COMMON /USRC01/ PLNTID(32), UTIL(32,15), CAPCST(32,7), OPCST(32,5)
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
C     Local variable declaration statements.
      DIMENSION COAL(10), CLEAN(10), XMID(10), REFUSE(10)
      DIMENSION UCOAL(8), UCLN(8), UMID(8), UREF(8), FCLN(7), FMID(7)
      DIMENSION UROM(8)
C
      DIMENSION PSA(5,10)
C     PSA(J,K) is the Plant Stream Array, where
C       J = Stream number identifier
C           1 => The inlet coal stream
C           2 => The clean coal product stream
C           3 => The middling coal stream
C           4 => The refuse stream
C           5 => The waste water stream
C       K = Stream property identifier
C           1 => Future use
C           2 => Coal flow rate (dry basis), Mlbs/hr
C           3 => Stream temperature, degrees Fahrenheit
C           4 => Stream pressure, PSIA
C           5 => Water flow rate, Mlbs/hr
C           6 => Total flow rate, Mlbs/hr
C           7 - 10 => Future use
C
      DIMENSION FILEID(5), ICN(2), ICNAME(4), ICNUMB(2), PN(5)
C
      CHARACTER * 4  ICN, ICNAME
      CHARACTER * 6  PLNTID, PN, PNAME
      CHARACTER * 12 FILEID
C
C     Initialize the output file identifications for the plant
C     summary report if it is written to a separate output file.
      DATA FILEID / 'DCL01B.REP  ', 'DCL01A1.REP ', 'DCL01A2.REP ',
     1   'DCL01G.REP  ', 'DCL01D.REP  ' /
C
C     Initialize the component identification of water, H2O.
C     Use a second component, the same as water, in case one may be
C     required at a later date.
      DATA ICNAME / 'H2O ', '    ', 'H2O ', '    ' /
C
C     Initialize the plant identification vector.
      DATA PN  / '1. -00', '1. -01', '1. -02', '1. -09', '1.4   ' /
C
C
```

```
C     PARAMETER INITIALIZATION SECTION
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)
C
C     If requested, write the subroutine heading to the history file.
C     stream vector to the history file.
      IF ( KTEST .GE. 1 )  THEN
        WRITE (NHSTRY, 701)  IPASS
  701   FORMAT ( // 1X, 'Plant 1 - Supplementary data from subroutine',
     1    ' USR01' /
     2    2X, 'Coal Cleaning and Preparation Plant', 10X,
     3    'IPASS =', I3 )
      END IF
C
C     Load and check the coal cleaning option switch.
      KOPT = INT(5)
      IF ( KOPT .LT. 0 .OR. KOPT .GE. 5 )  THEN
        IF ( KTEST .LE. 0 )  WRITE (NHSTRY, 701)  IPASS
        WRITE (NHSTRY, 702)  KOPT
  702     FORMAT ( / 1X, '* WARNING * - An invalid value of the coal',
     1  ' cleaning option switch,' /
     2  3X, 'INT(5), of', I4, ' has been supplied.  It is being set',
     3  ' to 0 (zero) for ' /
     4  3X, 'coal cleaning by jigs for liquefaction.',
     5  '  Execution is continuing.' / )
        KOPT = 0
      ENDIF
      PNAME = PN(KOPT + 1)
C
      IF ( KTEST .GE. 1 )  THEN
        IF ( KOPT .EQ. 0 )  WRITE (NHSTRY, 703)
  703   FORMAT ( 2X, 'Base case - Coal cleaning by jigs for',
     1    ' liquefaction.')
        IF ( KOPT .EQ. 1 )  WRITE (NHSTRY, 704)
  704   FORMAT ( 2X, 'Alternate case 1 - Coal cleaning by heavy media',
     1    ' separation.' )
        IF ( KOPT .EQ. 2 )  WRITE (NHSTRY, 705)
  705   FORMAT ( 2X, 'Alternate case 2 - Coal cleaning by heavy media',
     1    ' separation and spherical agglomeration.' )
        IF ( KOPT .EQ. 3 )  WRITE (NHSTRY, 741)
  741   FORMAT ( 2X, 'Coal cleaning by jigs for gasification.' )
        IF ( KOPT .EQ. 4 )  WRITE (NHSTRY, 742)
  742   FORMAT ( 2X, 'Coal grinding and drying only.' )
      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 )  THEN
          WRITE (NHSTRY, 701)  IPASS
          IF ( KOPT .EQ. 0 )  WRITE (NHSTRY, 703)
          IF ( KOPT .EQ. 1 )  WRITE (NHSTRY, 704)
```

```
          IF ( KOPT .EQ. 2 )  WRITE (NHSTRY, 705)
          IF ( KOPT .EQ. 3 )  WRITE (NHSTRY, 741)
          IF ( KOPT .EQ. 4 )  WRITE (NHSTRY, 742)
        ENDIF
        WRITE (NHSTRY, 706)  NSIN
  706   FORMAT ( / 1X, '* ERROR * - The coal cleaning plant ',
     1    'requires exactly 1 inlet streams.' /
     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 are exactly 4 outlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSOUT .NE. 4 ) THEN
        IF ( KTEST .LE. 0 )  THEN
          WRITE (NHSTRY, 701)  IPASS
          IF ( KOPT .EQ. 0 )  WRITE (NHSTRY, 703)
          IF ( KOPT .EQ. 1 )  WRITE (NHSTRY, 704)
          IF ( KOPT .EQ. 2 )  WRITE (NHSTRY, 705)
          IF ( KOPT .EQ. 3 )  WRITE (NHSTRY, 741)
          IF ( KOPT .EQ. 4 )  WRITE (NHSTRY, 742)
        ENDIF
        IF ( NSOUT .EQ. 0 )   WRITE (NHSTRY, 707)
  707   FORMAT ( / 1X, '* ERROR * - The coal cleaning plant ',
     1    'requires exactly 4 outlet streams.' //
     2    3X, 'It currently does not have this number of outlet ',
     3    'streams.' //
     4    3X, 'Please correct this problem and try again.' //
     5    3X, 'EXECUTION IS BEING TERMINATED.' / )
        IF ( NSOUT .NE. 0 )   WRITE (NHSTRY, 708)  NSOUT
  708   FORMAT ( / 1X, '* ERROR * - The coal cleaning plant ',
     1    'requires exactly 4 outlet streams.' /
     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 )  THEN
          WRITE (NHSTRY, 701)  IPASS
          IF ( KOPT .EQ. 0 )  WRITE (NHSTRY, 703)
          IF ( KOPT .EQ. 1 )  WRITE (NHSTRY, 704)
          IF ( KOPT .EQ. 2 )  WRITE (NHSTRY, 705)
          IF ( KOPT .EQ. 3 )  WRITE (NHSTRY, 741)
          IF ( KOPT .EQ. 4 )  WRITE (NHSTRY, 742)
        ENDIF
        WRITE (NHSTRY, 709)
  709   FORMAT ( / 1X, '* ERROR * - The input streams to Plant 1, ',
     1    'the coal cleaning and preparation plant,' /
```

```
     2    3X, 'are not of stream class MIXNC or MIXNCPSD.  This ',
     3    'model will not work.' /
     4    3X, 'Please 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 + 9 + NNCC + 1
      FLOWIN = CF * ( SIN1(NCC+1)*SIN1(NCC+9) + SIN1(J) )
C
      IF ( FLOWIN .LE. 0.09D0 )   THEN
C       Skip all remaing calculations if this plant has no flow.
        IF ( KTEST .GE. 1 )  WRITE (NHSTRY, 710)  KOPT
  710   FORMAT ( / ' There is no material entering plant 1, the ',
     1    'coal cleaning and' /
     2    ' preparation plant when the cleaning option is', I2, '.' )
        GO TO 999
C       ---------
      ENDIF
C
C     Find the relative component number of H2O and load it in the
```

```
C     variable KH2O.
      DO 10 J = 1, 2
        K = 2 * J - 1
        ICN(1) = ICNAME(K)
        ICN(2) = ICNAME(K+1)
        CALL USRCCN (ICN, ICNUMB(J))
        IF ( ICNUMB(J) .EQ. 0 ) THEN
          IF ( KTEST .LE. 0 )  THEN
            WRITE (NHSTRY, 701)  IPASS
            IF ( KOPT .EQ. 0 )  WRITE (NHSTRY, 703)
            IF ( KOPT .EQ. 1 )  WRITE (NHSTRY, 704)
            IF ( KOPT .EQ. 2 )  WRITE (NHSTRY, 705)
            IF ( KOPT .EQ. 3 )  WRITE (NHSTRY, 741)
            IF ( KOPT .EQ. 4 )  WRITE (NHSTRY, 742)
          ENDIF
          WRITE (NHSTRY, 711)  ICN(1), ICN(2)
  711     FORMAT ( / 1X, '* ERROR * - The following component is ',
     1      'missing from your component list' / 5X, 2A4 /
     2      3X, 'The coal cleaning plant requires this component.  ',
     3      'Please add it to' /
     4      3X, 'your component list and try again.' //
     5      3X, 'EXECUTION IS BEING TERMINATED.' / )
          STOP
        ENDIF
   10 CONTINUE
      KH2O  = ICNUMB(1)
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
      DO 12 J = 1, 7
C       Component distribution factors for the clean coal product.
        FCLN(J) = REAL(2*J - 1)
C       Component distribution factors for the middling coal.
        FMID(J) = REAL(2*J)
   12 CONTINUE
C     Moisture contents of the clean coal product, middling coal and
C     refuse in wt%.
      PCWP = REAL(15)
      PCWM = REAL(16)
      PCWR = REAL(17)
C     Set up the maximum and minimum plant flow rates in Mlbs/hr of
C     dry clean coal.
      PMAXF = REAL(52)
      PMINF = REAL(53)
C
C     If requested, write the items of interest in the inlet coal
C     stream vector to the history file.
      IF ( KTEST .GE. 4 )  THEN
```

```
        WRITE (NHSTRY, 712)
  712   FORMAT ( / '  Inlet coal stream vector' )
        DO 1001 J = 1, ITEMS
          WRITE (NHSTRY, 713) J, SIN1(J)
  713     FORMAT ( 1X, I6, 3X,  1PE15.5 )
 1001   CONTINUE
      END IF
C
C     Load and normalize the Ultimate analysis of the inlet coal.
      UROM(1) = SIN1(NCCONV+6)
      UROM(2) = SIN1(NCCONV+7)
      UROM(3) = SIN1(NCCONV+8)
      UROM(4) = SIN1(NCCONV+9)
      UROM(5) = SIN1(NCCONV+10)
      UROM(6) = SIN1(NCCONV+11)
      UROM(7) = SIN1(NCCONV+5)
      SUM = 0.0D0
      DO 20 J = 1, 7
        SUM = SUM + UROM(J)
   20 CONTINUE
      DO 22 J = 1, 7
        UROM(J) = UROM(J) * 100.0D0 / SUM
   22 CONTINUE
C
C     Set up the main components in the inlet coal stream in lbs/hr.
C     CF is the conversion factor from Kg/sec to Lbs/hr.
C     Composition of the inlet coal.
      DO 24 J = 1, 7
        COAL(J) = 0.01D0 * UROM(J) * SIN1(NCONV+1) * CF
   24 CONTINUE
C     Water.
      COAL(8) = SIN1(KH2O) * XMW(KH2O) * CF
C     Other conventional and non-conventional components.
      OTHERS = 0.0D0
      IF ( NCC .GE. 2 )   THEN
        DO 26 J = 1, NCC
          IF (J .NE. KH2O)  OTHERS = OTHERS + SIN1(J) * XMW(J) * CF
   26   CONTINUE
      ENDIF
      IF ( NNCC .EQ. 2 )   OTHERS = OTHERS + SIN1(NCONV+2) * CF
      IF ( NNCC .GE. 3 )   THEN
        DO 28 J = 2, NNCC
          OTHERS = OTHERS + SIN1(NCONV+J) * CF
   28   CONTINUE
      ENDIF
C
C     Write a warning message to the history file if any components
C     other than water or coal are in the inlet stream.
      IF ( OTHERS .GE. 0.1D0 )  THEN
        IF ( KTEST .LE. 0 )  THEN
          WRITE (NHSTRY, 701)  IPASS
          IF ( KOPT .EQ. 0 )  WRITE (NHSTRY, 703)
          IF ( KOPT .EQ. 1 )  WRITE (NHSTRY, 704)
          IF ( KOPT .EQ. 2 )  WRITE (NHSTRY, 705)
          IF ( KOPT .EQ. 3 )  WRITE (NHSTRY, 741)
```

```
          IF ( KOPT .EQ. 4 )  WRITE (NHSTRY, 742)
        ENDIF
        WRITE (NHSTRY, 714)  OTHERS
  714   FORMAT ( / 1X, '* WARNING * - The input stream to Plant 1, ',
     1    'the coal cleaning and preparation,' /
     2    3X, 'plant, contains components other than water and coal.',
     3    '  It contains ', F9.1 /
     4    3X, 'lbs/hr of other components.  These components all ',
     5    'will be placed in the' /
     5    3X, 'refuse stream.' / )
      ENDIF
C
C     If requested, write the user supplied component distribution
C     factors.
      IF ( KTEST .GE. 2 )  WRITE (NHSTRY, 715)  (REAL(J), J = 1, 17)
  715 FORMAT ( / ' Initial Component Distribution Factors;' /
     1  3X, 'Carbon    ', 2F10.3 /
     2  3X, 'Hydrogen  ', 2F10.3 /
     3  3X, 'Nitrogen  ', 2F10.3 /
     4  3X, 'Chlorine  ', 2F10.3 /
     5  3X, 'Sulfur    ', 2F10.3 /
     6  3X, 'Oxygen    ', 2F10.3 /
     7  3X, 'Ash       ', 2F10.3 /
     8  1X, 'Pct water in clean, middling & ash', 3F10.1 / )
C
C
C     CALCULATIONS PASS SECTION
C     -------------------------
C     Calculation Method:
C     1.  On a dry basis, the coal crushing. grinding and cleaning
C         plant is simulated by distributing the carbon, hydrogen,
C         nitrogen, chlorine, sulfur, oxygen and ash into the clean
C         coal product, middling coal and refuse streams (using the
C         supplied component distribution factors).  The sum of the
C         two distribution factors for any component must be 1.0 or
C         less.  The remaining material not put in either of the two
C         coal streams is placed in the refuse stream.
C     2.  After the flow rates of all components in all streams on a
C         dry basis, the inlet water is distributed among the three
C         product streams based on the specified moisture contents of
C         the three outlet streams.
C
C
C     Check the component distribution factors for each component to
C     insure that their sum is 1.0 or less.  If it is greater than
C     1.0, normalize the two distribution factors to 1.0.  Set the
C     variable IER to the number of components for which the
C     distribution factors had to be normalized.
      IER = 0
      DO 110 J = 1, 7
        IF ( (FCLN(J) + FMID(J)) .GT. 1.0D0 )   THEN
          IER = IER + 1
          FCLN(J) = FCLN(J) / (FCLN(J) + FMID(J))
          FMID(J) = 1.0 - FCLN(J)
        END IF
```

```
  110 CONTINUE
C
C     If the component distribution factors had to be adjusted, write
C     a warning message to the history file.
      IF ( IER .GE. 1 )   THEN
        IF ( KTEST .LE. 0 )  THEN
          WRITE (NHSTRY, 701)  IPASS
          IF ( KOPT .EQ. 0 )  WRITE (NHSTRY, 703)
          IF ( KOPT .EQ. 1 )  WRITE (NHSTRY, 704)
          IF ( KOPT .EQ. 2 )  WRITE (NHSTRY, 705)
          IF ( KOPT .EQ. 3 )  WRITE (NHSTRY, 741)
          IF ( KOPT .EQ. 4 )  WRITE (NHSTRY, 742)
        ENDIF
        WRITE (NHSTRY, 716)
  716   FORMAT ( / ' * * * * * W A R N I N G * * * * *' /
     1    2X, 'The supplied coal component distribution factors are',
     2    ' in error.' /
     3    2X, 'They have been adjusted as follows.' )
        WRITE (NHSTRY, 717)  ( REAL(2*K-1), REAL(2*K), FCLN(K),
     1    FMID(K), K = 1, 7 ), IER
  717   FORMAT ( / 19X, 'Supplied Values', 7X, 'Adjusted Values' /
     1    3X, 'Component ', 6X, 'Clean', 3X, 'Middling', 6X, 'Clean',
     2    3X, 'Middling' /          3X, 'Carbon    ', 4F11.3 /
     3    3X, 'Hydrogen  ', 4F11.3 / 3X, 'Nitrogen  ', 4F11.3 /
     4    3X, 'Chlorine  ', 4F11.3 / 3X, 'Sulfur    ', 4F11.3 /
     5    3X, 'Oxygen    ', 4F11.3 / 3X, 'Ash       ', 4F11.3 /
     6    2X, 'The above distribution factors were adjusted for', I3,
     7    ' components.' / )
      END IF
C
C     On a dry basis, calculate the lbs of carbon, hydrogen, nitrogen,
C     chlorine, sulfur, oxygen and ash leaving in the clean coal
C     product, middling coal and refuse streams.
      DO 120 J = 1, 7
        CLEAN(J)  = FCLN(J) * COAL(J)
        XMID(J)   = FMID(J) * COAL(J)
        REFUSE(J) = COAL(J) - CLEAN(J) - XMID(J)
  120 CONTINUE
C
      TSULF = SIN1(NCCONV+12) + SIN1(NCCONV+13) + SIN1(NCCONV+14)
      IF ( (FCLN(5)+FMID(5)).LE.1.0D-8 .AND. TSULF.GE.0.001D0 )   THEN
C       If the sulfur distribution factors were not supplied (i.e,;
C       were set to zero) and a SULFANAL was supplied, distribute the
C       sulfur among the products by the following method.
C         1.  Distribute the ORGANIC sulfur in the same proportions
C             as the carbon is distributed.
C         2.  Distribute the PYRITIC and SULFATE sulfur in the same
C             proportions as the ash is distributed.
        CLEAN(5) = COAL(5) *
     1    ( (SIN1(NCCONV+14)/TSULF) * (CLEAN(1)/COAL(1)) +
     2    (1.0D0 - SIN1(NCCONV+14)/TSULF) * (CLEAN(7)/COAL(7)) )
        XMID(5) = COAL(5) *
     1    ( (SIN1(NCCONV+14)/TSULF) * (XMID(1)/COAL(1)) +
     2    (1.0D0 - SIN1(NCCONV+14)/TSULF) * (XMID(7)/COAL(7)) )
        REFUSE(5) = COAL(5) - CLEAN(5) - XMID(5)
```

```
      ENDIF
C
C     Calculate the total lbs of the inlet coal, clean coal
C     product, middling coal and refuse on a dry basis.
      COAL(9)   = 0.0D0
      CLEAN(9)  = 0.0D0
      XMID(9)   = 0.0D0
      REFUSE(9) = 0.0D0
      DO 130 J = 1, 7
        COAL(9)   = COAL(9)  + COAL(J)
        CLEAN(9)  = CLEAN(9) + CLEAN(J)
        XMID(9)   = XMID(9)  + XMID(J)
        REFUSE(9) = REFUSE(9)+ REFUSE(J)
  130 CONTINUE
C
C     Calculate the Ultimate analysis (dry basis) of the inlet
C     coal, clean coal product, middling coal and refuse.
      UCOAL(8) = 0.0D0
      UCLN(8) = 0.0D0
      UMID(8) = 0.0D0
      UREF(8) = 0.0D0
      DO 150 J = 1, 7
C       Inlet coal.
        IF ( COAL(9) .GE. 0.001D0 )   THEN
            UCOAL(J) = 100.0 * COAL(J) / COAL(9)
          ELSE
            UCOAL(J) = 0.0
        END IF
        UCOAL(8) = UCOAL(8) + UCOAL(J)
C       Clean coal product.
        IF ( CLEAN(9) .GE. 0.001D0 )   THEN
            UCLN(J) = 100.0 * CLEAN(J) / CLEAN(9)
          ELSE
            UCLN(J) = 0.0
        END IF
        UCLN(8) = UCLN(8) + UCLN(J)
C       Middling coal.
        IF ( XMID(9) .GE. 0.001D0 )   THEN
            UMID(J) = 100.0 * XMID(J) / XMID(9)
          ELSE
            UMID(J) = 0.0
        END IF
        UMID(8) = UMID(8) + UMID(J)
C       Refuse.
        IF ( REFUSE(9) .GE. 0.001D0 )   THEN
            UREF(J) = 100.0 * REFUSE(J) / REFUSE(9)
          ELSE
            UREF(J) = 0.0
        END IF
        UREF(8) = UREF(8) + UREF(J)
  150 CONTINUE
C
C     Adjust the above dry basis flow rates to include the water.
      CLEAN(8) = 0.01D0 * PCWP * CLEAN(9)
      XMID(8) = 0.01D0 * PCWM * XMID(9)
```

```
      REFUSE(8) = 0.01D0 * PCWR * REFUSE(9)
      TOTW = CLEAN(8) + XMID(8) + REFUSE(8)
C
C     Insure that no more water is leaving the plant in the two coal
C     streams and the refuse stream than entered with the feed coal.
C     Although this is possible because some of the wash water could be
C     adsorbed, this effect is not considered here because we are not
C     considering process water in this simplified model.  If the water
C     specifications for the three product streams cause more water to
C     leave the plant than entered with the feed coal, adjust the water
C     content of the refuse stream to maintain a water balance.
      IF ( TOTW .GT. COAL(8))   THEN
        XSW = TOTW - COAL(8)
        REFUSE(8) = REFUSE(8) - XSW
C       If the adjusted water content of the refuse stream is negative,
C       set it to zero, and print a warning message that the water
C       specifications do not allow a water balance.
        IF ( REFUSE(8) .LT. 0.0D0)   REFUSE(8) = 0.0D0
      END IF
      COAL(10)   = COAL(8)   + COAL(9)
      CLEAN(10)  = CLEAN(8)  + CLEAN(9)
      XMID(10)   = XMID(8)   + XMID(9)
      REFUSE(10) = REFUSE(8) + REFUSE(9)
C
C     Calculate the amount of water in the inlet coal leaving in
C     the waste water stream.
      WATER = COAL(8) - CLEAN(8) - XMID(8) - REFUSE(8)
      IF ( WATER .LT. 0 )  WATER = 0.0D0
C
      IF ( KTEST .GE. 3 )  THEN
C       If requested, write the component mass balance to the history
C       file
        WRITE (NHSTRY, 721)
  721   FORMAT (/ 1X, 'Mass balance in lbs/hour' )
        WRITE (NHSTRY, 722)
  722   FORMAT ( 1X, '                    ', 4X, 'Feed Coal', 3X,
     1    'Clean Coal', 4X, 'Middling', 6X, 'Refuse' )
        WRITE (NHSTRY, 723) (COAL(J), CLEAN(J), XMID(J), REFUSE(J),
     1    J = 1, 7)
  723   FORMAT (1X, 'Carbon   ', F22.0, 2X, F11.0, 2F12.0 /
     1    1X, 'Hydrogen ', F22.0, 2X, F11.0, 2F12.0 /
     2    1X, 'Nitrogen ', F22.0, 2X, F11.0, 2F12.0 /
     2    1X, 'Chlorine ', F22.0, 2X, F11.0, 2F12.0 /
     3    1X, 'Sulfur   ', F22.0, 2X, F11.0, 2F12.0 /
     4    1X, 'Oxygen   ', F22.0, 2X, F11.0, 2F12.0 /
     6    1X, 'Ash      ', F22.0, 2X, F11.0, 2F12.0 )
        WRITE (NHSTRY, 724) COAL(9), CLEAN(9), XMID(9), REFUSE(9)
  724   FORMAT (1X, 'Dry coal', F23.0, 2X, F11.0, 2F12.0 )
        WRITE (NHSTRY, 725) COAL(8), CLEAN(8), XMID(8), REFUSE(8)
  725   FORMAT (1X, 'Water', F26.0, 2X, F11.0, 2F12.0 )
        WRITE (NHSTRY, 726) COAL(10), CLEAN(10), XMID(10), REFUSE(10)
  726   FORMAT (1X, 'Total', F26.0, 2X, F11.0, 2F12.0 )
        X1 = COAL(10) + OTHERS
        X2 = REFUSE(10) + OTHERS
        WRITE (NHSTRY, 727) OTHERS, OTHERS
```

```
  727   FORMAT (1X, 'Others', F25.0, 25X, F12.0 )
        WRITE (NHSTRY, 728) X1, X2
  728   FORMAT (1X, 'Total', F26.0, 25X, F12.0 )
        WRITE (NHSTRY, 729) WATER
  729   FORMAT (/ 1X, 'Waste water, lbs/hr', F12.0 )
      ENDIF
C
C     Set up the properties of the product streams.
C     ---------------------------------------------
      IF ( IPASS .NE. 4 )   THEN
C       First, zero all the items in the product stream vectors.
        DO 200 J = 1, ITEMS
          SOUT1(J) = 0.0D0
          SOUT2(J) = 0.0D0
          SOUT3(J) = 0.0D0
          SOUT4(J) = 0.0D0
  200   CONTINUE
C
C       Set the water flow rates of water in Kg-moles/sec in the CONV
C       portion of the product streams to their calculated values.
        SOUT1(KH2O) = CLEAN(8) / (XMW(KH2O) * CF)
        SOUT2(KH2O) = XMID(8) / (XMW(KH2O) * CF)
        SOUT3(KH2O) = REFUSE(8) / (XMW(KH2O) * CF)
        SOUT4(KH2O) = WATER / (XMW(KH2O) * CF)
C       Put all components other than water and coal in the refuse.
        IF (NCC .GE. 2 )  THEN
          DO 42 J = 1, NCC
            IF (J .NE. KH2O)  SOUT3(J) = SIN1(J)
   42     CONTINUE
        ENDIF
C       Set the total CONV flow rates in Kg-moles/sec.
        SOUT1(NCC+1) = SOUT1(KH2O)
        SOUT2(NCC+1) = SOUT2(KH2O)
        SOUT3(NCC+1) = SOUT3(KH2O)
        SOUT4(NCC+1) = SOUT4(KH2O)
        IF (NCC .GE. 2)  THEN
          SOUT3(NCC+1) = 0.0D0
          DO 44 J = 1, NCC
            SOUT3(NCC+1) = SOUT3(NCC+1) + SOUT3(J)
   44     CONTINUE
        ENDIF
C
C       Set the coal flow rates in the NONCONV portion of the product
C       streams to their calculated values.
        J = NCONV + 1
        SOUT1(NCONV+1) = CLEAN(9) / CF
        SOUT2(NCONV+1) = XMID(9) / CF
        SOUT3(NCONV+1) = REFUSE(9) / CF
        SOUT4(NCONV+1) = 0.0D0
C       Put all other non-conventional components in the refuse.
        IF (NNCC .EQ. 2)  SOUT3(NCONV+2) = SIN1(NCONV+2)
        IF (NNCC .GE. 3)  THEN
          DO 52 J = 2, NNCC
            SOUT3(NCONV+J) = SIN1(NCONV+J)
   52     CONTINUE
```

```
      ENDIF
C     Set the total mass flow rates of the NONCONV substream.
      SOUT1(NCONV+NNCC+1) = SOUT1(NCONV+1)
      SOUT2(NCONV+NNCC+1) = SOUT2(NCONV+1)
      SOUT3(NCONV+NNCC+1) = SOUT3(NCONV+1)
      SOUT4(NCONV+NNCC+1) = SOUT4(NCONV+1)
      IF (NNCC .GE. 2)  THEN
        SOUT3(NCONV+NNCC+1) = 0.0D0
        DO 54 J = 1, NNCC
          SOUT3(NCONV+NNCC+1) = SOUT3(NCONV+NNCC+1) + SOUT3(NCONV+J)
   54   CONTINUE
      ENDIF
C
C     Set the default temperature and pressure of the outlet streams
C     to 70 F and 15 PSIA.  Return these values to ASPEN/SP in degrees
C     Kelvin and Pascals.  These default values can be overriden by
C     the FLASH-SPECS sentence in the ASPEN/SP input file.
      SOUT1(NCC+2) = (70.0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT1(NCC+3) = 15.0 * 6.8947573D+3
      SOUT1(NCONV+NNCC+2) = SOUT1(NCC+2)
      SOUT1(NCONV+NNCC+3) = SOUT1(NCC+3)
      SOUT2(NCC+2) = (70.0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT2(NCC+3) = 15.0 * 6.8947573D+3
      SOUT2(NCONV+NNCC+2) = SOUT2(NCC+2)
      SOUT2(NCONV+NNCC+3) = SOUT2(NCC+3)
      SOUT3(NCC+2) = (70.0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT3(NCC+3) = 15.0 * 6.8947573D+3
      SOUT3(NCONV+NNCC+2) = SOUT3(NCC+2)
      SOUT3(NCONV+NNCC+3) = SOUT3(NCC+3)
      SOUT4(NCC+2) = (70.0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT4(NCC+3) = 15.0 * 6.8947573D+3
      SOUT4(NCONV+NNCC+2) = SOUT3(NCC+2)
      SOUT4(NCONV+NNCC+3) = SOUT3(NCC+3)
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)
      CALL CPACK (SOUT2, NCP, IDX, XPACK, TMASS)
      SOUT2(NCC+9) = AVEMW (NCP, IDX, XPACK)
      CALL CPACK (SOUT3, NCP, IDX, XPACK, TMASS)
      SOUT3(NCC+9) = AVEMW (NCP, IDX, XPACK)
      CALL CPACK (SOUT4, NCP, IDX, XPACK, TMASS)
      SOUT4(NCC+9) = AVEMW (NCP, IDX, XPACK)
C
C     Set the Ultimate analyses of the coal in the NONCONV portion
C     of the product streams to their calculated values.
      J = NCONV + 1
      SOUT1(NCCONV+5) = UCLN(7)
      SOUT1(NCCONV+6) = UCLN(1)
      SOUT1(NCCONV+7) = UCLN(2)
      SOUT1(NCCONV+8) = UCLN(3)
      SOUT1(NCCONV+9) = UCLN(4)
      SOUT1(NCCONV+10) = UCLN(5)
```

```
      SOUT1(NCCONV+11) = UCLN(6)
      SOUT2(NCCONV+5) = UMID(7)
      SOUT2(NCCONV+6) = UMID(1)
      SOUT2(NCCONV+7) = UMID(2)
      SOUT2(NCCONV+8) = UMID(3)
      SOUT2(NCCONV+9) = UMID(4)
      SOUT2(NCCONV+10) = UMID(5)
      SOUT2(NCCONV+11) = UMID(6)
      SOUT3(NCCONV+5) = UREF(7)
      SOUT3(NCCONV+6) = UREF(1)
      SOUT3(NCCONV+7) = UREF(2)
      SOUT3(NCCONV+8) = UREF(3)
      SOUT3(NCCONV+9) = UREF(4)
      SOUT3(NCCONV+10) = UREF(5)
      SOUT3(NCCONV+11) = UREF(6)
C
C     Approximate the Proximate analysis of the product streams.
C     Moisture.
C     NOTE:  ASPEM/SP uses a moisture free basis for the Proximate
C            analysis, and therefore, moisture is reported on a dry
C            basis.  Thus, the proximate ash content is the same as
C            Ultimate analysis.
      SOUT1(NCCONV+1) = 100.0D0 * CLEAN(8) / CLEAN(9)
      IF ( XMID(9) .GE. 0.001D0 )   THEN
          SOUT2(NCCONV+1) = 100.0D0 * XMID(8) / XMID(9)
        ELSE
          SOUT2(NCCONV+1) = 0.0D0
      ENDIF
      IF ( REFUSE(9) .GE. 0.001D0 )   THEN
          SOUT3(NCCONV+1) = 100.0D0 * REFUSE(8) / REFUSE(9)
        ELSE
          SOUT3(NCCONV+1) = 0.0D0
      ENDIF
C     Ash.
      SOUT1(NCCONV+4) = 100.0D0 * CLEAN(7) / CLEAN(9)
      IF ( XMID(9) .GE. 0.001D0 )   THEN
          SOUT2(NCCONV+4) = 100.0D0 * XMID(7) / XMID(9)
        ELSE
          SOUT2(NCCONV+4) = 0.0D0
      ENDIF
      IF ( REFUSE(9) .GE. 0.001D0 )   THEN
          SOUT3(NCCONV+4) = 100.0D0 * REFUSE(7) / REFUSE(9)
        ELSE
          SOUT3(NCCONV+4) = 0.0D0
      ENDIF
C     Fixed Carbon and Volatile Matter - Assume the same ratio as that
C     in the entering coal.
      FRACFC = SIN1(NCCONV+2) / (SIN1(NCCONV+2) + SIN1(NCCONV+3))
      SOUT1(NCCONV+2) = (100.0D0 - SOUT1(NCCONV+4)) * FRACFC
      SOUT1(NCCONV+3) = 100.0D0 - SOUT1(NCCONV+2) - SOUT1(NCCONV+4)
      IF ( SOUT2(NCONV+1) .GE. 1.0E-20)  THEN
        SOUT2(NCCONV+2) = (100.0D0 - SOUT2(NCCONV+4)) * FRACFC
        SOUT2(NCCONV+3) = 100.0D0 - SOUT2(NCCONV+2) - SOUT2(NCCONV+4)
      ENDIF
      IF ( SOUT3(NCONV+1) .GE. 1.0E-20)  THEN
```

```
          SOUT3(NCCONV+2) = (100.0D0 - SOUT3(NCCONV+4)) * FRACFC
          SOUT3(NCCONV+3) = 100.0D0 - SOUT3(NCCONV+2) - SOUT3(NCCONV+4)
        ENDIF
C
C       Approximate the Sulfur forms (SULFANAL) in the product streams
C       by ratio to that in the entering coal.  Ratio the pyritic and
C       sulfatic amounts to the ash, and calculate the organic sulfur
C       by difference from the Ultimate analysis (ULTANAL).
        SOUT1(NCCONV+12) = SIN1(NCCONV+12) * UCLN(7) / UCOAL(7)
        SOUT2(NCCONV+12) = SIN1(NCCONV+12) * UMID(7) / UCOAL(7)
        SOUT3(NCCONV+12) = SIN1(NCCONV+12) * UREF(7) / UCOAL(7)
        SOUT1(NCCONV+13) = SIN1(NCCONV+13) * UCLN(7) / UCOAL(7)
        SOUT2(NCCONV+13) = SIN1(NCCONV+13) * UMID(7) / UCOAL(7)
        SOUT3(NCCONV+13) = SIN1(NCCONV+13) * UREF(7) / UCOAL(7)
        SOUT1(NCCONV+14) = UCLN(5) -SOUT1(NCCONV+12) -SOUT1(NCCONV+13)
        SOUT2(NCCONV+14) = UMID(5) -SOUT2(NCCONV+12) -SOUT2(NCCONV+13)
        SOUT3(NCCONV+14) = UREF(5) -SOUT3(NCCONV+12) -SOUT3(NCCONV+13)
C
C       Approximate the Ash Composition (AOXANAL) of the products to be
C       the same as that of the entering coal.
        JSTART = NCCONV + 15
        JEND = NCCONV + 24
        DO 210 J = JSTART, JEND
          SOUT1(J) = SIN1(J)
          IF ( SOUT2(NCONV+1) .GE. 1.0E-20)  SOUT2(J) = SIN1(J)
          IF ( SOUT3(NCONV+1) .GE. 1.0E-20)  SOUT3(J) = SIN1(J)
  210   CONTINUE
C
C       If requested, write the items of interest in the outlet stream
C       vectors to the history file.
        IF ( KTEST .GE. 4 )  THEN
          WRITE (NHSTRY, 731)
  731     FORMAT ( // ' The outlet stream vectors' /
     1      14X, 'SOUT1', 10X, 'SOUT2', 10X, 'SOUT3', 10X, 'SOUT4' )
          DO 1002 J = 1, ITEMS
            WRITE (NHSTRY, 732) J, SOUT1(J), SOUT2(J), SOUT3(J),
     1        SOUT4(J)
  732       FORMAT ( 2X, I5, 4(1PE15.5) )
 1002     CONTINUE
        END IF
C
      END IF
C
C     Calculate the dry clean coal product stream flow rate in Mlbs/hr.
      CCFLOW = 0.001D0 * CLEAN(9)
C
C     If it has not been specified by the user in variable INT(3),
C     calculate the number of operating duplicate trains, excluding
C     spares (NPLNT), based on the maximum flow rate of the reference
C     stream.  However, if the maximum capacity of a single train
C     has not been specified, set the number of operating trains to 1.
      NPLNT = INT(3)
      IF ( (NPLNT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
          NPLNT = CCFLOW  / PMAXF
          IF ( (MOD(CCFLOW, PMAXF)) .GT. 0.0D0 )  NPLNT = NPLNT + 1
```

```
        ELSE
          IF ( NPLNT .EQ. 0 )   NPLNT = 1
      END IF
C
C     Calculate the dry clean coal product stream flow rate in Mlbs/hr
C     (PFLOW) for each of the individual duplicate trains.
      XPLANT = NPLNT
      PFLOW = CCFLOW / XPLANT
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 this user block report.
            LSTRM = 25
            LUTIL = 16
            LCOST = 11
            IF ( IER .GE. 1 )  LSTRM = LSTRM + 4
            X = COAL(8) - CLEAN(8) - XMID(8) - REFUSE(8) - WATER
            IF ( DABS(X) .GT. 1.0D0 )  THEN
                LSTRM = LSTRM + 6
              ELSE
                LSTRM = LSTRM + 4
            ENDIF
            NDUP = REAL(58) + 0.001D0
            IF ( (NPLNT + NDUP) .EQ. 1 )  LCOST = 9
            IF ( PFLOW .LT. PMINF )  LCOST = LCOST + 3
            IF ( PFLOW .GT .PMAXF )  LCOST = LCOST + 3
            IF ( NDUP .GE. 1 )  LCOST = LCOST + 1
            LINES = LSTRM + LUTIL + LCOST
C           Now, subtract the number of lines for those portions of
C           the user block summary report which will not be written.
            IF ( INT(1) .GE. 2 )   LINES = LINES - LUTIL
            IF ( INT(1) .GE. 1 )   LINES = LINES - LCOST
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 either DCL01B.REP,
C           DCL01A1, DCL01A2, DCL01D or DCL01G, as appropriate, to
C           contain this user block summary report.
            OPEN (UNIT=62, FILE=FILEID(KOPT+1), STATUS='UNKNOWN',
     1        ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2        BUFFERED='BUFFERED')
            WRITE (NOUT, 800)
C           FORMAT statement 800 will print across a page because it
C           contains the PC top-of-form character (ASCII character 012)
C           between two quote marks ( i.e., 'TOF').
  800       FORMAT ( 'TOF' )
        ENDIF
      ENDIF
C
```

```
C     If requested, skip writing the entire user model report if the
C     ouput report control switch, INT(1), has a value of 3 or more.
      IF ( IPASS .EQ. 4 .AND.  INT(1) .LE. 2 )   THEN
C
C       STREAM INPUT/OUTPUT REPORT SECTION.
C       Calculate the required stream values for the plant summary
C       report from the inlet and outlet stream vectors, and save them
C       in the Plant Stream Array, PSA(J,K).
C
C       Coal flow rate (dry basis), Mlbs/hr.
        PSA(1,2) = 0.001D0 * COAL(9)
        PSA(2,2) = 0.001D0 * CLEAN(9)
        PSA(3,2) = 0.001D0 * XMID(9)
        PSA(4,2) = 0.001D0 * REFUSE(9)
        PSA(5,2) = 0.0D0
C       TOTAL INPUT and OUTPUT stream flow rates in Mlbs/hour.
        TFIN =  PSA(1,2)
        TFOUT = PSA(2,2) + PSA(3,2) + PSA(4,2)
C       Stream temperature, degrees Fahrenheit.
        PSA(1,3) = SIN1(NCC+2) * 1.8D0 - 459.67D0
        PSA(2,3) = SOUT1(NCC+2) * 1.8D0 - 459.67D0
        PSA(3,3) = SOUT2(NCC+2) * 1.8D0 - 459.67D0
        PSA(4,3) = SOUT3(NCC+2) * 1.8D0 - 459.67D0
        PSA(5,3) = SOUT4(NCC+2) * 1.8D0 - 459.67D0
C       Stream pressure, PSIA.
        PSA(1,4) = SIN1(NCC+3) / 6.8947573D+3
        PSA(2,4) = SOUT1(NCC+3) / 6.8947573D+3
        PSA(3,4) = SOUT2(NCC+3) / 6.8947573D+3
        PSA(4,4) = SOUT3(NCC+3) / 6.8947573D+3
        PSA(5,4) = SOUT4(NCC+3) / 6.8947573D+3
C       Water flow rate, Mlbs/hr.
        PSA(1,5) = 0.001D0 * COAL(8)
        PSA(2,5) = 0.001D0 * CLEAN(8)
        PSA(3,5) = 0.001D0 * XMID(8)
        PSA(4,5) = 0.001D0 * REFUSE(8)
        PSA(5,5) = 0.001D0 * WATER
C       Total flow rate, Mlbs/hr.
        PSA(1,6) = PSA(1,2) + PSA(1,5) + 0.001D0 * OTHERS
        PSA(2,6) = PSA(2,2) + PSA(2,5)
        PSA(3,6) = PSA(3,2) + PSA(3,5)
        PSA(4,6) = PSA(4,2) + PSA(4,5) + 0.001D0 * OTHERS
        PSA(5,6) = PSA(5,2) + PSA(5,5)
C
C       Write the component mass balance.
        IF ( KOPT .NE. 4 )  WRITE (NOUT, 801)
  801   FORMAT (// 28X, 'PLANT 1 - SUMMARY REPORT' )
        IF ( KOPT .EQ. 4 )  WRITE (NOUT, 802)
  802   FORMAT (// 27X, 'PLANT 1.4 - SUMMARY REPORT' )
        WRITE (NOUT, 803)
  803   FORMAT (23X, 'COAL CLEANING AND PREPARATION PLANT')
C
        IF ( KOPT .EQ. 0 )  WRITE (NOUT, 804)
  804   FORMAT ( 21X, 'COAL CLEANING BY JIGS FOR LIQUEFACTION' )
        IF ( KOPT .EQ. 1 )  WRITE (NOUT, 805)
  805   FORMAT ( 21X, 'COAL CLEANING BY HEAVY MEDIA SEPARATION' )
```

```
      IF ( KOPT .EQ. 2 )  WRITE (NOUT, 806)
806   FORMAT ( 7X, 'COAL CLEANING BY HEAVY MEDIA SEPARATION AND ',
     1   'SPHERICAL AGGLOMERATION' )
      IF ( KOPT .EQ. 3 )  WRITE (NOUT, 807)
807   FORMAT ( 21X, 'COAL CLEANING BY JIGS FOR GASIFICATION' )
      IF ( KOPT .EQ. 4 )  WRITE (NOUT, 808)
808   FORMAT ( 28X, 'COAL GRINDING AND DRYING' )
C
      WRITE (NOUT, 811)
811   FORMAT (// 1X, '                    ', 4X, 'FEED COAL', 3X,
     1   'CLEAN COAL', 4X, 'MIDDLING', 6X, 'REFUSE' )
C
      X1 = 0.001D0 * OTHERS
      WRITE (NOUT, 812) (PSA(J,2), J = 1, 4),
     1   (PSA(J,5), J = 1, 4), X1, X1, (PSA(J,6), J = 1, 4)
812   FORMAT (1X, 'DRY COAL, MLBS/HR', 3X, F11.3, 2X, F11.3, 2F12.3 /
     1   1X, 'WATER, MLBS/HR', 6X, F11.3, 2X, F11.3, 2F12.3 /
     2   1X, 'OTHERS, MLBS/HR', 5X, F11.3, 25X, F12.3 /
     3   1X, 'TOTAL, MLBS/HR', 6X, F11.3, 2X, F11.3, 2F12.3 )
C
      WRITE (NOUT, 813) PSA(5,6)
813   FORMAT (/ 1X, 'WASTE WATER, MLBS/HR', F11.3 )
C
C     Write the Ultimate analyses of the coal containing streams.
      WRITE (NOUT, 814)
814   FORMAT (// 1X, 'ULTIMATE ANALYSIS, WT%' )
      WRITE (NOUT, 815) (UCOAL(J), UCLN(J), UMID(J), UREF(J), J=1, 8)
815   FORMAT ( 1X, ' CARBON   ', 10X, F11.2, 2X, F11.2, 2F12.2 /
     1   1X, ' HYDROGEN ', 10X, F11.2, 2X, F11.2, 2F12.2 /
     2   1X, ' NITROGEN ', 10X, F11.2, 2X, F11.2, 2F12.2 /
     3   1X, ' CHLORINE ', 10X, F11.2, 2X, F11.2, 2F12.2 /
     4   1X, ' SULFUR   ', 10X, F11.2, 2X, F11.2, 2F12.2 /
     5   1X, ' OXYGEN   ', 10X, F11.2, 2X, F11.2, 2F12.2 /
     6   1X, ' ASH      ', 10X, F11.2, 2X, F11.2, 2F12.2 /
     7   1X, ' TOTAL    ', 10X, F11.2, 2X, F11.2, 2F12.2 )
C
C
C     If the supplied component distribution factors for one or more
C     components had to be adjusted because their sum was greater
C     than 1.0, write a warning message.
      IF ( IER .GE. 1 )  WRITE (NOUT, 816)
816   FORMAT ( / ' WARNING - THE SUPPLIED COMPONENT DISTRIBUTION ',
     1   'FACTORS FOR ONE OR MORE' /
     2   11X, 'COMPONENTS WERE NORMALIZED TO 1.0 BECAUSE THEIR SUM ',
     3   'EXCEEDED' /
     4   11X, '1.0.  SEE THE HISTORY FILE FOR DETAILED INFORMATION.' )
C
C     If the plant is not in water balance based on the water
C     entering with the feed coal, write a warning message.
      X = COAL(8) - CLEAN(8) - XMID(8) - REFUSE(8) - WATER
      IF ( DABS(X) .GT. 1.0D0 )  THEN
          WRITE (NOUT, 817)
817       FORMAT ( / ' WARNING - THE COAL CLEANING AND PREPARATION ',
     1      'PLANT IS NOT IN WATER BALANCE' /
     2      11X, 'BASED ON THE WATER CONTAINED IN THE ENTERING COAL',
```

```
     3        ' STREAM.  SOME WASH' /
     4        11X, 'WATER HAS BEEN ADSORBED ON THE CLEAN AND MIDDLING',
     5        ' COALS.  SETTING' /
     6        11X, 'THE WATER CONTENT OF THE REFUSE STREAM TO ZERO ',
     7        'COULD NOT FORCE A' /
     8        11X, 'WATER BALANCE.' )
          ELSE
C           If the water content of the refuse stream is not what was
C           specified, write a message stating that the water content
C           of the refuse stream has been adjusted to maintain a water
C           balance based on the water in the inlet coal stream.
            IF ( REFUSE(9) .GE. 0.001D0 )   THEN
                Y = 100.0D0*REFUSE(8)/REFUSE(9)
              ELSE
                Y = 0.0D0
            ENDIF
            IF (DABS(PCWR - Y ) .GT. 0.01D0 .AND. WATER .LE. 0.0D0)
     1        WRITE (NOUT, 818)
  818       FORMAT ( / ' WARNING - THE WATER CONTENT OF THE REFUSE ',
     1        'STREAM HAS BEEN ADJUSTED TO' /
     2        11X, 'MAINTAIN A WATER BALANCE BASED ON THE WATER ',
     3        'CONTAINED IN THE' /
     4        11X, 'ENTERING COAL STREAM.' )
        END IF
C
      ENDIF
C
C     Call subroutine USRUCO to calculate, save and report the
C     utilities, capital and operating costs for the plant.
C     Location ID = 1 is for the coal cleaning plant for liquefaction,
C     location 17 is for a coal drying plant, and 20 is for the
C     gasification coal cleaning plant.
      ID = 1
      IF ( KOPT .EQ. 3 )   ID = 20
      IF ( KOPT .EQ. 4 )   ID = 17
      IF ( FLOWIN .GE. 4.0D0 )  THEN
          KUNITS = 3
          CALL USRUCO (NOUT, NOUT, IPASS, ID, PNAME, INT(1), INT(3),
     1      KTEST, REAL(21), CCFLOW, KUNITS)
        ELSE
          PLNTID(ID) = '      '
          CAPCST(ID,1) = 1.
          CAPCST(ID,2) = 0.
          CAPCST(ID,3) = 0.
          CAPCST(ID,4) = 0.
          CAPCST(ID,5) = 0.
          CAPCST(ID,6) = 0.
          OPCST(ID,1) = 0.
      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, 790)
  790 FORMAT ( / ' Leaving subroutine USR01' )
C
      RETURN
      END
C
C$  Subroutine USR02
C
C     This file contains the following subroutines:
C       USR02    Main routine for Plant 2, the coal liquefaction plant
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 total reactor effluent stream.
C                2 coal liquefaction reactor.
C       USR02S   Subroutine to distribute the net yields from plant 2,
C                into the six product streams.
C       USR02Z   Subroutine to write the overall material balance for
C                plant 2 and any warning messages.
C       USR2CS   Subroutine to write the cost summary report by plant
C                section.
C       USR2ES   Subroutine to write the major equipment summary list.
C
C     The above subroutines use named commons /USRC01/, /USRC02/ and
C     /USRC04/.
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 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       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 /USRC01/.
C
C$ USR02
      SUBROUTINE USR02 (NSIN,NINFI,SIN1,SIN2,SIN3,SIN4,
     1 SIN5, SIN6, SIN7, SIN8, SINFI,NSOUT,
     2 NINFO,SOUT1,SOUT2,SOUT3,SOUT4, SOUT5, SOUT6, SOUT7, SOUT8,
     3 SINFO,NSUBS,IDXSUB,ITYPE,NINT,
     4 INT,NREAL,REAL,IDS,NPO,NBOPST,NIW,IW,NW,W,NSIZE,SIZE)
C
C  ASPEN USER UNIT OPERATION BLOCK:  USR02
C
C  BLOCK DESCRIPTION:  Plant 2, DOE Coal Liquefction Plant
C
C                  Simplified Fortran Block Model
C
C                    ----------------------
```

```
C                    |                      |-----> H2-rich gas to Plt 6.1
C     Hydrogen ---->|                      |
C                    |       Plant 2        |-----> Low P gas to Plt 6.2
C     Wet Coal ---->|                      |
C                    |       Coal           |-----> Naphtha
C     Solvent ----->|    Liquefaction      |
C                    |       Plant          |-----> Gas-oil
C     ROSE Extract->|                      |
C                    |                      |-----> Bottoms to ROSE-SR
C     Water ------->|                      |         unit
C                    |                      |-----> Sour water
C                   -----------------------
C
C
C  Prepared under DOE contract no. DE-AC22 90PC89857.
C
C  FUNCTION (MODEL, REPORT, OR BOTH):  Both
C
C  Last revision - November 6, 1992.
C
C  ASSUMPTIONS, SPECIAL FEATURES AND LIMITATIONS:
C     1.  The five inlet stream are:   1. Hydrogen stream
C                                      2. Wet coal stream
C                                      3. Solvent stream
C                                      4. ROSE-SR Extract stream
C                                      5. Water stream
C     2.  The six outlet streams are:  1. High press gas to Plant 6.1
C                                      2. Low press gas to Plant 6.2
C                                      3. Naphtha product stream
C                                      4. Gas-oil hydrotreater feed
C                                      5. Bottoms to ROSE-SR unit
C                                      6. Sour water 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 COAL present in the input streams may be liquefied.  Any
C         COAL, URCOAL or SLAG present in the input streams leaves in
C         the bottoms stream, the ROSE-SR unit feed stream.
C     7.  The 6 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 DCL02.REP.
C        INT(3)  = Number of operating duplicate trains, excluding
C                  spares.
C                  If INT(3) = 0, the minimum number of duplicate
C                    trains will be determined so that the capacity
C                    each train does not exceed the maximum train
C                    capacity specified by variable REAL(52).
C                  If INT(3) > 0, this number of duplicate trains will
C                    be used.
C        INT(4)  = History file additional output control switch.
C                 0 => Write no additional output to the history 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)  = Switch to write the major equipment summary list
C                  and cost summary report by plant section for the
C                  baseline design to the separate block output summary
C                  report file on logical unit 62 called DCL02.REP.
C                  These reports only are availabe for the baseline
C                  design; i.e., when INT(6) = 0.
C                 0 => Do not write the major equipment summary list.
C                 1 => Write the major equipment summary list to the
C                      separate block output file only when
C                         INT(1) <= 2, INT(2) = 1, and INT(6) = 0.
C                 2 => Write the major equipment summary list and the
C                      cost summary report by plant section to the
C                      separate block output file only when
C                         INT(1) <= 2, INT(2) = 1, and INT(6) = 0.
C        INT(6)  = Switch to select which coal liquefaction reactor
C                  yields are calculated.
C                 0 => Baseline design two-reactor model.
C                 3 => Option 3 - Yields for Thermal/Catalytic two
C                      -reactor model.
C                 4 => Option 4 - Two-reactor model with interstage
C                      vent gas separation.
C                 5 => Option 5 - Yields for two-reactor coker model.
C                 8 => Improved Baseline (Option 8) - High space
C                      velocity two-reactor model.
C     8. The 70 real parameters are:
C        REAL(1)   = Percent coal conversion based on fresh MAF coal
C                    entering the coal liquefaction reactors.
```

```
C          REAL(2) -
C           REAL(20) = Future use.
C          REAL(21)  = Constant factor for the power consumption, kw.
C          REAL(22)  = Power consumption per Mlbs/hr of dry coal feed,
C                      kw/(Mlbs/hr of dry coal)
C          REAL(23)  = Constant factor for the 900 psig / 750 F steam
C                      consumption, Mlbs/hr.
C          REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr
C                      of dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
C          REAL(25)  = Constant factor for the 900 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr
C                      of dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
C          REAL(27)  = Constant factor for the 600 psig / 720 F steam
C                      consumption, Mlbs/hr.
C          REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr
C                      of dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
C          REAL(29)  = Constant factor for the 600 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr
C                      of dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
C          REAL(31)  = Constant factor for the 150 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr
C                      of dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
C          REAL(33)  = Constant factor for the 50 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr
C                      of dry coal feed, (Mlbs/hr)/(Mlbs/hr of dry coal).
C          REAL(35)  = Constant factor for the plant fuel consumption,
C                      MM BTU/hr.
C          REAL(36)  = Plant fuel consumption per Mlbs/hr of dry coal
C                      feed, (MM BTU/hr)/(Mlbs/hr of dry coal).
C          REAL(37)  = Constant factor for the cooling water consumption,
C                      Mgal/hr.
C          REAL(38)  = Cooling water consumption per Mlbs/hr of dry coal
C                      feed, (Mgal/hr)/(Mlbs/hr of dry coal).
C          REAL(39)  = Constant factor for the process water consumption,
C                      Mgal/hr.
C          REAL(40)  = Process water consumption per Mlbs/hr of dry coal
C                      feed, (Mgal/hr)/(Mlbs/hr of dry coal).
C          REAL(41)  = Constant factor for the nitrogen consumption,
C                      MM SCF/hr of N2.
C          REAL(42)  = Nitrogen consumption per Mlbs/hr of dry coal feed,
C                      (MM SCF/hr of N2)/(Mlbs/hr of dry coal).
C          REAL(43) -
C           REAL(48) = Future use.
C          REAL(49)  = Constant factor for the number of operators per
C                      day, operators/day.
C          REAL(50)  = Number of operators per day per train,
C                      (operators/day)/train.
C          REAL(51)  = Reference dry coal feed rate to a single plant in
C                      Mlbs/hr for the calculation of the ISBL field cost
C                      of a single plant as a function of plant capacity.
C          REAL(52)  = Maximum size of a single plant as defined by the
```

```
C                       dry coal feed rate in Mlbs/hr of dry coal.
C          REAL(53)  = Minimum size of a single plant as defined by the
C                      dry coal feed rate in Mlbs/hr of dry coal.
C          REAL(54)  = Constant A in the plant ISBL field cost equation.
C          REAL(55)  = Constant B in the plant ISBL field cost equation.
C          REAL(56)  = Constant E in the plant ISBL field cost equation.
C          REAL(57)  = Constant F in the plant ISBL field cost equation.
C          REAL(58)  = Number of spare plants.
C          REAL(59) -
C           REAL(70) = 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)
      DIMENSION SIN5(1),SIN6(1),SIN7(1),SIN8(1),SOUT5(1),
     1 SOUT6(1),SOUT7(1),SOUT8(1)
      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 make conventional
C                        components and unreacted coal (URCOAL)
C       47.  URCOAL      Unreacted coal which leaves in the bottoms
C                        product stream, the ROSE-SR unit feed stream.
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 /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
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5)
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 the 5 inlet and
C         6 outlet streams, in order, where J designates the stream 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
C     Local variable declaration statements.
      DIMENSION FLOW(7), OXIN1(10), OXIN1N(10), UIN1(7), UIN2(7),
     1  UIN1N(7), UIN2N(7), ULTOUT(7), WTUC(7), WTUCC(7)
C
      DIMENSION ICN(2), ICNAME(100)
C
      CHARACTER * 4  BLANK4, ICN, ICNAME
      CHARACTER * 6  PNAME
C
      DATA KMAXC / 50 /
      DATA KOMPS / 37 /
      DATA BLANK4 / '    ' /
C     Initialize the component identifications.
      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 / '2     ' /
C
C
C     PARAMETER INITIALIZATION SECTION
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)
C
C     If requested, write the subroutine heading to the history file.
      IF ( KTEST .GE. 1 )  THEN
        WRITE (NHSTRY, 501) IPASS, (INT(K), K = 1, NINT)
  501   FORMAT ( // 1X, 'Plant 2 - Supplementary data from ',
     1    'subroutine USR02' /
     2    2X, 'Coal Liquefaction Plant', 20X, 'IPASS =', I3 /
     3    2X, 'Integer Parameters: ', 8I4 )
      ENDIF
```

```
C
C     Check to insure that there are exactly 5 inlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSIN .NE. 5 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS,
     1    (INT(K), K = 1, NINT)
        WRITE (NHSTRY, 502)  NSIN
  502   FORMAT ( / 1X, '* ERROR * - Plant 2 requires exactly ',
     1    '5 inlet streams.' /
     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 are exactly 6 outlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSOUT .NE. 6 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501) IPASS,
     1    (INT(K), K = 1, NINT)
        WRITE (NHSTRY, 503)  NSOUT
  503   FORMAT ( / 1X, '* ERROR * - Plant 2 requires exactly ',
     1    '6 outlet streams.' /
     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,
     1    (INT(K), K = 1, NINT)
        WRITE (NHSTRY, 504)
  504   FORMAT ( / 1X, '* ERROR * - The input streams to Plant 2, ',
     1    'the coal liquefaction plant, are' /
     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) + SIN2(J)*SIN2(K) + SIN3(J)*SIN3(K)
      J = NCC + 9 + NNCC + 1
      FLOWIN = CF * (X + SIN1(J) + SIN2(J) + SIN3(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 Plant 2, the ',
     1    'coal liquefaction plant.' )
        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,
     1    (INT(K), K = 1, NINT)
        WRITE (NHSTRY, 506)
  506   FORMAT ( / 1X, '* ERROR * - The input streams to Plant 2, ',
     1    'the coal liquefaction plant,' /
     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
        ICNUMB(J) = 0
   20 CONTINUE
      DO 22 J = 1, KOMPS
        K = 2 * J - 1
        ICN(1) = ICNAME(K)
        ICN(2) = ICNAME(K+1)
        CALL USRCCN (ICN, ICNUMB(J))
        IF ( ICNUMB(J) .EQ. 0 ) THEN
          IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS,
     1    (INT(K), K = 1, NINT)
          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
   22 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     Set MODE to 1 to tell subroutine USR02R that it is being called
C     by subroutine USR02.  The various other mode options are described
C     in subroutine USR02R.
      MODE = 1
      IF ( INT(6) .EQ. 3 )  MODE = 13
      IF ( INT(6) .EQ. 4 )  MODE = 14
      IF ( INT(6) .EQ. 5 )  MODE = 15
      IF ( INT(6) .EQ. 8 )  MODE = 18
C
C     Load the percent coal conversion based on fresh MAF coal entering
C     he reactors.
      CONMAF = REAL(1)
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,
     1    (INT(K), K = 1, NINT)
        WRITE (NHSTRY, 508)  CONMAF
  508   FORMAT ( / 1X, '* WARNING * - The supplied coal ',
     1    'converion based on fresh MAF coal to plant 2' /
```

```
     2    3X, 'has an invalid value of', F10.3, '.  A converion per',
     3    ' pass of 92.5% will' /
     4    3X, 'be assumed, and execution will continue using this',
     5    ' conversion per pass.' )
        CONMAF = 92.5D0
      ENDIF
C
C     Set up the maximum and minimum train flow rates in Mlbs/hr of
C     dry coal feed.
      PMAXF = REAL(52)
      PMINF = REAL(53)
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)
C
C     If requested, write the items of interest in the inlet
C     stream vectors to the history file.
      IF ( KTEST .GE. 5 )  THEN
        WRITE (NHSTRY, 509)
  509   FORMAT ( / '  The inlet stream vectors:'/
     1    3X, 'Item', 8X, 'SIN1', 11X, 'SIN2', 11X, 'SIN3', 11X,
     2    'SIN4', 11X, 'SIN5' )
        DO 30 J = 1, ITEMS
          WRITE (NHSTRY, 510) J, SIN1(J), SIN2(J), SIN3(J), SIN4(J),
     1      SIN5(J)
  510     FORMAT ( 1X, I6, 1X, 5(1PE15.5) )
   30   CONTINUE
      ENDIF
C
C     Load the total entering component flow rates from all the inlet
C     streams in the CIN vector in lbs/hr.
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) + SIN2(J) + SIN3(J)
     1      + SIN4(J) + SIN5(J))
          GO TO 44
        ENDIF
   42   CONTINUE
        CIN(50) = CIN(50) + CF * XMW(J) * (SIN1(J) + SIN2(J) + SIN3(J)
     1    + SIN4(J) + SIN5(J))
   44 CONTINUE
C
C     Non-conventional components.
      CIN(46) = CF * (SIN1(NCONV+1) + SIN2(NCONV+1) + SIN3(NCONV+1)
     1  + SIN4(NCONV+1) + SIN5(NCONV+1))
      CIN(47) = CF * (SIN1(NCONV+2) + SIN2(NCONV+2) + SIN3(NCONV+2)
```

```
     1  + SIN4(NCONV+2) + SIN5(NCONV+2))
      CIN(48) = CF * (SIN1(NCONV+3) + SIN2(NCONV+3) + SIN3(NCONV+3)
     1  + SIN4(NCONV+3) + SIN5(NCONV+3))
C
      IER1 = 0
      IF ( CIN(50) .GE. 1.0D0 ) THEN
        IER1 = 1
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS,
     1    (INT(K), K = 1, NINT)
        WRITE (NHSTRY, 511)  CIN(50)
  511   FORMAT ( / 1X, '* WARNING * - The feed to plant 2, the coal ',
     1    'liquefaction plant, ' /
     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 be' /
     6    3X, 'lost in the process.  Plant 2 will not be in mass ',
     7    'balance.  Please remove' /
     8    3X, 'these component(s) from the feed stream(s).' //
     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,L), L = 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     Load the Ultimate analyses of the fresh inlet coal from the second
C     inlet stream, the Ultimate analysis of URCOAL from the fourth
C     inlet stream, and normalize both to 100 wt%.
      N1 = NCCONV + 4
      N2 = N1 + 24
C     N3 = N2 + 24
```

```
      SUMIN1 = 0.0D0
      SUMIN2 = 0.0D0
      DO 50 J = 1, 7
        UIN1(J) = SIN2(J+N1)
        UIN2(J) = SIN4(J+N2)
        SUMIN1 = SUMIN1 + UIN1(J)
        SUMIN2 = SUMIN2 + UIN2(J)
   50 CONTINUE
      SUM1 = 0.0D0
      SUM2 = 0.0D0
      DO 52 J = 1, 7
        UIN1N(J) =  100.0D0 * UIN1(J) / SUMIN1
        UIN2N(J) =  100.0D0 * UIN2(J) / SUMIN2
        SUM1 = SUM1 + UIN1N(J)
        SUM2 = SUM2 + UIN2N(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), J = 1, 7)
  518   FORMAT ( ' Component', 9X, 'Coal', 7X, 'URCOAL' /
     1    2X, 'Ash     ', 2F13.2 /
     2    2X, 'Carbon  ', 2F13.2 /
     3    2X, 'Hydrogen', 2F13.2 /
     4    2X, 'Nitrogen', 2F13.2 /
     5    2X, 'Chlorine', 2F13.2 /
     6    2X, 'Sulfur  ', 2F13.2 /
     7   2X, 'Oxygen  ', 2F13.2 )
        WRITE (NHSTRY, 519)  SUMIN1, SUMIN2
  519   FORMAT ( 2X, 'Total   ', 2F13.2 )
C
        WRITE (NHSTRY, 520)
  520   FORMAT ( / ' Normalized non-conventional component Ultimate ',
     1    'analyses:')
        WRITE (NHSTRY, 518)  (UIN1N(J), UIN2N(J), J = 1, 7)
        WRITE (NHSTRY, 519)  SUM1, SUM2
      ENDIF
C
C     Load the ash oxide (AOXANAL) analyses of the fresh inlet coal from
C     the second inlet stream and normalize to 100%.
      N1 = NCCONV + 14
      SUM = 0.0D0
      DO 60 J = 1, 10
        OXIN1(J) = SIN2(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     fresh coal entering the unit (WTUCC) and the total lbs/hr of
C     all Ultimate analysis components entering the unit (WTUC), and
C     normalize the totals to match the total entering weights.
      N1 = NCCONV + 4
      N2 = N1 + 24
      N3 = N2 + 24
      SUM1 = 0.0D0
      SUM2 = 0.0D0
      DO 70 J = 1, 7
        WTUCC(J) = SIN1(NCONV+1)*SIN1(J+N1) + SIN2(NCONV+1)*SIN2(J+N1)
     1           + SIN3(NCONV+1)*SIN3(J+N1) + SIN4(NCONV+1)*SIN4(J+N1)
     2           + SIN5(NCONV+1)*SIN5(J+N1)
        WTUC(J) = SIN1(NCONV+2)*SIN1(J+N2) + SIN1(NCONV+3)*SIN1(J+N3)
     1          + SIN2(NCONV+2)*SIN2(J+N2) + SIN2(NCONV+3)*SIN2(J+N3)
     2          + SIN3(NCONV+2)*SIN3(J+N2) + SIN3(NCONV+3)*SIN3(J+N3)
     3          + SIN4(NCONV+2)*SIN4(J+N2) + SIN4(NCONV+3)*SIN4(J+N3)
     4          + SIN5(NCONV+2)*SIN5(J+N2) + SIN5(NCONV+3)*SIN5(J+N3)
     5          + WTUCC(J)
        SUM1 = SUM1 + WTUCC(J)
        SUM2 = SUM2 + WTUC(J)
   70 CONTINUE
      TSOLID = CIN(46) + CIN(47) + CIN(48)
      DO 72 J = 1, 7
        WTUCC(J) = CIN(46) * WTUCC(J) / SUM1
        WTUC(J) = TSOLID * WTUC(J) / SUM2
   72 CONTINUE
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
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.
      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     Calculate the total dry coal feed rate in Mlbs/hr.
      COALIN = 0.001D0 * CIN(46)
C
C     If it has not been specified by the user in variable INT(3),
C     calculate the number of operating duplicate trains, excluding
C     spares (NPLNT), based on the total flow rate of the reference
C     stream.  However, if the maximum capacity of a single train
C     has not been specified, set the number of operating trains to 1.
      NPLNT = INT(3)
      IF ( (NPLNT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
          NPLNT = COALIN  / PMAXF
          IF ( (MOD(COALIN, PMAXF)) .GT. 0.0D0 )  NPLNT = NPLNT + 1
        ELSE
          IF ( NPLNT .EQ. 0 )   NPLNT = 1
      ENDIF
C
C     Calculate the feed rate for each of the duplicate plants (PFLOW)
C     in Mlbs/hr.
      XPLNT = NPLNT
      PFLOW = COALIN / XPLNT
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           Set the number of lines in the first page of the report.
            LINES = 54
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 DCL02.REP to contain
C           this user block summary report.
            OPEN (UNIT=62, FILE='DCL02.REP', STATUS='UNKNOWN',
```

```
     1         ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2         BUFFERED='BUFFERED')
            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' )
        ENDIF
      ENDIF
C
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  UIN1N, ULTOUT, UIN2N)
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     If this is the report pass and the plant sumamry report is being
C     written to a separate file, start a new page.
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 2 )  THEN
        IF ( INT(2) .EQ. 0 )   THEN
C           Set the number of lines in the second page of the report.
            LINES = 51
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
            WRITE (NOUT, 800)
        ENDIF
      ENDIF
C
C     Call Subroutine USR02S to distribute the net yields from plant 2
C     into the six product streams.
      CALL USR02S (ICNAME, INT(1), IPASS, ITEMS, KMAXC, KOMPS,
     1  KTEST, MODE, NCC, NCCONV, NCONV, NHSTRY, NNCC, NOUT, SIN2,
     2  SOUT1, SOUT2, SOUT3, SOUT4, SOUT5, SOUT6, ULTOUT)
C
C     If this is the report pass and the plant sumamry report is being
C     written to a separate file, start a new page.
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 2 )  THEN
        IF ( INT(2) .EQ. 0 )  THEN
C           Calculate the number of lines in third page of the report.
            LSTRM = 23
            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
            LUTIL = 16
            LCOST = 11
            NDUP = REAL(58) + 0.001D0
```

```
            IF ( (NPLNT + NDUP) .EQ. 1 )  LCOST = 9
            IF ( PFLOW .LT. PMINF )  LCOST = LCOST + 3
            IF ( PFLOW .GT .PMAXF )  LCOST = LCOST + 3
            IF ( NDUP .GE. 1 )  LCOST = LCOST + 1
            LINES = LSTRM + LUTIL + LCOST
C           Now, subtract the number of lines for those portions of
C           the user block summary report which will not be written.
            IF ( INT(1) .GE. 2 )   LINES = LINES - LUTIL
            IF ( INT(1) .GE. 1 )   LINES = LINES - LCOST
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
            WRITE (NOUT, 800)
        ENDIF
C
C       Load the overall stream properties in the ST1 and ST2 arrays.
C
C       Load the total stream flow rates in Mlbs/hr.
C       CF is the conversion factor from Kg/sec to Mlbs/hr.
        CF = 0.001D0 * 3600.0D0 / 0.45359237D0
        J = NCONV + NNCC + 1
        ST1(1,1) = CF * (SIN1(NCC+1)*SIN1(NCC+9) + SIN1(J))
        ST1(2,1) = CF * (SIN2(NCC+1)*SIN2(NCC+9) + SIN2(J))
        ST1(3,1) = CF * (SIN3(NCC+1)*SIN3(NCC+9) + SIN3(J))
        ST1(4,1) = CF * (SIN4(NCC+1)*SIN4(NCC+9) + SIN4(J))
        ST1(5,1) = CF * (SIN5(NCC+1)*SIN5(NCC+9) + SIN5(J))
        ST2(1,1) = CF * (SOUT1(NCC+1)*SOUT1(NCC+9) + SOUT1(J))
        ST2(2,1) = CF * (SOUT2(NCC+1)*SOUT2(NCC+9) + SOUT2(J))
        ST2(3,1) = CF * (SOUT3(NCC+1)*SOUT3(NCC+9) + SOUT3(J))
        ST2(4,1) = CF * (SOUT4(NCC+1)*SOUT4(NCC+9) + SOUT4(J))
        ST2(5,1) = CF * (SOUT5(NCC+1)*SOUT5(NCC+9) + SOUT5(J))
        ST2(6,1) = CF * (SOUT6(NCC+1)*SOUT6(NCC+9) + SOUT6(J))
C
C       Load the stream temperatures in degrees Fahrenheit.
        X = 1.8D0
        X1 = 459.67D0
        ST1(1,2) = X * SIN1(NCC+2) - X1
        ST1(2,2) = X * SIN2(NCC+2) - X1
        ST1(3,2) = X * SIN3(NCC+2) - X1
        ST1(4,2) = X * SIN4(NCC+2) - X1
        ST1(5,2) = X * SIN5(NCC+2) - X1
        ST2(1,2) = X * SOUT1(NCC+2) - X1
        ST2(2,2) = X * SOUT2(NCC+2) - X1
        ST2(3,2) = X * SOUT3(NCC+2) - X1
        ST2(4,2) = X * SOUT4(NCC+2) - X1
        ST2(5,2) = X * SOUT5(NCC+2) - X1
        ST2(6,2) = X * SOUT6(NCC+2) - X1
C
C       Load the stream pressures in PSIA.
        X = 1.0D0 / 6.8947573D+3
        ST1(1,3) = X * SIN1(NCC+3)
        ST1(2,3) = X * SIN2(NCC+3)
        ST1(3,3) = X * SIN3(NCC+3)
        ST1(4,3) = X * SIN4(NCC+3)
```

```
          ST1(5,3) = X * SIN5(NCC+3)
          ST2(1,3) = X * SOUT1(NCC+3)
          ST2(2,3) = X * SOUT2(NCC+3)
          ST2(3,3) = X * SOUT3(NCC+3)
          ST2(4,3) = X * SOUT4(NCC+3)
          ST2(5,3) = X * SOUT5(NCC+3)
          ST2(6,3) = X * SOUT6(NCC+3)
C
C         Load the vapor stream flow rates in MM SCF/hr.
          ST1(1,4) = CF * SIN1(NCC+1) * 379.495D-3
          ST2(1,4) = CF * SOUT1(NCC+1) * 379.495D-3
          ST2(2,4) = CF * SOUT2(NCC+1) * 379.495D-3
C
C         Call Subroutine USR02Z to write the overall material balance
C         and any warning messages.
          CALL USR02Z (IER1, IER2, IER3, IER4, INT(1), IPASS, MODE, NOUT)
C
        ENDIF
C
C       Call subroutine USRUCO to calculate, save and report the
C       utilities, capital and operating costs for the plant.
        ID = 2
        KUNITS = 3
        CALL USRUCO (NHSTRY, NOUT, IPASS, ID, PNAME, INT(1), INT(3),
     1  KTEST, REAL(21), COALIN, KUNITS)
C
C       If requested and this is the baseline design case, write the
C       major equipment summary list.
        IF (INT(5) .GE. 1 .AND. MODE .EQ. 1)  THEN
C         This report only can be written to the separate output report
C         file only when other parts of the report are being written.
C         Check to see if these conditions are met.
          IF (IPASS.EQ.4 .AND. INT(1).LE.2 .AND. INT(2).GE.1)  THEN
C           Set up the flow rates for the various plant sections.
            FLOW(1) = PFLOW
            FLOW(2) = PFLOW
            FLOW(3) = PFLOW
            FLOW(4) = PFLOW
            FLOW(5) = PFLOW
            FLOW(6) = PFLOW
            FLOW(7) = PFLOW
C           Call subroutine USR2ES to write the equipment summary list.
            CALL USR2ES (NOUT, FLOW)
          ENDIF
        ENDIF
C
C       If requested and this is the baseline design case, write the
C       cost summary report by plant section.
        IF (INT(5) .GE. 1 .AND. MODE .EQ. 1)  THEN
C         This report only can be written to the separate output report
C         file only when the capital cost portion of the summary report
C         is being wriiten.
C         Check to see if these conditions are met.
          IF (IPASS.EQ.4 .AND. INT(1).LE.0 .AND. INT(2).GE.1)  THEN
C           Call subroutine USR2CS to write the cost summary report.
```

```
          CALL USR2CS (NOUT)
        ENDIF
      ENDIF
C
C     Call subroutine USR31T to check to insure that the Utilities
C     summary table output is correct.
C     IF ( IPASS .EQ. 4 .AND. INT(2) .EQ. 1 )  THEN
C       WRITE (NOUT, 800)
C       CALL USR31T (NHSTRY, NOUT, IPASS, INT(1), INT(2), KTEST)
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 USR02' )
C
C
      RETURN
      END
C
C$ USR02A
      SUBROUTINE USR02A (KTEST, NCC, NHSTRY)
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 - October 7, 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 /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5)
C
C     In COMMON /USR02M/
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
      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
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)
          IF ( STDVOL .NE. 0.0D0 )  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     The following elemental compositions for the Baseline design case
C     were taken from the  Aug. 20, 1990 letter to S. N. Habash from
C     A. Basu and A. B. Schachtschneider.  The 850+ F components were
C     estimated.
C     Load the C6+ component sulfur contents in wt%.
      CPROP(18,5) = 0.01D0
      CPROP(19,5) = 0.01D0
      CPROP(20,5) = 0.01D0
      CPROP(21,5) = 0.01D0
      CPROP(22,5) = 0.01D0
      CPROP(23,5) = 0.01D0
      CPROP(24,5) = 0.01D0
      CPROP(25,5) = 0.02D0
      CPROP(26,5) = 0.02D0
      CPROP(27,5) = 0.02D0
      CPROP(28,5) = 0.02D0
      CPROP(29,5) = 0.06D0
      CPROP(30,5) = 0.06D0
      CPROP(31,5) = 0.06D0
      CPROP(32,5) = 0.06D0
```

```
      CPROP(33,5) = 0.10D0
      CPROP(34,5) = 0.15D0
      CPROP(35,5) = 0.20D0
      CPROP(36,5) = 0.50D0
      CPROP(37,5) = 0.50D0
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     If mode equals 18, load the High Space Velocity Factors.
C     The following elemental compositions were developed from the
C     June 30, 1992 FAX from A. Basu to S. Poddar.  The 850+ F
C     components were estimated.
      IF ( MODE .EQ. 18 )  THEN
C       Load the C6+ component sulfur contents in wt%.
        CPROP(18,5) = 0.04D0
        CPROP(19,5) = 0.04D0
        CPROP(20,5) = 0.04D0
        CPROP(21,5) = 0.04D0
        CPROP(22,5) = 0.04D0
        CPROP(23,5) = 0.03D0
        CPROP(24,5) = 0.03D0
        CPROP(25,5) = 0.02D0
        CPROP(26,5) = 0.02D0
        CPROP(27,5) = 0.02D0
        CPROP(28,5) = 0.02D0
        CPROP(29,5) = 0.02D0
        CPROP(30,5) = 0.02D0
        CPROP(31,5) = 0.02D0
        CPROP(32,5) = 0.02D0
        CPROP(33,5) = 0.10D0
        CPROP(34,5) = 0.15D0
        CPROP(35,5) = 0.20D0
        CPROP(36,5) = 1.50D0
        CPROP(37,5) = 1.50D0
C
C       Load the C6+ component nitrogen contents in wt%.
        CPROP(18,6) = 0.03D0
        CPROP(19,6) = 0.03D0
        CPROP(20,6) = 0.03D0
        CPROP(21,6) = 0.03D0
        CPROP(22,6) = 0.03D0
        CPROP(23,6) = 0.20D0
        CPROP(24,6) = 0.20D0
        CPROP(25,6) = 0.35D0
        CPROP(26,6) = 0.35D0
        CPROP(27,6) = 0.35D0
```

```
      CPROP(28,6) = 0.35D0
      CPROP(29,6) = 0.38D0
      CPROP(30,6) = 0.38D0
      CPROP(31,6) = 0.38D0
      CPROP(32,6) = 0.38D0
      CPROP(33,6) = 0.40D0
      CPROP(34,6) = 0.45D0
      CPROP(35,6) = 0.50D0
      CPROP(36,6) = 1.20D0
      CPROP(37,6) = 1.20D0
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) = 0.55D0
      CPROP(24,7) = 0.55D0
      CPROP(25,7) = 0.50D0
      CPROP(26,7) = 0.50D0
      CPROP(27,7) = 0.50D0
      CPROP(28,7) = 0.50D0
      CPROP(29,7) = 0.65D0
      CPROP(30,7) = 0.65D0
      CPROP(31,7) = 0.65D0
      CPROP(32,7) = 0.65D0
      CPROP(33,7) = 0.70D0
      CPROP(34,7) = 0.75D0
      CPROP(35,7) = 0.80D0
      CPROP(36,7) = 3.30D0
      CPROP(37,7) = 3.30D0
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) = 11.03D0
      CPROP(26,4) = 11.03D0
      CPROP(27,4) = 11.03D0
      CPROP(28,4) = 11.03D0
      CPROP(29,4) = 10.00D0
      CPROP(30,4) = 10.00D0
      CPROP(31,4) = 10.00D0
      CPROP(32,4) = 10.00D0
      CPROP(33,4) = 9.90D0
      CPROP(34,4) = 9.80D0
      CPROP(35,4) = 9.70D0
      CPROP(36,4) = 5.50D0
      CPROP(37,4) = 5.50D0
    ENDIF
```

```
C
C     Calculate the C6+ component carbon contents in wt% by 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
C
C     If this is the Thermal/Catalytic two-reactor yields case, reset
C     the T1000+ component properties to the appropriate values.
      IF ( MODE .EQ. 13 )  THEN
        CPROP(36,3) = 89.5D0
        CPROP(36,4) = 8.0D0
        CPROP(36,5) = 1.0D0
        CPROP(36,6) = 0.75D0
        CPROP(36,7) = 0.75D0
      ENDIF
C
C     If this is the COKER two-reactor yields case, reset the T1000+
C     component properties to the appropriate values.
      IF ( MODE .EQ. 15 )  THEN
        CPROP(36,3) = 88.0D0
        CPROP(36,4) = 5.5D0
        CPROP(36,5) = 1.5D0
        CPROP(36,6) = 1.2D0
        CPROP(36,7) = 3.8D0
      ENDIF
C
C
      RETURN
      END
C
C$ USR02B
      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 - June 30, 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 /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5)
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
          EINC(K)  = EINC(K)  + CIN(J)  * CPROP(J,L)
          EOUTC(K) = EOUTC(K) + COUT(J) * CPROP(J,L)
   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$ USR02R
      SUBROUTINE USR02R (CONMAF, CONVSN, ICNAME, IER1, IER2, IER3, IER4,
     1  INT1, IPASS, KMAXC, KOMPS, KTEST, MODE, NHSTRY, NOUT,
```

```
     2  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 - October 7, 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 - Baseline design yields.
C                 1 => Called by subroutine USR02, the block model for
C                      Plant 2 - Baseline design yields.
C                 2 => Called by subroutine USR2R, the detailed model for
C                      both Plant 2 coal liquefaction reactors - Base-
C                      line design yields.
C                 3 => Called by subroutine USRR1, the detailed model for
C                      the first Plant 2 coal liquefaction reactor -
C                      Baseline design first reactor yields.
C                 4 => Called by subroutine USRR2, the detailed model for
C                      the second Plant 2 coal liquefaction reactor -
C                      THIS OPTION IS NOT YET AVAILABLE.
C                 13 => Called by subroutine USR02, the block model for
C                       the Plant 2 Thermal/Catalytic Option yields.
C                 15 => Called by subroutine USR02, the block model for
C                       Plant 2 - COKER Option yields.
C                 18 => Called by subroutine USR02, the block model for
C                       The Plant 2 HIGH SPACE VELOCITY OPTION.
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)
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 YFC0(J), YFH0(J),
C       YFS0(J), YFN0(J) and YFO0(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     * For the two reactor coker yields model, the YFCC(J), YFHC(J),
C       YFSC(J), YFNC(J) and YFOC(J) factors were developed from Vol.3
```

```
C       of the Bechtel Topical report for Task III at 92.79 conversion
C       and adjusted to 100% fresh MAF coal conversion.
C     * For the two reactor High Space Velocity Yields model, the
C       YFCH(J), YFHH(J), YFSH(J), YFNH(J) and YFOH(J) factors were
C       developed from the Poddar to Schachtschneider letter of Sept 2,
C       1992, at 92.0 conversion and adjusted to 100% fresh MAF coal
C       conversion.
C     * For the two reactor Thermal/Catalytic yields model, the YFCT(J),
C       YFHT(J), YFST(J), YFNT(J) and YFOT(J) factors were developed
C       from Vol.3 of the Bechtel Topical report for Task III at 92.79
C       conversion and adjusted to 100% fresh MAF coal 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     * For the two reactor coker yields model, the YFUCC(J) factors
C       were developed from data at 92.79 fresh MAF coal conversion.
C     * For the two reactor high space velocity yields model, the
C       YFUCH(J) factors were developed from data at 92.0 fresh MAF
C       coal conversion.
C     * For the two reactor Thermal/catalytic yields model, the YFUCT(J)
C       factors developed from data at 92.79 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),
     3  YFCC(50), YFHC(50), YFNC(50), YFOC(50), YFSC(50), YFUCC(5),
     4  YFCH(50), YFHH(50), YFNH(50), YFOH(50), YFSH(50), YFUCH(5),
     5  YFCT(50), YFHT(50), YFNT(50), YFOT(50), YFST(50), YFUCT(5)
C
      DIMENSION CPROD(50), ENAME(5), EYLD(50,5), SUME(5), UANAME(8),
     1  WTEIN(5), WTUOUT(7), XYF(20,5)
C
      CHARACTER * 4  BLANK4, ICNAME
      CHARACTER * 8  ENAME, UANAME
C
      DATA BLANK4 / '    ' /
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 following factors are based on the yields in the August 20,
C     1990 and October 9, 1990 letters to S. N. Habash from  A. B.
C     Schachtschneider and A. Basu.  These yields are consistent with
C     the HRI report received by Bechtel on Jan. 21, 1991.  The iC5/NC5
C     split was assumed to be the same as the IC4/NC4 split.  The
C     properties of the 850+ F material were estimated based on the data
C     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
C     FIRST REACTOR ELEMENTAL YIELD FACTORS.
C     -------------------------------------
C     The following factors are based on the yields in the August 20,
C     1990 and October 9, 1990 letters to S. N. Habash from  A. B.
C     Schachtschneider and A. Basu.  The iC5/NC5 split was assumed to
C     be the same as the IC4/NC4 split.  The properties of the 850+ F
C     material were estimated based on the 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
C     OVERALL TWO REACTOR COKER ELEMENTAL YIELD FACTORS.
C     -------------------------------------------------
C     The following factors are based on the yields in Volume 3 of the
C     Task II Topical report of March 1992.
C
C     Carbon.
C     Wt fraction to  H2     N2         O2         H2S        CO
      DATA YFCC /    0.0 , 0.000000 , 0.000000 , 0.0000000, 0.0002876,
C       CO2        NH3        H2O        HCL        COS
     1  0.0004393, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       CH4        C2H6       C3H8       IC4H10     N C4H10
     2  0.0161693, 0.0133954, 0.0146881, 0.0011088, 0.0055440,
C       IC5H12     N C5H12    T125       T175       T225
     3  0.0003722, 0.0018609, 0.0278569, 0.0278569, 0.0278569,
C       T275       T325       T375       T425       T475
     4  0.0278569, 0.0278569, 0.0333425, 0.0333425, 0.0899665,
C       T525       T575       T625       T675       T725
     5  0.0899665, 0.0899665, 0.0899665, 0.0171655, 0.0171655,
C       T775       T825       T875       T925       T975
     6  0.0171655, 0.0171655, 0.0000000, 0.0000000, 0.0000000,
C       T1000+     I1000+     Future     Future     Future
     7  0.3116369, 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 YFHC /-0.051730, 0.000000 , 0.000000 , 0.0142794, 0.0000000,
```

```
C        CO2        NH3        H2O        HCL        COS
      1  0.0000000, 0.0209016, 0.0918766, 0.0000000, 0.0000000,
C        CH4        C2H6       C3H8       IC4H10     N C4H10
      2  0.0400265, 0.0248698, 0.0242398, 0.0017155, 0.0085774,
C        IC5H12     N C5H12    T125       T175       T225
      3  0.0005528, 0.0027640, 0.0343007, 0.0343007, 0.0343007,
C        T275       T325       T375       T425       T475
      4  0.0343007, 0.0343007, 0.0344047, 0.0344047, 0.0823819,
C        T525       T575       T625       T675       T725
      5  0.0823819, 0.0823819, 0.0823819, 0.0141782, 0.0141782,
C        T775       T825       T875       T925       T975
      6  0.0141782, 0.0141782, 0.0000000, 0.0000000, 0.0000000,
C        T1000+     I1000+     Future     Future     Future
      7  0.1436433, 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 YFSC / 0.000000, 0.000000 , 0.000000 , 0.8493051, 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, 0.0000903, 0.0000903, 0.0000903,
C        T275       T325       T375       T425       T475
      4  0.0000903, 0.0000903, 0.0001058, 0.0001058, 0.0005627,
C        T525       T575       T625       T675       T725
      5  0.0005627, 0.0005627, 0.0005627, 0.0003191, 0.0003191,
C        T775       T825       T875       T925       T975
      6  0.0003191, 0.0003191, 0.0000000, 0.0000000, 0.0000000,
C        T1000+     I1000+     Future     Future     Future
      7  0.1465046, 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 YFNC / 0.000000, 0.000000 , 0.000000 , 0.0000000, 0.0000000,
C        CO2        NH3        H2O        HCL        COS
      1  0.0000000, 0.6902347, 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, 0.0029253, 0.0029253, 0.0029253,
C        T275       T325       T375       T425       T475
      4  0.0029253, 0.0029253, 0.0044374, 0.0044374, 0.0128721,
C        T525       T575       T625       T675       T725
      5  0.0128721, 0.0128721, 0.0128721, 0.0028386, 0.0028386,
C        T775       T825       T875       T925       T975
```

```
     6  0.0028386, 0.0028386, 0.0000000, 0.0000000, 0.0000000,
C       T1000+     I1000+     Future     Future     Future
     7  0.2234212, 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 YFOC / 0.000000, 0.000000 , 0.000000 , 0.0000000, 0.0032409,
C       CO2        NH3        H2O        HCL        COS
     1  0.0099009, 0.0000000, 0.8364691, 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, 0.0013844, 0.0013844, 0.0013844,
C       T275       T325       T375       T425       T475
     4  0.0013844, 0.0013844, 0.0022718, 0.0022718, 0.0051779,
C       T525       T575       T625       T675       T725
     5  0.0051779, 0.0051779, 0.0051779, 0.0010929, 0.0010929,
C       T775       T825       T875       T925       T975
     6  0.0010929, 0.0010929, 0.0000000, 0.0000000, 0.0000000,
C       T1000+     I1000+     Future     Future     Future
     7  0.1138403, 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 YFUCC  / 0.0711101, 0.0111050, 0.2522040, 0.1221595,
C                    O
     1              0.0308581 /
C
C
C     OVERALL HIGH SPACE TWO REACTOR VELOCITY ELEMENTAL YIELD FACTORS.
C     ---------------------------------------------------------------
C     The following factors are based on the yields in letter from
C     Task II Topical report of March 1992.
C
C     Carbon.
C     Wt fraction to  H2     N2         O2         H2S        CO
      DATA YFCH /    0.0 , 0.000000 , 0.000000 , 0.0000000, 0.0005834,
C       CO2        NH3        H2O        HCL        COS
     1  0.0007426, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       CH4        C2H6       C3H8       IC4H10     N C4H10
     2  0.0203708, 0.0202040, 0.0200432, 0.0022490, 0.0097833,
C       IC5H12     N C5H12    T125       T175       T225
     3  0.0004233, 0.0018414, 0.0338530, 0.0338530, 0.0338530,
C       T275       T325       T375       T425       T475
     4  0.0338530, 0.0338530, 0.0429930, 0.0429930, 0.1029717,
```

```
C       T525       T575       T625       T675       T725
     5  0.1029717, 0.1029717, 0.1029717, 0.0416726, 0.0416726,
C       T775       T825       T875       T925       T975
     6  0.0416726, 0.0416726, 0.0025398, 0.0026592, 0.0025369,
C       T1000+     I1000+     Future     Future     Future
     7  0.0821951, 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 YFHH /-0.068478, 0.000000 , 0.000000 , 0.0152459, 0.0000000,
C       CO2        NH3        H2O        HCL        COS
     1  0.0000000, 0.0215605, 0.0905209, 0.0000000, 0.0000000,
C       CH4        C2H6       C3H8       IC4H10     N C4H10
     2  0.0439099, 0.0326628, 0.0288026, 0.0030299, 0.0131801,
C       IC5H12     N C5H12    T125       T175       T225
     3  0.0005475, 0.0023815, 0.0362499, 0.0362499, 0.0362499,
C       T275       T325       T375       T425       T475
     4  0.0362499, 0.0362499, 0.0385629, 0.0385629, 0.0827893,
C       T525       T575       T625       T675       T725
     5  0.0827893, 0.0827893, 0.0827893, 0.0300858, 0.0300858,
C       T775       T825       T875       T925       T975
     6  0.0300858, 0.0300858, 0.0018163, 0.0018836, 0.0017796,
C       T1000+     I1000+     Future     Future     Future
     7  0.0328036, 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 YFSH / 0.000000, 0.000000 , 0.000000 , 0.9582216, 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, 0.0004032, 0.0004032, 0.0004032,
C       T275       T325       T375       T425       T475
     4  0.0004032, 0.0004032, 0.0003760, 0.0003760, 0.0005932,
C       T525       T575       T625       T675       T725
     5  0.0005932, 0.0005932, 0.0005932, 0.0002378, 0.0002378,
C       T775       T825       T875       T925       T975
     6  0.0002378, 0.0002378, 0.0000725, 0.0001139, 0.0001450,
C       T1000+     I1000+     Future     Future     Future
     7  0.0353547, 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 YFNH / 0.000000, 0.000000 , 0.000000 , 0.0000000, 0.0000000,
C       CO2         NH3         H2O         HCL         COS
     1  0.0000000, 0.8053383, 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, 0.0006171, 0.0006171, 0.0006171,
C       T275        T325        T375        T425        T475
     4  0.0006171, 0.0006171, 0.0051143, 0.0051143, 0.0211831,
C       T525        T575        T625        T675        T725
     5  0.0211831, 0.0211831, 0.0211831, 0.0092187, 0.0092187,
C       T775        T825        T875        T925        T975
     6  0.0092187, 0.0092187, 0.0005917, 0.0006974, 0.0007397,
C       T1000+      I1000+      Future      Future      Future
     7  0.0577117, 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 YFOH / 0.000000, 0.000000 , 0.000000 , 0.0000000, 0.0063250,
C       CO2         NH3         H2O         HCL         COS
     1  0.0161023, 0.0000000, 0.9106473, 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, 0.0016167, 0.0016167, 0.0016167,
C       T275        T325        T375        T425        T475
     4  0.0016167, 0.0016167, 0.0022108, 0.0022108, 0.0047568,
C       T525        T575        T625        T675        T725
     5  0.0047568, 0.0047568, 0.0047568, 0.0024787, 0.0024787,
C       T775        T825        T875        T925        T975
     6  0.0024787, 0.0024787, 0.0001628, 0.0001827, 0.0001860,
C       T1000+      I1000+      Future      Future      Future
     7  0.0249470, 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 92.0 conversion.
C     Weight fraction of element in the fresh MAF coal going to URCOAL
C     (unconverted coal) for the base MAF coal at 92.0 conversion.
C                    C           H           S           N
      DATA YFUCH  / 0.0840885, 0.0234989, 0.1986652, 0.1211761,
C                    O
     1              0.0068383 /
C
C
C     OVERALL TWO REACTOR THERMAL/CATALYTIC ELEMENTAL YIELD FACTORS.
C     ------------------------------------------------------------
```

```
C     The following factors are based on the yields in Volume 3 of the
C     Task II Topical report of March 1992.
C
C     Carbon.
C     Wt fraction to  H2      N2          O2          H2S         CO
      DATA YFCT /    0.0 , 0.000000 , 0.000000 , 0.0000000, 0.0004080,
C       CO2         NH3         H2O         HCL         COS
     1  0.0005935, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       CH4         C2H6        C3H8        IC4H10      N C4H10
     2  0.0273753, 0.0226951, 0.0246578, 0.0013483, 0.0075278,
C       IC5H12      N C5H12     T125        T175        T225
     3  0.0002750, 0.0015353, 0.0285745, 0.0285745, 0.0285745,
C       T275        T325        T375        T425        T475
     4  0.0285745, 0.0285745, 0.0372710, 0.0372710, 0.0648811,
C       T525        T575        T625        T675        T725
     5  0.0648811, 0.0648811, 0.0648812, 0.0542690, 0.0542690,
C       T775        T825        T875        T925        T975
     6  0.0542690, 0.0542690, 0.0201550, 0.0201527, 0.0201384,
C       T1000+      I1000+      Future      Future      Future
     7  0.1591228, 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 YFHT /-0.066818, 0.000000 , 0.000000 , 0.0172785, 0.0000000,
C       CO2         NH3         H2O         HCL         COS
     1  0.0000000, 0.0253082, 0.0930568, 0.0000000, 0.0000000,
C       CH4         C2H6        C3H8        IC4H10      N C4H10
     2  0.0591173, 0.0367578, 0.0354992, 0.0018197, 0.0101602,
C       IC5H12      N C5H12     T125        T175        T225
     3  0.0003563, 0.0019893, 0.0306938, 0.0306938, 0.0306938,
C       T275        T325        T375        T425        T475
     4  0.0306938, 0.0306938, 0.0335500, 0.0335500, 0.0518288,
C       T525        T575        T625        T675        T725
     5  0.0518288, 0.0518288, 0.0518288, 0.0391036, 0.0391036,
C       T775        T825        T875        T925        T975
     6  0.0391036, 0.0391036, 0.0144321, 0.0142863, 0.0141321,
C       T1000+      I1000+      Future      Future      Future
     7  0.0915076, 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 YFST / 0.000000, 0.000000 , 0.000000 , 0.9529185, 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, 0.0000749, 0.0000749, 0.0000749,
C       T275       T325       T375       T425       T475
     4  0.0000749, 0.0000749, 0.0000957, 0.0000957, 0.0003283,
C       T525       T575       T625       T675       T725
     5  0.0003283, 0.0003283, 0.0003283, 0.0008160, 0.0008160,
C       T775       T825       T875       T925       T975
     6  0.0008160, 0.0008160, 0.0005055, 0.0007583, 0.0010104,
C       T1000+     I1000+     Future     Future     Future
     7  0.0396643, 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 YFNT / 0.000000, 0.000000 , 0.000000 , 0.0000000, 0.0000000,
C       CO2        NH3        H2O        HCL        COS
     1  0.0000000, 0.8400966, 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, 0.0026313, 0.0026313, 0.0026313,
C       T275       T325       T375       T425       T475
     4  0.0026313, 0.0026313, 0.0043496, 0.0043496, 0.0081403,
C       T525       T575       T625       T675       T725
     5  0.0081403, 0.0081403, 0.0081403, 0.0078696, 0.0078696,
C       T775       T825       T875       T925       T975
     6  0.0078696, 0.0078696, 0.0036562, 0.0041786, 0.0046981,
C       T1000+     I1000+     Future     Future     Future
     7  0.0614752, 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 YFOT / 0.000000, 0.000000 , 0.000000 , 0.0000000, 0.0043978,
C       CO2        NH3        H2O        HCL        COS
     1  0.0127954, 0.0000000, 0.9289541, 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, 0.0013584, 0.0013584, 0.0013584,
C       T275       T325       T375       T425       T475
     4  0.0013584, 0.0013584, 0.0024291, 0.0024291, 0.0035719,
C       T525       T575       T625       T675       T725
     5  0.0035719, 0.0035719, 0.0035719, 0.0033051, 0.0033051,
C       T775       T825       T875       T925       T975
     6  0.0033051, 0.0033051, 0.0012835, 0.0013018, 0.0013193,
C       T1000+     I1000+     Future     Future     Future
     7  0.0107899, 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 YFUCT  / 0.0833053, 0.0160707, 0.0876770, 0.0120754,
C                   O
     1              0.0001258 /
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 USR02R.' /
     2  3X, 'MODE =', I3 )
C
C     Load the appropriate element yield distribution factors into the
C     working element yield distribution factors loacations.
C
C       Load the Baseline Overall Two Reactor Yield Factors.
        DO 4 J = 1, 50
          YFC(J) = YFC0(J)
          YFH(J) = YFH0(J)
          YFS(J) = YFS0(J)
          YFN(J) = YFN0(J)
          YFO(J) = YFO0(J)
    4   CONTINUE
        DO 5 J = 1, 5
          YFUC(J) = YFUC0(J)
    5   CONTINUE
C
C     Load the Baseline First Reactor Yield Factors.
      IF ( MODE .EQ. 3 )   THEN
        DO 6 J = 1, 50
          YFC(J) = YFC1(J)
          YFH(J) = YFH1(J)
          YFS(J) = YFS1(J)
          YFN(J) = YFN1(J)
          YFO(J) = YFO1(J)
    6   CONTINUE
        DO 7  J = 1, 5
          YFUC(J) = YFUC1(J)
    7   CONTINUE
      ENDIF
C
C     Load the Thermal/Catalytic Overall Two Reactor Yield Factors.
      IF ( MODE .EQ. 13 )   THEN
```

```
          DO 8 J = 1, 50
            YFC(J) = YFCT(J)
            YFH(J) = YFHT(J)
            YFS(J) = YFST(J)
            YFN(J) = YFNT(J)
            YFO(J) = YFOT(J)
      8   CONTINUE
          DO 9  J = 1, 5
            YFUC(J) = YFUCT(J)
      9   CONTINUE
        ENDIF
C
C       Load the COKER Overall Two Reactor Yield Factors.
        IF ( MODE .EQ. 15 )   THEN
          DO 12 J = 1, 50
            YFC(J) = YFCC(J)
            YFH(J) = YFHC(J)
            YFS(J) = YFSC(J)
            YFN(J) = YFNC(J)
            YFO(J) = YFOC(J)
     12   CONTINUE
          DO 13  J = 1, 5
            YFUC(J) = YFUCC(J)
     13   CONTINUE
        ENDIF
C
C       Load the Overall HIGH SPACE VELOCITY Two Reactor Yield Factors.
        IF ( MODE .EQ. 18 )   THEN
          DO 14 J = 1, 50
            YFC(J) = YFCH(J)
            YFH(J) = YFHH(J)
            YFS(J) = YFSH(J)
            YFN(J) = YFNH(J)
            YFO(J) = YFOH(J)
     14   CONTINUE
          DO 15  J = 1, 5
            YFUC(J) = YFUCH(J)
     15   CONTINUE
        ENDIF
C
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' )
          SUME(1) = -YFC(1)
          SUME(2) = -YFH(1)
          SUME(3) = -YFS(1)
          SUME(4) = -YFN(1)
          SUME(5) = -YFO(1)
          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 )
          SUME(1) = SUME(1) + YFC(J)
          SUME(2) = SUME(2) + YFH(J)
          SUME(3) = SUME(3) + YFS(J)
          SUME(4) = SUME(4) + YFN(J)
          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
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.
      WTCONV = 0.01 * CONMAF * TOTMAF
      WTUC = TOTMAF - WTCONV
C
      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.
      WTEIN(2) = WTEIN(2) - WTCONV * YFH(1)
```

```
      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     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     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(10,5) 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)
        DO 62 K = 1, 5
          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
        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
          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.
      CPROD(1) = WTCONV * YFH(1)
      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.
      CPROD(47) = CPROD(47) + 0.01D0 * CIN(46) * UFCOAL(1)
C
C
C     Calculate the Ultimate analysis of the soild URCOAL that is
C     produced by the reaction of the fresh coal.
      WTUOUT(1) = 0.01D0 * CIN(46) * UFCOAL(1)
      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
      SUM = 0.0D0
      DO 120 J = 1, 7
        SUM = SUM + WTUOUT(J)
```

```
     1  KTEST, MODE, NCC, NCCONV, NCONV, NHSTRY, NNCC, NOUT, SIN2,
     2  SOUT1, SOUT2, SOUT3, SOUT4, SOUT5, SOUT6, ULTOUT)
C
C     This subroutine splits the net yields produced by the coal
C     liquefaction plant, into the six product streams by a very simple
C     model, and loads them in the SOUT1 through SOUT6 vectors.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - October 8, 1992.
C
C     Method of calculation:
C       1.  The net yields are split into the six net product streams
C           using component distribution factors for the last five
C           product streams.
C           Stream 1 - the high pressure gas stream goint to plant 6.1
C           Stream 2 - the low pressure gas stream going to plant 6.2
C           Stream 3 - the naphtha stream
C           Stream 4 - the gas-oil hydrotreater feed stream
C           Stream 5 - the ROSE-SR unit feed stream
C           Stream 6 - the sour water stream
C       2.  All remaining material is placed in the first net product
C           stream, the high pressure gas stream going to plant 6.1
C
C     Calling arguments:
C     ICNAME() = Vector of component identifications (CHARACTER * 4)
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     ITEMS    = Total number of items in the SOUT1 - SOUT5 vectors.
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 distribution factors
C                are to be used.
C                1  => Use the Baseline design distribution factors.
C                13 => Use the Thermal/Catalytic option distribution
C                      factors.
C                15 => Use the Coker option distribution factors.
C                18 => Use the High Space Velocity option distribution
C                      factors.
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     NOUT     = Logical unit number of the plant output report file.
C     SIN2()   = ASPEN/SP stream vector for inlet stream nunber 2 -
```

```
C                 the fresh wet coal stream.
C     SOUT1()  = ASPEN/SP stream vector for outlet stream number 1 -
C                the high pressure gas stream going to plant 6.1.
C     SOUT2()  = ASPEN/SP stream vector for outlet stream number 2 -
C                the low pressure gas stream going to plant 6.2.
C     SOUT3()  = ASPEN/SP stream vector for outlet stream number 3 -
C                the naphtha stream.
C     SOUT4()  = ASPEN/SP stream vector for outlet stream number 4 -
C                the gas-oil hydrotreater feed stream.
C     SOUT5()  = ASPEN/SP stream vector for outlet stream number 5 -
C                the bottoms strean going to the ROSE-SR unit.
C     SOUT6()  = ASPEN/SP stream vector for outlet stream number 6 -
C                the sour water stream.
C     ULTOUT() = Ultimate analysis of the URCOAL (unconverted coal and
C                ash) leaving the ROSE-SR unit.
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)
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(*), SIN2(*),
     1  SOUT1(*), SOUT2(*), SOUT3(*), SOUT4(*), SOUT5(*), SOUT6(*)
C
C     Local variable declarations.
C
C     CDF2(J) are the component distribution factors for stream 2.
C     CDF3(J) are the component distribution factors for stream 3.
C     CDF4(J) are the component distribution factors for stream 4.
C     CDF5(J) are the component distribution factors for stream 5.
C     CDF6(J) are the component distribution factors for stream 6.
      DIMENSION CDF2(50), CDF3(50), CDF4(50), CDF5(50), CDF6(50),
     1  CDF2B(50), CDF3B(50), CDF4B(50), CDF5B(50), CDF6B(50),
     2  CDF2C(50), CDF3C(50), CDF4C(50), CDF5C(50), CDF6C(50),
     3  CDF2H(50), CDF3H(50), CDF4H(50), CDF5H(50), CDF6H(50),
     4  CDF2T(50), CDF3T(50), CDF4T(50), CDF5T(50), CDF6T(50)
C
      DIMENSION S1(50), S2(50), S3(50), S4(50), S5(50), S6(50)
C
      CHARACTER * 4  BLANK4, ICNAME
C
      DATA BLANK4 / '    ' /
C
C
C     BASELINE DESIGN COMPONENT DISTRIBUTION FACTORS.
C     ===============================================
C
C     The following component distribution factors were calculated in
```

```
C     Lotus spreadsheed P2B.WK1 on 9/20/91 based on the data in the
C     Bechtel draft of the Task II topical report of August, 1991.
C
C     Initialize the component distribution factors for stream 2,
C     the low pressure gas stream going to plant 6.2.
C     Fraction of   H2       N2        O2        H2S       CO
      DATA CDF2B/ 0.207095, 0.300341, 0.000000, 0.282904, 0.300518,
C       CO2       NH3       H2O       HCL       COS
     1  0.226629, 0.011406, 0.003231, 0.000000, 0.000000,
C       CH4       C2H6      C3H8      IC4H10    N C4H10
     2  0.409831, 0.544966, 0.673329, 0.508097, 0.854749,
C       IC5H12    N C5H12   T125      T175      T225
     3  0.056075, 0.125000, 0.131202, 0.131202, 0.131202,
C       T275      T325      T375      T425      T475
     4  0.131202, 0.131202, 0.002849, 0.002849, 0.000078,
C       T525      T575      T625      T675      T725
     5  0.000078, 0.000078, 0.000078, 0.000000, 0.000000,
C       T775      T825      T875      T925      T975
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T1000+    I1000+    Future    Future    Future
     7  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Future    Future    Future    Future    Future
     8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Coal      URCOAL    Slag      Future    OTHERS
     9  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for stream 3,
C     the naphtha stream.
C     Fraction of   H2       N2        O2        H2S       CO
      DATA CDF3B/ 0.000000, 0.000000, 0.000000, 0.003186, 0.000000,
C       CO2       NH3       H2O       HCL       COS
     1  0.000000, 0.000000, 0.001624, 0.000000, 1.000000,
C       CH4       C2H6      C3H8      IC4H10    N C4H10
     2  0.000326, 0.006040, 0.034644, 0.287449, 0.111732,
C       IC5H12    N C5H12   T125      T175      T225
     3  0.373832, 0.806818, 0.839433, 0.839433, 0.839433,
C       T275      T325      T375      T425      T475
     4  0.839433, 0.839433, 0.033295, 0.033295, 0.000000,
C       T525      T575      T625      T675      T725
     5  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T775      T825      T875      T925      T975
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T1000+    I1000+    Future    Future    Future
     7  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Future    Future    Future    Future    Future
     8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Coal      URCOAL    Slag      Future    OTHERS
     9  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for stream 4,
C     the gas-oil hydrotreater feed stream.
C     Fraction of   H2       N2        O2        H2S       CO
      DATA CDF4B/ 0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CO2       NH3       H2O       HCL       COS
     1  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
```

```
C        CH4       C2H6      C3H8      IC4H10    N C4H10
      2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        IC5H12    N C5H12   T125      T175      T225
      3  0.000000, 0.000000, 0.027186, 0.027186, 0.027186,
C        T275      T325      T375      T425      T475
      4  0.027186, 0.027186, 0.836745, 0.836745, 0.988084,
C        T525      T575      T625      T675      T725
      5  0.988084, 0.988084, 0.988084, 0.998592, 0.998592,
C        T775      T825      T875      T925      T975
      6  0.998592, 0.998592, 0.000000, 0.000000, 0.000000,
C        T1000+    I1000+    Future    Future    Future
      7  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        Future    Future    Future    Future    Future
      8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        Coal      URCOAL    Slag      Future    OTHERS
      9  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for stream 5,
C     the bottoms stream going to the ROSE-SR unit.
C     Fraction of   H2       N2        O2        H2S       CO
      DATA CDF5B/ 0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        CO2       NH3       H2O       HCL       COS
      1  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        CH4       C2H6      C3H8      IC4H10    N C4H10
      2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        IC5H12    N C5H12   T125      T175      T225
      3  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        T275      T325      T375      T425      T475
      4  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        T525      T575      T625      T675      T725
      5  0.000000, 0.000000, 0.000000, 0.001408, 0.001408,
C        T775      T825      T875      T925      T975
      6  0.001408, 0.001408, 1.000000, 1.000000, 1.000000,
C        T1000+    I1000+    Future    Future    Future
      7  1.000000, 1.000000, 0.000000, 0.000000, 0.000000,
C        Future    Future    Future    Future    Future
      8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        Coal      URCOAL    Slag      Future    OTHERS
      9  1.000000, 1.000000, 1.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for stream 6,
C     the sour water stream.
C     Fraction of   H2       N2        O2        H2S       CO
      DATA CDF6B/ 0.000000, 0.000000, 0.000000, 0.433777, 0.000000,
C        CO2       NH3       H2O       HCL       COS
      1  0.283286, 0.850870, 0.994119, 0.000000, 0.000000,
C        CH4       C2H6      C3H8      IC4H10    N C4H10
      2  0.000163, 0.000000, 0.000000, 0.000000, 0.000000,
C        IC5H12    N C5H12   T125      T175      T225
      3  0.000000, 0.000000, 0.002179, 0.002179, 0.002179,
C        T275      T325      T375      T425      T475
      4  0.002179, 0.002179, 0.127111, 0.127111, 0.011838,
C        T525      T575      T625      T675      T725
      5  0.011838, 0.011838, 0.011838, 0.000000, 0.000000,
C        T775      T825      T875      T925      T975
```

```
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T1000+    I1000+    Future    Future    Future
     7  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Future    Future    Future    Future    Future
     8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Coal      URCOAL    Slag      Future    OTHERS
     9  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C
C     COKER OPTION COMPONENT DISTRIBUTION FACTORS.
C     ============================================
C
C     Initialize the component distribution factors for stream 2,
C     the low pressure gas stream going to plant 6.2.
C     Fraction of   H2        N2        O2        H2S       CO
      DATA CDF2C/ 0.252995, 0.300412, 0.000000, 0.281377, 0.305882,
C       CO2       NH3       H2O       HCL       COS
     1  0.069307, 0.011326, 0.004003, 0.000000, 0.000000,
C       CH4       C2H6      C3H8      IC4H10    N C4H10
     2  0.415679, 0.594765, 0.703327, 0.787115, 0.787115,
C       IC5H12    N C5H12   T125      T175      T225
     3  0.133681, 0.133681, 0.133681, 0.133681, 0.133681,
C       T275      T325      T375      T425      T475
     4  0.133681, 0.133681, 0.032978, 0.032978, 0.000000,
C       T525      T575      T625      T675      T725
     5  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T775      T825      T875      T925      T975
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T1000+    I1000+    Future    Future    Future
     7  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Future    Future    Future    Future    Future
     8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Coal      URCOAL    Slag      Future    OTHERS
     9  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for stream 3,
C     the naphtha stream.
C     Fraction of   H2        N2        O2        H2S       CO
      DATA CDF3C/ 0.000000, 0.000000, 0.000000, 0.002923, 0.000000,
C       CO2       NH3       H2O       HCL       COS
     1  0.000000, 0.000000, 0.001548, 0.000000, 1.000000,
C       CH4       C2H6      C3H8      IC4H10    N C4H10
     2  0.000354, 0.005286, 0.029791, 0.147339, 0.147339,
C       IC5H12    N C5H12   T125      T175      T225
     3  0.837192, 0.837192, 0.837192, 0.837192, 0.837192,
C       T275      T325      T375      T425      T475
     4  0.837192, 0.837192, 0.033601, 0.033601, 0.000000,
C       T525      T575      T625      T675      T725
     5  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T775      T825      T875      T925      T975
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T1000+    I1000+    Future    Future    Future
     7  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Future    Future    Future    Future    Future
     8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
```

```
C        Coal       URCOAL     Slag       Future     OTHERS
      9  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C      Initialize the component distribution factors for stream 4,
C      the gas-oil hydrotreater feed stream.
C      Fraction of   H2        N2         O2         H2S        CO
       DATA CDF4C/ 0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        CO2        NH3        H2O        HCL        COS
      1  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        CH4        C2H6       C3H8       IC4H10     N C4H10
      2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        IC5H12     N C5H12    T125       T175       T225
      3  0.024262, 0.024262, 0.024262, 0.024262, 0.024262,
C        T275       T325       T375       T425       T475
      4  0.024262, 0.024262, 0.766523, 0.766523, 0.980070,
C        T525       T575       T625       T675       T725
      5  0.980070, 0.980070, 0.980070, 0.980070, 0.980070,
C        T775       T825       T875       T925       T975
      6  0.980070, 0.980070, 0.000000, 0.000000, 0.000000,
C        T1000+     I1000+     Future     Future     Future
      7  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        Future     Future     Future     Future     Future
      8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        Coal       URCOAL     Slag       Future     OTHERS
      9  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C      Initialize the component distribution factors for stream 5,
C      the bottoms stream going to the coker unit.
C      Fraction of   H2        N2         O2         H2S        CO
       DATA CDF5C/ 0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        CO2        NH3        H2O        HCL        COS
      1  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        CH4        C2H6       C3H8       IC4H10     N C4H10
      2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        IC5H12     N C5H12    T125       T175       T225
      3  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        T275       T325       T375       T425       T475
      4  0.000000, 0.000000, 0.000000, 0.000000, 0.011614,
C        T525       T575       T625       T675       T725
      5  0.011614, 0.011614, 0.011614, 0.011614, 0.011614,
C        T775       T825       T875       T925       T975
      6  0.011614, 0.011614, 1.000000, 1.000000, 1.000000,
C        T1000+     I1000+     Future     Future     Future
      7  1.000000, 1.000000, 0.000000, 0.000000, 0.000000,
C        Future     Future     Future     Future     Future
      8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C        Coal       URCOAL     Slag       Future     OTHERS
      9  1.000000, 1.000000, 1.000000, 0.000000, 0.000000 /
C
C      Initialize the component distribution factors for stream 6,
C      the sour water stream.
C      Fraction of   H2        N2         O2         H2S        CO
       DATA CDF6C/ 0.000000, 0.000000, 0.000000, 0.433674, 0.000000,
C        CO2        NH3        H2O        HCL        COS
      1  0.247525, 0.850100, 0.993207, 0.000000, 0.000000,
```

```
C        CH4        C2H6       C3H8       IC4H10     N C4H10
     2   0.000177,  0.000000,  0.000000,  0.000000,  0.000000,
C        IC5H12     N C5H12    T125       T175       T225
     3   0.002798,  0.002798,  0.002798,  0.002798,  0.002798,
C        T275       T325       T375       T425       T475
     4   0.002798,  0.002798,  0.166898,  0.166898,  0.008316,
C        T525       T575       T625       T675       T725
     5   0.008316,  0.008316,  0.008316,  0.008316,  0.008316,
C        T775       T825       T875       T925       T975
     6   0.008316,  0.008316,  0.000000,  0.000000,  0.000000,
C        T1000+     I1000+     Future     Future     Future
     7   0.000000,  0.000000,  0.000000,  0.000000,  0.000000,
C        Future     Future     Future     Future     Future
     8   0.000000,  0.000000,  0.000000,  0.000000,  0.000000,
C        Coal       URCOAL     Slag       Future     OTHERS
     9   0.000000,  0.000000,  0.000000,  0.000000,  0.000000 /
C
C
C     HIGH SPACE VELOCITY OPTION COMPONENT DISTRIBUTION FACTORS.
C     ==========================================================
C
C     Initialize the component distribution factors for stream 2,
C     the low pressure gas stream going to plant 6.2.
C     Fraction of   H2         N2         O2         H2S        CO
      DATA CDF2H/ 0.413895,  0.391534,  0.000000,  0.164070,  0.400955,
C        CO2        NH3        H2O        HCL        COS
     1   0.097384,  0.014020,  0.005855,  0.000000,  0.000000,
C        CH4        C2H6       C3H8       IC4H10     N C4H10
     2   0.524751,  0.704708,  0.784618,  0.792705,  0.792705,
C        IC5H12     N C5H12    T125       T175       T225
     3   0.201902,  0.201902,  0.201902,  0.201902,  0.201902,
C        T275       T325       T375       T425       T475
     4   0.201902,  0.201902,  0.005048,  0.005048,  0.001583,
C        T525       T575       T625       T675       T725
     5   0.001583,  0.001583,  0.001583,  0.000042,  0.000042,
C        T775       T825       T875       T925       T975
     6   0.000042,  0.000042,  0.000000,  0.000000,  0.000000,
C        T1000+     I1000+     Future     Future     Future
     7   0.000000,  0.000000,  0.000000,  0.000000,  0.000000,
C        Future     Future     Future     Future     Future
     8   0.000000,  0.000000,  0.000000,  0.000000,  0.000000,
C        Coal       URCOAL     Slag       Future     OTHERS
     9   0.000000,  0.000000,  0.000000,  0.000000,  0.000000 /
C
C     Initialize the component distribution factors for stream 3,
C     the naphtha stream.
C     Fraction of   H2         N2         O2         H2S        CO
      DATA CDF3H/ 0.000000,  0.000000,  0.000000,  0.003155,  0.000000,
C        CO2        NH3        H2O        HCL        COS
     1   0.000000,  0.001674,  0.000061,  0.000000,  1.000000,
C        CH4        C2H6       C3H8       IC4H10     N C4H10
     2   0.000243,  0.003566,  0.025688,  0.094726,  0.094726,
C        IC5H12     N C5H12    T125       T175       T225
     3   0.754550,  0.754550,  0.754550,  0.754550,  0.754550,
C        T275       T325       T375       T425       T475
```

```
     4  0.754550, 0.754550, 0.018268, 0.018268, 0.000000,
C       T525      T575      T625      T675      T725
     5  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T775      T825      T875      T925      T975
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T1000+    I1000+    Future    Future    Future
     7  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Future    Future    Future    Future    Future
     8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Coal      URCOAL    Slag      Future    OTHERS
     9  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for stream 4,
C     the gas-oil hydrotreater feed stream.
C     Fraction of   H2        N2        O2        H2S       CO
      DATA CDF4H/ 0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CO2       NH3       H2O       HCL       COS
     1  0.000000, 0.000000, 0.000241, 0.000000, 0.000000,
C       CH4       C2H6      C3H8      IC4H10    N C4H10
     2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       IC5H12    N C5H12   T125      T175      T225
     3  0.029867, 0.029867, 0.029867, 0.029867, 0.029867,
C       T275      T325      T375      T425      T475
     4  0.029867, 0.029867, 0.976403, 0.976403, 0.989674,
C       T525      T575      T625      T675      T725
     5  0.989674, 0.989674, 0.989674, 0.992996, 0.992996,
C       T775      T825      T875      T925      T975
     6  0.992996, 0.992996, 0.084377, 0.084377, 0.084377,
C       T1000+    I1000+    Future    Future    Future
     7  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Future    Future    Future    Future    Future
     8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Coal      URCOAL    Slag      Future    OTHERS
     9  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for stream 5,
C     the combined 850-1000 F and bottoms stream going to the
C     gasifier and ROSE units. This stream will be further split
C     into two streams outside this model.
C     Fraction of   H2        N2        O2        H2S       CO
      DATA CDF5H/ 0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CO2       NH3       H2O       HCL       COS
     1  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CH4       C2H6      C3H8      IC4H10    N C4H10
     2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       IC5H12    N C5H12   T125      T175      T225
     3  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T275      T325      T375      T425      T475
     4  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T525      T575      T625      T675      T725
     5  0.000000, 0.000000, 0.000000, 0.006962, 0.006962,
C       T775      T825      T875      T925      T975
     6  0.006962, 0.006962, 0.915623, 0.915623, 0.915623,
C       T1000+    I1000+    Future    Future    Future
     7  1.000000, 1.000000, 0.000000, 0.000000, 0.000000,
```

```
C        Future     Future     Future     Future     Future
     8   0.000000,  0.000000,  0.000000,  0.000000,  0.000000,
C        Coal       URCOAL     Slag       Future     OTHERS
     9   1.000000,  1.000000,  1.000000,  0.000000,  0.000000 /
C
C     Initialize the component distribution factors for stream 6,
C     the sour water stream.
C     Fraction of   H2        N2         O2         H2S        CO
      DATA CDF6H/ 0.000456,  0.000000,  0.000000,  0.786235,  0.000000,
C        CO2        NH3        H2O        HCL        COS
     1   0.866279,  0.984097,  0.993785,  0.000000,  0.000000,
C        CH4        C2H6       C3H8       IC4H10     N C4H10
     2   0.001092,  0.000856,  0.000152,  0.000000,  0.000000,
C        IC5H12     N C5H12    T125       T175       T225
     3   0.000000,  0.000000,  0.000000,  0.000000,  0.000000,
C        T275       T325       T375       T425       T475
     4   0.000000,  0.000000,  0.000000,  0.000000,  0.008726,
C        T525       T575       T625       T675       T725
     5   0.008726,  0.008726,  0.008726,  0.000000,  0.000000,
C        T775       T825       T875       T925       T975
     6   0.000000,  0.000000,  0.000000,  0.000000,  0.000000,
C        T1000+     I1000+     Future     Future     Future
     7   0.000000,  0.000000,  0.000000,  0.000000,  0.000000,
C        Future     Future     Future     Future     Future
     8   0.000000,  0.000000,  0.000000,  0.000000,  0.000000,
C        Coal       URCOAL     Slag       Future     OTHERS
     9   0.000000,  0.000000,  0.000000,  0.000000,  0.000000 /
C
C
C     THERMAL/CATALYTIC OPTION COMPONENT DISTRIBUTION FACTORS.
C     ========================================================
C
C     Initialize the component distribution factors for stream 2,
C     the low pressure gas stream going to plant 6.2.
C     Fraction of   H2        N2         O2         H2S        CO
      DATA CDF2T/ 0.252903,  0.298057,  0.000000,  0.282179,  0.301282,
C        CO2        NH3        H2O        HCL        COS
     1   0.069444,  0.011572,  0.004523,  0.000000,  0.000000,
C        CH4        C2H6       C3H8       IC4H10     N C4H10
     2   0.415878,  0.596664,  0.713742,  0.814557,  0.814557,
C        IC5H12     N C5H12    T125       T175       T225
     3   0.128015,  0.128015,  0.128015,  0.128015,  0.128015,
C        T275       T325       T375       T425       T475
     4   0.128015,  0.128015,  0.032970,  0.032970,  0.000000,
C        T525       T575       T625       T675       T725
     5   0.000000,  0.000000,  0.000000,  0.000000,  0.000000,
C        T775       T825       T875       T925       T975
     6   0.000000,  0.000000,  0.000000,  0.000000,  0.000000,
C        T1000+     I1000+     Future     Future     Future
     7   0.000000,  0.000000,  0.000000,  0.000000,  0.000000,
C        Future     Future     Future     Future     Future
     8   0.000000,  0.000000,  0.000000,  0.000000,  0.000000,
C        Coal       URCOAL     Slag       Future     OTHERS
     9   0.000000,  0.000000,  0.000000,  0.000000,  0.000000 /
C
```

```
C     Initialize the component distribution factors for stream 3,
C     the naphtha stream.
C     Fraction of   H2        N2        O2        H2S       CO
      DATA CDF3T/ 0.000000, 0.000000, 0.000000, 0.002159, 0.000000,
C       CO2       NH3       H2O       HCL       COS
     1  0.000000, 0.000000, 0.001258, 0.000000, 1.000000,
C       CH4       C2H6      C3H8      IC4H10    N C4H10
     2  0.000166, 0.003428, 0.019472, 0.120253, 0.120253,
C       IC5H12    N C5H12   T125      T175      T225
     3  0.838104, 0.838104, 0.838104, 0.838104, 0.838104,
C       T275      T325      T375      T425      T475
     4  0.838104, 0.838104, 0.030772, 0.030772, 0.000000,
C       T525      T575      T625      T675      T725
     5  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T775      T825      T875      T925      T975
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T1000+    I1000+    Future    Future    Future
     7  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Future    Future    Future    Future    Future
     8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Coal      URCOAL    Slag      Future    OTHERS
     9  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for stream 4,
C     the gas-oil hydrotreater feed stream.
C     Fraction of   H2        N2        O2        H2S       CO
      DATA CDF4T/ 0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CO2       NH3       H2O       HCL       COS
     1  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CH4       C2H6      C3H8      IC4H10    N C4H10
     2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       IC5H12    N C5H12   T125      T175      T225
     3  0.029022, 0.029022, 0.029022, 0.029022, 0.029022,
C       T275      T325      T375      T425      T475
     4  0.029022, 0.029022, 0.784948, 0.784948, 0.986110,
C       T525      T575      T625      T675      T725
     5  0.986110, 0.986110, 0.986110, 0.994078, 0.994078,
C       T775      T825      T875      T925      T975
     6  0.994078, 0.994078, 0.000000, 0.000000, 0.000000,
C       T1000+    I1000+    Future    Future    Future
     7  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Future    Future    Future    Future    Future
     8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Coal      URCOAL    Slag      Future    OTHERS
     9  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for stream 5,
C     the combined 850-1000 F and bottoms stream going to the
C     gasifier and ROSE units. This stream will be further split
C     into two streams outside this model.
C     Fraction of   H2        N2        O2        H2S       CO
      DATA CDF5T/ 0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CO2       NH3       H2O       HCL       COS
     1  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CH4       C2H6      C3H8      IC4H10    N C4H10
```

```
     2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       IC5H12    N C5H12   T125      T175      T225
     3  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T275      T325      T375      T425      T475
     4  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T525      T575      T625      T675      T725
     5  0.000000, 0.000000, 0.000000, 0.005922, 0.005922,
C       T775      T825      T875      T925      T975
     6  0.005922, 0.005922, 1.000000, 1.000000, 1.000000,
C       T1000+    I1000+    Future    Future    Future
     7  1.000000, 1.000000, 0.000000, 0.000000, 0.000000,
C       Future    Future    Future    Future    Future
     8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Coal      URCOAL    Slag      Future    OTHERS
     9  1.000000, 1.000000, 1.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for stream 6,
C     the sour water stream.
C     Fraction of   H2       N2        O2        H2S       CO
      DATA CDF6T/ 0.000000, 0.000000, 0.000000, 0.433649, 0.000000,
C       CO2       NH3       H2O       HCL       COS
     1  0.246528, 0.849898, 0.992815, 0.000000, 0.000000,
C       CH4       C2H6      C3H8      IC4H10    N C4H10
     2  0.000166, 0.000000, 0.000000, 0.000000, 0.000000,
C       IC5H12    N C5H12   T125      T175      T225
     3  0.002783, 0.002783, 0.002783, 0.002783, 0.002783,
C       T275      T325      T375      T425      T475
     4  0.002783, 0.002783, 0.151310, 0.151310, 0.013890,
C       T525      T575      T625      T675      T725
     5  0.013890, 0.013890, 0.013890, 0.000000, 0.000000,
C       T775      T825      T875      T925      T975
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T1000+    I1000+    Future    Future    Future
     7  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Future    Future    Future    Future    Future
     8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Coal      URCOAL    Slag      Future    OTHERS
     9  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C
C
      IF ( KTEST .GE. 2 )   WRITE (NHSTRY, 501)  MODE
  501 FORMAT ( / ' Starting the product separation calculations ',
     1  'in Subroutine USR02S' / 2X, 'MODE =', I5 )
C
C     Load the appropriate set of component distribution factors.
C     Baseline case distribution factors.
      DO 2 J = 1, 50
        CDF2(J) = CDF2B(J)
        CDF3(J) = CDF3B(J)
        CDF4(J) = CDF4B(J)
        CDF5(J) = CDF5B(J)
        CDF6(J) = CDF6B(J)
    2 CONTINUE
C
```

```
C     Thermal/Catalytic option component distribution factors.
      IF ( MODE .EQ. 13 )  THEN
        DO 4 J = 1, 50
          CDF2(J) = CDF2T(J)
          CDF3(J) = CDF3T(J)
          CDF4(J) = CDF4T(J)
          CDF5(J) = CDF5T(J)
          CDF6(J) = CDF6T(J)
    4   CONTINUE
      ENDIF
C
C     COKER option component distribution factors.
      IF ( MODE .EQ. 15 )  THEN
        DO 6 J = 1, 50
          CDF2(J) = CDF2C(J)
          CDF3(J) = CDF3C(J)
          CDF4(J) = CDF4C(J)
          CDF5(J) = CDF5C(J)
          CDF6(J) = CDF6C(J)
    6   CONTINUE
      ENDIF
C
C     HIGH SPACE VELOCITY option component distribution factors.
      IF ( MODE .EQ. 18 )  THEN
        DO 8 J = 1, 50
          CDF2(J) = CDF2H(J)
          CDF3(J) = CDF3H(J)
          CDF4(J) = CDF4H(J)
          CDF5(J) = CDF5H(J)
          CDF6(J) = CDF6H(J)
    8   CONTINUE
      ENDIF
C
      IF ( KTEST .GE. 2 )   THEN
        WRITE (NHSTRY, 502)
  502   FORMAT ( / ' The component product distribution factors:' /
     1    ' No.', 3X, 'Component', 3X, 'Gas to 6.1',
     2    3X, 'Gas to 6.2', 6X, 'Naphtha', 6X, 'Gas-oil', 6X,
     3    'Bottoms',5X, 'Sour H2O' )
        DO 12 J = 1, KMAXC
          K = 2 * J - 1
          IF ( ICNAME(K) .NE. BLANK4 )  THEN
            X = 1.0D0 - CDF2(J) - CDF3(J) - CDF4(J) - CDF5(J) - CDF6(J)
            WRITE (NHSTRY, 503)  J, ICNAME(K), ICNAME(K+1), X,
     1        CDF2(J), CDF3(J), CDF4(J), CDF5(J), CDF6(J)
  503       FORMAT ( 1X, I3, 3X, 2A4, 1X, 6F13.6 )
          ENDIF
   12   CONTINUE
        WRITE (NHSTRY, 504)
  504   FORMAT ( ' The distribution factors for the gas to plant 6.1 ',
     1    'are calculated by difference.' )
      ENDIF
C
C     Zero the component flow rates in the six net product streams.
      DO 20 J = 1, KMAXC
```

```
          S1(J) = 0.0D0
          S2(J) = 0.0D0
          S3(J) = 0.0D0
          S4(J) = 0.0D0
          S5(J) = 0.0D0
          S6(J) = 0.0D0
   20 CONTINUE
C
C     Distribute the net unit yields among the six product streams.
      SUMC = 0.0D0
      SUM1 = 0.0D0
      SUM2 = 0.0D0
      SUM3 = 0.0D0
      SUM4 = 0.0D0
      SUM5 = 0.0D0
      SUM6 = 0.0D0
      DO 30 J = 1, KMAXC
        IF ( ICNAME(2*J-1) .NE. BLANK4 )  THEN
          X = CDF2(J) + CDF3(J) + CDF4(J) + CDF5(J) + CDF6(J)
          IF ( X .GT. 1.000001D0 )  THEN
C           The component distributions factors for this component are
C           greater than 1.0.  Therefore, adjust the distribution so
C           that this component is distributed in the same ratio as the
C           specified component distribution factors, and write a
C           warning message.
            IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 505) IPASS
  505       FORMAT ( // 1X, 'Plant 2 - Supplementary data',
     1        ' from subroutine USR02' /
     2        2X, 'Coal Liquefaction plant', 20X, 'IPASS =', I3 /)
            WRITE (NHSTRY, 506)  J, ICNAME(2*J-1), ICNAME(2*J),
     1        CDF2(J), CDF3(J), CDF4(J), CDF5(J), CDF6(J)
  506       FORMAT ( / 1X, '* WARNING * - The component product ',
     1        'distribution factors for component no.', I3 /
     2        3X, 2A4, ' sum to a total greater than 1.0.  They are' /,
     3        3X, 5F10.6, '  They will be normalized to 1.0' //
     4        3X, 'Please correct this problem in the next run.  ',
     5        'Execution is continuing.' / )
            CDF2(J) = CDF2(J) / X
            CDF3(J) = CDF3(J) / X
            CDF4(J) = CDF4(J) / X
            CDF5(J) = CDF5(J) / X
            CDF6(J) = CDF6(J) / X
          ENDIF
          CMLBS = 0.001D0 * COUT(J)
          S2(J) = CDF2(J) * CMLBS
          S3(J) = CDF3(J) * CMLBS
          S4(J) = CDF4(J) * CMLBS
          S5(J) = CDF5(J) * CMLBS
          S6(J) = CDF6(J) * CMLBS
          S1(J) = CMLBS - S2(J) - S3(J) - S4(J) - S5(J) - S6(J)
          SUMC = SUMC + CMLBS
          SUM1 = SUM1 + S1(J)
          SUM2 = SUM2 + S2(J)
          SUM3 = SUM3 + S3(J)
          SUM4 = SUM4 + S4(J)
```

```
          SUM5 = SUM5 + S5(J)
          SUM6 = SUM6 + S6(J)
        ENDIF
   30 CONTINUE
C
      IF ( KTEST .GE. 3 )   THEN
        WRITE (NHSTRY, 507)
  507   FORMAT ( / ' Total net stream flows leaving plant 2, ',
     1    'in Mlbs/hr:' /
     2    ' No.', 3X, 'Component', 5X, 'Total', 2X,
     3    'Gas to P6.1', 2X, 'Gas to P6.2', 1X, 'Naphtha', 4X,
     4    'Gas-oil', 4X, 'Bottoms', 3X, 'Sour H2O' )
        DO 40 J = 1, KMAXC
          K = 2 * J - 1
          IF ( ICNAME(K) .NE. BLANK4 )  THEN
            CMLBS = 0.001D0 * COUT(J)
            WRITE (NHSTRY, 508)  J, ICNAME(K), ICNAME(K+1), CMLBS,
     1        S1(J), S2(J), S3(J), S4(J), S5(J), S6(J)
  508       FORMAT ( 1X, I3, 3X, 2A4, 7F11.3 )
          ENDIF
   40   CONTINUE
        WRITE (NHSTRY, 509)  SUMC, SUM1, SUM2, SUM3, SUM4, SUM5, SUM6
  509   FORMAT ( 1X, 'Total', 9X, 7F11.3 )
      ENDIF
C
      IF ( IPASS .EQ. 4 .AND. INT1 .LE. 0 )  THEN
C
C       Write the output report.
C       ========================
        WRITE (NOUT, 801)
  801   FORMAT ( / 21X, 'PLANT 2 - SUMMARY REPORT (CONTINUED)'
     1    / 28X, 'COAL LIQUEFACTION PLANT')
C
        WRITE (NOUT, 802)
  802   FORMAT ( / ' OUTLET STREAMS, MLBS/HR')
C
C       Write the net outlet stream flow rates in Mlbs/hr.
        WRITE (NOUT, 803)
  803   FORMAT ( / 4X, 'COMPONENT', 5X, 'H2 GAS', 5X, 'LO P GAS',
     1    5X, 'NAPHTHA', 5X, 'GAS-OIL', 5X, 'BOTTOMS' )
        DO 110 J = 1, KMAXC
          K = 2 * J - 1
          IF ( ICNAME(K) .NE. BLANK4 )  THEN
            WRITE (NOUT, 804) ICNAME(K), ICNAME(K+1), S1(J), S2(J),
     1        S3(J), S4(J), S5(J)
  804       FORMAT ( 4X, 2A4, 5F12.3 )
          ENDIF
  110   CONTINUE
        WRITE (NOUT, 805) SUM1, SUM2, SUM3, SUM4, SUM5
  805   FORMAT ( 4X, 'TOTAL', 3X, 5F12.3 )
C
        WRITE (NOUT, 806)
  806   FORMAT ( / 25X, '- CONTINUED ON NEXT PAGE -' )
      ENDIF
C
```

```
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 vectors.
        DO 200 J = 1, NCCONV
          SOUT1(J) = 0.0D0
          SOUT2(J) = 0.0D0
          SOUT3(J) = 0.0D0
          SOUT4(J) = 0.0D0
          SOUT5(J) = 0.0D0
          SOUT6(J) = 0.0D0
  200   CONTINUE
C
C       CF is the conversion factor from Kg/sec to Mlbs/hr.
        CF = 0.001D0 * 3600.0D0 / 0.45359237D0
C
C       Set the molar flow rates of the conventional components.
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        SUM4 = 0.0D0
        SUM5 = 0.0D0
        SUM6 = 0.0D0
        DO 210 J = 1, NCC
          DO 208 K = 1, KOMPS
            IF ( J .EQ. ICNUMB(K) )  THEN
              SOUT1(J) = S1(K) / (CF * CPROP(K,1))
              SOUT2(J) = S2(K) / (CF * CPROP(K,1))
              SOUT3(J) = S3(K) / (CF * CPROP(K,1))
              SOUT4(J) = S4(K) / (CF * CPROP(K,1))
              SOUT5(J) = S5(K) / (CF * CPROP(K,1))
              SOUT6(J) = S6(K) / (CF * CPROP(K,1))
              SUM1 = SUM1 + SOUT1(J)
              SUM2 = SUM2 + SOUT2(J)
              SUM3 = SUM3 + SOUT3(J)
              SUM4 = SUM4 + SOUT4(J)
              SUM5 = SUM5 + SOUT5(J)
              SUM6 = SUM6 + SOUT6(J)
              GO TO 210
            ENDIF
  208     CONTINUE
  210   CONTINUE
C
C       Set the total molar flow rates of the conventional components.
        SOUT1(NCC+1) = SUM1
        SOUT2(NCC+1) = SUM2
        SOUT3(NCC+1) = SUM3
        SOUT4(NCC+1) = SUM4
        SOUT5(NCC+1) = SUM5
        SOUT6(NCC+1) = SUM6
C
C       Set the mass flow rates of the non-conventional components.
        SUM1 = 0.0D0
        SUM2 = 0.0D0
```

```
      SUM3 = 0.0D0
      SUM4 = 0.0D0
      SUM5 = 0.0D0
      SUM6 = 0.0D0
      DO 220 J = 1, 3
        SOUT1(NCONV+J) = S1(J+45) / CF
        SOUT2(NCONV+J) = S2(J+45) / CF
        SOUT3(NCONV+J) = S3(J+45) / CF
        SOUT4(NCONV+J) = S4(J+45) / CF
        SOUT5(NCONV+J) = S5(J+45) / CF
        SOUT6(NCONV+J) = S6(J+45) / CF
        SUM1 = SUM1 + SOUT1(NCONV+J)
        SUM2 = SUM2 + SOUT2(NCONV+J)
        SUM3 = SUM3 + SOUT3(NCONV+J)
        SUM4 = SUM4 + SOUT4(NCONV+J)
        SUM5 = SUM5 + SOUT5(NCONV+J)
        SUM6 = SUM6 + SOUT6(NCONV+J)
  220 CONTINUE
C
C     Set the total mass flow rates of the non-conventionals.
      SOUT1(NCONV+NNCC+1) = SUM1
      SOUT2(NCONV+NNCC+1) = SUM2
      SOUT3(NCONV+NNCC+1) = SUM3
      SOUT4(NCONV+NNCC+1) = SUM4
      SOUT5(NCONV+NNCC+1) = SUM5
      SOUT6(NCONV+NNCC+1) = SUM6
C
C     Set the default temperature and pressure of the outlet streams
C     to 70 F and 15 PSIA.  Return these values to ASPEN/SP in degrees
C     Kelvin and Pascals.  These default values can be overriden by
C     the FLASH-SPECS sentence in the ASPEN/SP input file.
      SOUT1(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT1(NCC+3) = 15.0D0 * 6.8947573D+3
      SOUT1(NCONV+NNCC+2) = SOUT1(NCC+2)
      SOUT1(NCONV+NNCC+3) = SOUT1(NCC+3)
      SOUT2(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT2(NCC+3) = 15.0D0 * 6.8947573D+3
      SOUT2(NCONV+NNCC+2) = SOUT2(NCC+2)
      SOUT2(NCONV+NNCC+3) = SOUT2(NCC+3)
      SOUT3(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT3(NCC+3) = 15.0D0 * 6.8947573D+3
      SOUT3(NCONV+NNCC+2) = SOUT3(NCC+2)
      SOUT3(NCONV+NNCC+3) = SOUT3(NCC+3)
      SOUT4(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT4(NCC+3) = 15.0D0 * 6.8947573D+3
      SOUT4(NCONV+NNCC+2) = SOUT4(NCC+2)
      SOUT4(NCONV+NNCC+3) = SOUT4(NCC+3)
      SOUT5(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT5(NCC+3) = 15.0D0 * 6.8947573D+3
      SOUT5(NCONV+NNCC+2) = SOUT5(NCC+2)
      SOUT5(NCONV+NNCC+3) = SOUT5(NCC+3)
      SOUT6(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT6(NCC+3) = 15.0D0 * 6.8947573D+3
      SOUT6(NCONV+NNCC+2) = SOUT6(NCC+2)
      SOUT6(NCONV+NNCC+3) = SOUT6(NCC+3)
```

```
C
      SOUT1(NCONV+NNCC+9) = 1.0D0
      SOUT2(NCONV+NNCC+9) = 1.0D0
      SOUT3(NCONV+NNCC+9) = 1.0D0
      SOUT4(NCONV+NNCC+9) = 1.0D0
      SOUT5(NCONV+NNCC+9) = 1.0D0
      SOUT6(NCONV+NNCC+9) = 1.0D0
C
C     Set the Ultiminate analysis of the unconveted 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)) * SIN2(NCCONV+2) /
     1  (SIN2(NCCONV+2) + SIN2(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 = SIN2(NCCONV+12) + SIN2(NCCONV+13) + SIN2(NCCONV+14)
      X1 = SOUT1(NCCONV+34) * SIN2(NCCONV+12) / X
      X2 = SOUT1(NCCONV+34) * SIN2(NCCONV+13) / X
      X3 = SOUT1(NCCONV+34) * SIN2(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) = SIN2(J + N2)
  240 CONTINUE
C
C     Copy the URCOAL properties from the first  outlet strean to
C     all the others.
      DO 250 J = 25, 48
        SOUT2(J+NCCONV) = SOUT1(J+NCCONV)
        SOUT3(J+NCCONV) = SOUT1(J+NCCONV)
        SOUT4(J+NCCONV) = SOUT1(J+NCCONV)
```

```
          SOUT5(J+NCCONV) = SOUT1(J+NCCONV)
          SOUT6(J+NCCONV) = SOUT1(J+NCCONV)
  250   CONTINUE
C
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)
        CALL CPACK (SOUT2, NCP, IDX, XPACK, TMASS)
        SOUT2(NCC+9) = AVEMW (NCP, IDX, XPACK)
        CALL CPACK (SOUT3, NCP, IDX, XPACK, TMASS)
        SOUT3(NCC+9) = AVEMW (NCP, IDX, XPACK)
        CALL CPACK (SOUT4, NCP, IDX, XPACK, TMASS)
        SOUT4(NCC+9) = AVEMW (NCP, IDX, XPACK)
        CALL CPACK (SOUT5, NCP, IDX, XPACK, TMASS)
        SOUT5(NCC+9) = AVEMW (NCP, IDX, XPACK)
        CALL CPACK (SOUT6, NCP, IDX, XPACK, TMASS)
        SOUT6(NCC+9) = AVEMW (NCP, IDX, XPACK)
C
C       If requested, write the items of interest in the outlet stream
C       vectors to the history file.
        IF ( KTEST .GE. 5 )  THEN
          WRITE (NHSTRY, 531)
  531     FORMAT ( // ' The outlet stream vectors' /
     1      14X, 'SOUT1', 10X, 'SOUT2', 10X, 'SOUT3', 10X, 'SOUT4',
     2      10X, 'SOUT5', 10X, 'SOUT6' )
          DO 290 J = 1, ITEMS
            WRITE (NHSTRY, 532) J, SOUT1(J), SOUT2(J), SOUT3(J),
     1        SOUT4(J), SOUT5(J), SOUT6(J)
  532       FORMAT ( 2X, I5, 6(1PE15.5) )
  290     CONTINUE
        ENDIF
C
      ENDIF
C
      RETURN
      END
C
C$ USR02Z
      SUBROUTINE USR02Z (IER1, IER2, IER3, IER4, INT1, IPASS, MODE,
     1  NOUT)
C
C     This subroutine writes the overall material balance summary for
C     plant 2, the coal liquefaction plant, and any warning messages.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - October 7, 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     MODE      = Switch to indicate which model and/or subroutine
C                 has called this subroutine.
C                 0 - 12 => Not applicatbe in this routine.
C                 13 => The Thermal/Catalytic reactor option.
C                 15 => The COKER option.
C                 18 => The HIGH SPACE VELOCITY option.
C     NOUT      = Logical unit number of the plant output report file.
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)
C
C     ST1(J,K) and ST2(J,K) contain the properties of the five inlet and
C     six outlet streams, in order, where J designates the stream 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
C
      IF ( IPASS .EQ. 4 .AND. INT1 .LE. 0 )  THEN
C
        SUMIN = ST1(1,1) + ST1(2,1) + ST1(3,1) + ST1(4,1) + ST1(5,1)
        SUMOUT = ST2(1,1) + ST2(2,1) + ST2(3,1) + ST2(4,1) + ST2(5,1)
     1    + ST2(6,1)
        TGOUT = ST2(1,4) + ST2(2,4)
C
C       Write the input/output stream summary report.
C       ============================================
        WRITE (NOUT, 801)
  801   FORMAT ( / 21X, 'PLANT 2 - SUMMARY REPORT (CONTINUED)'
```

```
     1    / 28X, 'COAL LIQUEFACTION PLANT')
C
        WRITE (NOUT, 802)
  802   FORMAT ( / ' OVERALL STREAM BALANCE' /
     1    23X, 'FLOW,', 10X, 'FLOW',  9X, 'TEMP,', 7X, 'PRESS,' /
     2    21X, 'MM SCF/HR', 6X, 'MLBS/HR', 8X, 'DEG F', 8X, 'PSIA' )
C
        IF ( MODE. NE. 15 ) WRITE (NOUT, 803) ST1(1,4),
     1    ((ST1(K,J), J = 1, 3), K = 1, 5), ST1(1,4), SUMIN
  803   FORMAT ( 2X, 'INLET STREAMS' /
     1    2X, 'HYDROGEN FEED  ', F11.3, F15.3, F13.1, F13.1 /
     2    2X, 'COAL FEED      ', F26.3, F13.1, F13.1 /
     3    2X, 'SOLVENT        ', F26.3, F13.1, F13.1 /
     4    2X, 'ROSE-SR EXTRACT', F26.3, F13.1, F13.1 /
     5    2X, 'WATER          ', F26.3, F13.1, F13.1 /
     6    2X, 'TOTAL INPUT    ', F11.3, F15.3 )
C
        IF ( MODE. EQ. 15 ) WRITE (NOUT, 804) ST1(1,4),
     1    ((ST1(K,J), J = 1, 3), K = 1, 5), ST1(1,4), SUMIN
  804   FORMAT ( 2X, 'INLET STREAMS' /
     1    2X, 'HYDROGEN FEED  ', F11.3, F15.3, F13.1, F13.1 /
     2    2X, 'COAL FEED      ', F26.3, F13.1, F13.1 /
     3    2X, 'SOLVENT        ', F26.3, F13.1, F13.1 /
     4    2X, 'COKER RECYCLE  ', F26.3, F13.1, F13.1 /
     5    2X, 'WATER          ', F26.3, F13.1, F13.1 /
     6    2X, 'TOTAL INPUT    ', F11.3, F15.3 )
C
        IF ( MODE .EQ. 13 )  THEN
          WRITE (NOUT, 806) ST2(1,4), ST2(1,1), ST2(1,2), ST2(1,3),
     1      ST2(2,4), ((ST2(K,J), J = 1,3), K = 2,6), TGOUT, SUMOUT
  806     FORMAT ( / 2X, 'OUTLET STREAMS' /
     1      2X, 'H2 GAS TO PLT 6', F11.3, F15.3, F13.1, F13.1 /
     2      2X, 'GASES TO PLT 3 ', F11.3, F15.3, F13.1, F13.1 /
     3      2X, 'NAPHTHA        ', F26.3, F13.1, F13.1 /
     4      2X, 'GAS OIL        ', F26.3, F13.1, F13.1 /
     5      2X, 'BOTTOMS        ', F26.3, F13.1, F13.1 /
     6      2X, 'SOUR WATER     ', F26.3, F13.1, F13.1 /
     7      2X, 'TOTAL OUTPUT   ', F11.3, F15.3 )
          GOTO 100
        ENDIF
C
        IF ( MODE .EQ. 15 )  THEN
          WRITE (NOUT, 807) ST2(1,4), ST2(1,1), ST2(1,2), ST2(1,3),
     1      ST2(2,4), ((ST2(K,J), J = 1,3), K = 2,6), TGOUT, SUMOUT
  807     FORMAT ( / 2X, 'OUTLET STREAMS' /
     1      2X, 'H2 GAS TO PLT 6', F11.3, F15.3, F13.1, F13.1 /
     2      2X, 'GASES TO PLT 3 ', F11.3, F15.3, F13.1, F13.1 /
     3      2X, 'NAPHTHA        ', F26.3, F13.1, F13.1 /
     4      2X, 'GAS OIL        ', F26.3, F13.1, F13.1 /
     5      2X, 'COKER FEED     ', F26.3, F13.1, F13.1 /
     6      2X, 'SOUR WATER     ', F26.3, F13.1, F13.1 /
     7      2X, 'TOTAL OUTPUT   ', F11.3, F15.3 )
          GOTO 100
        ENDIF
C
```

```
      WRITE (NOUT, 809) ST2(1,4), ST2(1,1), ST2(1,2), ST2(1,3),
     1  ST2(2,4), ((ST2(K,J), J = 1,3), K = 2,6), TGOUT, SUMOUT
  809 FORMAT ( / 2X, 'OUTLET STREAMS' /
     1  2X, 'H2 GAS TO PLT 6', F11.3, F15.3, F13.1, F13.1 /
     2  2X, 'GASES TO PLT 3 ', F11.3, F15.3, F13.1, F13.1 /
     3  2X, 'NAPHTHA        ', F26.3, F13.1, F13.1 /
     4  2X, 'GAS OIL        ', F26.3, F13.1, F13.1 /
     5  2X, 'ROSE-SR FEED   ', F26.3, F13.1, F13.1 /
     6  2X, 'SOUR WATER     ', F26.3, F13.1, F13.1 /
     7  2X, 'TOTAL OUTPUT   ', F11.3, F15.3 )
C
  100 CONTINUE
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 BALANCE.  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$ USR2CS
      SUBROUTINE USR2CS (NOUT)
C
C     This subroutine calculates and prints the cost breakdown of the
C     Plant 2 costs by section by scaling them from the baseline design
C     case for a single train based on the cost of the first train when
C     multiple trains are present.
C
```

```
C     Note: This routine is based on the baseline design plant
C     configuration and a complete single train plant.  The cost of
C     each of the seven sections is calculated as a given fraction
C     of the total plant cost for a single independent train.  For
C     train sizes which are significantly different than the baseline
C     design case train size of 285 Mlbs/hr of dry coal, the relative
C     costs of the various plant sections may be in error.
C     Cost savings may be possible in multiple train installations
C     by using common sections.
C
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     FUNCTION (MODEL, REPORT, OR BOTH): Report
C
C     Last revision - June 30, 1992.
C
C     Calling arguments:
C      NOUT   = Logical unit number of the plant output report file.
C
C     Variable declarations.
      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     UTIL(J,K)    = Plant utilities consumptions.
C     CAPCST(J,K) = Plant capital costs.
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.
C
      CHARACTER * 6  PLNTID
C
      DIMENSION FRAC(7), SCOST(7)
C
C     Load the fractional costs of the seven sections of the plant
C     in the FRAC vector.  The seven plant sections are:
C       1.  Coal slurry preparation section
C       2.  Coal slurry heating section
C       3.  First stage reaction section
```

```
C       4.  Second stage reaction section
C       5.  Primary separation section
C       6.  Product fractionation
C       7.  Recycle gas compression section
C
      DATA FRAC / 0.0252420, 0.1045413, 0.3547142, 0.2501728,
     1            0.1878170, 0.0548640, 0.0226487 /
C
C
C     Get the total ISBL field cost of the first train.
      TCOST = CAPCST(2,3)
C
C     Distribute this cost among the seven plant sections.
      DO 30 J = 1, 7
        SCOST(J) = TCOST * FRAC(J)
   30 CONTINUE
C
C     Start a new page.
      WRITE (NOUT, 600)
C     FORMAT statement 800 will print across a page on a PC because it
C     contains the PC top-of-form character (ASCII character 012)
C     between two quote marks ( i.e., 'TOF').
  600 FORMAT ( 'TOF' )
C
      WRITE (NOUT, 601)
  601 FORMAT (/ 25X, 'Plant 2 - Coal Liquefaction' /
     1          27X, 'ISBL field Cost Summary' /// )
C
      WRITE (NOUT, 602)
  602 FORMAT (2X, 'The following ISBL field cost summary by plant ',
     1  'section is based on' /
     2  2X, 'the baseline design configuration of independent ',
     3  'processing trains.' /
     4  2X, 'The following costs are for a single train.  These ',
     5  'costs are based' /
     6  2X, 'on the ISBL cost of the first train when multiple ',
     7  'trains are present.' //)
C
C     Print the calculated results in tables.
      WRITE (NOUT, 610)
  610 FORMAT ( 6X, 'Plant', 41X, 'ISBL Train' /
     1  5X, 'Section', 5X, 'Description', 25X, 'Cost, MM$' /
     2  5X, 7('-'), 5X, 31('-'), 5X, 9('-') )

      WRITE (NOUT, 611)  (SCOST(J), J = 1, 7), TCOST
  611 FORMAT (
     1  8X, '1', 8X, 'Coal Slurry Preparation  ', F18.1 /
     2  8X, '2', 8X, 'Coal Slurry Heating      ', F18.1 /
     3  8X, '3', 8X, 'First Stage Reaction     ', F18.1 /
     4  8X, '4', 8X, 'Second Stage Reaction    ', F18.1 /
     5  8X, '5', 8X, 'Primary Separation       ', F18.1 /
     6  8X, '6', 8X, 'Product Fractionation    ', F18.1 /
     7  8X, '7', 8X, 'Recycle Gas Compression  ', F18.1 /
     8  8X, ' ', 8X, 'Total                    ', F18.1 )
C
```

```
C
      RETURN
      END
C
C$ USR2ES
      SUBROUTINE USR2ES (NOUT, F)
C
C     This subroutine calculates and prints the sizes of the major
C     equipment design of Plant 2 (Coal Liquefaction Plant) by scaling
C     them from the baseline design case for a single train.
C
C     Note: This routine is based on the baseline design plant
C     configuration and a complete single train plant.  The seven
C     sections of the plant have the capability to be sized
C     independently based on a characteristic flow rate in that
C     section.  If the routine is to be modified to do this, then
C     the seven characteristic flow rates for the baseline design
C     should be supplied in the DATA statement which initializes
C     the XRF vector.  Accordingly, corresponding values must be
C     supplied in the F vector when the routine is called.
C
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     FUNCTION (MODEL, REPORT, OR BOTH): Report
C
C     Last revision - June 30, 1992.
C
C     Calling arguments:
C      NOUT   = Logical unit number of the plant output report file.
C      F(J)   = Actual flow rates in plant section J for scaling the
C               sizes of the reactors and vessels, heat exchangers,
C               towers, fired heaters, compressors and pumps in that
C               section.  The seven plant sections are:
C               1.  Coal Slurry Preparation Section
C               2.  Coal Slurry Heating Section
C               3.  First Stage Reaction Section
C               4.  Second Stage Reaction Section
C               5.  Primary Separation Section
C               6.  Crude Product Fractionation Section
C               7.  Recycle Gas Compression Section
C
C     Variable declarations.
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C     The following variables contain the reference flow rates and
C     equipment dimensions for the baseline design case.
      DIMENSION XRF(7), RANDV(2,23), PUMPS(2,21), HEATEX(22),
     1  TOWERS(2,6), FHEAT(2,4), COMP(2,3)
C     The following variables contain the actual flow rates and
C     equipment dimensions for the current case.
      DIMENSION F(7), RV(2,23), PMP(2,21), HX(22), TWR(2,6), FHT(2,4),
     1  CMP(2,3)
C
C     Set the reference flow rates for the baseline design case.
C     For this simple block Plant 2 model, base everything on the
```

```
C     dry coal feed rate to the plant in Mlbs/hr.
      DATA XRF / 7 * 285.035 /
C
C     Set the length and diameter (in feet) of the reactors and vessels
C     for the baseline design case.
      DATA RANDV / 11.0,11.0, 16.0,13.0, 43.0,18.0, 32.0,4.0, 9.0,3.0,
     1  85.5,15.0, 85.5,15.0, 22.5,10.5, 26.0,9.5, 24.0,9.5, 19.0,9.5,
     2  22.5,6.5, 12.0,3.0, 27.0,9.5, 26.0,6.5, 24.5,7.0, 26.5,7.5,
     3  13.0,6.5, 29.5,10.5, 26.0,6.5, 8.0,4.0, 16.0,4.0, 8.0,4.0 /
C
C     Set the duties of the heat exchangers (MM Btu/hr) for the base-
C     line design case.
      DATA HEATEX /34.5, 4.3, 6.5, 6.5, 24.8, 9.1, 13.9, 3.5, 30.8,
     1  28.6, 36.3, 5.9, 7.0, 0.5, 34.6, 6.2, 1.7, 3.9, 30.3, 15.6,
     2  0.08, 0.003 /
C
C     Set the height and diameter (in feet) of the towers for the base-
C     line design case.
      DATA TOWERS / 150.0,5.6, 150.0,8.5, 30.0,2.5, 60.0,6.5, 60.0,16,
     1  30.0,3.5 /
C
C     Set the absorbed duty (MM Btu/hr) and fired duty (MM Btu/hr) of
C     the fired heaters for the baseline design case.
      DATA FHEAT / 88.0,115.0, 44.0,57.0, 19.9,25.6, 15.7,19.9 /
C
C     Set the flow rate (MMSCFD) and brake horsepower (hp) of the
C     compressors for the baseline design case.
      DATA COMP / 176.0, 1086.0, 0.4, 25.0, 0.03, 2.0 /
C
C     Set the flow rate (gpm) and brake horsepower (hp) of the pumps
C     for the baseline design case.
      DATA PUMPS / 1.0,1.0, 15.0,1.0, 1100.0,70.0, 535.0,3450.0,
     1  1625.0,120.0, 15.0,1.0, 1.0,1.0, 630.0,20.0, 455.0,30.0,
     2  215.0,545.0, 1145.0,150.0, 370.0,50.0, 120.0,45.0,
     3  1110.0,150.0, 15.0,50.0, 1500.0,50.0, 120.0,50.0, 85.0,100.0,
     4  455.0,100.0, 90.0,50.0, 5.0,50.0 /
C
C
C     In equations below, XRF() is the reference flow rate for the
C     baseline design case, and XRF(J) is the actual flow rate for this
C     case.
C
C     Size the reactors and vessels.
      DO 29 J = 1, 2
        DO 21 K = 1, 5
          RV(J,K) = (F(1) / XRF(1)) ** 0.33333 * RANDV(J,K)
   21   CONTINUE
        RV(J,6) = (F(3) / XRF(3)) ** 0.33333 * RANDV(J,K)
        RV(J,7) = (F(4) / XRF(4)) ** 0.33333 * RANDV(J,K)
C       The sizes of the coal liquefaction reactors calculated by the
C       above equation are incorrect.  The kinetic model will size
C       these reactors by accounting for hydrodynamic effects.
        DO 25 K = 8, 18
          RV(J,K) = (F(5) / XRF(5)) ** 0.33333 * RANDV(J,K)
   25   CONTINUE
```

```
      DO 26 K = 19, 21
        RV(J,K) = (F(6) / XRF(6)) ** 0.33333 * RANDV(J,K)
26    CONTINUE
      DO 27 K = 22, 23
        RV(J,K) = (F(7) / XRF(7)) ** 0.33333 * RANDV(J,K)
27    CONTINUE
29 CONTINUE
C
C     Size the heat exchangers.
      DO 31 K = 1, 3
        HX(K) = (F(1) / XRF(1)) * HEATEX(K)
31 CONTINUE
      DO 35 K = 4, 10
        HX(K) = (F(5) / XRF(5)) * HEATEX(K)
35 CONTINUE
      DO 36 K = 11, 22
        HX(K) = (F(6) / XRF(6)) * HEATEX(K)
36 CONTINUE
C
C     Size the towers.
      DO 46 J = 1, 6
        TWR (1,J) = TOWERS(1,J)
        TWR (2,J) = SQRT(F(6) / XRF(6)) * TOWERS(2,J)
46 CONTINUE
C
C     Size the fired heaters.
      DO 59 J = 1, 2
        FHT(J,1) = (F(2) / XRF(2)) * FHEAT(J,1)
        FHT(J,2) = (F(3) / XRF(3)) * FHEAT(J,2)
        DO 56 K = 3, 4
          FHT(J,K) = (F(6) / XRF(6)) * FHEAT(J,K)
56      CONTINUE
59 CONTINUE
C
C     Size the compressors.
      DO 69 J = 1, 2
        DO 66 K = 2, 3
          CMP(J,K) = (F(6) / XRF(6)) * COMP(J,K)
66      CONTINUE
C       The recycle gas compressor.
        CMP(J,1) = (F(7) / XRF(7)) * COMP(J,1)
69 CONTINUE
C
C     Size the pumps.
      DO 79 J = 1, 2
        DO 71 K = 1, 3
          PMP(J,K) = (F(1) / XRF(1)) * PUMPS(J,K)
71      CONTINUE
        PMP(J,4) = (F(3) / XRF(3)) * PUMPS(J,4)
        DO 75 K = 5, 10
          PMP(J,K) = (F(5) / XRF(5)) * PUMPS(J,K)
75      CONTINUE
        DO 76 K = 11, 21
          PMP(J,K) = (F(6) / XRF(6)) * PUMPS(J,K)
76      CONTINUE
```

```
   79 CONTINUE
C
C     Start a new page.
      WRITE (NOUT, 800)
C     FORMAT statement 800 will print across a page on a PC because it
C     contains the PC top-of-form character (ASCII character 012)
C     between two quote marks ( i.e., 'TOF').
  800 FORMAT ( 'TOF' )
C
      WRITE (NOUT, 801)
  801 FORMAT (/ 30X, 'EQUIPMENT SUMMARY' /
     1  25X, 'Plant 2 - Coal Liquefaction' //
     2  17X, 'All Sizes Are Based on a Single Train Plant.' /// )
C
C     Print the calculated results in tables.
      WRITE (NOUT, 600)
  600 FORMAT (  28X, 'Reactors and Vessels' /
     1  28X, 20('-') // )
      WRITE (NOUT, 601)
  601 FORMAT (2X, 'Equipment', 38X, 'Length', 8X, 'Diameter' /
     1  5X, 'No.', 6X, 'Equipment Description',
     2  12X, '(T-T in ft)', 4X, '(ID in ft)' /
     3  2X, 9('-'), 3X, 30('-'), 3X, 2(11('-'), 4X) / )
C
      WRITE (NOUT, 602) ((RV(J,K), J = 1, 2), K = 1, 5)
  602 FORMAT (2X, 'COAL SLURRY PREPARATION' /
     1  2X,'2.1- C101   Slurry Vortex Mx Tnk Innr Shll',6X,2(F5.1,9X) /
     2  2X,'            Slurry Vortex Mx Tnk Outr Shll',6X,2(F5.1,9X) /
     3  2X,'2.1- C102   Slurry Surge Tank             ',6X,2(F5.1,9X) /
     4  2X,'2.1- C103   Slurry Surge Tank Vent Scrubbr',6X,2(F5.1,9X) /
     5  2X,'2.1- C104   Scrubber Overhead Receiver    ',6X,2(F5.1,9X)/)
C
      WRITE (NOUT, 603) ((RV(J,K), J = 1, 2), K = 6, 7)
  603 FORMAT (2X, 'REACTOR SYSTEM' /
     1  2X,'2.3- C105   Coal Liquefaction - Stage 1   ',6X,2(F5.1,9X) /
     2  2X,'2.4- C106   Coal Liquefaction - Stage 2   ',6X,2(F5.1,9X)/)
C
      WRITE (NOUT, 604) ((RV(J,K), J = 1, 2), K = 8, 18)
  604 FORMAT (2X, 'PRIMARY SEPARATION' /
     1  2X,'2.5- C107   Hot High Pressure Separator   ',6X,2(F5.1,9X) /
     2  2X,'2.5- C108   Hot Low Pressure Separator    ',6X,2(F5.1,9X) /
     3  2X,'2.5- C109   Recycle Slurry Hold Drum      ',6X,2(F5.1,9X) /
     4  2X,'2.5- C110   Warm High Pressure Separator  ',6X,2(F5.1,9X) /
     5  2X,'2.5- C111   Warm Low Pressure Separator   ',6X,2(F5.1,9X) /
     6  2X,'2.5- C112   Recy Slry Hold Drm Cond Accum ',6X,2(F5.1,9X) /
     7  2X,'2.5- C113   Cold High Pressure Separator  ',6X,2(F5.1,9X) /
     8  2X,'2.5- C114   Cold Low Pressure Separator   ',6X,2(F5.1,9X) /
     9  2X,'2.5- C115   Wash Water Drum               ',6X,2(F5.1,9X) /
     A  2X,'2.5- C116   Sour Water Drum               ',6X,2(F5.1,9X) /
     B  2X,'2.5- C117   Compressor Knockout Drum      ',6X,2(F5.1,9X)/)
C
      WRITE (NOUT, 605) ((RV(J,K), J = 1, 2), K = 19, 21)
  605 FORMAT (2X, 'CRUDE PRODUCT FRACTIONATION - ATMOSPHERIC TOWER' /
     2  2X,'2.6- C117    Feed Flash Drum              ',6X,2(F5.1,9X) /
     3  2X,'2.6- C120    Overhead Accumulator         ',6X,2(F5.1,9X) /
```

```
     4  2X,'2.6- C121    Vent Gas Compress Knockout   ',6X,2(F5.1,9X)/)
C
      WRITE (NOUT, 606) ((RV(J,K), J = 1, 2), K = 22, 23)
  606 FORMAT (2X, 'CRUDE PRODUCT FRACTIONATION - VACUUM TOWER' /
     2  2X,'2.6- C124   Vacuum Jet Condenser Accum    ',6X,2(F5.1,9X) /
     3  2X,'2.6- C125   Vent Gas Compress Knockout    ',6X,2(F5.1,9X)//)
C
C     Start a new page.
      WRITE (NOUT, 800)
C
      WRITE (NOUT, 802)
  802 FORMAT (/ 24X, 'EQUIPMENT SUMMARY (Continued)' /
     1  25X, 'Plant 2 - Coal Liquefaction' //
     2  17X, 'All Sizes Are Based on a Single Train Plant.' /// )
C
      WRITE (NOUT, 607)
  607 FORMAT (29X, 'Heat Exchangers' /
     1  29X, 15('-') // )
      WRITE (NOUT,608)
  608 FORMAT (2X, 'Equipment', 40X, 'Duty', 10X, 'Type of' /
     1  5X, 'No.', 6X, 'Equipment Description',
     2  13X, '(MM Btu/hr)', 5X, 'Exchanger' /
     3  2X, 9('-'), 3X, 30('-'), 4X, 2(11('-'), 4X) / )
C
      WRITE (NOUT, 609) (HX(J), J = 1, 3)
  609 FORMAT (2X, 'COAL SLURRY PREPARATION' /
     1  2X,'2.1- E101   Recycle Slurry Steam Generator',6X,F5.1,7X,
     1                                                 'Shell & Tube' /
     2  2X,'2.1- E102   Recycle Solvent Cooler        ',6X,F5.1,7X,
     2                                                'Air-Fin'       /
     3  2X,'2.1- E103   Slurry Surge Tank Ovhd Cond   ',6X,F5.1,7X,
     3                                                 'Air-Fin'     /)
C
      WRITE (NOUT, 610) (HX(J), J = 4, 10)
  610 FORMAT (2X, 'PRIMARY SEPARATION' /
     1  2X,'2.5- E104   Hot LP Sep Vapor Cooler       ',6X,F5.1,7X,
     1                                                 'Shell & Tube' /
     2  2X,'2.5- E105   Hot LP Sep Vapor Steam Gen    ',6X,F5.1,7X,
     2                                                 'Shell & Tube' /
     3  2X,'2.5- E106   1st Hydrogen Preheater        ',6X,F5.1,7X,
     3                                                 'Shell & Tube' /
     4  2X,'2.5- E107   2nd Hydrogen Preheater        ',6X,F5.1,7X,
     4                                                 'Shell & Tube' /
     5  2X,'2.5- E108   Slurry Hold Drum Vapor Cond   ',6X,F5.1,7X,
     5                                                 'Air-Fin'       /
     6  2X,'2.5- E109   Warm HP Sep Vapor Cooler      ',6X,F5.1,7X,
     6                                                 'Air-Fin'       /
     7  2X,'2.5- E110   Warm LP Sep Vapor Cooler      ',6X,F5.1,7X,
     7                                                 'Air-Fin'     /)
C
      WRITE (NOUT, 611) (HX(J), J = 11, 14)
  611 FORMAT (2X, 'CRUDE PRODUCT FRACTIONATION - ATMOSPHERIC TOWER' /
     2  2X,'2.6- E111   Atmos Frac Ovhd Condenser     ',6X,F5.1,7X,
     2                                                 'Air-Fin'       /
     3  2X,'2.6- E112   AGO Product Cross Exchange    ',6X,F5.1,7X,
```

```
     3                                                  'Shell & Tube' /
     4  2X,'2.6- E113   AGO Product Cooler            ',6X,F5.1,7X,
     4                                                  'Shell & Tube' /
     5  2X,'2.6- E121   Atm VG Comp Aftercooler       ',6X,F5.1,7X,
     5                                                  'Air-Fin'      /)
C
      WRITE (NOUT, 612) (HX(J), J = 15, 22)
  612 FORMAT (2X, 'CRUDE PRODUCT FRACTIONATION - VACUUM TOWER ' /
     2  2X,'2.6- E114   LVGO Pumparound Cooler        ',6X,F5.1,7X,
     2                                                  'Air-Fin'     /
     3  2X,'2.6- E115   HVGO Pumparound Steam Gen     ',6X,F5.1,7X,
     3                                                  'Shell & Tube'/
     4  2X,'2.6- E116   HVGO Pumparound Cooler        ',6X,F5.1,7X,
     4                                                  'Air-Fin'     /
     5  2X,'2.6- E117   HVGO Product Steam Gen        ',6X,F5.1,7X,
     5                                                  'Shell & Tube'/
     6  2X,'2.6- E118   Bottoms Product Steam Gen     ',6X,F5.1,7X,
     6                                                  'Shell & Tube'/
     7  2X,'2.6- E119   1st Steam Jet Condenser       ',6X,F5.1,7X,
     7                                                  'Shell & Tube'/
     8  2X,'2.6- E120   2nd Steam Jet Condenser       ',6X,F5.2,7X,
     8                                                  'Shell & Tube'/
     9  2X,'2.6- E122   Vac VG Aftercooler            ',6X,F5.3,7X,
     9                                                  'Shell & Tube'/)
C
C     Start a new page.
      WRITE (NOUT, 800)
      WRITE (NOUT, 802)
C
      WRITE (NOUT, 613)
  613 FORMAT (33X, 'Towers' /
     1  33X, 6('-') / )
      WRITE (NOUT, 614)
  614 FORMAT (2X, 'Equipment', 39X, 'Length', 8X, 'Diameter' /
     1  5X, 'No.', 6X, 'Equipment Description',
     2  13X, '(T-T in ft)', 4X, '(ID in ft)' /
     3  2X, 9('-'), 3X, 30('-'), 4X, 2(11('-'), 4X) / )
C
      WRITE (NOUT, 615) ((TWR(J,K), J = 1, 2), K = 1, 6)
  615 FORMAT (2X, 'CRUDE PRODUCT FRACTIONATION' /
     1  2X,'2.6- C118   Atmospheric Fractionator      ',6X,2(F5.1,9X) /
     1  2X,'                                          ',6X,2(F5.1,9X) /
     2  2X,'2.6- C119   AGO Stripper                  ',6X,2(F5.1,9X) /
     3  2X,'2.6- C122   Vacuum Fractionator           ',6X,2(F5.1,9X) /
     3  2X,'                                          ',6X,2(F5.1,9X) /
     4  2X,'2.6- C123   Vac Recy Solvent Stripper     ',6X,2(F5.1,9X)//)
C
      WRITE (NOUT, 616)
  616 FORMAT (/ 31X, 'Fired Heaters' /
     1  31X, 13('-') / )
      WRITE (NOUT, 617)
  617 FORMAT (49X, 'Absorbed        Fired' /
     1  2X, 'Equipment', 40X, 'Duty', 11X, 'Duty' /
     2  5X, 'No.', 6X, ' Equipment Description            ',
     3  '(MM Btu/hr)', 4X, '(MM Btu/hr)' /
```

```
     4  2X, 9('-'), 3X, 30('-'), 3X, 2(12('-'), 3X) / )
C
      WRITE (NOUT, 618) ((FHT(J,K), J = 1, 2), K = 1, 4)
  618 FORMAT (2X,'REACTION SYSTEM' /
     1  2X,'2.2- F101   Coal Slurry Heater            ',6X,2(F5.1,9X)/
     2  2X,'2.3- F102   Gas Heater                    ',6X,2(F5.1,9X)//
     3  2X, 'CRUDE PRODUCT FRACTIONATION' /
     4  2X,'2.6- F103   Atmospheric Fractionator Htr  ',6X,2(F5.1,9X)/
     5  2X,'2.6- F104   Vacuum Fractionator Preheater ',6X,2(F5.1,9X)//)
C
      WRITE (NOUT, 619)
  619 FORMAT (/ 31X, 'Compressors' /
     1  31X, 11('-') / )
      WRITE (NOUT, 620)
  620 FORMAT (2X, 'Equipment', 37X, 'Flow Rate', 8X, 'Brake'/
     1  5X, 'No.', 6X, 'Equipment Description      ',
     2  7X, '(MMSCFD)', 7X, 'Horsepower' /
     3  2X, 9('-'), 3X, 30('-'), 3X, 2(12('-'), 3X) / )
C
      WRITE (NOUT,621) ((CMP(J,K), J = 1, 2), K = 1, 3)
  621 FORMAT (2X, 'PRIMARY SEPARATION' /
     1  2X,'2.7- K101   Recycle Hydrogen              ',6X,2(F5.0,9X)//
     2  2X,'CRUDE PRODUCT FRACTIONATION' /
     3  2X,'2.6- K102   Atmospheric Vent Gas          ',6X,2(F5.1,9X)/
     4  2X,'2.6- K103   Vacuum Vent Gas               ',6X,2(F5.2,9X)//)
C
C     Start a new page.
      WRITE (NOUT, 800)
      WRITE (NOUT, 802)
C
      WRITE (NOUT, 622)
  622 FORMAT (34X, 'Pumps' /
     1  34X, 5('-') //)
      WRITE (NOUT, 623)
  623 FORMAT (2X, 'Equipment', 37X, 'Flow Rate', 9X, 'Brake' /
     1  5X, 'No.', 6X, 'Equipment Description            ',
     2  3X, '(gpm)', 9X, 'Horsepower' /
     3  2X, 9('-'), 3X, 30('-'), 3X, 2(12('-'), 4X) / )
C
      WRITE (NOUT, 624) ((PMP(J,K), J = 1, 2), K = 1, 10)
  624 FORMAT (2X, 'COAL SLURRY PREPARATION'/
     1  2X,'2.1- G101   Scrubber Condenser Product    ',6X,2(F6.1,9X)/
     2  2X,'2.1- G102   Scrubber Sour Water           ',6X,2(F6.1,9X)/
     3  2X,'2.1- G103   Coal Slurry Booster Pump      ',6X,2(F6.1,9X)//
     4  2X, 'REACTION SYSTEM' /
     5  2X,'2.3- G105   Slurry Charge                 ',6X,2(F6.1,9X)/
     6  2X,'2.3- G108   Stage 1 Ebullating            ',5X,
     7     '------ Proprietary ------ '                                /
     8  2X,'2.4- G109   Stage 2 Ebullating            ',5X,
     9     '------ Proprietary ------ '                               //
     A  2X, 'PRIMARY SEPARATION' /
     B  2X,'2.5- G110   Slurry Recycle Pump           ',6X,2(F6.1,9X)/
     C  2X,'2.5- G111   Recy Slr Hld Drm Cnd Acumm Liq',6X,2(F6.1,9X)/
     D  2X,'2.5- G112   Recy Slr Dr Cnd ac Sour Water ',6X,2(F6.1,9X)/
     E  2X,'2.5- G113   Sour Water Drum Pump          ',6X,2(F6.1,9X)/
```

```
     F  2X,'2.5- G114   Wash Water LP Pump            ',6X,2(F6.1,9X)/
     G  2X,'2.5- G115   Wash Water HP Pump            ',6X,2(F6.1,9X)/)
C
      WRITE (NOUT, 625) ((PMP(J,K), J = 1, 2), K = 11, 21)
  625 FORMAT (2X, 'CRUDE PRODUCT FRACTIONATION - ATMOSPHERIC TOWER'/
     2  2X,'2.6- G116   Atmos Heater Charge           ',6X,2(F6.1,9X)/
     3  2X,'2.6- G117   Reflux Naphtha Product        ',6X,2(F6.1,9X)/
     4  2X,'2.6- G118   AGO Product                   ',6X,2(F6.1,9X)/
     5  2X,'2.6- G119   Bottoms Product               ',6X,2(F6.1,9X)/
     6  2X,'2.6- G120   Atmos Ovhd Accum Sour Water   ',6X,2(F6.1,9X)//
     7  2X, 'CRUDE PRODUCT FRACTIONATION - VACUUM TOWER' /
     9  2X,'2.6- G121   LVGO Pumparound               ',6X,2(F6.1,9X)/
     A  2X,'2.6- G122   HVGO Pumparound               ',6X,2(F6.1,9X)/
     B  2X,'2.6- G123   HVGO Product                  ',6X,2(F6.1,9X)/
     C  2X,'2.6- G124   Bottoms Product               ',6X,2(F6.1,9X)/
     D  2X,'2.6- G125   Vacuum Jet Accum Sour Water   ',6X,2(F6.1,9X)/
     E  2X,'2.6- G126   Vacuum Jet Accum Product      ',6X,2(F6.1,9X)/)
C
      RETURN
      END
C
C$  Subroutine USR03
C
C     This file contains the following subroutines:
C       USR03    Main routine for Plant 3, the gas plant
C       USR03A   Subroutine to load the pure component properties in
C                the CIN array in named COMMON /USR03M/.
C       USR03B   Subroutine to distribute the net yields from plant 3,
C                into the six product streams.
C       USR03C   Subroutine to write the first page of the plant
C                summary report.
C       USR03D   Subroutine to write the second page of the plant
C                summary report.
C       USR03E   Subroutine to load the outlet stream vectors.
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 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       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 /USRC01/.
C
C$ USR03
      SUBROUTINE USR03 (NSIN,NINFI,SIN1,SIN2,SIN3,SIN4,
     1 SIN5, SIN6, SIN7, SIN8, SINFI,NSOUT,
     2 NINFO,SOUT1,SOUT2,SOUT3,SOUT4, SOUT5, SOUT6, SOUT7, SOUT8,
     3 SINFO,NSUBS,IDXSUB,ITYPE,NINT,
     4 INT,NREAL,REAL,IDS,NPO,NBOPST,NIW,IW,NW,W,NSIZE,SIZE)
C
```

```
C  ASPEN USER UNIT OPERATION BLOCK:  USR03
C
C  BLOCK DESCRIPTION:  Plant 3, The Gas Plant
C
C                 Simplified Fortran Block Model
C
C                   -----------------------
C                   |                     |-----> Sour Gas to Plant 6
C                   |                     |
C     Lean Oil      |       Plant 3       |-----> Fuel Gas
C     Make-up ----->|                     |
C     from Plant 2  |         The         |-----> Propane
C                   |                     |
C     Sweet Gas --->|      Gas Plant      |-----> Butanes
C                   |                     |
C                   |                     |-----> Lean Oil to Plant 4
C                   |                     |
C                   |                     |-----> Sour water
C                   -----------------------
C
C
C  Prepared under DOE contract no. DE-AC22 90PC89857.
C
C  FUNCTION (MODEL, REPORT, OR BOTH):  Both
C
C  Last revision - May 29, 1992.
C
C  ASSUMPTIONS, SPECIAL FEATURES AND LIMITATIONS:
C     1.  The two inlet stream are:    1. Lean oil make-up stream
C                                      2. Sweet gas stream
C     2.  The six outlet streams are:  1. Sour Gas to Plant 6
C                                      2. Fuel Gas
C                                      3. Propane
C                                      4. Butanes
C                                      5. Lean Oil to Plant 4
C                                         (Naphtha Hydrotreater)
C                                      6. Sour water
C     3.  This user block model will work with any number of
C         conventional components, but requires that 55 specific
C         conventional components must be available in the component
C         list.  Up to three non-conventional coal type components also
C         may be in the component list.
C     4.  This user block Fortran model requires that the inupt and
C         output streams are of the ASPEN/SP conventional stream class
C         or of ASPEN/SP stream class MIXNC or 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 any ATTR-COMPS statements
C         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 solid components in the input streams will be ignored,
C         and plant 3 will not be in mass balance.
```

```
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 DCL03.REP.
C         INT(3)  = Number of operating duplicate trains, excluding
C                   spares.
C                   If INT(3) = 0, the minimum number of duplicate
C                     trains will be determined so that the capacity
C                     each train does not exceed the maximum train
C                     capacity specified by variable REAL(52).
C                   If INT(3) > 0, this number of duplicate trains will
C                     be used.
C         INT(4)  = History file additional output control switch.
C                   0 => Write no additional output to the history 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     8.  The 70 real parameters are:
C         REAL(1) -
C          REAL(20) = Future use.
C         REAL(21)  = Constant factor for the power consumption, kw.
C         REAL(22)  = Power consumption per MM SCF/hr of dry C4- gas,
C                     kw/(MM SCF/hr of dry C4- gas)
C         REAL(23)  = Constant factor for the 900 psig / 750 F steam
C                     consumption, Mlbs/hr.
C         REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr
C                     of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4-
C                     gas).
C         REAL(25)  = Constant factor for the 900 psig saturated steam
C                     consumption, Mlbs/hr.
C         REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr
C                     of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4-
C                     gas).
C         REAL(27)  = Constant factor for the 600 psig / 720 F steam
C                     consumption, Mlbs/hr.
C         REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr
C                     of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4-
C                     gas).
C         REAL(29)  = Constant factor for the 600 psig saturated steam
```

```
C                       consumption, Mlbs/hr.
C          REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr
C                      of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4-
C                      gas).
C          REAL(31)  = Constant factor for the 150 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr
C                      of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4-
C                      gas).
C          REAL(33)  = Constant factor for the 50 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr
C                      of dry C4- gas, (Mlbs/hr)/(MM SCF/hr of dry C4-
C                      gas).
C          REAL(35)  = Constant factor for the plant fuel consumption,
C                      MM BTU/hr.
C          REAL(36)  = Plant fuel consumption per MM SCF/hr of dry C4-
C                      gas, (MM BTU/hr)/(MM SCF/hr of dry C4- gas).
C          REAL(37)  = Constant factor for the cooling water consumption,
C                      Mgal/hr.
C          REAL(38)  = Cooling water consumption per MM SCF/hr of dry C4-
C                      gas, (Mgal/hr)/(MM SCF/hr of dry C4- gas).
C          REAL(39)  = Constant factor for the process water consumption,
C                      Mgal/hr.
C          REAL(40)  = Process water consumption per MM SCF/hr of dry C4-
C                      gas, (Mgal/hr)/(MM SCF/hr of dry C4- gas).
C          REAL(41)  = Constant factor for the nitrogen consumption,
C                      MM SCF/hr of N2.
C          REAL(42)  = Nitrogen consumption per MM SCF/hr of dry C4- gas,
C                      (MM SCF/hr of N2)/(MM SCF/hr of dry C4- gas).
C          REAL(43) -
C           REAL(48) = Future use.
C          REAL(49)  = Constant factor for the number of operators per
C                      day, operators/day.
C          REAL(50)  = Number of operators per day per train,
C                      (operators/day)/train.
C          REAL(51)  = Reference dry C4- gas feed rate to a single plant
C                      in MM SCF/hr of dry C4- gas for the calculation of
C                      the ISBL field cost of a single plant as a
C                      function of plant capacity.
C          REAL(52)  = Maximum size of a single plant as defined by the
C                      gas feed rate in MM SCF/hr of dry C4- gas.
C          REAL(53)  = Minimum size of a single plant as defined by the
C                      gas feed rate in MM SCF/hr of dry C4- gas.
C          REAL(54)  = Constant A in the plant ISBL field cost equation.
C          REAL(55)  = Constant B in the plant ISBL field cost equation.
C          REAL(56)  = Constant E in the plant ISBL field cost equation.
C          REAL(57)  = Constant F in the plant ISBL field cost equation.
C          REAL(58) -
C           REAL(70) = Future use.
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)
      DIMENSION SIN5(1),SIN6(1),SIN7(1),SIN8(1),SOUT5(1),
     1 SOUT6(1),SOUT7(1),SOUT8(1)
      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
      COMMON /USR03M/ CIN(55,7), STRM(55,11)
      COMMON /USR03N/ CNAME(55), ICNUMB(55)
C
C     In CIN(J,K) and STRM(J,K), subscript J designates the following
C     components.
C      1.  H2            16.  T125          36.  P125
C      2.  NH3           17.  T175          37.  P175
C      3.  H2O           18.  T225          38.  P225
C      4.  H2S           19.  T275          39.  P275
C      5.  CO            20.  T325          40.  P325
C      6.  N2            21.  T375          41.  P375
C      7.  CO2           22.  T425          42.  P425
C      8.  CH4           23.  T475          43.  P475
C      9.  C2H6          24.  T525          44.  P575
C     10.  C3H8          25.  T575          45.  P575
C     11.  IC4H10        26.  T625          46.  P625
C     12.  NC4H10        27.  T675          47.  P675
C     13.  IC5H12        28.  T725          48.  P725
C     14.  NC5H12        29.  T775          49.  P775
C     15.  -             30.  T825          50.  P825
C                        31.  T875          51.  P875
C                        32.  T925          52.  P925
C                        33.  T975          53.  P975
C                        34.  T1000+        54.  P1000+
C                        35.  -             55.  -
C     where T225 means the entering material in the 200-250 F boiling
C     range in the CIN array and P225 means the hydrotreated material
C     in the same boiling range.
C     In CIN(J,K), subscript K designates
C       1.  Component molecular weight, lbs/lb-mole.
C       2.  Component standard liquid density at 60 F in lbs/barrel.
C       3.  Sulfur, wt% sulfur.
C       4.  Nitrogen, wt% nitrogen.
C       5.  Oxygen, wt% oxygen.
C       6.  Carbon, wt% carbon.
C       7.  Hydrogen, wt% hydrogen.
C     In STRM(J,K), subscript K designates
C       1.  The inlet lean-oil make-up stream.
C       2.  The inlet gas stream.
```

```
C       3.  The sour gas stream leaving the make-up lean-oil stripper.
C       4.  The lean-oil stream leaving the make-up lean-oil stripper
C           which is a feed stream to the absorber/deethanizer.
C       5.  The absorber/deethanizer overhead stream which is the fuel
C           gas product stream).
C       6.  The absorber/deethanizer bottoms stream which is the
C           lean-oil stripper/debutanizer feed stream.
C       7.  The lean-oil stripper/debutanizer overhead C3/C4s stream
C           which is the depropanizer feed stream.
C       8.  The lean-oil stripper/debutanizer bottoms stream (lean-oil
C           product stream).
C       9.  Depropanizer overhead stream (Propane product stream).
C       10. Depropanizer bottoms stream (Butanes product stream).
C       11. Sour water produced from the make-up lean-oil stripper
C           column.
C       Streams 2 and 4 are the fresh feed to the absorber/deethanizer.
C
C
C     Local variable declaration statements.
      DIMENSION ICN(2), ICNAME(110)
C
      CHARACTER * 4  BLANK4, ICN, ICNAME
      CHARACTER * 6  PNAME
      CHARACTER * 8  CNAME
C
      DATA BLANK4 / '    ' /
      DATA SCFM / 379.495D0 /
C
C     Initialize the component identification of the above 55
C     conventional components.
      DATA ICNAME / 'H2  ', '    ', 'NH3 ', '    ', 'H2O ', '    ',
     1  'H2S ', '    ', 'CO  ', '    ', 'N2  ', '    ', 'CO2 ', '    ',
     2  'CH4 ', '    ', 'C2H6', '    ', 'C3H8', '    ', 'IC4H', '10  ',
     3  'NC4H', '10  ', 'IC5H', '12  ', 'NC5H', '12  ', '    ', '    ',
     4  'T125', '    ', 'T175', '    ', 'T225', '    ', 'T275', '    ',
     5  'T325', '    ', 'T375', '    ', 'T425', '    ', 'T475', '    ',
     6  'T525', '    ', 'T575', '    ', 'T625', '    ', 'T675', '    ',
     7  'T725', '    ', 'T775', '    ', 'T825', '    ', 'T875', '    ',
     8  'T925', '    ', 'T975', '    ', 'T100', '0+  ', '    ', '    ',
     9  'P125', '    ', 'P175', '    ', 'P225', '    ', 'P275', '    ',
     A  'P325', '    ', 'P375', '    ', 'P425', '    ', 'P475', '    ',
     B  'P525', '    ', 'P575', '    ', 'P625', '    ', 'P675', '    ',
     C  'P725', '    ', 'P775', '    ', 'P825', '    ', 'P875', '    ',
     D  'P925', '    ', 'P975', '    ', 'P100', '0+  ', '    ', '    '/
C
      DATA PNAME / '3     ' /
C
C
C     PARAMETER INITIALIZATION SECTION
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)
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 3 - Supplementary data from ',
     1    'subroutine USR03' /
     2    2X, 'The Gas Plant', 25X, 'IPASS =', I3 )
      ENDIF
C
C     Check to insure that there are exactly 2 inlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSIN .NE. 2 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 502)  NSIN
  502   FORMAT ( / 1X, '* ERROR * - Plant 3, the gas plant, requires',
     1    ' exactly two inlet' /
     2    3X, 'streams.  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 are exactly 6 outlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSOUT .NE. 6 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501) IPASS
        WRITE (NHSTRY, 503)  NSOUT
  503   FORMAT ( / 1X, '* ERROR * - Plant 3, the gas plant, requires',
     1    ' exactly six outlet' /
     2    3X, 'streams.  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     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 = 1
C
C     Does the inlet stream contain non-conventional components?
      NUMPSD = 0
      IF ( NSUBS .EQ. 2 .AND. ITYPE(2) .EQ. 3 )   THEN
        KLASS = 2
C       Check for a substream PSD attribute on the second substream of
C       the first inlet stream.
        CALL GETSTR (IDS(1,4), NB, LB, NBD, LBD)
        NUMATT = NPAT (LBD, 2)
        IF ( NUMATT .GT. 0 )   THEN
          NUMPSD = NAVAR (LBD, 2, 1)
          KLASS = 3
        ENDIF
      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     non-conventional substream.
      NCCONV = NCONV
      IF ( KLASS .GE. 2 )   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) + SIN2(J)*SIN2(K)
      IF ( KLASS .GE. 2 )   THEN
          J = NCC + 9 + NNCC + 1
          FLOWIN = CF * (X + SIN1(J) + SIN2(J))
        ELSE
          FLOWIN = CF * X
      ENDIF
C
      IF ( FLOWIN .LE. 1.0D0 )   THEN
C       Skip all remaing calculations if this plant has no flow.
        IF ( KTEST .GE. 1 )  WRITE (NHSTRY, 504)
  504   FORMAT ( / ' There is no material entering plant 3, the ',
     1    'gas plant.' )
        GO TO 999
C       ---------
      ENDIF
C
C
C     Find the relative component numbers of the required conventional
C     components, and save then in the ICNUMB vector.
      DO 20 J = 1, 55
        K = 2 * J - 1
        IF ( ICNAME(K) .EQ. BLANK4 )   THEN
          ICNUMB(J) = 0
          CNAME(J) = BLANK4 // BLANK4
          GO TO 20
        ENDIF
        ICN(1) = ICNAME(K)
        ICN(2) = ICNAME(K+1)
        IF ( J .LE. 55 )  CNAME(J) = ICN(1) // ICN(2)
        CALL USRCCN (ICN, ICNUMB(J))
        IF ( ICNUMB(J) .EQ. 0 ) THEN
          IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
          WRITE (NHSTRY, 506)  ICN(1), ICN(2)
  506     FORMAT ( / 1X, '* ERROR * - The following component is ',
     1      'missing from your component list' / 5X, 2A4 /
```

```
     2      3X, 'Plant 3, the gas 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     Set up the maximum and minimum train flow rates in MM SCF/hr
C     of dry C4- gas.
      PMAXF = REAL(52)
      PMINF = REAL(53)
C
C
C     Call subroutine USR03A to load the inlet component densities and
C     elemental compositions into the CIN array.
      CALL USR03A (KTEST, NCC, NHSTRY)
C
C     If requested, write the items of interest in the inlet stream
C     vector to the history file.
      IF ( KTEST .GE. 5 )  THEN
        WRITE (NHSTRY, 511)
  511   FORMAT ( / '  The inlet stream vectors:'/
     1    3X, 'Item', 10X, 'SIN1', 11X, 'SIN2' )
        DO 30 J = 1, ITEMS
          WRITE (NHSTRY, 512) J, SIN1(J), SIN2(J)
  512     FORMAT ( 1X, I6, 3X, 2(1PE15.5) )
   30   CONTINUE
      ENDIF
C
C     Load the total entering component flow rates from all the inlet
C     streams in the STRM vector in Mlbs/hr.
C     CF is the conversion factor from Kg/sec to Mlbs/hr.
      CF = 0.001D0 * 3600.0D0 / 0.45359237D0
C     First, zero all the STRM vectors.
      DO 40 J = 1, 55
        DO 38 K = 1, 11
          STRM(J,K) = 0.0D0
   38   CONTINUE
   40 CONTINUE
C
C     Load the two inlet streams.
C     ---------------------------
C     Conventional components - Load the flow rate in Mlbs/hr and the
C     component MWs.
      OTHERS = 0.0
```

```
      DO 44 J = 1, NCC
        DO 42 K = 1, 55
        IF ( J .EQ. ICNUMB(K) )  THEN
C         The lean-oil make-up stream.
          STRM(K,1) = CF * XMW(J) * SIN1(J)
C         The gas stream.
          STRM(K,2) = CF * XMW(J) * SIN2(J)
          GO TO 44
        ENDIF
   42   CONTINUE
        OTHERS = OTHERS + CF * XMW(J) * (SIN1(J) + SIN2(J))
   44 CONTINUE
C
      IF ( KLASS .GE. 2 )   THEN
C       Non-conventional components.
        SOLIDS = CF * (SIN1(NCONV+1) + SIN1(NCONV+2) + SIN1(NCONV+3) +
     1                 SIN2(NCONV+1) + SIN2(NCONV+2) + SIN2(NCONV+3))
      ENDIF
C
      UNKNWN = OTHERS + SOLIDS
      IF ( UNKNWN .GE. 1.0D-3 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 513)  UNKNWN
  513   FORMAT ( / 1X, '* WARNING * - The feed to plant 3, the ',
     1    'gas plant, contains one or' /
     2    3X, 'more components that this model cannot handle.  It ',
     3    'contains', F10.3 /
     4    3X, 'Mlbs/hr of these components.  These components will be',
     5    ' lost in the process.' /
     6    3X, 'Plant 3 will not be in mass balance.  Please remove',
     7    ' these component(s)' /
     8    3X, 'from the feed stream.' //
     9    3X, 'Execution is continuing.' / )
      ENDIF
C
C
C     If requested, write the inlet stream information.
      IF ( KTEST .GE. 3 )  THEN
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        WRITE (NHSTRY, 704)
  704   FORMAT ( / ' Inlet stream flow rates, Mlbs/hr:' /
     1    '   No.  Name', 6X, 'Lean-oil', 6X, 'Gas' )
        DO 55 J = 1, 55
          IF ( ICNUMB(J) .NE. 0 )   THEN
            WRITE (NHSTRY, 705)  J, CNAME(J), (STRM(J,K), K = 1, 2)
  705       FORMAT ( 1X, I5, 2X, A8, 2F10.3 )
            SUM1 = SUM1 + STRM(J,1)
            SUM2 = SUM2 + STRM(J,2)
          ENDIF
   55   CONTINUE
        WRITE (NHSTRY, 706)  SUM1, SUM2
  706   FORMAT ( 8X, 'Total', 3X, 2F10.3 )
      ENDIF
C
```

```
C
C     CALCULATION SECTION
C     -------------------
C     Call subroutine USR03B to calculate the product stream flow rates.
      CALL USR03B (KTEST, NHSTRY)
C
C     Call subroutine USR03E to load the outlet stream vectors.
      CALL USR03E (IPASS, ITEMS, KTEST, NCC, NNCC, NCONV, NCCONV,
     1  NHSTRY, SOUT1, SOUT2, SOUT3, SOUT4, SOUT5, SOUT6)
C
C     Calculate the total dry C4- gas feed rate in MM SCF/hr of dry C4-
C     gas for all of the duplicate plants.
      FEEDIN = 0.0D0
      DO 260 J = 1, 12
        IF ( J .NE. 3 .AND. ICNUMB(J) .NE. 0 )   FEEDIN = FEEDIN +
     1    (STRM(J,1) + STRM(J,2))/CIN(J,1)
  260 CONTINUE
      FEEDIN = SCFM * FEEDIN * 0.001D0
C
C     If requested, write the total dry C4- feed in MM SCF/hr.
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 707)  FEEDIN
  707   FORMAT ( / ' Total dry C4- feed =', F12.6, ' MM SCF/hr.' )
      ENDIF
C
C
C     REPORT SECTION
C     --------------
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 ( IPASS .EQ. 4 .AND. INT(1) .LE. 2 )  THEN
        IF ( INT(2) .EQ. 0 )   THEN
C           Calculate the number of lines in the first page.
            LINES = 39
            IF ( UNKNWN .GE. 0.001D0 )  LINES = LINES + 5
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 DCL03.REP to contain
C           this user block summary report.
            OPEN (UNIT=62, FILE='DCL03.REP', STATUS='UNKNOWN',
     1        ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2        BUFFERED='BUFFERED')
            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')
        ENDIF
C       Call subroutine USR03C to write the first page of the summary
C       report.
```

```
        CALL USR03C (INT(1), IPASS, NOUT, FEEDIN, UNKNWN)
      ENDIF
C
C
C     If this is the report pass and the plant sumamry report is being
C     written, prepare for writing the second page.
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 2 )  THEN
        IF ( INT(2) .EQ. 0 )   THEN
C           Calculate the number of lines in the second page.
            LINES = 41
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           If the summary report is going to a separate file, start
C           a new page.
            WRITE (NOUT, 800)
        ENDIF
C       Call subroutine USR03D to write the second page of the summary
C       report.
        CALL USR03D (INT(1), IPASS, NOUT)
      ENDIF
C
C     If it has not been specified by the user in variable INT(3),
C     calculate the number of operating duplicate plants, excluding
C     spares (NPLNT), based on the total flow rate of the reference
C     stream.  However, if the maximum capacity of a single plant
C     has not been specified, set the number of operating plants to 1.
      NPLNT = INT(3)
      IF ( (NPLNT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
          NPLNT = FEEDIN  / PMAXF
          IF ( (MOD(FEEDIN, PMAXF)) .GT. 0.0D0 )  NPLNT = NPLNT + 1
        ELSE
          IF ( NPLNT .EQ. 0 )   NPLNT = 1
      ENDIF
C
C     Calculate the feed rate for each of the duplicate trains (PFLOW)
C     in Mlbs/hr.
      XPLNT = NPLNT
      PFLOW = FEEDIN / XPLNT
C
C     If this is the report pass and the plant summary report is being
C     written, prepare for writing the third page of the plant summary
C     report, the utilities summary and capital cost information.
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 1 )  THEN
        IF ( INT(2) .EQ. 0 )  THEN
C           Calculate the number of lines in third page.
            LSTRM = 4
            LUTIL = 16
            LCOST = 11
            NDUP = REAL(58) + 0.001D0
            IF ( (NPLNT + NDUP) .EQ. 1 )  LCOST = 9
            IF ( PFLOW .LT. PMINF )  LCOST = LCOST + 3
            IF ( PFLOW .GT .PMAXF )  LCOST = LCOST + 3
            IF ( NDUP .GE. 1 )  LCOST = LCOST + 1
```

```
            LINES = LSTRM + LUTIL + LCOST
C           Now, subtract the number of lines for those portions of
C           the user block summary report which will not be written.
            IF ( INT(1) .GE. 2 )   LINES = LINES - LUTIL
            IF ( INT(1) .GE. 1 )   LINES = LINES - LCOST
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
            WRITE (NOUT, 800)
        ENDIF
        WRITE (NOUT, 801)
  801   FORMAT ( / 21X, 'PLANT 3 - SUMMARY REPORT (CONTINUED)' /
     1    33X, 'THE GAS PLANT' / )
      ENDIF
C
C     Call subroutine USRUCO to calculate, save and report the
C     utilities, capital and operating costs for the plant.
      ID = 3
      KUNITS = 4
      CALL USRUCO (NHSTRY, NOUT, IPASS, ID, PNAME, INT(1), INT(3),
     1  KTEST, REAL(21), FEEDIN, KUNITS)
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 USR03' )
C
      RETURN
      END
C
C$ USR03A
      SUBROUTINE USR03A (KTEST, NCC, NHSTRY)
C
C     This subroutine loads the inlet component densities and elemental
C     compositions into the CIN array.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - September 30, 1991.
C
C     Calling arguments:
C     KTEST  = Switch for controlling the printing to the history file.
C     NCC    = Number of conventional components.
C     NHSTRY = Logical unit number of the history file.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON/MW/XMW(1)
C
      COMMON /USR03M/ CIN(55,7), STRM(55,11)
```

```
      COMMON /USR03N/ CNAME(55), ICNUMB(55)
C
C     In CIN(J,K) and STRM(J,K), subscript J designates the following
C     components.
C      1.  H2            16.  T125          36.  P125
C      2.  NH3           17.  T175          37.  P175
C      3.  H2O           18.  T225          38.  P225
C      4.  H2S           19.  T275          39.  P275
C      5.  CO            20.  T325          40.  P325
C      6.  N2            21.  T375          41.  P375
C      7.  CO2           22.  T425          42.  P425
C      8.  CH4           23.  T475          43.  P475
C      9.  C2H6          24.  T525          44.  P575
C     10.  C3H8          25.  T575          45.  P575
C     11.  IC4H10        26.  T625          46.  P625
C     12.  NC4H10        27.  T675          47.  P675
C     13.  IC5H12        28.  T725          48.  P725
C     14.  NC5H12        29.  T775          49.  P775
C     15.  -             30.  T825          50.  P825
C                        31.  T875          51.  P875
C                        32.  T925          52.  P925
C                        33.  T975          53.  P975
C                        34.  T1000+        54.  P1000+
C                        35.  -             55.  -
C     where T225 means the entering material in the 200-250 F boiling
C     range in the CIN array and P225 means the hydrotreated material
C     in the same boiling range.
C     In CIN(J,K), subscript K designates
C       1.  Component molecular weight, lbs/lb-mole.
C       2.  Component standard liquid density at 60 F in lbs/barrel.
C       3.  Sulfur, wt% sulfur.
C       4.  Nitrogen, wt% nitrogen.
C       5.  Oxygen, wt% oxygen.
C       6.  Carbon, wt% carbon.
C       7.  Hydrogen, wt% hydrogen.
C
      DIMENSION SVOL(55)
C
      CHARACTER * 8  CNAME
C
C
C     Conventional components - Load the component molecular weights
C     and standard volumes in m**3/Kg.
      DO 10 J = 1, NCC
        DO 8 K = 1, 55
        IF ( J .EQ. ICNUMB(K) )  THEN
          CIN(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.
          SVOL(K) = XMW(J+NCC)
          GO TO 10
        ENDIF
    8   CONTINUE
   10 CONTINUE
C
```

```
C
C     Convert the component standard volumes from m**3/Kg-mole to
C     densities in lbs/bbl and load them in the CIN and STRM arrays.
C     X is the conversion factor from Kg/m**3 to 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     Load the inlet component densities in lbs/bbl.
      DO 30 J = 1, 55
        IF ( ICNUMB(J) .NE. 0 )   CIN(J,2) = X * CIN(J,1) / SVOL(J)
   30 CONTINUE
C
C     Load the molecular weights of atomic carbon, hydrogen, sulfur,
C     nitrogen and oxygen.
      XMWH = 0.5D0 * CIN(1,1)
      XMWC = CIN(7,1) - 2.0D0 * CIN(1,1)
      XMWS = CIN(4,1) - CIN(1,1)
      XMWN = CIN(2,1) - 1.5D0 * CIN(1,1)
      XMWO = CIN(3,1) - CIN(1,1)
C
C     Zero all the pure component compositions.
      DO 38 J = 1, 15
        DO 36 K = 3, 7
          CIN(J,K) = 0.0D0
   36   CONTINUE
   38 CONTINUE
C
C     Load the pure component carbon, hydrogen, sulfur, nitrogen and
C     oxygen contents in wt%.
C     Hydrogen.
      CIN(1,7) = 100.0D0
C     Ammonia.
      CIN(2,7) = 100.0D0 * 3.0D0 * XMWH / CIN(2,1)
      CIN(2,4) = 100.0D0 * XMWN / CIN(2,1)
C     Water.
      CIN(3,7) = 100.0D0 * 2.0D0 * XMWH / CIN(3,1)
      CIN(3,5) = 100.0D0 * XMWO / CIN(3,1)
C     Hydrogen sulfide.
      CIN(4,7) = 100.0D0 * 2.0D0 * XMWH / CIN(4,1)
      CIN(4,3) = 100.0D0 * XMWS / CIN(4,1)
C     Carbon Monoxide.
      CIN(5,6) = 100.0D0 * XMWC / CIN(5,1)
      CIN(5,5) = 100.0D0 * XMWO / CIN(5,1)
C     Nitrogen.
      CIN(6,4) = 100.0D0 * 2.0D0 * XMWN / CIN(6,1)
C     Carbon Dioxide.
      CIN(7,6) = 100.0D0 * XMWC / CIN(7,1)
      CIN(7,5) = 100.0D0 * 2.0D0 * XMWO / CIN(7,1)
C     Methane.
      CIN(8,6) = 100.0 * XMWC / CIN(8,1)
      CIN(8,7) = 100.0 * 4.0 * XMWH / CIN(8,1)
C     Ethane.
      CIN(9,6) = 100.0D0 * 2.0D0 * XMWC / CIN(9,1)
      CIN(9,7) = 100.0D0 * 6.0D0 * XMWH / CIN(9,1)
C     Propane.
```

```
      CIN(10,6) = 100.0D0 * 3.0D0 * XMWC / CIN(10,1)
      CIN(10,7) = 100.0D0 * 8.0D0 * XMWH / CIN(10,1)
C     Butanes.
      CIN(11,6) = 100.0 * 4.0 * XMWC / CIN(11,1)
      CIN(11,7) = 100.0 * 10.0 * XMWH / CIN(11,1)
      CIN(12,6) = CIN(11,6)
      CIN(12,7) = CIN(11,7)
C     Pentanes.
      CIN(13,6) = 100.0D0 * 5.0D0 * XMWC / CIN(13,1)
      CIN(13,7) = 100.0D0 * 12.0D0 * XMWH / CIN(13,1)
      CIN(14,6) = CIN(13,6)
      CIN(14,7) = CIN(13,7)
C
C     The following elemental compositions were taken from the
C     Aug. 20, 1990 letter to S. N. Habash from A. Basu and
C     A. B. Schachtschneider.  The 850+ F components were estimated.
C
C     Load the C6+ component sulfur contents in wt%.
      CIN(16,3) = 0.01
      CIN(17,3) = 0.01
      CIN(18,3) = 0.01
      CIN(19,3) = 0.01
      CIN(20,3) = 0.01
      CIN(21,3) = 0.01
      CIN(22,3) = 0.01
      CIN(23,3) = 0.02
      CIN(24,3) = 0.02
      CIN(25,3) = 0.02
      CIN(26,3) = 0.02
      CIN(27,3) = 0.06
      CIN(28,3) = 0.06
      CIN(29,3) = 0.06
      CIN(30,3) = 0.06
      CIN(31,3) = 0.10
      CIN(32,3) = 0.15
      CIN(33,3) = 0.20
      CIN(34,3) = 0.25
      CIN(35,3) = 0.0
C     Load the P boiling range components.
      DO 42 J = 36, 55
        K = J - 20
        CIN(J,3) = 0.001D0 * CIN(K,3)
   42 CONTINUE
C
C     Load the C6+ component nitrogen contents in wt%.
      CIN(16,4) = 0.17
      CIN(17,4) = 0.17
      CIN(18,4) = 0.17
      CIN(19,4) = 0.17
      CIN(20,4) = 0.17
      CIN(21,4) = 0.22
      CIN(22,4) = 0.22
      CIN(23,4) = 0.24
      CIN(24,4) = 0.24
      CIN(25,4) = 0.24
```

```
      CIN(26,4) = 0.24
      CIN(27,4) = 0.28
      CIN(28,4) = 0.28
      CIN(29,4) = 0.28
      CIN(30,4) = 0.28
      CIN(31,4) = 0.35
      CIN(32,4) = 0.40
      CIN(33,4) = 0.45
      CIN(34,4) = 0.50
      CIN(35,4) = 0.0
C     Load the P boiling range components.
      DO 44 J = 36, 55
        K = J - 20
        CIN(J,4) = 0.005D0 * CIN(K,4)
   44 CONTINUE
C
C     Load the C6+ component oxygen contents in wt%.
      CIN(16,5) = 0.50
      CIN(17,5) = 0.50
      CIN(18,5) = 0.50
      CIN(19,5) = 0.50
      CIN(20,5) = 0.50
      CIN(21,5) = 0.70
      CIN(22,5) = 0.70
      CIN(23,5) = 0.60
      CIN(24,5) = 0.60
      CIN(25,5) = 0.60
      CIN(26,5) = 0.60
      CIN(27,5) = 0.67
      CIN(28,5) = 0.67
      CIN(29,5) = 0.67
      CIN(30,5) = 0.67
      CIN(31,5) = 0.70
      CIN(32,5) = 0.72
      CIN(33,5) = 0.74
      CIN(34,5) = 0.76
      CIN(35,5) = 0.76
C     Load the P boiling range components.
      DO 46 J = 36, 55
        K = J - 20
        CIN(J,5) = 0.002D0 * CIN(K,5)
   46 CONTINUE
C
C     Load the C6+ component hydrogen contents in wt%.
      CIN(16,7) = 14.21
      CIN(17,7) = 14.21
      CIN(18,7) = 14.21
      CIN(19,7) = 14.21
      CIN(20,7) = 14.21
      CIN(21,7) = 12.16
      CIN(22,7) = 12.16
      CIN(23,7) = 10.95
      CIN(24,7) = 10.95
      CIN(25,7) = 10.95
      CIN(26,7) = 10.95
```

```
      CIN(27,7) = 9.97
      CIN(28,7) = 9.97
      CIN(29,7) = 9.97
      CIN(30,7) = 9.97
      CIN(31,7) = 9.90
      CIN(32,7) = 9.85
      CIN(33,7) = 9.80
      CIN(34,7) = 9.75
      CIN(35,7) = 9.0
C     Load the P boiling range components.
      DO 48 J = 36, 55
        K = J - 20
        CIN(J,7) = 0.95D0 * CIN(K,7)
   48 CONTINUE
C
C     Calculate the C6+ component carbon contents in wt% by difference.
      DO 50 J = 16, 55
        CIN(J,6) = 100.0D0 - CIN(J,3) - CIN(J,4) - CIN(J,5) - CIN(J,7)
   50 CONTINUE
C
      IF ( KTEST .GE. 4 )  THEN
        WRITE (NHSTRY, 503)
  503   FORMAT ( / ' Component properties:' /
     1    3X, 'No.', 2X, 'Name', 9X, 'MW', 4X, 'lbs/bbl', 4X, 'Wt% S',
     2    4X, 'Wt% N', 4X, 'Wt% O', 4X, 'Wt% C', 4X, 'Wt% H', 3X, 'ID')
        DO 60 J = 1, 55
          IF ( ICNUMB(J) .NE. 0 )   WRITE (NHSTRY, 504) J, CNAME(J),
     1      (CIN(J,K), K = 1,7), ICNUMB(J)
  504     FORMAT ( 1X, I5, 2X, A8, 2F9.3, 5F9.4, I5)
   60   CONTINUE
      ENDIF
C
C
      RETURN
      END
C
C$ USR03B
      SUBROUTINE USR03B (KTEST, NHSTRY)
C
C     This subroutine simulates the strippers, absorbers and
C     fractionators in the gas plant.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - November 5, 1992.
C
C     Calling arguments:
C     KTEST    = Switch for controlling the printing to the history
C                file.
C     NHSTRY   = Logical unit number of the history file.
C
C     Method of calculation:
C       The net yields are from the gas plant are calculated from the
C       feed (ignoring any inlet steam) by using component distribution
C       factors based only on the inlet material for each of the four
```

```
C       towers (columns) in the plant.  This technique ignores any
C       internal recycle streams within the gas plant.  The flow scheme
C       is as follows.
C       1. Make-up lean-oil stripper column.
C          The inlet make-up lean-oil naphtha stream (stream 1) enters
C          a make-up lean-oil stripper column which produces an overhead
C          sour-gas (stream 3), a sour water stream from the overhead
C          condenser (stream 11), and a bottoms lean-oil stream (stream
C          4).  The component distribution factors for this column are
C          saved in the CDF1 vector.
C       2. The lean-oil absorber/deethanizer column.
C          The feed to this column is the inlet gas stream (stream 2)
C          and the make-up lean-oil from the previous column.  This
C          column produces 2 products, the overhead fuel gas stream
C          (stream 5) and a bottoms rich-oil stream (stream 6), which
C          is the feed to the lean-oil debutanizer column.  The
C          component distribution factors for this column are saved in
C          the CDF2 vector.
C       3. The lean-oil debutanizer column.
C          This column splits the rich-oil into a C3/C4 overhead stream
C          (stream 7) and a lean-oil stream, part of which is recycled
C          to the absorber and par of which is the lean-oil product
C          naphtha stream (stream 8).  The component distribution
C          factors for this column are saved in the CDF3 vector.
C       4. The Depropanizer column.
C          This column splits the C3/C4 stream (stream 7) into the
C          propane product stream (stream 9) and the butanes product
C          stream (stream 10). The component distribution factors for
C          this column are saved in the CDF1 vector.
C       Thus, the six net product streams from the gas plant are
C           Stream 1 - the sour gas stream.
C           Stream 2 - the fuel gas stream.
C           Stream 3 - the propane product stream.
C           Stream 4 - the butanes product stream.
C           Stream 5 - the reject lean-oil (naphtha) product stream.
C           Stream 6 - the sour water stream from the overhead condenser
C                      of the make-up lean-oil stripper column.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
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
C     See subroutine USR03 for a description of the items in named
C     COMMON blocks /USR03M/ and /USR03N/.
      COMMON /USR03M/ CIN(55,7), STRM(55,11)
      COMMON /USR03N/ CNAME(55), ICNUMB(55)
C
C     Loacal variable declarations.
      DIMENSION CDF1(35), CDF2(35), CDF3(35), CDF4(35), CDF1H(35),
     1  CDF2H(35), CDF3H(35), CDF4H(35)
```

```
C
      CHARACTER * 8  CNAME
C
C     The following component distribution factors specify the fraction
C     of fresh entering material leaving in the overhead of each column.
C     The CDFH factors are for the High Space Velocity case.
C     CDF1(J) are the component distribution factors for the make-up
C             lean-oil stripper which produces the overhead sour gas
C             stream and the lean-oil make-up stream going to the
C             absorber/deethanizer.
C     CDF2(J) are the component distribution factors for absorber/
C             deethanizer which produces the overhead fuel gas stream
C             and the bottoms lean-oil stripper/debutanizer feed stream.
C     CDF3(J) are the component distribution factors for the lean-oil
C             stripper/debutanizer which produces the overhead C3/C4
C             depropanizer feed stream and the bottoms lean-oil purge
C             strean which goes to plant 4.
C     CDF4(J) are the component distribution factors for the debutanizer
C             which produces the overhead propane product stream and
C             the bottoms butanes product stream.
C
C     Initialize the Baseline component distribution factors for the
C     sour gas overhead stream from the make-up lean-oil stripper.
C     Fraction of  H2         NH3        H2O        H2S        CO
      DATA CDF1  / 1.000000, 1.000000, 0.0189300, 1.000000, 1.000000,
C       N2         CO2        CH4        C2H6       C3H8
     1  1.0000000, 1.0000000, 1.0000000, 1.0000000, 1.0000000,
C       IC4H10     NC4H10     IC5H12     NC5H12     Future
     2  1.0000000, 1.0000000, 0.8627451, 0.8627451, 0.0000000,
C       T125        T175        T225        T275        T325
     3  0.00385767, 0.00385767, 0.00385767, 0.00385767, 0.00385767,
C       T375       T425       T475       T525       T575
     4  0.0000000, 0 0000000, 0.0000000, 0.0000000, 0.0000000,
C       T625       T675       T725       T775       T825
     5  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       T875       T925       T975       T1000+     Future
     6  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000 /
C
C     Initialize the Baseline component distribution factors for the
C     fuel gas overhead stream from the absorber/deethanizer.
C     Fraction of  H2         NH3        H2O        H2S        CO
      DATA CDF2  / 1.000000, 1.000000, 1.000000, 1.000000, 1.000000,
C       N2         CO2        CH4        C2H6       C3H8
     1  1.0000000, 1.0000000, 0.9999384, 0.9833232, 0.0015118,
C       IC4H10     NC4H10     IC5H12     NC5H12     Future
     2  0.0019202, 0.0071988, 0.2160554, 0.2160554, 0.0000000,
C       T125       T175       T225       T275       T325
     3  0.0159102, 0.0159102, 0.0159102, 0.0159102, 0.0159102,
C       T375       T425       T475       T525       T575
     4  0.0009662, 0 0000000, 0.0000000, 0.0000000, 0.0000000,
C       T625       T675       T725       T775       T825
     5  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       T875       T925       T975       T1000+     Future
     6  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000 /
C
```

```
C     Initialize the Baseline component distribution factors for the
C     C3/C4s overhead stream from the lean-oil stripper/debutanizer
C     column.
C     Fraction of  H2         NH3        H2O        H2S        CO
      DATA CDF3  / 1.000000, 1.000000, 1.000000, 1.000000, 1.000000,
C       N2         CO2        CH4        C2H6       C3H8
     1  1.0000000, 1.0000000, 1.0000000, 1.0000000, 1.0000000,
C       IC4H10     NC4H10     IC5H12     NC5H12     Future
     2  0.9939322, 0.9923674, 0.0612641, 0.0612641, 0.0000000,
C       T125       T175       T225       T275       T325
     3  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       T375       T425       T475       T525       T575
     4  0.0000000, 0 0000000, 0.0000000, 0.0000000, 0.0000000,
C       T625       T675       T725       T775       T825
     5  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       T875       T925       T975       T1000+     Future
     6  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000 /
C
C     Initialize the Baseline component distribution factors for the
C     propane product overhead stream from the depropanizer column.
C     Fraction of  H2         NH3        H2O        H2S        CO
      DATA CDF4  / 1.000000, 1.000000, 1.000000, 1.000000, 1.000000,
C       N2         CO2        CH4        C2H6       C3H8
     1  1.0000000, 1.0000000, 1.0000000, 0.9818182, 0.9867516,
C       IC4H10     NC4H10     IC5H12     NC5H12     Future
     2  0.0477963, 0.0041020, 0.0000000, 0.0000000, 0.0000000,
C       T125       T175       T225       T275       T325
     3  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       T375       T425       T475       T525       T575
     4  0.0000000, 0 0000000, 0.0000000, 0.0000000, 0.0000000,
C       T625       T675       T725       T775       T825
     5  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       T875       T925       T975       T1000+     Future
     6  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000 /
C
C     Initialize the High Space Velocity Case component distribution
C     factors for the sour gas overhead stream from the make-up
C     lean-oil stripper.
C     Fraction of  H2         NH3        H2O        H2S        CO
      DATA CDF1H / 1.000000, 1.000000, 0.5454545, 1.000000, 1.000000,
C       N2         CO2        CH4        C2H6       C3H8
     1  1.0000000, 1.0000000, 1.0000000, 0.9800000, 0.9970414,
C       IC4H10     NC4H10     IC5H12     NC5H12     Future
     2  0.8961219, 0.8961219, 0.0073701, 0.0073701, 0.0000000,
C       T125       T175       T225       T275       T325
     3  0.0073701, 0.0073701, 0.0073701, 0.0073701, 0.0073701,
C       T375       T425       T475       T525       T575
     4  0.0000000, 0 0000000, 0.0000000, 0.0000000, 0.0000000,
C       T625       T675       T725       T775       T825
     5  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       T875       T925       T975       T1000+     Future
     6  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000 /
C
C     Initialize the High Space Velocity Case component distribution
C     factors for the fuel gas overhead stream from the absorber/
```

```
C     deethanizer.
C     Fraction of  H2         NH3        H2O        H2S        CO
      DATA CDF2H / 1.000000, 1.000000, 1.000000, 1.000000, 1.000000,
C       N2         CO2        CH4        C2H6       C3H8
     1  1.0000000, 1.0000000, 1.0000000, 0.9829465, 0.0008612,
C       IC4H10     NC4H10     IC5H12     NC5H12     Future
     2  0.0070967, 0.0070967, 0.0352566, 0.0352566, 0.0000000,
C       T125       T175       T225       T275       T325
     3  0.0352566, 0.0352566, 0.0352566, 0.0352566, 0.0352566,
C       T375       T425       T475       T525       T575
     4  0.0000000, 0 0000000, 0.0000000, 0.0000000, 0.0000000,
C       T625       T675       T725       T775       T825
     5  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       T875       T925       T975       T1000+     Future
     6  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000 /
C
C     Initialize the High Space Velocity Case component distribution
C     factors for the C3/C4s overhead stream from the lean-oil
C     stripper/debutanizer column.
C     Fraction of  H2         NH3        H2O        H2S        CO
      DATA CDF3H / 1.000000, 1.000000, 1.000000, 1.000000, 1.000000,
C       N2         CO2        CH4        C2H6       C3H8
     1  1.0000000, 1.0000000, 1.0000000, 1.0000000, 0.9999282,
C       IC4H10     NC4H10     IC5H12     NC5H12     Future
     2  0.9886921, 0.9886921, 0.0018933, 0.0018933, 0.0000000,
C       T125       T175       T225       T275       T325
     3  0.0018933, 0.0018933, 0.0018933, 0.0018933, 0.0018033,
C       T375       T425       T475       T525       T575
     4  0.0000000, 0 0000000, 0.0000000, 0.0000000, 0.0000000,
C       T625       T675       T725       T775       T825
     5  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       T875       T925       T975       T1000+     Future
     6  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000 /
C
C     Initialize the High Space Velocity Case component distribution
C     factors for the propane product overhead stream from the
C     depropanizer column.
C     Fraction of  H2         NH3        H2O        H2S        CO
      DATA CDF4H / 1.000000, 1.000000, 1.000000, 1.000000, 1.000000,
C       N2         CO2        CH4        C2H6       C3H8
     1  1.0000000, 1.0000000, 1.0000000, 1.0000000, 0.9897996,
C       IC4H10     NC4H10     IC5H12     NC5H12     Future
     2  0.0297799, 0.0297799, 0.0000000, 0.0000000, 0.0000000,
C       T125       T175       T225       T275       T325
     3  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       T375       T425       T475       T525       T575
     4  0.0000000, 0 0000000, 0.0000000, 0.0000000, 0.0000000,
C       T625       T675       T725       T775       T825
     5  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000,
C       T875       T925       T975       T1000+     Future
     6  0.0000000, 0.0000000, 0.0000000, 0.0000000, 0.0000000 /
C
C
      IF ( KTEST .GE. 3 )   WRITE (NHSTRY, 701)
  701 FORMAT ( / ' Starting the gas plant separation calculations',
```

```
     1  ' in Subroutine USR03B.' )
C
C
C     HIGH SPACE VELOCITY option component distribution factors.
      IF ( MODE .EQ. 18 )  THEN
        DO 10 J = 1, 35
          CDF1(J) = CDF1H(J)
          CDF2(J) = CDF2H(J)
          CDF3(J) = CDF3H(J)
          CDF4(J) = CDF4H(J)
   10   CONTINUE
      ENDIF
C
      IF ( KTEST .GE. 2 )   THEN
        WRITE (NHSTRY, 702) MODE
  702   FORMAT ( / ' The component overhead product distribution ',
     1    'factors: MODE = ', I4 /
     2    ' No.', 3X, 'Component', 4X, 'Sour Gas',
     3    6X, 'Fuel Gas', 7X, 'Debut.', 7X, 'Deprop.' )
        DO 20 J = 1, 35
          IF ( ICNUMB(J) .NE. 0 ) WRITE (NHSTRY, 703)  J, CNAME(J),
     1      CDF1(J), CDF2(J), CDF3(J), CDF4(J)
  703     FORMAT ( 1X, I3, 3X, A8, F13.7, 3F14.7 )
   20   CONTINUE
        WRITE (NHSTRY, 704)
  704   FORMAT ( 2X, 'The component distribution factors for the',
     1    ' P boiling range cuts' /
     2    2X, 'are the same as those for the T boiling range cuts.' /)
      ENDIF
C
C
C     Simulate the Make-up Lean-oil Stripper Column.
C     ----------------------------------------------
      DO 30 J = 1, 55
C       Get the distribution factor for this component going to the
C       sour gas overhead stream.  Use the T boiling range cut factors
C       for the boiling range cut components also.
        IF ( J .LE. 35 )  THEN
            CDF = CDF1(J)
          ELSE
            CDF = CDF1(J-20)
        ENDIF
        STRM(J,3) = CDF * STRM(J,1)
        STRM(J,4) = STRM(J,1) - STRM(J,3)
   30 CONTINUE
C     Remove all remaing water and put it in the overhead sour water
C     stream.
      STRM(3,11) = STRM(3,4)
      STRM(3,4) = 0.0D0
C
      IF ( KTEST .GE. 4 )   THEN
        WRITE (NHSTRY, 711)
  711   FORMAT ( / ' The Make-up Lean-oil Stripper',
     1    ' (flows in Mlbs/hr)' /
     2    ' No.', 3X, 'Component', 3X, 'Dist Factor',
```

```
     3    4X, 'Oil Fd', 3X, 'Sour Gas', 5X, 'Lean Oil', 4X, 'Sour H2O')
          SUM1 = 0.0D0
          SUM2 = 0.0D0
          SUM3 = 0.0D0
          SUM4 = 0.0D0
          DO 40 J = 1, 55
            IF ( ICNUMB(J) .NE. 0 )  THEN
              IF ( STRM(J,1) .GE. 0.0005D0 )  THEN
                IF ( J .LE. 35 )  THEN
                    CDF = CDF1(J)
                  ELSE
                    CDF = CDF1(J-20)
                ENDIF
                WRITE (NHSTRY, 712)  J, CNAME(J), CDF, STRM(J,1),
     1            STRM(J,3), STRM(J,4), STRM(J,11)
   712          FORMAT ( 1X, I3, 3X, A8, F12.6, 4F12.3 )
                SUM1 = SUM1 + STRM(J,1)
                SUM2 = SUM2 + STRM(J,3)
                SUM3 = SUM3 + STRM(J,4)
                SUM4 = SUM4 + STRM(J,11)
              ENDIF
            ENDIF
    40    CONTINUE
          WRITE (NHSTRY, 713)  SUM1, SUM2, SUM3, SUM4
   713    FORMAT ( 7X, 'Total', 15X, 4F12.3 )
        ENDIF
C
C
C       Simulate the Lean-oil Absorber/Deethanizer Column.
C       ---------------------------------------------------
        DO 50 J = 1, 55
C         Get the distribution factor for this component going to the
C         fuel gas overhead stream.  Use the T boiling range cut factors
C         for the boiling range cut components also.
          IF ( J .LE. 35 )  THEN
              CDF = CDF2(J)
            ELSE
              CDF = CDF2(J-20)
          ENDIF
          STRM(J,5) = CDF * ( STRM(J,2) + STRM(J,4) )
          STRM(J,6) = STRM(J,2) + STRM(J,4) - STRM(J,5)
    50  CONTINUE
C
        IF ( KTEST .GE. 4 )   THEN
          WRITE (NHSTRY, 716)
   716    FORMAT ( / ' The Lean-oil Absorber/Deethanizer Column',
     1      ' (flows in Mlbs/hr)' /
     2      ' No.', 3X, 'Component', 3X, 'Dist Factor',
     3      3X, 'Fresh Fd', 3X, 'Fuel Gas', 5X, 'Bottoms')
          SUM1 = 0.0D0
          SUM2 = 0.0D0
          SUM3 = 0.0D0
          DO 60 J = 1, 55
            IF ( ICNUMB(J) .NE. 0 )  THEN
              FD = STRM(J,2) + STRM(J,4)
```

```
            IF ( FD .GE. 0.0005 )  THEN
              IF ( J .LE. 35 )  THEN
                  CDF = CDF2(J)
                ELSE
                  CDF = CDF2(J-20)
              ENDIF
              WRITE (NHSTRY, 717)  J, CNAME(J), CDF, FD, STRM(J,5),
     1          STRM(J,6)
  717         FORMAT ( 1X, I3, 3X, A8, F12.6, 3F12.3 )
              SUM1 = SUM1 + FD
              SUM2 = SUM2 + STRM(J,5)
              SUM3 = SUM3 + STRM(J,6)
            ENDIF
          ENDIF
   60   CONTINUE
        WRITE (NHSTRY, 718)  SUM1, SUM2, SUM3
  718   FORMAT ( 7X, 'Total', 15X, 3F12.3 )
      ENDIF
C
C
C     Simulate the Lean-oil Stripper/Debutanizer Column.
C     ---------------------------------------------------
      DO 70 J = 1, 55
C       Get the distribution factor for this component going to the
C       C3/C4s overhead stream.  Use the T boiling range cut factors
C       for the P boiling range cut components also.
        IF ( J .LE. 35 )  THEN
            CDF = CDF3(J)
          ELSE
            CDF = CDF3(J-20)
        ENDIF
        STRM(J,7) = CDF * STRM(J,6)
        STRM(J,8) = STRM(J,6) - STRM(J,7)
   70 CONTINUE
C
      IF ( KTEST .GE. 4 )   THEN
        WRITE (NHSTRY, 721)
  721   FORMAT ( / ' The Lean-oil Stripper/Debutanizer Column',
     1    ' (flows in Mlbs/hr)' /
     2    ' No.', 3X, 'Component', 3X, 'Dist Factor',
     3    3X, 'Fresh Fd', 4X, 'C3/C4s', 5X, 'Lean-oil' )
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        DO 80 J = 1, 55
          IF ( ICNUMB(J) .NE. 0 )  THEN
            IF ( STRM(J,6) .GE. 0.0005 )  THEN
              IF ( J .LE. 35 )  THEN
                  CDF = CDF3(J)
                ELSE
                  CDF = CDF3(J-20)
              ENDIF
              WRITE (NHSTRY, 722)  J, CNAME(J), CDF, STRM(J,6),
     1          STRM(J,7), STRM(J,8)
  722         FORMAT ( 1X, I3, 3X, A8, F12.6, 3F12.3 )
```

```
                SUM1 = SUM1 + STRM(J,6)
                SUM2 = SUM2 + STRM(J,7)
                SUM3 = SUM3 + STRM(J,8)
              ENDIF
            ENDIF
   80     CONTINUE
          WRITE (NHSTRY, 723)  SUM1, SUM2, SUM3
  723     FORMAT ( 7X, 'Total', 15X, 3F12.3 )
        ENDIF
C
C
C       Simulate the Depropanizer Column.
C       --------------------------------
        DO 90 J = 1, 55
C         Get the distribution factor for this component going to the
C         propane product overhead stream.  Use the T boiling range cut
C         factors for the P boiling range cut components also.
          IF ( J .LE. 35 )  THEN
              CDF = CDF4(J)
            ELSE
              CDF = CDF4(J-20)
          ENDIF
          STRM(J,9) = CDF * STRM(J,7)
          STRM(J,10) = STRM(J,7) - STRM(J,9)
   90 CONTINUE
C
        IF ( KTEST .GE. 4 )   THEN
          WRITE (NHSTRY, 726)
  726     FORMAT ( / ' The Depropanizer Column',
     1      ' (flows in Mlbs/hr)' /
     2      ' No.', 3X, 'Component', 3X, 'Dist Factor',
     3      3X, 'Fresh Fd', 3X, 'Propane', 5X, 'Butanes' )
          SUM1 = 0.0D0
          SUM2 = 0.0D0
          SUM3 = 0.0D0
          DO 100 J = 1, 55
            IF ( ICNUMB(J) .NE. 0 )  THEN
              IF ( STRM(J,7) .GE. 0.0005 )  THEN
                IF ( J .LE. 35 )  THEN
                    CDF = CDF4(J)
                  ELSE
                    CDF = CDF4(J-20)
                ENDIF
                WRITE (NHSTRY, 727)  J, CNAME(J), CDF, STRM(J,7),
     1            STRM(J,9), STRM(J,10)
  727           FORMAT ( 1X, I3, 3X, A8, F12.6, 3F12.3 )
                SUM1 = SUM1 + STRM(J,7)
                SUM2 = SUM2 + STRM(J,9)
                SUM3 = SUM3 + STRM(J,10)
              ENDIF
            ENDIF
  100     CONTINUE
          WRITE (NHSTRY, 728)  SUM1, SUM2, SUM3
  728     FORMAT ( 7X, 'Total', 15X, 3F12.3 )
        ENDIF
```

```
C
      RETURN
      END
C
C$ USR03C
      SUBROUTINE USR03C (INT1, IPASS, NOUT, C4M, UNKNWN)
C
C     This subroutine writes the first page of the gas plant
C     summary report.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - September 30, 1991.
C
C     Calling arguments:
C     INT1    = 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 report.
C               2 => Skip the capital cost and utilities portions of the
C                    summary report.
C               3 => Skip writing the entire user block summary report.
C     IPASS     = The results pass flag.
C     NOUT      = Logical unit of the plant summary report file.
C     C4M       = MM SCF/hr of dry C4- in the total feed.
C     UNKNWN    = Mlbs/hr of unknown or solid components in the feed to
C                 the gas plant.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
C     See subroutine USR03 for a description of the items in named
C     COMMON blocks /USR03M/ and /USR03N/.
      COMMON /USR03M/ CIN(55,7), STRM(55,11)
      COMMON /USR03N/ CNAME(55), ICNUMB(55)
C
      CHARACTER * 8  CNAME
C
      DATA SCFM / 379.495D0 /
C
C
      IF ( IPASS .EQ. 4 .AND. INT1 .LE. 0 )  THEN
C       Write the inlet stream section of the plant summary report.
C       ==========================================================
        WRITE (NOUT, 801)
  801   FORMAT ( / 27X, 'PLANT 3 - SUMMARY REPORT' /
     1    32X, 'THE GAS PLANT' //
     2    29X, 'INLET STREAM SUMMARY' )
C
        WRITE (NOUT, 802)
  802   FORMAT ( / '  INLET STREAMS, MLBS/HR')
C
C       Write the net inlet stream flow rates in Mlbs/hr.
        WRITE (NOUT, 803)
  803   FORMAT ( 4X, 'COMPONENT', 5X, 'NAPHTHA', 9X, 'GAS', 7X, 'TOTAL')
        DO 310 J = 1, 15
```

```
          IF ( ICNUMB(J) .NE. 0 )  THEN
            X = STRM(J,1) + STRM(J,2)
            WRITE (NOUT, 804) CNAME(J), STRM(J,1), STRM(J,2), X
  804       FORMAT ( 4X, A8, F13.3, 2F12.3 )
          ENDIF
  310   CONTINUE
C       Combine the boiling range cuts up to 500 F.
        DO 320 J = 16, 23
          IF ( ICNUMB(J) .NE. 0 )  THEN
            K = J + 20
            X1 = STRM(J,1) + STRM(K,1)
            X2 = STRM(J,2) + STRM(K,2)
            X = X1 + X2
            WRITE (NOUT, 804) CNAME(J), X1, X2, X
          ENDIF
  320   CONTINUE
C       Combine the boiling range cuts above 500 F.
        X1 = 0.0D0
        X2 = 0.0D0
        DO 325 J = 24, 35
          IF ( ICNUMB(J) .NE. 0 )  THEN
            K = J + 20
            X1 = X1 + STRM(J,1) + STRM(K,1)
            X2 = X2 + STRM(J,2) + STRM(K,2)
            X = X1 + X2
          ENDIF
  325   CONTINUE
        WRITE (NOUT, 805) X1, X2, X
  805   FORMAT ( 4X, '500+ F', F15.3, 2F12.3 )
C
C       Calculate and write the total flow rates in Mlbs/hr, the gas
C       stream flow rates in MM SCF/hr, and the naphtha stream flow
C       rate in bbl/hr.
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SM2 = 0.0D0
        BBLS = 0.0
        DO 330 J = 1, 55
          IF ( ICNUMB(J) .NE. 0 )  THEN
            SUM1 = SUM1 + STRM(J,1)
            SUM2 = SUM2 + STRM(J,2)
            SM2 = SM2 + STRM(J,2) / CIN(J,1)
            BBLS = BBLS + STRM(J,1) / CIN(J,2)
          ENDIF
  330   CONTINUE
C       Convert the gas flow rate from M lb-moles/hr to MM SCF/hr.
        SCF2 = 0.001D0 * SCFM * SM2
C       Convert the naphtha flow rate from Mlbs/hr to bbl/hr.
        BBLS = 1.0D+3 * BBLS
C
        SUM3 = SUM1 + SUM2
        WRITE (NOUT, 806) SUM1, SUM2, SUM3
  806   FORMAT ( 4X, 'TOTAL', 3X, F13.3, 2F12.3 )
        WRITE (NOUT, 807) SCF2, BBLS, C4M
  807   FORMAT ( / 4X, 'MM SCF/HR', F24.3 /
```

```
     1    4X, 'BBL/HR', F15.3 //
     2    4X, 'MM SCF/HR OF DRY C4-', F25.3 )
C
        IF ( UNKNWN .GE. 1.0D-3 )  WRITE(NOUT, 825) UNKNWN
  825   FORMAT ( / ' *WARNING* THE FEED TO THIS PLANT CONTAINS', F8.3,
     1    ' MLBS/HR OF COMPONENT(S)' /
     2    2X, 'UNKNOWN TO THIS MODEL.  THEY ARE BEING IGNORED.  ',
     3    'THEREFORE, THE GAS'/
     3    2X, 'PLANT IS NOT IN MASS BALANCE.  PLEASE REMOVE ',
     4    'THESE EXTRA COMPONENT(S)' /
     5    2X, 'FROM THE FEED STREAM.' )
C
        WRITE (NOUT, 821)
  821   FORMAT ( / 25X, '- CONTINUED ON NEXT PAGE -' )
      ENDIF
C
      RETURN
      END
C
C$ USR03D
      SUBROUTINE USR03D (INT1, IPASS, NOUT)
C
C     This subroutine writes the second page of the gas plant
C     summary report.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - June 4, 1991.
C
C     Calling arguments:
C     INT1    = 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 report.
C               2 => Skip the capital cost and utilities portions of the
C                    summary report.
C               3 => Skip writing the entire user block summary report.
C     IPASS     = The results pass flag.
C     NOUT      = Logical unit of the plant summary report file.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
C     See subroutine USR03 for a description of the items in named
C     COMMON blocks /USR03M/ and /USR03N/.
      COMMON /USR03M/ CIN(55,7), STRM(55,11)
      COMMON /USR03N/ CNAME(55), ICNUMB(55)
C
      CHARACTER * 8  CNAME
C
      DATA SCFM / 379.495D0 /
C
C
      IF ( IPASS .EQ. 4 .AND. INT1 .LE. 0 )  THEN
C       Write the outlet stream section of the plant summary report.
C       ============================================================
```

```
      WRITE (NOUT, 801)
  801 FORMAT ( / 21X, 'PLANT 3 - SUMMARY REPORT (CONTINUED)' /
     1  33X, 'THE GAS PLANT' //
     2  29X, 'OUTLET STREAM SUMMARY' )
C
      WRITE (NOUT, 802)
  802 FORMAT ( / '  OUTLET STREAMS, MLBS/HR')
C
C     Write the net outlet stream flow rates in Mlbs/hr.
      WRITE (NOUT, 803)
  803 FORMAT ( 21X, 'SOUR', 8X, 'FUEL', 32X, 'LEAN' /
     1  4X, 'COMPONENT', 8X, 'GAS', 9X, 'GAS', 7X, 'PROPANE',
     2  5X, 'BUTANES', 7X, 'OIL' )
      DO 310 J = 1, 15
        IF ( ICNUMB(J) .NE. 0 )  THEN
          WRITE (NOUT, 804) CNAME(J), STRM(J,3), STRM(J,5),
     1      STRM(J,9), STRM(J,10), STRM(J,8)
  804     FORMAT ( 4X, A8, F13.3, 4F12.3 )
        ENDIF
  310 CONTINUE
C     Combine the boiling range cuts up to 500 F.
      DO 320 J = 16, 23
        IF ( ICNUMB(J) .NE. 0 )  THEN
          K = J + 20
          X1 = STRM(J,3) + STRM(K,3)
          X2 = STRM(J,5) + STRM(K,5)
          X3 = STRM(J,9) + STRM(K,9)
          X4 = STRM(J,10) + STRM(K,10)
          X5 = STRM(J,8) + STRM(K,8)
          WRITE (NOUT, 804) CNAME(J), X1, X2, X3, X4, X5
        ENDIF
  320 CONTINUE
C     Combine the boiling range cuts above 500 F.
      X1 = 0.0D0
      X2 = 0.0D0
      X3 = 0.0D0
      X4 = 0.0D0
      X5 = 0.0D0
      DO 325 J = 24, 35
        IF ( ICNUMB(J) .NE. 0 )  THEN
          K = J + 20
          X1 = X1 + STRM(J,3) + STRM(K,3)
          X2 = X2 + STRM(J,5) + STRM(K,5)
          X3 = X3 + STRM(J,9) + STRM(K,9)
          X4 = X4 + STRM(J,10) + STRM(K,10)
          X5 = X5 + STRM(J,8) + STRM(K,8)
        ENDIF
  325 CONTINUE
      WRITE (NOUT, 805) X1, X2, X3, X4, X5
  805 FORMAT ( 4X, '500+ F', F15.3, 4F12.3 )
C
C     Calculate and write the total flow rates in Mlbs/hr, the gas
C     stream flow rates in MM SCF/hr, and the naphtha stream flow
C     rate in bbl/hr.
      SUM1 = 0.0D0
```

```
      SUM2 = 0.0D0
      SUM3 = 0.0D0
      SUM4 = 0.0D0
      SUM5 = 0.0D0
      SM1 = 0.0D0
      SM2 = 0.0D0
      SM3 = 0.0D0
      SM4 = 0.0D0
      BBLS = 0.0
      DO 330 J = 1, 55
        IF ( ICNUMB(J) .NE. 0 )  THEN
          SUM1 = SUM1 + STRM(J,3)
          SUM2 = SUM2 + STRM(J,5)
          SUM3 = SUM3 + STRM(J,9)
          SUM4 = SUM4 + STRM(J,10)
          SUM5 = SUM5 + STRM(J,8)
          SM1 = SM1 + STRM(J,3) / CIN(J,1)
          SM2 = SM2 + STRM(J,5) / CIN(J,1)
          SM3 = SM3 + STRM(J,9) / CIN(J,1)
          SM4 = SM4 + STRM(J,10) / CIN(J,1)
          BBLS = BBLS + STRM(J,8) / CIN(J,2)
        ENDIF
  330 CONTINUE
C     Convert the gas flow rate from M lb-moles/hr to MM SCF/hr.
      SCF1 = 0.001D0 * SCFM * SM1
      SCF2 = 0.001D0 * SCFM * SM2
      SCF3 = 0.001D0 * SCFM * SM3
      SCF4 = 0.001D0 * SCFM * SM4
C     Convert the naphtha flow rate from Mlbs/hr to bbl/hr.
      BBLS = 1.0D+3 * BBLS
C     Convert the sour water flow rate from Mbbls/hr to gal/min.
      SOUR = 42.0D0 * 1.0D+3 * SOUR / 60.0D0
C
      WRITE (NOUT, 806) SUM1, SUM2, SUM3, SUM4, SUM5
  806 FORMAT ( 4X, 'TOTAL', 3X, F13.3, 4F12.3 )
      WRITE (NOUT, 807) SCF1, SCF2, SCF3, SCF4, BBLS
  807 FORMAT ( / 4X, 'MM SCF/HR', F12.3, 3F12.3 /
     1  4X, 'BBL/HR', F63.3 )
C
C     Convert the sour water flow rate from Mlbs/hr to gal/hr.
      X = 0.0D0
      IF ( CIN(3,2) .GE. 0.1D0 )   THEN
        X = 1.0D+3 * STRM(3,11) * 42.0D0 / CIN(3,2)
      ENDIF
      WRITE (NOUT, 811) STRM(3,11), X
  811 FORMAT ( // 4X, 'SOUR WATER', F11.3, ' MLBS/HR',
     1  F16.1, ' GAL/HR' )
C
      WRITE (NOUT, 821)
  821 FORMAT ( / 25X, '- CONTINUED ON NEXT PAGE -' )
    ENDIF
C
    RETURN
    END
C
```

```
C$ USR03E
      SUBROUTINE USR03E (IPASS, ITEMS, KTEST, NCC, NNCC, NCONV, NCCONV,
     1  NHSTRY, SOUT1, SOUT2, SOUT3, SOUT4, SOUT5, SOUT6)
C
C     This subroutine loads the six outlet stream vectors.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - June 4, 1991.
C
C     Calling arguments:
C     IPASS    = The results pass flag.
C     ITEMS    = Total number of items in the SOUT1 - SOUT3 vectors.
C     KTEST    = Switch for controlling the printing to the history
C                file.
C     NCC      = Number of conventional components.
C     NNCC     = Number of non-conventional components.
C     NCONV    = Offset for the conventional component substream.
C     NCCONV   = Offset for the non-conventional component substream.
C     NHSTRY   = Logical unit number of the history file.
C     SOUT1()  = ASPEN/SP stream vector for outlet stream number 1 -
C                the sour gas stream.
C     SOUT2()  = ASPEN/SP stream vector for outlet stream number 2 -
C                the fuel gas stream.
C     SOUT3()  = ASPEN/SP stream vector for outlet stream number 3 -
C                the propane stream.
C     SOUT4()  = ASPEN/SP stream vector for outlet stream number 4 -
C                the butanes stream.
C     SOUT5()  = ASPEN/SP stream vector for outlet stream number 5 -
C                the reject lean-oil naphtha stream.
C     SOUT6()  = ASPEN/SP stream vector for outlet stream number 6 -
C                the sour water stream.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
C     See subroutine USR03A for a description of the items in named
C     COMMON block /USR03M/.
      COMMON /USR03M/ CIN(55,7), STRM(55,11)
      COMMON /USR03N/ CNAME(55), ICNUMB(55)
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 SOUT1(*), SOUT2(*), SOUT3(*), SOUT4(*), SOUT5(*),
     1  SOUT6(*)
C
      CHARACTER * 8  CNAME
C
C
      IF ( IPASS .NE. 4 )   THEN
C       Set up the product stream properties in the SOUT vectors.
```

```
C       ==========================================================
C       First, zero all the items in the product stream vectors.
        DO 200 J = 1, ITEMS
          SOUT1(J) = 0.0D0
          SOUT2(J) = 0.0D0
          SOUT3(J) = 0.0D0
          SOUT4(J) = 0.0D0
          SOUT5(J) = 0.0D0
          SOUT6(J) = 0.0D0
  200   CONTINUE
C
C       CF is the conversion factor from Kg/sec to Mlbs/hr.
        CF = 0.001D0 * 3600.0D0 / 0.45359237D0
C
C       Set the molar flow rates of the conventional components.
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        SUM4 = 0.0D0
        SUM5 = 0.0D0
        SUM6 = 0.0D0
        DO 210 J = 1, NCC
          DO 208 K = 1, 55
            IF ( J .EQ. ICNUMB(K) )  THEN
              SOUT1(J) = STRM(K,3) / (CF * CIN(K,1))
              SOUT2(J) = STRM(K,5) / (CF * CIN(K,1))
              SOUT3(J) = STRM(K,9) / (CF * CIN(K,1))
              SOUT4(J) = STRM(K,10) / (CF * CIN(K,1))
              SOUT5(J) = STRM(K,8) / (CF * CIN(K,1))
              SOUT6(J) = STRM(K,11) / (CF * CIN(K,1))
              SUM1 = SUM1 + SOUT1(J)
              SUM2 = SUM2 + SOUT2(J)
              SUM3 = SUM3 + SOUT3(J)
              SUM4 = SUM4 + SOUT4(J)
              SUM5 = SUM5 + SOUT5(J)
              SUM6 = SUM6 + SOUT6(J)
              GO TO 210
            ENDIF
  208     CONTINUE
  210   CONTINUE
C
C       Set the total molar flow rates of the conventional components.
        SOUT1(NCC+1) = SUM1
        SOUT2(NCC+1) = SUM2
        SOUT3(NCC+1) = SUM3
        SOUT4(NCC+1) = SUM4
        SOUT5(NCC+1) = SUM5
        SOUT6(NCC+1) = SUM6
C
C       Since there are no non-conventional components leaving this
C       model, nothing needs to be done with them since their flow
C       rates and properties already have been set to zero.
C
C       Set the default temperature and pressure of the outlet streams
C       to 70 F and 15 PSIA.  Return these values to ASPEN/SP in degrees
```

```
C       Kelvin and Pascals.  These default values can be overriden by
C       the FLASH-SPECS sentence in the ASPEN/SP input file.
        SOUT1(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT1(NCC+3) = 15.0D0 * 6.8947573D+3
        SOUT2(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT2(NCC+3) = 15.0D0 * 6.8947573D+3
        SOUT3(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT3(NCC+3) = 15.0D0 * 6.8947573D+3
        SOUT4(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT4(NCC+3) = 15.0D0 * 6.8947573D+3
        SOUT5(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT5(NCC+3) = 15.0D0 * 6.8947573D+3
        SOUT6(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT6(NCC+3) = 15.0D0 * 6.8947573D+3
C
        IF ( NNCC .GT. 0 )   THEN
C         If present, set some overall stream properties of the non-
C         conventional component substream.
          SOUT1(NCONV+NNCC+9) = 1.0D0
          SOUT2(NCONV+NNCC+9) = 1.0D0
          SOUT3(NCONV+NNCC+9) = 1.0D0
          SOUT4(NCONV+NNCC+9) = 1.0D0
          SOUT5(NCONV+NNCC+9) = 1.0D0
          SOUT6(NCONV+NNCC+9) = 1.0D0
          SOUT1(NCONV+NNCC+2) = SOUT1(NCC+2)
          SOUT1(NCONV+NNCC+3) = SOUT1(NCC+3)
          SOUT2(NCONV+NNCC+2) = SOUT2(NCC+2)
          SOUT2(NCONV+NNCC+3) = SOUT2(NCC+3)
          SOUT3(NCONV+NNCC+2) = SOUT3(NCC+2)
          SOUT3(NCONV+NNCC+3) = SOUT3(NCC+3)
          SOUT4(NCONV+NNCC+2) = SOUT4(NCC+2)
          SOUT4(NCONV+NNCC+3) = SOUT4(NCC+3)
          SOUT5(NCONV+NNCC+2) = SOUT5(NCC+2)
          SOUT5(NCONV+NNCC+3) = SOUT5(NCC+3)
          SOUT6(NCONV+NNCC+2) = SOUT6(NCC+2)
          SOUT6(NCONV+NNCC+3) = SOUT6(NCC+3)
        ENDIF
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)
        CALL CPACK (SOUT2, NCP, IDX, XPACK, TMASS)
        SOUT2(NCC+9) = AVEMW (NCP, IDX, XPACK)
        CALL CPACK (SOUT3, NCP, IDX, XPACK, TMASS)
        SOUT3(NCC+9) = AVEMW (NCP, IDX, XPACK)
        CALL CPACK (SOUT4, NCP, IDX, XPACK, TMASS)
        SOUT4(NCC+9) = AVEMW (NCP, IDX, XPACK)
        CALL CPACK (SOUT5, NCP, IDX, XPACK, TMASS)
        SOUT5(NCC+9) = AVEMW (NCP, IDX, XPACK)
        CALL CPACK (SOUT6, NCP, IDX, XPACK, TMASS)
        SOUT6(NCC+9) = AVEMW (NCP, IDX, XPACK)
C
C       If requested, write the items of interest in the outlet stream
```

```
C         REAL(58)  = Number of spare trains.
C         REAL(59) -
C          REAL(70) = 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
      COMMON /USR04M/ CIN(35,7), COUT(35,7), CUTWT(35), CMWOUT(35)
      COMMON /USR04N/ CNAME(35), ICNUMB(55)
C
C     In CIN(J,K) and COUT(J,K), subscript J designates the following
C     components.
C      1.  H2          16.  T125, P125        26   T625, P625
C      2.  NH3         17.  T175, P175        27.  T675, P675
C      3.  H2O         18.  T225, P225        28.  T725, P725
C      4.  H2S         19.  T275, P275        29.  T775, P775
C      5.  N2          20.  T325, P325        30.  T825, P825
C      6.  CH4         21.  T375, P375        31   T875, P875
C      7.  C2H6        22.  T425, P425        33.  T925, P925
C      8.  C3H8        23.  T475, P475        33.  T975, P975
C      9.  IC4H10      24.  T525, P525        34.  T1000+, P1000+
C     10.  NC4H10      25.  T575, P575        35.  Future use
C     11.  IC5H12
C     12.  NC5H12
C     13.  Future use
C     14.  Future use
C     15.  Future use
C     where T225 means the entering material in the 200-250 F boiling
C     range in the CIN array and P225 means the leaving (hydrotreated)
C     material in the same boiling range in the COUT array, and
C     subscript K designates
C      1.  Component flow rate in Mlbs/hr.
C      2.  Component standard liquid density at 60 F in lbs/barrel.
C      3.  Sulfur flow rate in Mlbs/hr or wt% sulfur.
C      4.  Nitrogen flow rate in Mlbs/hr or wt% nitrogen.
C      5.  Oxygen flow rate in Mlbs/hr or wt% oxygen.
C      6.  Carbon flow rate in Mlbs/hr or wt% carbon.
C      7.  Hydrogen flow rate in Mlbs/hr or wt% hydrogen.
C
C      Component ordering in the various vectors.
```

```
C       No.  Component    Description
C        1.  H2           Hydrogen
C        2.  NH3          Ammonia
C        3.  H2O          Water
C        4.  H2S          Hydrogen sulfide
C        5   N2           Nitrogen
C        6.  CH4          Methane
C        7.  C2H6         Ethane
C        8.  C3H8         Propane
C        9.  IC4H10       Iso-butane
C       10.  NC4H10       Normal butane
C       11.  IC5H12       Iso-pentane
C       12.  NC5H12       Normal pentane
C       13.  Future use
C       14.  Future use
C       15.  Future use
C       16.  T125, P125   100 - 150 F boiling range fraction
C       17.  T175, P175   150 - 200 F boiling range fraction
C       18.  T225, P225   200 - 250 F boiling range fraction
C       19.  T275, P275   250 - 300 F boiling range fraction
C       20.  T325, P325   300 - 350 F boiling range fraction
C       21.  T375, P375   350 - 400 F boiling range fraction
C       22.  T425, P425   400 - 450 F boiling range fraction
C       23.  T475, P475   450 - 500 F boiling range fraction
C       24.  T525, P525   500 - 550 F boiling range fraction
C       25.  T575, P575   550 - 600 F boiling range fraction
C       26.  T625, P625   600 - 650 F boiling range fraction
C       27.  T675, P675   650 - 700 F boiling range fraction
C       28.  T725, P725   700 - 750 F boiling range fraction
C       29.  T775, P775   750 - 800 F boiling range fraction
C       30.  T825, P825   800 - 850 F boiling range fraction
C       31.  T875, P875   850 - 900 F boiling range fraction
C       32.  T925, P925   900 - 950 F boiling range fraction
C       33.  T975, P975   950 - 1000 F boiling range fraction
C       34.  T1000+, P1000+ 1000+ F boiling range material
C       35.  Future use
C       The following 20 items only are used in the vectors dimensioned
C       to 55 items for reference to the ASPEN/SP component list.
C       36.  P125       Hydrotreated 100 - 150 F boiling range fraction
C       37.  P175       Hydrotreated 150 - 200 F boiling range fraction
C       38.  P225       Hydrotreated 200 - 250 F boiling range fraction
C       39.  P275       Hydrotreated 250 - 300 F boiling range fraction
C       40.  P325       Hydrotreated 300 - 350 F boiling range fraction
C       41.  P375       Hydrotreated 350 - 400 F boiling range fraction
C       42.  P425       Hydrotreated 400 - 450 F boiling range fraction
C       43.  P475       Hydrotreated 450 - 500 F boiling range fraction
C       44.  P525       Hydrotreated 500 - 550 F boiling range fraction
C       45.  P575       Hydrotreated 550 - 600 F boiling range fraction
C       46.  P625       Hydrotreated 600 - 650 F boiling range fraction
C       47.  P675       Hydrotreated 650 - 700 F boiling range fraction
C       48.  P725       Hydrotreated 700 - 750 F boiling range fraction
C       49.  P775       Hydrotreated 750 - 800 F boiling range fraction
C       50.  P825       Hydrotreated 800 - 850 F boiling range fraction
C       51.  P875       Hydrotreated 850 - 900 F boiling range fraction
C       52.  P925       Hydrotreated 900 - 950 F boiling range fraction
```

```
     4    3X, 'Execution will continue assuming a hydrogen ',
     5    'consumption of 125 SCF/bbl.' )
        H2CONS = 125.0D0
      ENDIF
C
C     Set up the maximum and minimum train flow rates in Mlbs/hr of
C     C5+ feed.
      PMAXF = REAL(52)
      PMINF = REAL(53)
C
C
C     Call subroutine USR04B to load the inlet component densities and
C     elemental compositions into the CIN array, the outlet component
C     densities into the COUT array, and the outlet component molecular
C     weights into the CMWOUT vector.
      CALL USR04B (KTEST, NCC, NHSTRY)
C
C
C     If requested, write the items of interest in the inlet stream
C     vector to the history file.
      IF ( KTEST .GE. 5 )  THEN
        WRITE (NHSTRY, 511)
  511   FORMAT ( / '  The inlet stream vectors:'/
     1    3X, 'Item', 10X, 'SIN1', 11X, 'SIN2', 11X, 'SIN3'  )
        DO 30 J = 1, ITEMS
          WRITE (NHSTRY, 512) J, SIN1(J), SIN2(J), SIN3(J)
  512     FORMAT ( 1X, I6, 3X, 3(1PE15.5) )
   30   CONTINUE
      ENDIF
C
C     Load the total entering component flow rates from all the inlet
C     streams in the CIN vector in Mlbs/hr.
C     CF is the conversion factor from Kg/sec to Mlbs/hr.
      CF = 0.001D0 * 3600.0D0 / 0.45359237D0
C     First, zero the CIN vector.
      DO 40 J = 1, 35
        CIN(J,1) = 0.0D0
   40 CONTINUE
C
C     Load and mix all the inlet streams.
C     ----------------------------------
C     Conventional components - Load the flow rate in Mlbs/hr and the
C     component MWs.
      OTHERS = 0.0
      DO 44 J = 1, NCC
        DO 42 K = 1, 55
        IF ( J .EQ. ICNUMB(K) )  THEN
          L = K
          IF ( K .GT. 35)   L = K - 20
          CIN(L,1) = CIN(L,1) + CF * XMW(J) * (SIN1(J)+SIN2(J)+SIN3(J))
          GO TO 44
        ENDIF
   42   CONTINUE
        OTHERS = OTHERS + CF * XMW(J) * (SIN1(J) + SIN2(J) + SIN3(J))
   44 CONTINUE
```

```
C
      IF ( KLASS .GE. 2 )   THEN
C       Non-conventional components.
        SOLIDS = CF * (SIN1(NCONV+1) + SIN1(NCONV+2) + SIN1(NCONV+3) +
     1                 SIN2(NCONV+1) + SIN2(NCONV+2) + SIN2(NCONV+3) +
     2                 SIN3(NCONV+1) + SIN3(NCONV+2) + SIN3(NCONV+3))
      ENDIF
C
      IF ( OTHERS + SOLIDS .GE. 1.0D-3 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        UNKNWN = OTHERS + SOLIDS
        WRITE (NHSTRY, 513)  UNKNWN
  513   FORMAT ( / 1X, '* WARNING * - The feed to plant 4, the ',
     1    'naphtha hydrotreater, contains one' /
     2    3X, 'or more components that this model cannot handle.  It ',
     3    'contains', F10.3 /
     4    3X, 'Mlbs/hr of these components.  These components will be',
     5    ' lost in the process.' /
     6    3X, 'Plant 4 will not be in mass balance.  Please remove',
     7    ' these component(s)' /
     8    3X, 'from the feed stream.' //
     9    3X, 'Execution is continuing.' / )
      ENDIF
C
C
C     If requested, write the inlet component information.
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 702)
  702   FORMAT ( / ' Inlet component flow rates and properties:' /
     1    '   No.  Name', 6X, 'Mlbs/hr', 2X, 'lbs/bbl', 4X, 'Wt% S',
     2    4X, 'Wt% N', 4X, 'Wt% O', 4X, 'Wt% C', 4X, 'Wt% H' )
        SUM1 = 0.0D0
        DO 50 J = 1, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 50
            WRITE (NHSTRY, 703)  J, CNAME(J), (CIN(J,K), K = 1, 7)
  703       FORMAT ( 1X, I5, 2X, A8, F9.3, F9.3, 5F9.4 )
            SUM1 = SUM1 + CIN(J,1)
   50   CONTINUE
        WRITE (NHSTRY, 704)  SUM1
  704   FORMAT ( 8X, 'Total ', F11.3 )
      ENDIF
C
C
C     CALCULATION SECTION
C     -------------------
C     Copy the inlet component mass flow rates to the COUT array.
      DO 60 J = 1, 35
        COUT(J,1) = CIN(J,1)
   60 CONTINUE
C
C
C     Call subroutine USR04C to do the desulfurization calculations.
      CALL USR04C (IPASS, KTEST, NHSTRY, PCTDES)
      H22H2S = CIN(1,1) - COUT(1,1)
C
```

```
C     If requested, write the outlet component information after
C     desulfurization.
      IF ( KTEST .GE. 4 )  THEN
        WRITE (NHSTRY, 705)
  705   FORMAT ( / ' COUT array after desulfurization:' /
     1    '   No.  Name  ', 6X, 'Mlbs/hr', 4X, 'lbs/bbl', 7X,
     2    'Wt S' )
        SUM1 = 0.0D0
        SUM3 = 0.0D0
        DO 70 J = 1, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 70
            WRITE (NHSTRY, 706)  J, CNAME(J), (COUT(J,K), K = 1, 3)
  706       FORMAT ( 1X, I5, 2X, A8, F11.3, F11.3, F11.4 )
            SUM1 = SUM1 + COUT(J,1)
            SUM3 = SUM3 + COUT(J,3)
   70   CONTINUE
        WRITE (NHSTRY, 707)  SUM1, SUM3
  707   FORMAT ( 8X, 'Total ', F13.3, F22.4 )
      ENDIF
C
C
C     Call subroutine USR04D to do the denitrogenation calculations.
      CALL USR04D (IPASS, KTEST, NHSTRY, PCTDEN)
      H22NH3 = CIN(1,1) - COUT(1,1) - H22H2S
C
C     If requested, write the outlet component information after
C     denitrogenation.
      IF ( KTEST .GE. 4 )  THEN
        WRITE (NHSTRY, 708)
  708   FORMAT ( / ' COUT array after denitrogenation:' /
     1    '   No.  Name  ', 6X, 'Mlbs/hr', 4X, 'lbs/bbl', 7X,
     2    'Wt S', 7X, 'Wt N' )
        SUM1 = 0.0D0
        SUM3 = 0.0D0
        SUM4 = 0.0D0
        DO 80 J = 1, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 80
            WRITE (NHSTRY, 709)  J, CNAME(J), (COUT(J,K), K = 1, 4)
  709       FORMAT ( 1X, I5, 2X, A8, F11.3, F11.3, 2F11.4 )
            SUM1 = SUM1 + COUT(J,1)
            SUM3 = SUM3 + COUT(J,3)
            SUM4 = SUM4 + COUT(J,4)
   80   CONTINUE
        WRITE (NHSTRY, 710)  SUM1, SUM3, SUM4
  710   FORMAT ( 8X, 'Total ', F13.3, F22.4, F11.4 )
      ENDIF
C
C
C     Call subroutine USR04E to do the deoxygenation calculations.
      CALL USR04E (IPASS, KTEST, NHSTRY, PCTDEO)
      H22H2O = CIN(1,1) - COUT(1,1) - H22H2S - H22NH3
C
C     If requested, write the outlet component information after
C     deoxygenation.
      IF ( KTEST .GE. 4 )  THEN
```

```
      WRITE (NHSTRY, 711)
711   FORMAT ( / ' COUT array after deoxygenation:' /
     1   '   No.  Name  ', 6X, 'Mlbs/hr', 4X, 'lbs/bbl', 7X,
     2   'Wt S', 7X, 'Wt N', 7X, 'Wt O' )
      SUM1 = 0.0D0
      SUM3 = 0.0D0
      SUM4 = 0.0D0
      SUM5 = 0.0D0
      DO 90 J = 1, 35
        IF ( CNAME(J) .EQ. BLANK8 )   GO TO 90
          WRITE (NHSTRY, 712)  J, CNAME(J), (COUT(J,K), K = 1, 5)
712       FORMAT ( 1X, I5, 2X, A8, F11.3, F11.3, 3F11.4 )
          SUM1 = SUM1 + COUT(J,1)
          SUM3 = SUM3 + COUT(J,3)
          SUM4 = SUM4 + COUT(J,4)
          SUM5 = SUM5 + COUT(J,5)
 90   CONTINUE
      WRITE (NHSTRY, 713)  SUM1, SUM3, SUM4, SUM5
713   FORMAT ( 8X, 'Total ', F13.3, F22.4, 2F11.4 )
C
      H2USED = H22H2S + H22NH3 + H22H2O
      WRITE (NHSTRY, 714) H22H2S, H22NH3, H22H2O, H2USED
714   FORMAT ( / ' H2 consumed to H2S, NH3, H2O and total H2 ',
     1   'consumed in Mlbs/hr:' / 1X, 4F13.5 )
     ENDIF
C
C
C    Call subroutine USR04F to do the hydrogen consumption and yield
C    shift calculations.
     CALL USR04F (H2CONS, IPASS, KTEST, NHSTRY)
C
C    If the hydrogen consumption exceeds the makeup hydrogen, then
C    the leaving hydrogen flow rate will be negative.  If this is the
C    case, set the outlet hydrogen flow to zero and write a warning
C    message.
     IER1 = 0
     IF ( COUT(1,1) .LT. 0.0D0 )   THEN
       IER1 = 1
       IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
       X = - COUT(1,1)
       WRITE (NHSTRY, 721)  X
721    FORMAT ( / ' * WARNING * - The hydrogen consumption exceeds ',
     1   'the makeup rate by ', F10.3 /
     2   3X, 'Mlbs/hr.  The outlet hydrogen flow rate will be set to',
     3   ' zero.  The naphtha' /
     4   3X, 'hydrotreater will not be in mass balance.  Execution ',
     5   'is continuing.' )
       COUT(1,1) = 0.0D0
       COUT(1,7) = 0.0D0
     ENDIF
C
C    If requested, write the outlet component information.
     IF ( KTEST .GE. 3 )  THEN
       WRITE (NHSTRY, 722)
722    FORMAT ( / ' Outlet component and elemental flow rates:' /
```

```
     1    '   No.  Name', 7X, 'Mlbs/hr', 2X, 'lbs/bbl', 5X, 'Wt S',
     2    5X, 'Wt N', 5X, 'Wt O', 5X, 'Wt C', 5X, 'Wt H' )
        SUM1 = 0.0D0
        SUM3 = 0.0D0
        SUM4 = 0.0D0
        SUM5 = 0.0D0
        SUM6 = 0.0D0
        SUM7 = 0.0D0
        DO 100 J = 1, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 100
            WRITE (NHSTRY, 723)  J, CNAME(J), (COUT(J,K), K = 1, 7)
  723       FORMAT ( 1X, I5, 2X, A8, F10.3, F9.3, 5F9.3 )
            SUM1 = SUM1 + COUT(J,1)
            SUM3 = SUM3 + COUT(J,3)
            SUM4 = SUM4 + COUT(J,4)
            SUM5 = SUM5 + COUT(J,5)
            SUM6 = SUM6 + COUT(J,6)
            SUM7 = SUM7 + COUT(J,7)
  100   CONTINUE
        WRITE (NHSTRY, 724)  SUM1, SUM3, SUM4, SUM5, SUM6, SUM7
  724   FORMAT ( 8X, 'Total ', F12.3, F18.3, 4F9.3 )
      ENDIF
C
C
C     Convert the outlet sulfur, nitrogen, oxygen, carbon and hydrogen
C     flow rates in the COUT array from Mlbs/hr to wt%.
      DO 250 J = 1, 35
        IF ( COUT(J,1) .GT. 0.0D0 )  THEN
            DO 242 K = 3, 7
              COUT(J,K) = 100.0D0 * COUT(J,K) / COUT(J,1)
  242       CONTINUE
          ELSE
            DO 244 K = 3, 7
              COUT(J,K) = 0.0D0
  244       CONTINUE
        ENDIF
  250 CONTINUE
C
C     If requested, write the outlet component flow rates and
C     properties.
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 732)
  732   FORMAT ( / ' Outlet component flow rates and properties:' /
     1    '   No.  Name  ', 5X, 'Mlbs/hr', 2X, 'lbs/bbl', 4X, 'Wt% S',
     2    4X, 'Wt% N', 4X, 'Wt% O', 4X, 'Wt% C', 4X, 'Wt% H' )
        SUM1 = 0.0D0
        DO 252 J = 1, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 252
            WRITE (NHSTRY, 733)  J, CNAME(J), (COUT(J,K), K = 1, 7)
  733       FORMAT ( 1X, I5, 2X, A8, F10.3, F9.3, 5F9.3 )
            SUM1 = SUM1 + COUT(J,1)
  252   CONTINUE
        WRITE (NHSTRY, 734)  SUM1
  734   FORMAT ( 8X, 'Total', F13.3 )
      ENDIF
```

```
C
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 ( IPASS .EQ. 4 .AND. INT(1) .LE. 2 )  THEN
        IF ( INT(2) .EQ. 0 )   THEN
C           Calculate the number of lines in the first page.
            LINES = 48
            IF ( UNKNWN .GE. 0.001D0 )  LINES = LINES + 5
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 DCL04.REP to contain
C           this user block summary report.
            OPEN (UNIT=62, FILE='DCL04.REP', STATUS='UNKNOWN',
     1        ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2        BUFFERED='BUFFERED')
            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')
        ENDIF
C       Call subroutine USR04G to write the first page of the plant
C       summary report, the overall plant material balance.
        CALL USR04G (INT(1), INT(2), IPASS, NOUT, UNKNWN)
      ENDIF
C
C
C     If this is the report pass and the plant summary report is being
C     written, prepare for writing the second page.
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 2 )  THEN
        IF ( INT(2) .EQ. 0 )   THEN
C           Calculate the number of lines in the second page.
            LINES = 51
            IF ( IER1 .GE. 1 )   LINES = LINES + 4
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           If the summary report is going to a separate file, start
C           a new page.
            WRITE (NOUT, 800)
        ENDIF
      ENDIF
C
C     Call subroutine USR04H to distribute the net reactor yields
C     among the three product streams, load the outlet stream vectors,
C     and  if this is the results pass, write the second page of the
C     plant summary report, the stream summary.
      CALL USR04H (IER1, INT(1), INT(2), IPASS,
     1  ITEMS, KTEST, NCC, NNCC, NCONV, NCCONV, NHSTRY, NOUT,
```

```
     2  SOUT1, SOUT2, SOUT3)
C
C     Calculate the total C5+ feed rate in Mlbs/hr for all of
C     the duplicate plants.
      FEEDIN = 0.0D0
      DO 260 J = 11, 35
        FEEDIN = FEEDIN + CIN(J,1)
  260 CONTINUE
C
C     If it has not been specified by the user in variable INT(3),
C     calculate the number of operating duplicate trains, excluding
C     spares (NPLNT), based on the total flow rate of the reference
C     stream.  However, if the maximum capacity of a single train
C     has not been specified, set the number of operating trains to 1.
      NPLNT = INT(3)
      IF ( (NPLNT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
          NPLNT = FEEDIN  / PMAXF
          IF ( (MOD(FEEDIN, PMAXF)) .GT. 0.0D0 )  NPLNT = NPLNT + 1
        ELSE
          IF ( NPLNT .EQ. 0 )   NPLNT = 1
      ENDIF
C
C     Calculate the feed rate for each of the duplicate trains (PFLOW)
C     in Mlbs/hr.
      XPLNT = NPLNT
      PFLOW = FEEDIN / XPLNT
C
C
C     If this is the report pass and the plant summary report is being
C     written, prepare for writing the third page of the plant summary
C     report, the utilities summary and capital cost information.
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 1 )  THEN
        IF ( INT(2) .EQ. 0 )  THEN
C           Calculate the number of lines in third page.
            LSTRM = 4
            LUTIL = 16
            LCOST = 11
            NDUP = REAL(58) + 0.001D0
            IF ( (NPLNT + NDUP) .EQ. 1 )  LCOST = 9
            IF ( PFLOW .LT. PMINF )  LCOST = LCOST + 3
            IF ( PFLOW .GT .PMAXF )  LCOST = LCOST + 3
            IF ( NDUP .GE. 1 )  LCOST = LCOST + 1
            LINES = LSTRM + LUTIL + LCOST
C           Now, subtract the number of lines for those portions of
C           the user block summary report which will not be written.
            IF ( INT(1) .GE. 2 )   LINES = LINES - LUTIL
            IF ( INT(1) .GE. 1 )   LINES = LINES - LCOST
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
            WRITE (NOUT, 800)
        ENDIF
        WRITE (NOUT, 801)
  801   FORMAT ( / 21X, 'PLANT 4 - SUMMARY REPORT (CONTINUED)' /
```

```
     1    29X, 'NAPHTHA HYDROTREATER' / )
      ENDIF
C
C     Call subroutine USRUCO to calculate, save and report the
C     utilities, capital and operating costs for the plant.
      ID = 4
      KUNITS = 2
      CALL USRUCO (NHSTRY, NOUT, IPASS, ID, PNAME, INT(1), INT(3),
     1  KTEST, REAL(21), FEEDIN, KUNITS)
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 USR04' )
C
C
      RETURN
      END
C
C$ USR04B
      SUBROUTINE USR04B (KTEST, NCC, NHSTRY)
C
C     This subroutine loads the inlet component densities and elemental
C     compositions into the CIN array, the outlet component densities
C     into the COUT array, and the outlet component molecular weights
C     into the CMWOUT vector.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - October 14, 1992.
C
C     Calling arguments:
C     KTEST  = Switch for controlling the printing to the history file.
C     NCC    = Number of conventional components.
C     NHSTRY = Logical unit number of the history file.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON/MW/XMW(1)
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
      COMMON /USR04M/ CIN(35,7), COUT(35,7), CUTWT(35), CMWOUT(35)
      COMMON /USR04N/ CNAME(35), ICNUMB(55)
C
C     In CIN(J,K) and COUT(J,K), subscript J designates the following
C     components.
```

```
C      1.  H2          16.  T125, P125        26   T625, P625
C      2.  NH3         17.  T175, P175        27.  T675, P675
C      3.  H2O         18.  T225, P225        28.  T725, P725
C      4.  H2S         19.  T275, P275        29.  T775, P775
C      5.  N2          20.  T325, P325        30.  T825, P825
C      6.  CH4         21.  T375, P375        31   T875, P875
C      7.  C2H6        22.  T425, P425        33.  T925, P925
C      8.  C3H8        23.  T475, P475        33.  T975, P975
C      9.  IC4H10      24.  T525, P525        34.  T1000+, P1000+
C     10.  NC4H10      25.  T575, P575        35.  Future use
C     11.  IC5H12
C     12.  NC5H12
C     13.  Future use
C     14.  Future use
C     15.  Future use
C     where T225 means the entering material in the 200-250 F boiling
C     range in the CIN array and P225 means the leaving (hydrotreated)
C     material in the same boiling range in the COUT array, and
C     subscript K designates
C      1.  Component flow rate in Mlbs/hr.
C      2.  Component standard liquid density at 60 F in lbs/barrel.
C      3.  Sulfur flow rate in Mlbs/hr or wt% sulfur.
C      4.  Nitrogen flow rate in Mlbs/hr or wt% nitrogen.
C      5.  Oxygen flow rate in Mlbs/hr or wt% oxygen.
C      6.  Carbon flow rate in Mlbs/hr or wt% carbon.
C      7.  Hydrogen flow rate in Mlbs/hr or wt% hydrogen.
C
      DIMENSION CMW(55), SVOL(55)
C
      CHARACTER * 8  BLANK8, CNAME
C
      DATA BLANK8 / '        ' /
C
c
C     Conventional components - Load the component molecular weights
C     and standard volumes in m**3/Kg.
      DO 10 J = 1, NCC
        DO 8 K = 1, 55
        IF ( J .EQ. ICNUMB(K) )  THEN
          CMW(K) = 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.
          SVOL(K) = XMW(J+NCC)
          L = K
          IF ( K .GT. 35)   L = K - 20
          CMWOUT(L) = XMW(J)
          GO TO 10
        ENDIF
    8   CONTINUE
   10 CONTINUE
C
      IF ( KTEST .GE. 5 )  THEN
        WRITE (NHSTRY, 501)
  501   FORMAT ( / ' Component number, name, molecular weight, ',
     1    'standard volume and relative number:')
```

```
        DO 20 J = 1, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 20
            WRITE (NHSTRY, 502) J, CNAME(J), CMW(J), SVOL(J), ICNUMB(J)
  502       FORMAT ( 1X, I5, 2X, A8, 2F12.4, I8 )
   20   CONTINUE
      ENDIF
C
C     Convert the component standard volumes from m**3/Kg-mole to
C     densities in lbs/bbl and load them in the CIN and COUT arrays.
C     X is the conversion factor from Kg/m**3 to 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     Load the inlet component densities in lbs/bbl.
      DO 30 J = 1, 35
        IF ( CNAME(J) .NE. BLANK8 )   THEN
            CIN(J,2) = X * CMW(J) / SVOL(J)
          ELSE
            CIN(J,2) = 1.0D0
        ENDIF
   30 CONTINUE
C
C     Load the outlet component densities in lbs/bbl.
      DO 32 J = 1, 15
        COUT(J,2) = CIN(J,2)
   32 CONTINUE
      DO 34 J = 16, 35
        IF ( CNAME(J) .NE. BLANK8 )  THEN
            COUT(J,2) = X * CMW(J+20) / SVOL(J+20)
          ELSE
            COUT(J,2) = 1.0D0
        ENDIF
   34 CONTINUE
C
C
C     Load the molecular weights of atomic carbon, hydrogen, sulfur,
C     nitrogen and oxygen.
      XMWH = 0.5D0 * CMW(1)
      XMWC = CMW(6) - 2.0D0 * CMW(1)
      XMWS = CMW(4) - CMW(1)
      XMWN = CMW(2) - 1.5D0 * CMW(1)
      XMWO = CMW(3) - CMW(1)
C
C     Zero all the pure component compositions.
      DO 38 J = 1, 15
        DO 36 K = 3, 7
          CIN(J,K) = 0.0D0
   36   CONTINUE
   38 CONTINUE
C
C     Load the pure component hydrogen, carbon, sulfur, nitrogen and
C     oxygen contents in wt%.
C     Hydrogen.
      CIN(1,7) = 100.0D0
C     Ammonia.
```

```
      CIN(2,7) = 100.0D0 * 3.0D0 * XMWH / CMW(2)
      CIN(2,4) = 100.0D0 * XMWN / CMW(2)
C     Water.
      CIN(3,7) = 100.0D0 * 2.0D0 * XMWH / CMW(3)
      CIN(3,5) = 100.0D0 * XMWO / CMW(3)
C     Hydrogen sulfide.
      CIN(4,7) = 100.0D0 * 2.0D0 * XMWH / CMW(4)
      CIN(4,3) = 100.0D0 * XMWS / CMW(4)
C     Nitrogen.
      CIN(5,4) = 100.0D0
C     Methane.
      CIN(6,6) = 100.0 * XMWC / CMW(6)
      CIN(6,7) = 100.0 * 4.0 * XMWH / CMW(6)
C     Ethane.
      CIN(7,6) = 100.0D0 * 2.0D0 * XMWC / CMW(7)
      CIN(7,7) = 100.0D0 * 6.0D0 * XMWH / CMW(7)
C     Propane.
      CIN(8,6) = 100.0D0 * 3.0D0 * XMWC / CMW(8)
      CIN(8,7) = 100.0D0 * 8.0D0 * XMWH / CMW(8)
C     Butanes.
      CIN(9,6) = 100.0 * 4.0 * XMWC / CMW(9)
      CIN(9,7) = 100.0 * 10.0 * XMWH / CMW(9)
      CIN(10,6) = CIN(9,6)
      CIN(10,7) = CIN(9,7)
C     Pentanes.
      CIN(11,6) = 100.0D0 * 5.0D0 * XMWC / CMW(11)
      CIN(11,7) = 100.0D0 * 12.0D0 * XMWH / CMW(11)
      CIN(12,6) = CIN(11,6)
      CIN(12,7) = CIN(11,7)
C
C     The following elemental compositions were taken from the
C     Aug. 20, 1990 letter to S. N. Habash from A. Basu and
C     A. B. Schachtschneider.  The 850+ F components were estimated.
C
C     Load the C5+ component sulfur contents in wt%.
      CIN(16,3) = 0.01
      CIN(17,3) = 0.01
      CIN(18,3) = 0.01
      CIN(19,3) = 0.01
      CIN(20,3) = 0.01
      CIN(21,3) = 0.01
      CIN(22,3) = 0.01
      CIN(23,3) = 0.02
      CIN(24,3) = 0.02
      CIN(25,3) = 0.02
      CIN(26,3) = 0.02
      CIN(27,3) = 0.06
      CIN(28,3) = 0.06
      CIN(29,3) = 0.06
      CIN(30,3) = 0.06
      CIN(31,3) = 0.10
      CIN(32,3) = 0.15
      CIN(33,3) = 0.20
      CIN(34,3) = 0.25
      CIN(35,3) = 0.0
```

```
C
C     Load the C5+ component nitrogen contents in wt%.
      CIN(16,4) = 0.17
      CIN(17,4) = 0.17
      CIN(18,4) = 0.17
      CIN(19,4) = 0.17
      CIN(20,4) = 0.17
      CIN(21,4) = 0.22
      CIN(22,4) = 0.22
      CIN(23,4) = 0.24
      CIN(24,4) = 0.24
      CIN(25,4) = 0.24
      CIN(26,4) = 0.24
      CIN(27,4) = 0.28
      CIN(28,4) = 0.28
      CIN(29,4) = 0.28
      CIN(30,4) = 0.28
      CIN(31,4) = 0.35
      CIN(32,4) = 0.40
      CIN(33,4) = 0.45
      CIN(34,4) = 0.50
      CIN(35,4) = 0.0
C
C     Load the C5+ component oxygen contents in wt%.
      CIN(16,5) = 0.50
      CIN(17,5) = 0.50
      CIN(18,5) = 0.50
      CIN(19,5) = 0.50
      CIN(20,5) = 0.50
      CIN(21,5) = 0.70
      CIN(22,5) = 0.70
      CIN(23,5) = 0.60
      CIN(24,5) = 0.60
      CIN(25,5) = 0.60
      CIN(26,5) = 0.60
      CIN(27,5) = 0.67
      CIN(28,5) = 0.67
      CIN(29,5) = 0.67
      CIN(30,5) = 0.67
      CIN(31,5) = 0.70
      CIN(32,5) = 0.72
      CIN(33,5) = 0.74
      CIN(34,5) = 0.76
      CIN(35,5) = 0.0
C
C     Load the C5+ component hydrogen contents in wt%.
      CIN(16,7) = 14.21
      CIN(17,7) = 14.21
      CIN(18,7) = 14.21
      CIN(19,7) = 14.21
      CIN(20,7) = 14.21
      CIN(21,7) = 12.16
      CIN(22,7) = 12.16
      CIN(23,7) = 10.95
      CIN(24,7) = 10.95
```

```
      CIN(25,7) = 10.95
      CIN(26,7) = 10.95
      CIN(27,7) = 9.97
      CIN(28,7) = 9.97
      CIN(29,7) = 9.97
      CIN(30,7) = 9.97
      CIN(31,7) = 9.90
      CIN(32,7) = 9.85
      CIN(33,7) = 9.80
      CIN(34,7) = 9.75
      CIN(35,7) = 0.0
C
C     If mode equals 18, load the High Space Velocity Factors.
C     The following elemental compositions were developed from the
C     June 30, 1992 FAX from A. Basu to S. Poddar.  The 850+ F
C     components were estimated.
      IF ( MODE .EQ. 18 )  THEN
C       Load the C6+ component sulfur contents in wt%.
        CIN(16,3) = 0.04D0
        CIN(17,3) = 0.04D0
        CIN(18,3) = 0.04D0
        CIN(19,3) = 0.04D0
        CIN(20,3) = 0.04D0
        CIN(21,3) = 0.03D0
        CIN(22,3) = 0.03D0
        CIN(23,3) = 0.02D0
        CIN(24,3) = 0.02D0
        CIN(25,3) = 0.02D0
        CIN(26,3) = 0.02D0
        CIN(27,3) = 0.02D0
        CIN(28,3) = 0.02D0
        CIN(29,3) = 0.02D0
        CIN(30,3) = 0.02D0
        CIN(31,3) = 0.10D0
        CIN(32,3) = 0.15D0
        CIN(33,3) = 0.20D0
        CIN(34,3) = 1.50D0
        CIN(35,3) = 1.50D0
C
C       Load the C6+ component nitrogen contents in wt%.
        CIN(16,4) = 0.03D0
        CIN(17,4) = 0.03D0
        CIN(18,4) = 0.03D0
        CIN(19,4) = 0.03D0
        CIN(20,4) = 0.03D0
        CIN(21,4) = 0.20D0
        CIN(22,4) = 0.20D0
        CIN(23,4) = 0.35D0
        CIN(24,4) = 0.35D0
        CIN(25,4) = 0.35D0
        CIN(26,4) = 0.35D0
        CIN(27,4) = 0.38D0
        CIN(28,4) = 0.38D0
        CIN(29,4) = 0.38D0
        CIN(30,4) = 0.38D0
```

```
      CIN(31,4) = 0.40D0
      CIN(32,4) = 0.45D0
      CIN(33,4) = 0.50D0
      CIN(34,4) = 1.20D0
      CIN(35,4) = 1.20D0
C
C     Load the C6+ component oxygen contents in wt%.
      CIN(16,5) = 0.50D0
      CIN(17,5) = 0.50D0
      CIN(18,5) = 0.50D0
      CIN(19,5) = 0.50D0
      CIN(20,5) = 0.50D0
      CIN(21,5) = 0.55D0
      CIN(22,5) = 0.55D0
      CIN(23,5) = 0.50D0
      CIN(24,5) = 0.50D0
      CIN(25,5) = 0.50D0
      CIN(26,5) = 0.50D0
      CIN(27,5) = 0.65D0
      CIN(28,5) = 0.65D0
      CIN(29,5) = 0.65D0
      CIN(30,5) = 0.65D0
      CIN(31,5) = 0.70D0
      CIN(32,5) = 0.75D0
      CIN(33,5) = 0.80D0
      CIN(34,5) = 3.30D0
      CIN(35,5) = 3.30D0
C
C     Load the C6+ component hydrogen contents in wt%.
      CIN(16,7) = 14.21D0
      CIN(17,7) = 14.21D0
      CIN(18,7) = 14.21D0
      CIN(19,7) = 14.21D0
      CIN(20,7) = 14.21D0
      CIN(21,7) = 12.16D0
      CIN(22,7) = 12.16D0
      CIN(23,7) = 11.03D0
      CIN(24,7) = 11.03D0
      CIN(25,7) = 11.03D0
      CIN(26,7) = 11.03D0
      CIN(27,7) = 10.00D0
      CIN(28,7) = 10.00D0
      CIN(29,7) = 10.00D0
      CIN(30,7) = 10.00D0
      CIN(31,7) = 9.90D0
      CIN(32,7) = 9.80D0
      CIN(33,7) = 9.70D0
      CIN(34,7) = 5.50D0
      CIN(35,7) = 5.50D0
    ENDIF
C
C   Calculate the C5+ component carbon contents in wt% by difference.
    DO 40 J = 16, 35
      CIN(J,6) = 100.0D0 - CIN(J,3) - CIN(J,4) - CIN(J,5) - CIN(J,7)
 40 CONTINUE
```

```
C
      IF ( KTEST .GE. 5 )  THEN
        WRITE (NHSTRY, 503) MODE
  503   FORMAT ( / ' Component properties:   (MODE = ', I5, ')'  /
     1    3X, 'No.', 2X, 'Name', 9X, 'MW', 4X, 'lbs/bbl', 4X, 'Wt% S',
     2    4X, 'Wt% N', 4X, 'Wt% O', 4X, 'Wt% C', 4X, 'Wt% H')
        DO 50 J = 1, 35
          IF ( CNAME(J) .EQ. BLANK8 )  GO TO 50
            WRITE (NHSTRY, 504) J, CNAME(J), CMW(J), (CIN(J,K), K = 2,7)
  504       FORMAT ( 1X, I5, 2X, A8, 2F9.3, 5F9.4 )
   50   CONTINUE
      ENDIF
C
C
      RETURN
      END
C
C$ USR04C
      SUBROUTINE USR04C (IPASS, KTEST, NHSTRY, PCTDES)
C
C     This subroutine does the naphtha hydrotreater desulfurization
C     calculations.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - November 19, 1991.
C
C     Calling arguments:
C     IPASS  = The results pass flag.
C     KTEST  = Switch for controlling the printing to the history file.
C     NHSTRY = Logical unit number of the history file.
C     PCTDES = Overall percent desulfurization; i. e., percent
C              sulfur removed from the C5+ feed.
C
C     NOTE:  This model contains only two C5 components, IC5 and NC5,
C       both of which are are pure compoennts.  Therefore, percent
C       desulfurization on a C5+ basis is the same as on a C6+ basis.
C       Thus, these calculations will be done on a C6+ basis to
C       save computation time.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
C     See subroutine USR04A for a description of the items in named
C     COMMON block /USR04M/.
      COMMON /USR04M/ CIN(35,7), COUT(35,7), CUTWT(35), CMWOUT(35)
      COMMON /USR04N/ CNAME(35), ICNUMB(55)
C
      CHARACTER * 8  BLANK8, CNAME
C
C     Local variable declarations.
      DIMENSION RELDES(20), QX(2), QY(2)
C
      DATA BLANK8 / '        ' /
C
```

```
C     RELDES(J) is the relative desulfurability of component J compared
C     to the T275 cut (component 19 - the 250-300 F boiling range cut).
C     It is calculated as follows.
C                    100.0 - % Desulfurization of component 15
C       RELDES(K) = ------------------------------------------
C                    100.0 - % Desulfurization of component K
C
C     If the T275 cut (component 19) is 99.0% desulfurized and cut K is
C     only 98% desulfurized, then
C        RELDES(K) = (100. - 99.) / (100. - 98.) = 0.5
C
C     Load the RELDES vector with the relative desulfurability of
C     components 16 - 35 so that RELDES(J) corresponds to the relative
C     desulfurability of component J + 15.
C     The following values are crude estimates, and need to be refined.
      DATA RELDES / 1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0,
     1  1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0,
     2  1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0,
     3  1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0 /
C
C
C     Load the molecular weights of hydrogen and sulfur.
      XMWH2 = CMWOUT(1)
      XMWS = CMWOUT(4) - CMWOUT(1)
C
C     Calculate the entering amount of sulfur in the C6+ in Mlbs/hr.
      WTSIN = 0.0D0
      DO 10 J = 16, 35
        WTSIN = WTSIN + CIN(J,1) * CIN(J,3)
   10 CONTINUE
      WTSIN = 0.01D0 * WTSIN
C
C     If requested, write the entering amount of sulfur and desired
C     percent desulfurization of the C6+ feed.
      IF ( KTEST .GE. 3 )  WRITE (NHSTRY, 701)  WTSIN, PCTDES
  701 FORMAT ( / ' Entering sulfur in C6+, Mlbs/hr =', F10.4 /
     1  ' Target percent desulfurization =', F10.4 )
C
C     If requested, write the relative component desulfurabilities.
      IF ( KTEST .GE. 2 )  THEN
        WRITE (NHSTRY, 702)
  702   FORMAT ( / ' Relative component desulfurabilities:' )
        DO 20 J = 1, 10
          K = J + 15
          KP = J + 25
          JP = J + 10
          WRITE (NHSTRY, 703) K, CNAME(K), RELDES(J), KP, CNAME(KP),
     1      RELDES(JP)
  703     FORMAT ( 3X, I3, 3X, A8, F9.4, 10X, I3, 3X, A8, F9.4 )
   20   CONTINUE
      ENDIF
C
C     Initialize the component weights to zero,
      DO 30 J = 1, 35
        CUTWT(J) = 0.0D0
```

```
   30 CONTINUE
C
C     Converge on the specified overall percent desulfurization by
C     varying F, the fractional desulfurization of the reference
C     cut (component 19), the 250 - 300 F boiling range cut.
C
C     Initialize the iteration history.
      DO 40 J = 1, 2
        QX(J) = 0.0D0
        QY(J) = 0.0D0
   40 CONTINUE
C
C     For an initial guess, set F equal to the overall fractional
C     desulfurization.
      F = 0.01D0 * PCTDES
C
      DO 60 K = 1, 35
        ITER = K
C       Desulfurize the C6+ material and accumulate the total amount
C       of sulfur remaining in the C6+, SLEFT, in Mlbs/hr.
        SLEFT = 0.0D0
        DO 50 J = 16, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 50
C           CSIN is the weight of sulfur entering in this component.
            CSIN = 0.01D0 * CIN(J,1) * CIN(J,3)
C           CSLEFT is the weight of sulfur remaining in this component.
            CSLEFT = CSIN * (1.0D0 - F) / RELDES(J-15)
C           Adjust the weight flow rate for the amount of S removed.
            CUTWT(J) = COUT(J,1) - (CSIN - CSLEFT)
C           Load the remaining Mlbs/hr of sulfur in COUT(J,3).
            COUT(J,3) = CSLEFT
            SLEFT = SLEFT + COUT(J,3)
   50   CONTINUE
C       Calculate the overall percent desulfurization - SREM is the
C       amount of sulfur removed from the C6+ in Mlbs/hr.
        SREM = WTSIN - SLEFT
        CDES = 100.0D0 * SREM / WTSIN
C       Save the iteration results.
        QX(1) = QX(2)
        QY(1) = QY(2)
        QX(2) = F
        QY(2) = CDES
        IF ( KTEST .GE. 5 )  THEN
          IF ( K .EQ. 1 )  WRITE (NHSTRY, 704)
  704     FORMAT ( / ' Desulfurization iteration history:' )
          WRITE (NHSTRY, 705) K, QX(1), QX(2), QY(1), QY(2)
  705     FORMAT ( ' K, QX(1), QX(2), QY(1) & QY(2):', I5, 4F10.5 )
        ENDIF
C       Convergence check.
        IF ( DABS(PCTDES-QY(2)) .LT. 0.00001 )  THEN
C           Converged - Exit the convergence loop.
            GO TO 70
          ELSE
C           Make the guess for the next iteration.
            IF ( K .EQ. 1 )  THEN
```

```
C                 First iteration - make a small move.
                  IF ( CDES .LT. PCTDES )  THEN
C                     Calculated desulfurization is below target value.
                      F = 1.0D0 - 0.75D0 * (1.0D0 - F)
                    ELSE
C                     Calculated desulfurization is above target value.
                      F = 1.0D0 - 1.25D0 * (1.0D0 - F)
                  ENDIF
                ELSE
C                 Subsequent iterations - Use a damping factor for the
C                 third and fourth iterations.
                  DF = 0.25 * K
                  IF ( DF .GT. 1.0D0 )  DF = 1.0D0
                  F = QX(2) +
     1              DF * (PCTDES-QY(2))*(QX(2)-QX(1))/(QY(2)-QY(1))
              ENDIF
          ENDIF
   60 CONTINUE
C     End of desulfurization iteration loop.
C
C     The desulfurization loop did not converge, write a warning
C     message and continue using the last value.
      WRITE (NHSTRY, 706)  PCTDES, ITER, CDES
  706 FORMAT ( / ' * WARNING * - In subroutine USR04C, the overall',
     1  ' percent desulfurization did not' /
     2  3X, 'converge to the desired value of', F9.4, '% within', I3,
     3  ' iterations.  Execution' /
     4  3X, 'will continue using the calculated percent',
     5  ' desulfurization of', F10.4, '%.' )
C
C     If requested, write the calculated percent desulfurization.
   70 IF ( KTEST .GE. 4 )  WRITE (NHSTRY, 707)  CDES
  707 FORMAT ( / ' Calculated percent desulfurization =', F10.4 )
C
C     Load the adjusted component weights in the COUT array.
      DO 150 J = 16, 35
        COUT(J,1) = CUTWT(J)
  150 CONTINUE
C
C     Adjust the COUT array for the amount of sulfur converted to H2S.
      COUT(4,1) = COUT(4,1) + SREM * (XMWS + XMWH2) / XMWS
C     Load the Mlbs/hr of sulfur in COUT(4,3)
      COUT(4,3) = COUT(4,1) * XMWS / (XMWS + XMWH2)
C     Adjust the hydrogen for the amount used to make the H2S.
      COUT(1,1) = COUT(1,1) - SREM * XMWH2 / XMWS
C
C
      RETURN
      END
C
C$ USR04D
      SUBROUTINE USR04D (IPASS, KTEST, NHSTRY, PCTDEN)
C
C     This subroutine does the naphtha hydrotreater denitrogenation
C     calculations.
```

```
C     NOTE: This subroutine is similar to subroutine USR04C.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - December 2, 1991.
C
C     Calling arguments:
C     IPASS  = The results pass flag.
C     KTEST  = Switch for controlling the printing to the history file.
C     NHSTRY = Logical unit number of the history file.
C     PCTDEN = Overall percent denitrogenation; i. e., percent
C              nitrogen removed from the C5+ feed.
C
C     NOTE:  This model contains only two C5 components, IC5 and NC5,
C       both of which are are pure compoennts.  Therefore, percent
C       denitrogenation on a C5+ basis is the same as on a C6+ basis.
C       Thus, these calculations will be done on a C6+ basis to
C       save computation time.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
C     See subroutine USR04A for a description of the items in named
C     COMMON block /USR04M/.
      COMMON /USR04M/ CIN(35,7), COUT(35,7), CUTWT(35), CMWOUT(35)
      COMMON /USR04N/ CNAME(35), ICNUMB(55)
C
      CHARACTER * 8  BLANK8, CNAME
C
C     Local variable declarations.
      DIMENSION RELDEN(20), QX(2), QY(2)
C
      DATA BLANK8 / '        ' /
C
C     RELDEN(J) is the relative denitrogenability of component J
C     compared to the T275 cut (component 19 - the 250-300 F boiling
C     range cut).  It is calculated as follows.
C                    100.0 - % Denitrogenation of component 15
C       RELDEN(K) = ------------------------------------------
C                    100.0 - % Denitrogenation of component K
C     If the T275 cut (component 19) is 99.0% denitrogenated and cut K
C     is only 98% denitrogenated then
C        RELDEN(K) = (100. - 99.) / (100. - 98.) = 0.5
C
C     Load the RELDEN vector with the relative denitrogenability of
C     components 11 - 30 so that RELDEN(J) corresponds to the relative
C     denitrogenability of component J + 15.
C     The following values are crude estimates, and need to be refined.
      DATA RELDEN / 1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0,
     1  1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0,
     2  1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0,
     3  1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0 /
C
C
C     Load the molecular weights of 3 hydrogen atoms and 1 nitrogen
```

```
C
      XMWH3 = 1.5D0 * CMWOUT(1)
      XMWN = CMWOUT(2) - XMWH3
C
C
C     Calculate the entering amount of nitrogen in the C6+ in Mlbs/hr.
      WTNIN = 0.0D0
      DO 10 J = 16, 35
        WTNIN = WTNIN + CIN(J,1) * CIN(J,4)
   10 CONTINUE
      WTNIN = 0.01D0 * WTNIN
C
C     If requested, write the entering amount of nitrogen and desired
C     percent denitrogenation of the C6+ feed.
      IF ( KTEST .GE. 3 )  WRITE (NHSTRY, 701)  WTNIN, PCTDEN
  701 FORMAT ( / ' Entering nitrogen in C6+, Mlbs/hr =', F10.4 /
     1  ' Target percent denitrogenation =', F10.4 )
C
C     If requested, write the relative component denitrogenabilities.
      IF ( KTEST .GE. 2 )  THEN
        WRITE (NHSTRY, 702)
  702   FORMAT ( / ' Relative component denitrogenabilities:' )
        DO 20 J = 1, 10
          K = J + 15
          KP = J + 25
          JP = J + 10
          WRITE (NHSTRY, 703) K, CNAME(K), RELDEN(J), KP, CNAME(KP),
     1      RELDEN(JP)
  703     FORMAT ( 3X, I3, 3X, A8, F9.4, 10X, I3, 3X, A8, F9.4 )
   20   CONTINUE
      ENDIF
C
C     Initialize the component weights to zero,
      DO 30 J = 1, 35
        CUTWT(J) = 0.0D0
   30 CONTINUE
C
C     Converge on the specified overall percent denitrogenation by
C     varying F, the fractional denitrogenation of the reference
C     cut (component 19), the 250 - 300 F boiling range cut.
C
C     Initialize the iteration history.
      DO 40 J = 1, 2
        QX(J) = 0.0D0
        QY(J) = 0.0D0
   40 CONTINUE
C
C     For an initial guess, set F equal to the overall fractional
C     denitrogenation.
      F = 0.01D0 * PCTDEN
C
      DO 60 K = 1, 35
        ITER = K
C       Desulfurize the C6+ material and accumulate the total amount
C       of nitrogen remaining in the C6+, XNLEFT, in Mlbs/hr.
```

```
      XNLEFT = 0.0D0
      DO 50 J = 16, 35
        IF ( CNAME(J) .EQ. BLANK8 )   GO TO 50
C         CNIN is the weight of nitrogen entering in this component.
          CNIN = 0.01D0 * CIN(J,1) * CIN(J,4)
C         CNLEFT is the weight of nitrogen remaining in this
C         component.
          CNLEFT = CNIN * (1.0D0 - F) / RELDEN(J-15)
C         Adjust the weight flow rate for the amount of N removed.
          CUTWT(J) = COUT(J,1) - (CNIN - CNLEFT)
C         Load the remaining Mlbs/hr of nitrogen in COUT(J,4).
          COUT(J,4) = CNLEFT
          XNLEFT = XNLEFT + COUT(J,4)
   50 CONTINUE
C     Calculate the overall percent denitrogenation - XNREM is the
C     amount of nitrogen removed from the C6+ in Mlbs/hr.
      XNREM = WTNIN - XNLEFT
      CDEN = 100.0D0 * XNREM / WTNIN
C     Save the iteration results.
      QX(1) = QX(2)
      QY(1) = QY(2)
      QX(2) = F
      QY(2) = CDEN
      IF ( KTEST .GE. 5 )  THEN
        IF ( K .EQ. 1 )  WRITE (NHSTRY, 704)
  704   FORMAT ( / ' Denitrogenation iteration history:' )
        WRITE (NHSTRY, 705) K, QX(1), QX(2), QY(1), QY(2)
  705   FORMAT ( ' K, QX(1), QX(2), QY(1) & QY(2):', I5, 4F10.5 )
      ENDIF
C     Convergence check.
      IF ( DABS(PCTDEN-QY(2)) .LT. 0.00001 )  THEN
C         Converged - Exit the convergence loop.
          GO TO 70
        ELSE
C         Make the guess for the next iteration.
          IF ( K .EQ. 1 )  THEN
C             First iteration - make a small move.
              IF ( CDEN .LT. PCTDEN )  THEN
C                 Calculated denitrogenation is below target value.
                  F = 1.0D0 - 0.75D0 * (1.0D0 - F)
                ELSE
C                 Calculated denitrogenation is above target value.
                  F = 1.0D0 - 1.25D0 * (1.0D0 - F)
              ENDIF
            ELSE
C             Subsequent iterations - Use a damping factor for the
C             third and fourth iterations.
              DF = 0.25 * K
              IF ( DF .GT. 1.0D0 )  DF = 1.0D0
              F = QX(2) +
     1          DF * (PCTDEN-QY(2))*(QX(2)-QX(1))/(QY(2)-QY(1))
          ENDIF
      ENDIF
   60 CONTINUE
C    End of denitrogenation iteration loop.
```

```
C
C     The denitrogenation loop did not converge, write a warning
C     message and continue using the last value.
      WRITE (NHSTRY, 706)  PCTDEN, ITER, CDEN
  706 FORMAT ( / ' * WARNING * - In subroutine USR04D, the overall',
     1  ' percent denitrogenation did not' /
     2  3X, 'converge to the desired value of', F9.4, '% within', I3,
     3  ' iterations.  Execution' /
     4  3X, 'will continue using the calculated percent',
     5  ' denitrogenation of', F10.4, '%.' )
C
C     If requested, write the calculated percent denitrogenation.
   70 IF ( KTEST .GE. 4 )  WRITE (NHSTRY, 707)  CDEN
  707 FORMAT ( / ' Calculated percent denitrogenation =', F10.4 )
C
C     Load the adjusted component weights in the COUT array.
      DO 150 J = 16, 35
        COUT(J,1) = CUTWT(J)
  150 CONTINUE
C
C     Adjust the COUT array for the amount of nitrogen converted to NH3.
      COUT(2,1) = COUT(2,1) + XNREM * (XMWN + XMWH3) / XMWN
C     Load the Mlbs/hr of nitrogen in COUT(2,4)
      COUT(2,4) = COUT(2,1) * XMWN / (XMWN + XMWH3)
C     Adjust the hydrogen for the amount used to make the NH3.
      COUT(1,1) = COUT(1,1) - XNREM * XMWH3 / XMWN
C     Adjust for any entering nitrogen.
      COUT(5,4) = COUT(5,1)
C
C
      RETURN
      END

C$ USR04E
      SUBROUTINE USR04E (IPASS, KTEST, NHSTRY, PCTDEO)
C
C     This subroutine does the naphtha hydrotreater deoxygenation
C     calculations.
C     NOTE: This subroutine is similar to subroutine USR04C.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - November 19, 1991.
C
C     Calling arguments:
C     IPASS  = The results pass flag.
C     KTEST  = Switch for controlling the printing to the history file.
C     NHSTRY = Logical unit number of the history file.
C     PCTDEO = Overall percent deoxygenation; i .e., percent
C              oxygen removed from the C5+ feed.
C
C     NOTE:  This model contains only two C5 components, IC5 and NC5,
C       both of which are are pure compoennts.  Therefore, percent
C       deoxygenation on a C5+ basis is the same as on a C6+ basis.
C       Thus, these calculations will be done on a C6+ basis to
```

```
C       save computation time.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
C     See subroutine USR04A for a description of the items in named
C     COMMON block /USR04M/.
      COMMON /USR04M/ CIN(35,7), COUT(35,7), CUTWT(35), CMWOUT(35)
      COMMON /USR04N/ CNAME(35), ICNUMB(55)
C
      CHARACTER * 8  BLANK8, CNAME
C
C     Local variable declarations.
      DIMENSION RELDEO(20), QX(2), QY(2)
C
      DATA BLANK8 / '        ' /
C
C     RELDEO(J) is the relative deoxygenability of component J compared
C     to the T275 cut (component 19 - the 250-300 F boiling range cut).
C     It is calculated as follows.
C                    100.0 - % Deoxygenation of component 15
C       RELDEO(K) = ----------------------------------------
C                    100.0 - % Deoxygenation of component K
C     If the T275 cut (component 19) is 99.0% deoxygenated and cut K is
C     only 98% deoxygenated then
C        RELDEO(K) = (100. - 99.) / (100. - 98.) = 0.5
C
C     Load the RELDEO vector with the relative deoxygenability of
C     components 11 - 30 so that RELDEO(J) corresponds to the relative
C     deoxygenability of component J + 15.
C     The following values are crude estimates, and need to be refined.
      DATA RELDEO / 1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0,
     1  1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0,
     2  1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0,
     3  1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0 /
C
C     Load the molecular weight of H2 and an oxygen atom.
      XMWH2 = CMWOUT(1)
      XMWO = CMWOUT(3) - XMWH2
C
C
C     Calculate the entering amount of oxygen in the C6+ in Mlbs/hr.
      WTOIN = 0.0D0
      DO 10 J = 16, 35
        WTOIN = WTOIN + CIN(J,1) * CIN(J,5)
   10 CONTINUE
      WTOIN = 0.01D0 * WTOIN
C
C     If requested, write the entering amount of oxygen and desired
C     percent deoxygenation of the C6+ feed.
      IF ( KTEST .GE. 3 )  WRITE (NHSTRY, 701)  WTOIN, PCTDEO
  701 FORMAT ( / ' Entering oxygen in C6+, Mlbs/hr =', F10.4 /
     1  ' Target percent deoxygenation =', F10.4 )
C
C     If requested, write the relative component deoxygenabilities.
```

```
      IF ( KTEST .GE. 2 )  THEN
        WRITE (NHSTRY, 702)
  702   FORMAT ( / ' Relative component deoxygenabilities:' )
        DO 20 J = 1, 10
          K = J + 15
          KP = J + 25
          JP = J + 10
          WRITE (NHSTRY, 703) K, CNAME(K), RELDEO(J), KP, CNAME(KP),
     1      RELDEO(JP)
  703     FORMAT ( 3X, I3, 3X, A8, F9.4, 10X, I3, 3X, A8, F9.4 )
   20   CONTINUE
      ENDIF
C
C     Initialize the component weights to zero,
      DO 30 J = 1, 30
        CUTWT(J) = 0.0D0
   30 CONTINUE
C
C     Converge on the specified overall percent deoxygenation by
C     varying F, the fractional deoxygenation of the reference cut,
C     (component 19), the 250 - 300 F boiling range cut.
C
C     Initialize the iteration history.
      DO 40 J = 1, 2
        QX(J) = 0.0D0
        QY(J) = 0.0D0
   40 CONTINUE
C
C     For an initial guess, set F equal to the overall fractional
C     deoxygenation.
      F = 0.01D0 * PCTDEO
C
      DO 60 K = 1, 35
        ITER = K
C       Deoxygenate the C6+ material and accumulate the total amount
C       of oxygen remaining in the C6+, OLEFT, in Mlbs/hr.
        OLEFT = 0.0D0
        DO 50 J = 16, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 50
C           COIN is the weight of oxygen entering in this component.
            COIN = 0.01D0 * CIN(J,1) * CIN(J,5)
C           COLEFT is the weight of oxygen remaining in this component.
            COLEFT = COIN * (1.0D0 - F) / RELDEO(J-15)
C           Adjust the weight flow rate for the amount of O removed.
            CUTWT(J) = COUT(J,1) - (COIN - COLEFT)
C           Load the remaining Mlbs/hr of oxygen in COUT(J,5).
            COUT(J,5) = COLEFT
            OLEFT = OLEFT + COUT(J,5)
   50   CONTINUE
C       Calculate the overall percent deoxygenation - OREM is the
C       amount of oxygen removed from the C6+ in Mlbs/hr.
        OREM = WTOIN - OLEFT
        CDEO = 100.0D0 * OREM / WTOIN
C       Save the iteration results.
        QX(1) = QX(2)
```

```
        QY(1) = QY(2)
        QX(2) = F
        QY(2) = CDEO
        IF ( KTEST .GE. 5 )  THEN
          IF ( K .EQ. 1 )  WRITE (NHSTRY, 704)
  704     FORMAT ( / ' Deoxygenation iteration history:' )
          WRITE (NHSTRY, 705) K, QX(1), QX(2), QY(1), QY(2)
  705     FORMAT ( ' K, QX(1), QX(2), QY(1) & QY(2):', I5, 4F10.5 )
        ENDIF
C       Convergence check.
        IF ( DABS(PCTDEO-QY(2)) .LT. 0.00001 )  THEN
C           Converged - Exit the convergence loop.
            GO TO 70
          ELSE
C           Make the guess for the next iteration.
            IF ( K .EQ. 1 )  THEN
C               First iteration - make a small move.
                IF ( CDEO .LT. PCTDEO )  THEN
C                   Calculated deoxygenation is below target value.
                    F = 1.0D0 - 0.75D0 * (1.0D0 - F)
                  ELSE
C                   Calculated deoxygenation is above target value.
                    F = 1.0D0 - 1.25D0 * (1.0D0 - F)
                ENDIF
              ELSE
C               Subsequent iterations - Use a damping factor for the
C               third and fourth iterations.
                DF = 0.25 * K
                IF ( DF .GT. 1.0D0 )  DF = 1.0D0
                F = QX(2) +
     1            DF * (PCTDEO-QY(2))*(QX(2)-QX(1))/(QY(2)-QY(1))
            ENDIF
        ENDIF
   60 CONTINUE
C     End of deoxygenation iteration loop.
C
C     The deoxygenation loop did not converge, write a warning
C     message and continue using the last value.
      WRITE (NHSTRY, 706)  PCTDEO, ITER, CDEO
  706 FORMAT ( / ' * WARNING * - In subroutine USR04E, the overall',
     1  ' percent deoxygenation did not' /
     2  3X, 'converge to the desired value of', F9.4, '% within', I3,
     3  ' iterations.  Execution' /
     4  3X, 'will continue using the calculated percent',
     5  ' deoxygenation of', F10.4, '%.' )
C
C     If requested, write the calculated percent deoxygenation.
   70 IF ( KTEST .GE. 4 )  WRITE (NHSTRY, 707)  CDEO
  707 FORMAT ( / ' Calculated percent deoxygenation =', F10.4 )
C
C     Load the adjusted component weights in the COUT array.
      DO 150 J = 16, 35
        COUT(J,1) = CUTWT(J)
  150 CONTINUE
C
```

```
C     Adjust the COUT array for the amount of oxygen converted to H2O.
      COUT(3,1) = COUT(3,1) + OREM * (XMWO + XMWH2) / XMWO
C     Load the Mlbs/hr of oxygen in COUT(3,5)
      COUT(3,5) = COUT(3,1) * XMWO / (XMWO + XMWH2)
C     Adjust the hydrogen for the amount used to make the NH3.
      COUT(1,1) = COUT(1,1) - OREM * XMWH2 / XMWO
C
C
      RETURN
      END
C
C$ USR04F
      SUBROUTINE USR04F (H2CONS, IPASS, KTEST, NHSTRY)
C
C     This subroutine does the naphtha hydrotreater hydrogen
C     consumption and yield shift calculations.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - December 11, 1992.
C
C     Calling arguments:
C     H2CONS = Specified chemical hydrogen consumption in SCF/bbl of
C              C5+ feed.
C     IPASS  = The results pass flag.
C     KTEST  = Switch for controlling the printing to the history file.
C     NHSTRY = Logical unit number of the history file.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
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
C     See subroutine USR04A for a description of the items in named
C     COMMON block /USR04M/.
      COMMON /USR04M/ CIN(35,7), COUT(35,7), CUTWT(35), CMWOUT(35)
      COMMON /USR04N/ CNAME(35), ICNUMB(55)
C
      CHARACTER * 8  BLANK8, CNAME
C
C     Local variable declarations.
      DIMENSION DELYLD(35), DELY(35), DELY8(35)
C
      DATA BLANK8 / '        ' /
C
C     Load the DELY(35) vector with the net component productions
C     in wt % of C5+ feed ignoring the pure non-hydrocarbon
C     components since they have been previously calculated.
      DATA DELY   / 0.0D0,  0.0D0,  0.0D0,  0.0D0,  0.0D0,
     1   0.51601D0,  0.34591D0,  0.3322600,  0.65570D0,  0.66615D0,
     2  -0.2565780, -0.2565780,  0.00000D0,  0.00000D0,  0.00000D0,
```

```
     3  -1.4788410, -1.4788410, -1.4788410, -1.4788410, -1.4788410,
     4   2.7610685,  2.7610685, -0.0009500,  0.00000D0,  0.00000D0,
     5   0.00000D0,  0.00000D0,  0.00000D0,  0.00000D0,  0.00000D0,
     6   0.00000D0,  0.00000D0,  0.00000D0,  0.00000D0,  0.00000D0 /
C
C     Load the DELY8(35) vector with the net component productions
C     in wt % of C6+ feed for the High Space Velocity Design Case
C     ignoring the pure non-hydrocarbon components since they have
C     been previously calculated.
C                      H2        NH3       H2O       H2S       N2
      DATA DELY8  /  0.0D0,    0.0D0,    0.0D0,    0.0D0,    0.0D0,
C        CH4         C2H6         C3H8         IC4H10       NC4H10
     1   0.500749 ,  0.351035 ,  0.334684 ,  0.550750 ,  0.734334 ,
C        IC5H12      NC5H12       Future       Future       Future
     2   0.0      ,  0.0      ,  0.00000D0,  0.00000D0,  0.00000D0,
C        T125        T175         T225         T275         T325
     3   0.319355 ,  0.319365 ,  0.319355 ,  0.319355 ,  0.319355 ,
C        T375        T425         T475         T525         T575
     4   0.015585 ,  0.015585 ,  0.033596 ,  0.033596 ,  0.033596 ,
C        T625        T675         T725         T775         T825
     5   0.033596 ,  0.0      ,  0.0      ,  0.0      ,  0.0      ,
C        T875        T925         T975         T1000+       Future
     6   0.0      ,  0.0      ,  0.0      ,  0.0      ,  0.00000D0 /
C
C     Load the SCF per pound mole.
      DATA SCFPM / 379.495D0 /
C
C
C     Load the appropriate yield deltas in the DELYLD vector.
C     Baseline Design.
      DO 10 J = 1, 35
        DELYLD(J) = DELY(J)
   10 CONTINUE
C
C     The high space velocity Plant 2 option (MODE = 18).
      IF ( MODE .EQ. 18 )  THEN
        DO 18 J = 1, 35
          DELYLD(J) = DELY8(J)
   18   CONTINUE
      ENDIF
C
C     Calculate the C5+ density of the feed in lbs/bbl.
      C5PWT = 0.0D0
      C5PVOL = 0.0D0
      DO 30 J = 11, 35
        IF ( CNAME(J) .EQ. BLANK8 )   GO TO 30
          C5PWT = C5PWT + CIN(J,1)
          C5PVOL = C5PVOL + CIN(J,1) / CIN(J,2)
   30 CONTINUE
      C5PDEN = C5PWT / C5PVOL
C
C     Calculate the total weight of H2 that has to be consumed.
      TWTH2 = (H2CONS * CMWOUT(1) / SCFPM) * C5PVOL
C
      IF ( KTEST .GE. 4 )  THEN
```

```
        V = 1000.0D0 * C5PVOL
        WRITE (NHSTRY, 701) C5PWT, V, C5PDEN, H2CONS, TWTH2
  701   FORMAT ( / ' C5+ weight  =', F10.3, ' Mlbs/hr' /
     1    ' C5+ volume  =', F10.3, ' bbls/hr' /
     2    ' C5+ density =', F10.3, ' lbs/bbl' /
     3    ' Total H2 consumption =', F10.1, ' SCF/bbl or', F10.3,
     4    ' Mlbs/hr' )
      ENDIF
C
      IF ( KTEST .GE. 2 )  THEN
        WRITE (NHSTRY, 702) MODE, (J, DELYLD(J), J = 1, 35)
  702   FORMAT ( / ' Plant 2 Reactor MODE = ', I5 /
     1    ' Specified component productions in wt% of C5+ feed:',
     2    7 (/I4, F9.5, I7, F9.5, I7, F9.5, I7, F9.5, I7, F9.5 ) )
      ENDIF
C
C
C     Adjust the hydrogen for the total amount of hydrogen consumed as
C     specified by the supplied chemical hydrogen consumption.
      COUT(1,1) = CIN(1,1) - TWTH2
      COUT(1,7) = COUT(1,1)
C
C     Load the weight of hydrogen in the in the COUT array for H2, NH3,
C     H2O and H2S.
      DO 40 J = 2, 4
        COUT(J,7) = 0.01D0 * COUT(J,1) * CIN(J,7)
   40 CONTINUE
C
C     If requested, write the component information.
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 722)
  722   FORMAT ( / ' COMPONENT FLOW RATES IN USR04F:' /
     1    '   No.  Name', 7X, 'Mlbs/hr', 2X, 'lbs/bbl', 5X, 'Wt S',
     2    5X, 'Wt N', 5X, 'Wt O', 5X, 'Wt C', 5X, 'Wt H' )
  723   FORMAT ( 1X, I5, 2X, A8, F10.3, F9.3, 5F9.3 )
        SUM1 = 0.0D0
        SUM3 = 0.0D0
        SUM4 = 0.0D0
        SUM5 = 0.0D0
        SUM6 = 0.0D0
        SUM7 = 0.0D0
        DO 100 J = 1, 35
            IF ( CNAME(J) .EQ. BLANK8 )   GO TO 100
            WRITE (NHSTRY, 723)  J, CNAME(J), (COUT(J,K), K = 1, 7)
            SUM1 = SUM1 + COUT(J,1)
            SUM3 = SUM3 + COUT(J,3)
            SUM4 = SUM4 + COUT(J,4)
            SUM5 = SUM5 + COUT(J,5)
            SUM6 = SUM6 + COUT(J,6)
            SUM7 = SUM7 + COUT(J,7)
  100   CONTINUE
        WRITE (NHSTRY, 724)  SUM1, SUM3, SUM4, SUM5, SUM6, SUM7
  724   FORMAT ( 8X, 'Total ', F12.3, F18.3, 4F9.3 )
      ENDIF
C
```

```
C     Calculate the net C1 - C5 productions in Mlbs/hr.
      DO 42 J = 6, 12
        WT = COUT(J,1) + 0.01D0 * C5PWT * DELYLD(J)
        COUT(J,6) = WT * CIN(J,6) / (CIN(J,6) + CIN(J,7))
        COUT(J,7) = WT - COUT(J,6)
        COUT(J,1) = WT
   42 CONTINUE
C
C     Calculate the pseudocomponents.
      DO 44 J = 16, 35
        IF ( CNAME(J) .EQ. BLANK8 )   GO TO 44
          WT = 0.01D0 * C5PWT * DELYLD(J)
          COUT(J,6) = 0.01D0 * CIN(J,1) * CIN(J,6) +
     1      WT * CIN(J,6) / (CIN(J,6) + CIN(J,7))
          COUT(J,7) = 0.01D0 * CIN(J,1) * CIN(J,7) +
     1      WT * CIN(J,7) / (CIN(J,6) + CIN(J,7))
          COUT(J,1) = COUT(J,3) + COUT(J,4) + COUT(J,5) + COUT(J,6) +
     1      COUT(J,7)
   44 CONTINUE
C
C     If requested, write the component information.
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 722)
        SUM1 = 0.0D0
        SUM3 = 0.0D0
        SUM4 = 0.0D0
        SUM5 = 0.0D0
        SUM6 = 0.0D0
        SUM7 = 0.0D0
        DO 110 J = 1, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 110
            WRITE (NHSTRY, 723)  J, CNAME(J), (COUT(J,K), K = 1, 7)
            SUM1 = SUM1 + COUT(J,1)
            SUM3 = SUM3 + COUT(J,3)
            SUM4 = SUM4 + COUT(J,4)
            SUM5 = SUM5 + COUT(J,5)
            SUM6 = SUM6 + COUT(J,6)
            SUM7 = SUM7 + COUT(J,7)
  110   CONTINUE
        WRITE (NHSTRY, 724)  SUM1, SUM3, SUM4, SUM5, SUM6, SUM7
      ENDIF
C
C     Calculate a carbon/hydrogen balance.
      CARIN = 0.0D0
      CAROUT = 0.0D0
      HIN = 0.0D0
      HOUT = 0.0D0
      DO 50 J = 1, 35
        CARIN = CARIN + 0.01D0 * CIN(J,1) * CIN(J,6)
        HIN = HIN + 0.01D0 * CIN(J,1) * CIN(J,7)
        CAROUT = CAROUT + COUT(J,6)
        HOUT = HOUT + COUT(J,7)
   50 CONTINUE
C     Calculate the carbon and hydrogen imbalance.
      DC = CARIN - CAROUT
```

```
      DH = HIN - HOUT
C
      IF ( KTEST .GE. 4 )  THEN
        WRITE (NHSTRY, 705) CARIN, CAROUT, HIN, HOUT
  705   FORMAT ( / ' Preliminary carbon and hydrogen balances' /
     1    2X, 'Carbon:     In =', F12.3, 10X, 'Out =', F12.3 /
     2    2X, 'Hydrogen    In =', F12.3, 10X, 'Out =', F12.3 )
      ENDIF
C
C     Now adjust the carbon and hydrogen in the C6+ pseudocomponents
C     in proportion to their amounts to make a 100% balance.
C     Calculate the C6+ carbon and hydrogen.
      CC6P = 0.0D0
      HC6P = 0.0D0
      DO 60 J = 16, 35
        CC6P = CC6P + COUT(J,6)
        HC6P = HC6P + COUT(J,7)
   60 CONTINUE
C
C     Adjust the C6+ pseudocomponents in proportion to their amount.
      DO 62 J = 16, 35
        COUT(J,6) = COUT(J,6) + DC*COUT(J,6)/CC6P
        COUT(J,7) = COUT(J,7) + DH*COUT(J,7)/HC6P
        COUT(J,1) = COUT(J,3) + COUT(J,4) + COUT(J,5) + COUT(J,6) +
     1    COUT(J,7)
   62 CONTINUE
C
C     If requested, write the component information.
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 722)
        SUM1 = 0.0D0
        SUM3 = 0.0D0
        SUM4 = 0.0D0
        SUM5 = 0.0D0
        SUM6 = 0.0D0
        SUM7 = 0.0D0
        DO 120 J = 1, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 120
            WRITE (NHSTRY, 723)  J, CNAME(J), (COUT(J,K), K = 1, 7)
            SUM1 = SUM1 + COUT(J,1)
            SUM3 = SUM3 + COUT(J,3)
            SUM4 = SUM4 + COUT(J,4)
            SUM5 = SUM5 + COUT(J,5)
            SUM6 = SUM6 + COUT(J,6)
            SUM7 = SUM7 + COUT(J,7)
  120   CONTINUE
        WRITE (NHSTRY, 724)  SUM1, SUM3, SUM4, SUM5, SUM6, SUM7
      ENDIF
C
      RETURN
      END
C
C$ USR04G
      SUBROUTINE USR04G (INT1, INT2, IPASS, NOUT, UNKNWN)
C
```

```
C     This subroutine writes the first part of the naphtha hydrotreater
C     summary report.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - October 16, 1992.
C
C     Calling arguments:
C     INT1   = 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 report.
C              2 => Skip the capital cost and utilities portions of the
C                   summary report.
C              3 => Skip writing the entire user block summary report.
C     INT2   = User block summary report destination control switch.
C              0 => Write the user block summary report to the normal
C                   ASPEN/SP output report file.
C              1 => Write the user block summary report to a separate
C                   user block summary report file on logical unit 62.
C     IPASS  = The results pass flag.
C     NOUT   = Logical unit of the plant summary report file.
C     UNKNWN = Flow rate of unknown components in Mlbs/hr.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
C     See subroutine USR04A for a description of the items in named
C     COMMON block /USR04M/.
      COMMON /USR04M/ CIN(35,7), COUT(35,7), CUTWT(35), CMWOUT(35)
      COMMON /USR04N/ CNAME(35), ICNUMB(55)
C
      CHARACTER * 8  BLANK8, CNAME
C
      DATA BLANK8 / '        ' /
C
      DATA SCFM / 379.495D0 /
C
C
      IF ( IPASS .EQ. 4 .AND. INT1 .LE. 0 )  THEN
C       Write the first part of the plant summary report.
C       ================================================
        WRITE (NOUT, 801)
  801   FORMAT ( / 27X, 'PLANT 4 - SUMMARY REPORT' /
     1    29X, 'NAPHTHA HYDROTREATER' //
     2    31X, 'REACTOR SUMMARY' )
C
        WRITE (NOUT, 802)
  802   FORMAT ( / 18X, 'REACTOR INLET', 11X, 'REACTOR OUTLET' /
     1    ' COMPONENT ', 5X, 'MLBS/HR', 3X, 'BBLS/HR', 8X, 'MLBS/HR',
     2    3X, 'BBLS/HR' )
C
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        SUM4 = 0.0D0
```

```
      DO 10 J = 1, 8
        SUM1 = SUM1 + CIN(J,1)
        SUM3 = SUM3 + COUT(J,1)
        WRITE (NOUT, 803)  CNAME(J), CIN(J,1), COUT(J,1)
803     FORMAT ( 2X, A8, F13.3, F25.3 )
 10   CONTINUE
C
      DO 20 J = 9, 23
        IF ( CNAME(J) .EQ. BLANK8 )   GO TO 20
          BBLIN = 1.0D3 * CIN(J,1) / CIN(J,2)
          BBLOUT = 1.0D3 * COUT(J,1) / COUT(J,2)
          SUM1 = SUM1 + CIN(J,1)
          SUM2 = SUM2 + BBLIN
          SUM3 = SUM3 + COUT(J,1)
          SUM4 = SUM4 + BBLOUT
          WRITE (NOUT, 804)  CNAME(J), CIN(J,1), BBLIN,
     1      COUT(J,1), BBLOUT
804       FORMAT ( 2X, A8, F13.3, F10.1, F15.3, F10.1)
 20   CONTINUE
C
      X1 = 0.0D0
      X2 = 0.0D0
      X3 = 0.0D0
      X4 = 0.0D0
      DO 30 J = 24, 35
        IF ( CNAME(J) .EQ. BLANK8 )   GO TO 30
          BBLIN = 1.0D3 * CIN(J,1) / CIN(J,2)
          BBLOUT = 1.0D3 * COUT(J,1) / COUT(J,2)
          X1 = X1 + CIN(J,1)
          X2 = X2 + BBLIN
          X3 = X3 + COUT(J,1)
          X4 = X4 + BBLOUT
 30   CONTINUE
      WRITE (NOUT, 805)  X1, X2, X3, X4
805   FORMAT ( 2X, '500+ F', F15.3, F10.1, F15.3, F10.1)
C
      SUM1 = SUM1 + X1
      SUM2 = SUM2 + X2
      SUM3 = SUM3 + X3
      SUM4 = SUM4 + X4
      WRITE (NOUT, 806)  SUM1, SUM2, SUM3, SUM4
806   FORMAT ( 2X, 'TOTAL', F16.3, F10.1, F15.3, F10.1)
C
C     Calculate and write the butanes.
      SUM1 = 0.0D0
      SUM2 = 0.0D0
      SUM3 = 0.0D0
      SUM4 = 0.0D0
      X1 = CIN(9,1) + CIN(10,1)
      X2 = 1.0D3 * (CIN(9,1)/CIN(9,2) + CIN(10,1)/CIN(10,2))
      X3 = COUT(9,1) + COUT(10,1)
      X4 = 1.0D3 * (COUT(9,1)/COUT(9,2) + COUT(10,1)/COUT(10,2))
      SUM1 = SUM1 + X1
      SUM2 = SUM2 + X2
      SUM3 = SUM3 + X3
```

```
      SUM4 = SUM4 + X4
      WRITE (NOUT, 807)  X1, X2, X3, X4
  807 FORMAT ( / ' COMPONENT GROUPS' /
     1  2X, 'BUTANES', F14.3, F10.1, F15.3, F10.1 )
C
C     Calculate and write the pentanes.
      X1 = CIN(11,1) + CIN(12,1)
      X2 = 1.0D3 * (CIN(11,1)/CIN(11,2) + CIN(12,1)/CIN(12,2))
      X3 = COUT(11,1) + COUT(12,1)
      X4 = 1.0D3 * (COUT(11,1)/COUT(11,2) + COUT(12,1)/COUT(12,2))
      SUM1 = SUM1 + X1
      SUM2 = SUM2 + X2
      SUM3 = SUM3 + X3
      SUM4 = SUM4 + X4
      WRITE (NOUT, 808)  X1, X2, X3, X4
  808 FORMAT ( 2X, 'PENTANES', F13.3, F10.1, F15.3, F10.1 )
      C5PBBL = X2
C
C     Calculate and write the C6 TO 350 F material.
      X1 = 0.0D0
      X2 = 0.0D0
      X3 = 0.0D0
      X4 = 0.0D0
      DO 50 J = 16, 20
        X1 = X1 + CIN(J,1)
        X2 = X2 + 1.0D3 * CIN(J,1)/CIN(J,2)
        X3 = X3 +  COUT(J,1)
        X4 = X4 + 1.0D3 * COUT(J,1)/COUT(J,2)
   50 CONTINUE
      SUM1 = SUM1 + X1
      SUM2 = SUM2 + X2
      SUM3 = SUM3 + X3
      SUM4 = SUM4 + X4
      WRITE (NOUT, 809)  X1, X2, X3, X4
  809 FORMAT ( 2X, 'C6 - 350 F', F11.3, F10.1, F15.3, F10.1 )
      C5PBBL = C5PBBL + X2
C
C     Calculate and write the 350+ F material.
      X1 = 0.0D0
      X2 = 0.0D0
      X3 = 0.0D0
      X4 = 0.0D0
      DO 60 J = 21, 35
        IF ( CNAME(J) .EQ. BLANK8 )   GO TO 60
          X1 = X1 + CIN(J,1)
          X2 = X2 + 1.0D3 * CIN(J,1)/CIN(J,2)
          X3 = X3 +  COUT(J,1)
          X4 = X4 + 1.0D3 * COUT(J,1)/COUT(J,2)
   60 CONTINUE
      SUM1 = SUM1 + X1
      SUM2 = SUM2 + X2
      SUM3 = SUM3 + X3
      SUM4 = SUM4 + X4
      WRITE (NOUT, 810)  X1, X2, X3, X4
  810 FORMAT ( 2X, '350+ F', F15.3, F10.1, F15.3, F10.1 )
```

```
      C5PBBL = C5PBBL + X2
C
      WRITE (NOUT, 811)  SUM1, SUM2, SUM3, SUM4
  811 FORMAT ( 2X, 'TOTAL C4+', F12.3, F10.1, F15.3, F10.1 )
C
      WRITE (NOUT, 812)
  812 FORMAT ( / 1X, 'C5+ HETROATOM STATISTICS' /
     1   18X, 'REACTOR INLET', 11X, 'REACTOR OUTLET' /
     2   ' ELEMENT   ', 6X, 'LBS/HR', 3X, '   WT %', 9X, 'LBS/HR',
     3   3X, '   WT %', 4X, '% REMOVAL' )
C
C     Calculate and write the sulfur statistics.
      X1 = 0.0D0
      X2 = 0.0D0
      X3 = 0.0D0
      X4 = 0.0D0
      DO 100 J = 16, 35
        IF ( CNAME(J) .EQ. BLANK8 )   GO TO 100
          X1 = X1 + 0.01D0 * CIN(J,1) * CIN(J,3)
          X2 = X2 + CIN(J,1)
          X3 = X3 + 0.01D0 * COUT(J,1) * COUT(J,3)
          X4 = X4 + COUT(J,1)
  100 CONTINUE
        X2 = 100.0D0 * X1 / X2
        X4 = 100.0D0 * X3 / X4
        X1 = 1000.0D0 * X1
        X3 = 1000.0D0 * X3
        REMVAL = 100.0D0 * (X1 - X3) / X1
      WRITE (NOUT, 813)  X1, X2, X3, X4, REMVAL
  813 FORMAT ( 2X, 'SULFUR', F15.2, F10.5, F15.2, F10.5, F12.3 )
C
C     Calculate and write the nitrogen statistics.
      X1 = 0.0D0
      X2 = 0.0D0
      X3 = 0.0D0
      X4 = 0.0D0
      DO 110 J = 16, 35
        IF ( CNAME(J) .EQ. BLANK8 )   GO TO 110
          X1 = X1 + 0.01D0 * CIN(J,1) * CIN(J,4)
          X2 = X2 + CIN(J,1)
          X3 = X3 + 0.01D0 * COUT(J,1) * COUT(J,4)
          X4 = X4 + COUT(J,1)
  110 CONTINUE
        X2 = 100.0D0 * X1 / X2
        X4 = 100.0D0 * X3 / X4
        X1 = 1000.0D0 * X1
        X3 = 1000.0D0 * X3
        REMVAL = 100.0D0 * (X1 - X3) / X1
      WRITE (NOUT, 814)  X1, X2, X3, X4, REMVAL
  814 FORMAT ( 2X, 'NITROGEN', F13.2, F10.5, F15.2, F10.5, F12.3 )
C
C     Calculate and write the oxygen statistics.
      X1 = 0.0D0
      X2 = 0.0D0
      X3 = 0.0D0
```

```
      X4 = 0.0D0
      DO 120 J = 16, 35
        IF ( CNAME(J) .EQ. BLANK8 )   GO TO 120
          X1 = X1 + 0.01D0 * CIN(J,1) * CIN(J,5)
          X2 = X2 + CIN(J,1)
          X3 = X3 + 0.01D0 * COUT(J,1) * COUT(J,5)
          X4 = X4 + COUT(J,1)
 120  CONTINUE
        X2 = 100.0D0 * X1 / X2
        X4 = 100.0D0 * X3 / X4
        X1 = 1000.0D0 * X1
        X3 = 1000.0D0 * X3
        REMVAL = 100.0D0 * (X1 - X3) / X1
      WRITE (NOUT, 815)  X1, X2, X3, X4, REMVAL
 815  FORMAT ( 2X, 'OXYGEN', F15.2, F10.5, F15.2, F10.5, F12.3 )
C
C     Calculate and write the inlet hydrogen rate and chemical
C     hydrogen consumption in SCF/bbl of C5+ feed.
      H2IN = (1.0D3*SCFM / (CMWOUT(1)*C5PBBL)) * CIN(1,1)
      H2CONS = (1.0D3*SCFM / (CMWOUT(1)*C5PBBL)) * (CIN(1,1) -
     1  COUT(1,1))
      WRITE (NOUT, 820)  H2IN, H2CONS
 820  FORMAT ( / ' MAKEUP HYDROGEN RATE', F21.1, ' SCF/BBL OF C5+',
     1  ' FEED' /
     2  ' CHEMICAL HYDROGEN CONSUMPTION', F12.1, ' SCF/BBL OF C5+',
     3  ' FEED' )
C
      IF ( UNKNWN .GE. 1.0D-3 )  WRITE(NOUT, 825) UNKNWN
 825  FORMAT ( / ' *WARNING* THE FEED TO THIS PLANT CONTAINS', F8.3,
     1  ' MLBS/HR OF COMPONENT(S)' /
     2  2X, 'UNKNOWN TO THIS MODEL.  THEY ARE BEING IGNORED.  ',
     3  'THEREFORE, THE NAPHTHA' /
     3  2X, 'HYDROTREATER IS NOT IN MASS BALANCE.  PLEASE REMOVE ',
     4  'THESE EXTRA' /
     5  2X, 'COMPONENT(S) FROM THE FEED STREAM.' )
C
      WRITE (NOUT, 830)
 830  FORMAT ( / 25X, '- CONTINUED ON NEXT PAGE -' )
    ENDIF
C
C
    RETURN
    END
C
C$ USR04H
    SUBROUTINE USR04H (IER1, INT1, INT2, IPASS,
   1 ITEMS, KTEST, NCC, NNCC, NCONV, NCCONV, NHSTRY, NOUT,
   3 SOUT1, SOUT2, SOUT3)
C
C    This subroutine splits the net naphtha hydrotreater yields into
C    the three net product streams, loads the outlet stream vectors,
C    and writes the stream section of the summary report.
C
C    Prepared under DOE contract no. DE-AC22 90PC89857.
C
```

```
C     Last revision - December 2, 1991.
C
C     Calling arguments:
C     IER1    = Switch to specify if the insufficient hydrogen makeup
C               rate warning message is to be written.
C               0 => Normal - Do not write the warning message.
C               1 => Write the insufficient makeup hydrogen warning
C                    message.
C     INT1    = 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 report.
C               2 => Skip the capital cost and utilities portions of the
C                    summary report.
C               3 => Skip writing the entire user block summary report.
C     INT2    = User block summary report destination control switch.
C               0 => Write the user block summary report to the normal
C                    ASPEN/SP output report file.
C               1 => Write the user block summary report to a separate
C                    user block summary report file on logical unit 62.
C     IPASS     = The results pass flag.
C     ITEMS     = Total number of items in the SOUT1 - SOUT3 vectors.
C     KTEST     = Switch for controlling the printing to the history
C                 file.
C     NCC       = Number of conventional components.
C     NNCC      = Number of non-conventional components.
C     NCONV     = Offset for the conventional component substream.
C     NCCONV    = Offset for the non-conventional component substream.
C     NHSTRY    = Logical unit number of the history file.
C     NOUT      = Logical unit of the plant summary report file.
C     SOUT1()   = ASPEN/SP stream vector for outlet stream number 1 -
C                 the gas stream.
C     SOUT2()   = ASPEN/SP stream vector for outlet stream number 2 -
C                 the hydrotreated naphtha stream.
C     SOUT3()   = ASPEN/SP stream vector for outlet stream number 3 -
C                 the sour water stream.
C
C     Method of calculation:
C       The Bechtel plant model shows two gas streams going to plant
C       6, hydrogen recovery.  One is the reactor section purge gas,
C       and the other is the naphta stabilizer overhead gas.  Since,
C       they go to the same place, they are combined in one stream
C       in this model.
C
C       The net yields are split into the three net product streams
C       using component distribution factors for the second (the
C       naphtha stream) and third (the sour water stream) product
C       streams.  All remaining material is placed in the first net
C       product stream, the gas stream.
C           Stream 1 - the gas stream.
C           Stream 2 - the hydrotreated naphtha product stream,
C           Stream 3 - the sour water feed stream.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
```

```
C     See subroutine USR04A for a description of the items in named
C     COMMON block /USR04M/.
      COMMON /USR04M/ CIN(35,7), COUT(35,7), CUTWT(35), CMWOUT(35)
      COMMON /USR04N/ CNAME(35), ICNUMB(55)
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 SOUT1(*), SOUT2(*), SOUT3(*)
C
C     Loacal variable declarations.
      DIMENSION CDF2(35), CDF3(35), S1(35), S2(35), S3(35)
C
      CHARACTER * 8, BLANK8, CNAME
C
      DATA BLANK8 / '        ' /
C
C     CDF2(J) are the component distribution factors for stream 1, the
C             gas stream.
C     CDF3(J) are the component distribution factors for stream 3, the
C             sour water stream.
C     S1(J) are the component flow rates in Mlbs/hr in the first
C           product stream, the gas stream.
C     S2(J) are the component flow rates in Mlbs/hr in the second
C           product stream, the hydrotreated naphtha stream.
C     S3(J) are the component flow rates in Mlbs/hr in the third
C           product stream, the sour water stream.
C
C     Initialize the component distribution factors for the second
C     product stream, the hydrotreated naphtha stream.
C     Fraction of   H2       NH3       H2O       H2S       N2
      DATA CDF2 / 0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CH4       C2H6      C3H8      IC4H10    NC4H10
     1  0.000000, 0.000000, 0.000000, 0.069177, 0.115741,
C       IC5H12    NC5H12    Future    Future    Future
     2  0.970336, 0.970336, 0.000000, 0.000000, 0.000000,
C       T125      T175      T225      T275      T325
     3  0.997531, 0.997531, 0.997531, 0.997531, 0.997531,
C       T375      T425      T475      T525      T575
     4  1.000000, 1.000000, 1.000000, 1.000000, 1.000000,
C       T625      T675      T725      T775      T825
     5  1.000000, 1.000000, 1.000000, 1.000000, 1.000000,
C       T875      T925      T975      T1000+    Future
     6  1.000000, 1.000000, 1.000000, 1.000000, 1.000000 /
C
C     Initialize the component distribution factors for the third
C     product stream, the sour water stream.
C     Fraction of   H2       NH3       H2O       H2S       N2
      DATA CDF3 / 0.000000, 0.782609, 0.995337, 1.000000, 0.000000,
C       CH4       C2H6      C3H8      IC4H10    NC4H10
     1  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       IC5H12    NC5H12    Future    Future    Future
```

```
     2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T125      T175      T225      T275      T325
     3  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T375      T425      T475      T525      T575
     4  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T625      T675      T725      T775      T825
     5  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T875      T925      T975      T1000+    Future
     5  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
      DATA SCFM / 379.495D0 /
C
C
      IF ( KTEST .GE. 3 )   WRITE (NHSTRY, 701)
  701 FORMAT ( / ' Starting the naphtha hydrotreater separation',
     1  ' calculations in Subroutine USR04H.' )
C
      IF ( KTEST .GE. 2 )   THEN
        WRITE (NHSTRY, 702)
  702   FORMAT ( / ' The component product distribution factors:' /
     1    ' No.', 3X, 'Component', 6X, 'Gases*',
     2    5X, 'Naphtha', 5X, 'Sour H2O')
        DO 10 J = 1, 30
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 10
            X = 1.0D0 - CDF2(J) - CDF3(J)
            WRITE (NHSTRY, 703)  J, CNAME(J), X, CDF2(J), CDF3(J)
  703       FORMAT ( 1X, I3, 3X, A8, F12.5, 2F13.5 )
   10   CONTINUE
        WRITE (NHSTRY, 704)
  704   FORMAT ( 2X, '* The above gas stream component distribution',
     1    ' factors are calculated by difference.' )
      ENDIF
C
C     Distribute the net unit yields among the 3 product streams.
      SUMC = 0.0D0
      SUM1 = 0.0D0
      SUM2 = 0.0D0
      SUM3 = 0.0D0
      DO 30 J = 1, 35
        X = CDF2(J) + CDF3(J)
        IF ( X .GT. 1.0D0 )  THEN
C         The component distributions factors for this component are
C         greater than 1.0.  Therefore, adjust the distribution so
C         that this component is distributed in the same ratio as the
C         specified component distribution factors, and write a
C         warning message.
          IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 705) IPASS
  705     FORMAT ( // 1X, 'Plant 4 - Supplementary data',
     1      ' from subroutine USR04' /
     2      2X, 'the naphtha hydrotreater', 20X, 'IPASS =', I3 /)
          WRITE (NHSTRY, 706)  J, CNAME(J),  CDF2(J), CDF3(J)
  706     FORMAT ( / 1X, '* WARNING * - The component product ',
     1      'distribution factors for component no.', I3 /
     2      3X, A8, ' sum to a total greater than 1.0.  They are' /,
     3      3X, 2F10.4, '  They will be normalized to 1.0.' //
```

```
     4      3X, 'Please correct this problem in the next run.  ',
     5      'Execution is continuing.' / )
          CDF2(J) = CDF2(J) / X
          CDF3(J) = CDF3(J) / X
          S1(J) = 0.0D0
        ENDIF
        CMLBS = COUT(J,1)
        S2(J) = CDF2(J) * CMLBS
        S3(J) = CDF3(J) * CMLBS
        S1(J) = CMLBS - S2(J) - S3(J)
        SUMC = SUMC + CMLBS
        SUM1 = SUM1 + S1(J)
        SUM2 = SUM2 + S2(J)
        SUM3 = SUM3 + S3(J)
   30 CONTINUE
C
      IF ( KTEST .GE. 3 )   THEN
        WRITE (NHSTRY, 707)
  707   FORMAT ( / ' Total net stream flows leaving plant 4 ',
     1    'in Mlbs/hr:' /
     2    ' No.', 3X, 'Component', 7X, 'Total', 9X, 'Gases', 7X,
     3    'Naphtha', 6X, 'Sour H2O' )
        DO 40 J = 1, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 40
            WRITE (NHSTRY, 708)  J, CNAME(J), COUT(J,1), S1(J),
     1        S2(J), S3(J)
  708       FORMAT ( 1X, I3, 3X, A8, F13.3, 3F14.3 )
   40   CONTINUE
        WRITE (NHSTRY, 709)  SUMC, SUM1, SUM2, SUM3
  709   FORMAT ( 7X, 'Total', 2X, 4F14.3 )
      ENDIF
C
C
      IF ( IPASS .NE. 4 )   THEN
C       Set up the product stream properties in the SOUT vectors.
C       ==========================================================
C       First, zero all the items in the product stream vectors.
        DO 200 J = 1, ITEMS
          SOUT1(J) = 0.0D0
          SOUT2(J) = 0.0D0
          SOUT3(J) = 0.0D0
  200   CONTINUE
C
C       CF is the conversion factor from Kg/sec to Mlbs/hr.
        CF = 0.001D0 * 3600.0D0 / 0.45359237D0
C
C       Set the molar flow rates of the conventional components.
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        DO 210 J = 1, NCC
          DO 208 K = 1, 35
            K1 = K
            IF ( K .GE. 16 )  K1 = K + 20
            IF ( J .EQ. ICNUMB(K1) )  THEN
```

```
              SOUT1(J) = S1(K) / (CF * CMWOUT(K))
              SOUT2(J) = S2(K) / (CF * CMWOUT(K))
              SOUT3(J) = S3(K) / (CF * CMWOUT(K))
              SUM1 = SUM1 + SOUT1(J)
              SUM2 = SUM2 + SOUT2(J)
              SUM3 = SUM3 + SOUT3(J)
              GO TO 210
            ENDIF
  208     CONTINUE
  210   CONTINUE
C
C       Set the total molar flow rates of the conventional components.
        SOUT1(NCC+1) = SUM1
        SOUT2(NCC+1) = SUM2
        SOUT3(NCC+1) = SUM3
C
C       Since there are no non-conventional components leaving this
C       model, nothing needs to be done with them since their flow
C       rates and properties already have been set to zero.
C
C       Set the default temperature and pressure of the outlet streams
C       to 70 F and 15 PSIA.  Return these values to ASPEN/SP in degrees
C       Kelvin and Pascals.  These default values can be overriden by
C       the FLASH-SPECS sentence in the ASPEN/SP input file.
        SOUT1(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT1(NCC+3) = 15.0D0 * 6.8947573D+3
        SOUT2(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT2(NCC+3) = 15.0D0 * 6.8947573D+3
        SOUT3(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT3(NCC+3) = 15.0D0 * 6.8947573D+3
C
        IF ( NNCC .GT. 0 )   THEN
C         If present, set some overall stream properties of the non-
C         conventional component substream.
          SOUT1(NCONV+NNCC+9) = 1.0D0
          SOUT2(NCONV+NNCC+9) = 1.0D0
          SOUT3(NCONV+NNCC+9) = 1.0D0
          SOUT1(NCONV+NNCC+2) = SOUT1(NCC+2)
          SOUT1(NCONV+NNCC+3) = SOUT1(NCC+3)
          SOUT2(NCONV+NNCC+2) = SOUT2(NCC+2)
          SOUT2(NCONV+NNCC+3) = SOUT2(NCC+3)
          SOUT3(NCONV+NNCC+2) = SOUT3(NCC+2)
          SOUT3(NCONV+NNCC+3) = SOUT3(NCC+3)
        ENDIF
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)
        CALL CPACK (SOUT2, NCP, IDX, XPACK, TMASS)
        SOUT2(NCC+9) = AVEMW (NCP, IDX, XPACK)
        CALL CPACK (SOUT3, NCP, IDX, XPACK, TMASS)
        SOUT3(NCC+9) = AVEMW (NCP, IDX, XPACK)
C
```

```
C       If requested, write the items of interest in the outlet stream
C       vectors to the history file.
        IF ( KTEST .GE. 5 )  THEN
          WRITE (NHSTRY, 711)
  711     FORMAT ( // ' The outlet stream vectors' /
     1      14X, 'SOUT1', 10X, 'SOUT2', 10X, 'SOUT3' )
          DO 230 J = 1, ITEMS
            WRITE (NHSTRY, 712) J, SOUT1(J), SOUT2(J), SOUT3(J)
  712       FORMAT ( 2X, I5, 3(1PE15.5) )
  230     CONTINUE
        ENDIF
      ENDIF
C
C
      IF ( IPASS .EQ. 4 .AND. INT1 .LE. 0 )  THEN
C       Write the stream section of the plant summary report.
C       ====================================================
        WRITE (NOUT, 801)
  801   FORMAT ( / 21X, 'PLANT 4 - SUMMARY REPORT (CONTINUED)' /
     1    29X, 'NAPHTHA HYDROTREATER' //
     2    32X, 'STREAM SUMMARY' )
C
        WRITE (NOUT, 802)
  802   FORMAT ( / '  INLET AND OUTLET STREAMS, MLBS/HR')
C
C       Write the net outlet stream flow rates in Mlbs/hr.
        WRITE (NOUT, 803)
  803   FORMAT ( 19X, 'TOTAL' /
     1    4X, 'COMPONENT', 6X, 'INLET', 9X, 'GASES',
     2    5X, 'NAPHTHA', 4X, 'SOUR H2O' )
        DO 310 J = 1, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 310
            WRITE (NOUT, 804) CNAME(J), CIN(J,1), S1(J), S2(J),
     1        S3(J)
  804       FORMAT ( 4X, A8, F12.3, F14.3, 2F12.3 )
  310   CONTINUE
C
C       Calculate and write the total flow rates in Mlbs/hr, the gas
C       stream flow rate in MM SCF/hr, the naphtha stream flow rate in
C       bbl/hr, and the the sour water flow rate in gal/min.
        SUMC = 0.0D0
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        GAS = 0.0D0
        X = 0.0D0
        SOUR = 0.0D0
        DO 320 J = 1, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 320
            SUMC = SUMC + CIN(J,1)
            SUM1 = SUM1 + S1(J)
            SUM2 = SUM2 + S2(J)
            SUM3 = SUM3 + S3(J)
            GAS = GAS + S1(J) / CMWOUT(J)
            X = X + S2(J) / COUT(J,2)
```

```
            SOUR = SOUR + S3(J) / COUT(J,2)
  320     CONTINUE
C         Convert the gas flow rate from M lb-moles/hr to MM SCF/hr.
          SCF = 0.001D0 * SCFM * GAS
C         Convert the naphtha flow rate from Mlbs/hhr to bbl/hr.
          X = 1.0D+3 * X
C         Convert the sour water flow rate from Mbbls/hr to gal/min.
          SOUR = 42.0D0 * 1.0D+3 * SOUR / 60.0D0
C
          WRITE (NOUT, 805) SUMC, SUM1, SUM2, SUM3
  805     FORMAT ( 4X, 'TOTAL', 1X, 2F14.3, 2F12.3 )
          WRITE (NOUT, 806) SCF, X, SOUR
  806     FORMAT ( / 4X, 'FLOW, MM SCF/HR', F19.3 /
     1      4X, 'FLOW, BBL/HR', F34.3 /
     2      4X, 'FLOW, GAL/MIN', F45.3 )
C
C         Calculate and write the product naphtha properties.
          TS = 0.0D0
          TN = 0.0D0
          TO = 0.0D0
          DO 330 J = 1, 35
            TS = TS + S2(J) * COUT(J,3)
            TN = TN + S2(J) * COUT(J,4)
            TO = TO + S2(J) * COUT(J,5)
  330     CONTINUE
          TS = 1.0D+4 * TS / SUM2
          TN = 1.0D+4 * TN / SUM2
          TO = 1.0D+4 * TO / SUM2
          WRITE (NOUT, 807) TS, TN, TO
  807     FORMAT ( / 4X, 'SULFUR, WT PPM', F32.1 /
     1      4X, 'NITROGEN, WT PPM', F30.1 /
     2      4X, 'OXYGEN, WT PPM', F32.1 )
C
          IF ( IER1 .GE. 1 )   WRITE (NOUT, 811)
  811     FORMAT ( / ' *WARNING* INSUFFICIENT MAKEUP HYDROGEN HAS BEEN ',
     1      'SUPPLIED TO THE' /
     2      2X, 'NAPHTHA HYDROTREATER.  SUFFICIENT MAKEUP HYDROGEN HAS ',
     3      'BEEN ASSUMED. ' /
     4      2X, 'THE NAPHTHA HYDROTREATER IS NOT IN MASS BALANCE.' )
C
          WRITE (NOUT, 821)
  821     FORMAT ( / 25X, '- CONTINUED ON NEXT PAGE -' )
        ENDIF
C
C
        RETURN
        END
C
C$  Subroutine USR05
C
C       This file contains the following subroutines:
C         USR05  - Main routine for Plant 5, the gas-oil hydrotreater.
C         USR05A - This subroutine does not exist.
C         USR05B - Subroutine to load the required inlet and outlet
C                  component properties.
```

```
C       USR05C - Subroutine to do the desulfurization calculations.
C       USR05D - Subroutine to do the denitrogenation calculations.
C       USR05E - Subroutine to do the deoxygenation calculations.
C       USR05F - Subroutine to do the hydrogen consumption and yield
C                shift calculations.
C       USR05G - Subroutine to write the first part of the gas-oil
C                hydrotreater summary report.
C       USR05H - Subroutine to split the net yields into the product
C                streams, load the outlet stream vectors, and write
C                the stream section of the summary report.
C
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 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       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$ USR05
      SUBROUTINE USR05 (NSIN,NINFI,SIN1,SIN2,SIN3,SIN4,
     1 SIN5, SIN6, SIN7, SIN8, SINFI,NSOUT,
     2 NINFO,SOUT1,SOUT2,SOUT3,SOUT4, SOUT5, SOUT6, SOUT7, SOUT8,
     3 SINFO,NSUBS,IDXSUB,ITYPE,NINT,
     4 INT,NREAL,REAL,IDS,NPO,NBOPST,NIW,IW,NW,W,NSIZE,SIZE)
C
C  ASPEN USER UNIT OPERATION BLOCK:  USR05
C
C  BLOCK DESCRIPTION:  Plant 5, the gas-oil hydrotreater
C
C                 Simplified Fortran Block Model
C
C                   -----------------------
C                   |                     |-----> Hi press Purge Gas
C                   |                     |
C                   |                     |-----> Other gases
C                   |                     |
C     Hydrogen ---->|       Plant 5       |-----> Naphtha product
C                   |                     |
C                   |       Gas-oil       |-----> 350 - 450 F product
C     Gas-oil ----->|     Hydrotreater    |
C                   |                     |-----> 450 - 650 F product
C                   |                     |
C     Water ------->|                     | ----> 650 - 850 F product
C                   |                     |
C                   |                     |-----> Sour Water
C                   -----------------------
C
C
```

```
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     This subroutine is the master control routine for the gas-oil
C     hydrotreater calculations.
C
C     This subroutine calls subroutines USR05B, USR05C, USR05D, USR05E,
C       USR05F, USR05G, and USR05H.
C     In addtion these subroutines require named common /USR05M/.
C
C
C  FUNCTION (MODEL, REPORT, OR BOTH):  Both
C
C  Last revision - May 29, 1992.
C
C  ASSUMPTIONS, SPECIAL FEATURES AND LIMITATIONS:
C     1.  The gas-oil hydrotreater requires three inlet streams which
C         may be in any order since they are immediately mixed in this
C         model.  The three inlet streams are:
C              1. Hydrogen rich makeup gas
C              2. Gas-oil feed
C              3. Wash water
C     2.  The seven outlet streams produced by this model, in order,
C         are:
C              1. High pressure reactor section purge gas
C              2. Other gasses and light hydrocarbons
C              3. Hydrotreated naphtha product
C              4. Hydrotreated 350 - 450 F product
C              5. Hydrotreated 450 - 650 F product
C              6. Hydrotreated 650 - 850 F product
C              7. Sour water stream
C     3.  This user block model will work with any number of
C         conventional components, but requires that 50 specific
C         conventional components must be available in the component
C         list.  Up to three non-conventional coal type components also
C         may be in the component list.
C     4.  This user block Fortran model requires that the inupt and
C         output streams are of the ASPEN/SP conventional stream class
C         or of ASPEN/SP stream class MIXNC or 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 any ATTR-COMPS statements
C         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 solid components in the input streams will be ignored.
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 DCL09.REP.
C         INT(3)  = Number of operating duplicate trains, excluding
C                   spares.
C                   If INT(3) = 0, the minimum number of duplicate
C                     trains will be determined so that the capacity
C                     each train does not exceed the maximum train
C                     capacity specified by variable REAL(42).
C                   If INT(3) > 0, this number of duplicate trains will
C                     be used.
C         INT(4)  = History file additional output control switch.
C                   0 => Write no additional output to the history 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     8.  The 70 real parameters are:
C         REAL(1)   = Percent desulfurization of the C6+ feed; i. e.,
C                     Percent of sulfur removed from the entering C6+
C                     feed.
C         REAL(2)   = Percent denitrogenation of the C6+ feed; i. e.,
C                     Percent of nitrogen removed from the entering C6+
C                     feed.
C         REAL(3)   = Percent deoxygenation of the C6+ feed; i. e.,
C                     Percent of oxygen removed from the entering C6+
C                     feed.
C         REAL(4)   = Specified chemical hydrogen consumption,
C                     SCF/bbl of C6+ feed.
C         REAL(5) -
C          REAL(20) = Future use.
C         REAL(21)  = Constant factor for the power consumption, kw.
C         REAL(22)  = Power consumption per Mlbs/hr of C6+ feed,
C                     kw/(Mlbs/hr of C6+ feed)
C         REAL(23)  = Constant factor for the 900 psig / 750 F steam
C                     consumption, Mlbs/hr.
C         REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr
C                     of C6+ feed, (Mlbs/hr)/(Mlbs/hr of C6+ feed).
C         REAL(25)  = Constant factor for the 900 psig saturated steam
C                     consumption, Mlbs/hr.
C         REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr
C                     of C6+ feed, (Mlbs/hr)/(Mlbs/hr of C6+ feed).
C         REAL(27)  = Constant factor for the 600 psig / 720 F steam
C                     consumption, Mlbs/hr.
C         REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr
C                     of C6+ feed, (Mlbs/hr)/(Mlbs/hr of C6+ feed).
C         REAL(29)  = Constant factor for the 600 psig saturated steam
```

```
C                       consumption, Mlbs/hr.
C          REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr
C                      of C6+ feed, (Mlbs/hr)/(Mlbs/hr of C6+ feed).
C          REAL(31)  = Constant factor for the 150 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr
C                      of C6+ feed, (Mlbs/hr)/(Mlbs/hr of C6+ feed).
C          REAL(33)  = Constant factor for the 50 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr
C                      of C6+ feed, (Mlbs/hr)/(Mlbs/hr of C6+ feed).
C          REAL(35)  = Constant factor for the plant fuel consumption,
C                      MM BTU/hr.
C          REAL(36)  = Plant fuel consumption per Mlbs/hr of C6+ feed,
C                      (MM BTU/hr)/(Mlbs/hr of C6+ feed).
C          REAL(37)  = Constant factor for the cooling water consumption,
C                      Mgal/hr.
C          REAL(38)  = Cooling water consumption per Mlbs/hr of C6+ feed,
C                      (Mgal/hr)/(Mlbs/hr of C6+ feed).
C          REAL(39)  = Constant factor for the process water consumption,
C                      Mgal/hr.
C          REAL(40)  = Process water consumption per Mlbs/hr of C6+ feed,
C                      (Mgal/hr)/(Mlbs/hr of C6+ feed).
C          REAL(41)  = Constant factor for the nitrogen consumption,
C                      MM SCF/hr of N2.
C          REAL(42)  = Nitrogen consumption per Mlbs/hr of C6+ feed,
C                      (MM SCF/hr of N2)/(Mlbs/hr of C6+ feed).
C          REAL(43) -
C           REAL(48) = Future use.
C          REAL(49)  = Constant factor for the number of operators per
C                      day, operators/day.
C          REAL(50)  = Number of operators per day per train,
C                      (operators/day)/train.
C          REAL(51)  = Reference C6+ feed rate to a single train in
C                      Mlbs/hr for the calculation of the ISBL field cost
C                      of a single train as a function of train capacity.
C          REAL(52)  = Maximum size of a single train as defined by the
C                      C6+ feed rate in Mlbs/hr of C6+ feed.
C          REAL(53)  = Minimum size of a single train as defined by the
C                      C6+ feed rate in Mlbs/hr of C6+ feed.
C          REAL(54)  = Constant A in the plant ISBL field cost equation.
C          REAL(55)  = Constant B in the plant ISBL field cost equation.
C          REAL(56)  = Constant E in the plant ISBL field cost equation.
C          REAL(57)  = Constant F in the plant ISBL field cost equation.
C          REAL(58)  = Number of spare plants.
C          REAL(59) -
C           REAL(70) = 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)
```

```
      DIMENSION SIN5(1),SIN6(1),SIN7(1),SIN8(1),SOUT5(1),
     1 SOUT6(1),SOUT7(1),SOUT8(1)
      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
      COMMON /USR05M/ CIN(35,7), COUT(35,7), CUTWT(35), CMWOUT(35)
      COMMON /USR05N/ CNAME(35), ICNUMB(55)
C
C     In CIN(J,K) and COUT(J,K), subscript J designates the following
C     components.
C      1.  H2          16.  T125, P125        26   T625, P625
C      2.  NH3         17.  T175, P175        27.  T675, P675
C      3.  H2O         18.  T225, P225        28.  T725, P725
C      4.  H2S         19.  T275, P275        29.  T775, P775
C      5.  N2          20.  T325, P325        30.  T825, P825
C      6.  CH4         21.  T375, P375        31   T875, P875
C      7.  C2H6        22.  T425, P425        33.  T925, P925
C      8.  C3H8        23.  T475, P475        33.  T975, P975
C      9.  IC4H10      24.  T525, P525        34.  T1000+, P1000+
C     10.  NC4H10      25.  T575, P575        35.  Future use
C     11.  IC5H12
C     12.  NC5H12
C     13.  Future use
C     14.  Future use
C     15.  Future use
C     where T225 means the entering material in the 200-250 F boiling
C     range in the CIN array and P225 means the leaving (hydrotreated)
C     material in the same boiling range in the COUT array, and
C     subscript K designates
C      1.  Component flow rate in Mlbs/hr.
C      2.  Component standard liquid density at 60 F in lbs/barrel.
C      3.  Sulfur flow rate in Mlbs/hr or wt% sulfur.
C      4.  Nitrogen flow rate in Mlbs/hr or wt% nitrogen.
C      5.  Oxygen flow rate in Mlbs/hr or wt% oxygen.
C      6.  Carbon flow rate in Mlbs/hr or wt% carbon.
C      7.  Hydrogen flow rate in Mlbs/hr or wt% hydrogen.
C
C      Component ordering in the various vectors.
C      No.  Component    Description
C       1.  H2           Hydrogen
C       2.  NH3          Ammonia
C       3.  H2O          Water
C       4.  H2S          Hydrogen sulfide
C       5   N2           Nitrogen
C       6.  CH4          Methane
C       7.  C2H6         Ethane
C       8.  C3H8         Propane
```

```
C        9.  IC4H10        Iso-butane
C       10.  NC4H10        Normal butane
C       11.  IC5H12        Iso-pentane
C       12.  NC5H12        Normal pentane
C       13.  Future use
C       14.  Future use
C       15.  Future use
C       16.  T125, P125    100 - 150 F boiling range fraction
C       17.  T175, P175    150 - 200 F boiling range fraction
C       18.  T225, P225    200 - 250 F boiling range fraction
C       19.  T275, P275    250 - 300 F boiling range fraction
C       20.  T325, P325    300 - 350 F boiling range fraction
C       21.  T375, P375    350 - 400 F boiling range fraction
C       22.  T425, P425    400 - 450 F boiling range fraction
C       23.  T475, P475    450 - 500 F boiling range fraction
C       24.  T525, P525    500 - 550 F boiling range fraction
C       25.  T575, P575    550 - 600 F boiling range fraction
C       26.  T625, P625    600 - 650 F boiling range fraction
C       27.  T675, P675    650 - 700 F boiling range fraction
C       28.  T725, P725    700 - 750 F boiling range fraction
C       29.  T775, P775    750 - 800 F boiling range fraction
C       30.  T825, P825    800 - 850 F boiling range fraction
C       31.  T875, P875    850 - 900 F boiling range fraction
C       32.  T925, P925    900 - 950 F boiling range fraction
C       33.  T975, P975    950 - 1000 F boiling range fraction
C       34.  T1000+, P1000+ 1000+ F boiling range material
C       35.  Future use
C       The following 20 items only are used in the vectors dimensioned
C       to 55 items for reference to the ASPEN/SP component list.
C       36.  P125       Hydrotreated 100 - 150 F boiling range fraction
C       37.  P175       Hydrotreated 150 - 200 F boiling range fraction
C       38.  P225       Hydrotreated 200 - 250 F boiling range fraction
C       39.  P275       Hydrotreated 250 - 300 F boiling range fraction
C       40.  P325       Hydrotreated 300 - 350 F boiling range fraction
C       41.  P375       Hydrotreated 350 - 400 F boiling range fraction
C       42.  P425       Hydrotreated 400 - 450 F boiling range fraction
C       43.  P475       Hydrotreated 450 - 500 F boiling range fraction
C       44.  P525       Hydrotreated 500 - 550 F boiling range fraction
C       45.  P575       Hydrotreated 550 - 600 F boiling range fraction
C       46.  P625       Hydrotreated 600 - 650 F boiling range fraction
C       47.  P675       Hydrotreated 650 - 700 F boiling range fraction
C       48.  P725       Hydrotreated 700 - 750 F boiling range fraction
C       49.  P775       Hydrotreated 750 - 800 F boiling range fraction
C       50.  P825       Hydrotreated 800 - 850 F boiling range fraction
C       51.  P875       Hydrotreated 850 - 900 F boiling range fraction
C       52.  P925       Hydrotreated 900 - 950 F boiling range fraction
C       53.  P975       Hydrotreated 950 - 1000 F boiling range fraction
C       54.  P1000+     Hydrotreated 1000+ F boiling range material
C       35.  Future use
C
C     CMWOUT(J) contains the outlet component molecular weights.
C
C
C     Local variable declaration statements.
      DIMENSION ICN(2), ICNAME(110)
```

```
C
      CHARACTER * 4  BLANK4, ICN, ICNAME
      CHARACTER * 6  PNAME
      CHARACTER * 8  BLANK8, CNAME
C
      DATA BLANK4 / '    ' /
      DATA BLANK8 / '        ' /
C
C     Initialize the identifications of the above 55 components.
      DATA ICNAME /     'H2  ', '    ', 'NH3 ', '    ', 'H2O ', '    ',
     1  'H2S ', '    ', 'N2  ', '    ', 'CH4 ', '    ', 'C2H6', '    ',
     2  'C3H8', '    ', 'IC4H', '10  ', 'NC4H', '10  ', 'IC5H', '12  ',
     3  'NC5H', '12  ', '    ', '    ', '    ', '    ', '    ', '    ',
     4  'T125', '    ', 'T175', '    ', 'T225', '    ', 'T275', '    ',
     5  'T325', '    ', 'T375', '    ', 'T425', '    ', 'T475', '    ',
     6  'T525', '    ', 'T575', '    ', 'T625', '    ', 'T675', '    ',
     7  'T725', '    ', 'T775', '    ', 'T825', '    ', 'T875', '    ',
     8  'T925', '    ', 'T975', '    ', 'T100', '0+  ', '    ', '    ',
     9  'P125', '    ', 'P175', '    ', 'P225', '    ', 'P275', '    ',
     A  'P325', '    ', 'P375', '    ', 'P425', '    ', 'P475', '    ',
     B  'P525', '    ', 'P575', '    ', 'P625', '    ', 'P675', '    ',
     C  'P725', '    ', 'P775', '    ', 'P825', '    ', 'P875', '    ',
     D  'P925', '    ', 'P975', '    ', 'P100', '0+  ', '    ', '    '/
C
C
      DATA PNAME / '5     ' /
C
C
C     PARAMETER INITIALIZATION SECTION
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)
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 5 - Supplementary data from ',
     1    'subroutine USR05' /
     2    2X, 'The Gas-oil Hydrotreater', 25X, 'IPASS =', I3 )
      ENDIF
C
C     Check to insure that there are exactly 3 inlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSIN .NE. 3 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 502)  NSIN
  502   FORMAT ( / 1X, '* ERROR * - Plant 5 requires exactly three ',
     1    'inlet streams.' /
     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 are exactly 7 outlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSOUT .NE. 7 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501) IPASS
        WRITE (NHSTRY, 503)  NSOUT
  503   FORMAT ( / 1X, '* ERROR * - Plant 5 requires exactly seven ',
     1    'outlet streams.' /
     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     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 = 1
C
C     Does the inlet stream contain non-conventional components?
      IF ( NSUBS .EQ. 2 .AND. ITYPE(2) .EQ. 3 )   THEN
        KLASS = 2
C       Check for a substream PSD attribute on the second substream of
C       the 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
      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     non-conventional 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) + SIN2(J)*SIN2(K) + SIN3(J)*SIN3(K)
      IF  ( KLASS .GE. 2 )  THEN
```

```
          J = NCC + 9 + NNCC + 1
          FLOWIN = CF * (X + SIN1(J) + SIN2(J) + SIN3(J) )
        ELSE
          FLOWIN = CF * X
      ENDIF
C
      IF ( FLOWIN .LE. 1.0D0 )   THEN
C       Skip all remaing calculations if this plant has no flow.
        IF ( KTEST .GE. 1 )  WRITE (NHSTRY, 504)
  504   FORMAT ( / ' There is no material entering plant 5, the ',
     1    'gas-oil hydrotreater.' )
        GO TO 999
C       ---------
      ENDIF
C
C
C     Find the relative component numbers of the required conventional
C     components, and save then in the ICNUMB vector.
      DO 20 J = 1, 55
        K = 2 * J - 1
        IF ( ICNAME(K) .EQ. BLANK4 )   THEN
          IF ( J .LE. 35 )  CNAME(J) = BLANK8
          ICNUMB(J) = 0
          GO TO 20
        ENDIF
        ICN(1) = ICNAME(K)
        ICN(2) = ICNAME(K+1)
        IF ( J .LE. 35 )  CNAME(J) = ICN(1) // ICN(2)
        CALL USRCCN (ICN, ICNUMB(J))
        IF ( ICNUMB(J) .EQ. 0 ) THEN
          IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
          WRITE (NHSTRY, 506)  ICN(1), ICN(2)
  506     FORMAT ( / 1X, '* ERROR * - The following component is ',
     1      'missing from your component list' / 5X, 2A4 /
     2      3X, 'Plant 5, the gas-oil hydrotreater 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 specified percent desulfurization, percent
C     denitrogenation, percent deoxygenation, and the chemical
C     hydrogen consumption.
      PCTDES = REAL(1)
```

```
      PCTDEN = REAL(2)
      PCTDEO = REAL(3)
      H2CONS = REAL(4)
C
C     Check to the above input values are valid, and if not, set a
C     reasonable value and write a warning message to the history file.
      IF ( PCTDES .LE. 10.0D0 .OR. PCTDES .GE. 100.0D0 )  THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 507)  PCTDES
  507   FORMAT ( / ' * WARNING * - An invalid value for the percent',
     1    ' desulfurization of ', F9.3 /
     2    3X, 'has been supplied.  Please correct the input value.' /
     3    3X, 'Execution will continue assuming a 95.0 percent ',
     4    'desulfurization.' )
        PCTDES = 95.0D0
      ENDIF
C
      IF ( PCTDEN .LE. 10.0D0 .OR. PCTDEN .GE. 100.0D0 )  THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 508)  PCTDEN
  508   FORMAT ( / ' * WARNING * - An invalid value for the percent',
     1    ' denitrogenation of ', F9.3 /
     2    3X, 'has been supplied.  Please correct the input value.' /
     3    3X, 'Execution will continue assuming a 94.0 percent ',
     4    'denitrogenation.' )
        PCTDEN = 94.0D0
      ENDIF
C
      IF ( PCTDEO .LE. 10.0D0 .OR. PCTDEO .GE. 100.0D0 )  THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 509)  PCTDEO
  509   FORMAT ( / ' * WARNING * - An invalid value for the percent',
     1    ' deoxygenation of ', F9.3 /
     2    3X, 'has been supplied.  Please correct the input value.' /
     3    3X, 'Execution will continue assuming a 96.0 percent ',
     4    'deoxygenation.' )
        PCTDEO = 96.0D0
      ENDIF
C
      IF ( H2CONS .LE. 10.0D0 .OR. H2CONS .GE. 1500.0D0 )  THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 510)  H2CONS
  510   FORMAT ( / ' * WARNING * - An invalid value for the chemical',
     1    ' hydrogen consumption of ', F9.1 /
     2    3X, 'SCF/bbl has been supplied.  Please correct the input',
     4    ' value.' /
     4    3X, 'Execution will continue assuming a hydrogen ',
     5    'consumption of 300 SCF/bbl.' )
        H2CONS = 300.0D0
      ENDIF
C
C     Set up the maximum and minimum train flow rates in Mlbs/hr of
C     C6+ feed.
      PMAXF = REAL(52)
      PMINF = REAL(53)
```

```
C
C
C     Call subroutine USR05B to load the inlet component densities and
C     elemental compositions into the CIN array, the outlet component
C     densities into the COUT array, and the outlet component molecular
C     weights in the CMWOUT vector.
      CALL USR05B (KTEST, NCC, NHSTRY)
C
C
C     If requested, write the items of interest in the inlet stream
C     vector to the history file.
      IF ( KTEST .GE. 5 )  THEN
        WRITE (NHSTRY, 511)
  511   FORMAT ( / '  The inlet stream vectors:'/
     1    3X, 'Item', 10X, 'SIN1', 11X, 'SIN2', 11X, 'SIN3'  )
        DO 30 J = 1, ITEMS
          WRITE (NHSTRY, 512) J, SIN1(J), SIN2(J), SIN3(J)
  512     FORMAT ( 1X, I6, 3X, 3(1PE15.5) )
   30   CONTINUE
      ENDIF
C
C     Load the total entering component flow rates from all the inlet
C     streams in the CIN vector in Mlbs/hr.
C     CF is the conversion factor from Kg/sec to Mlbs/hr.
      CF = 0.001D0 * 3600.0D0 / 0.45359237D0
C     First, zero the CIN vector.
      DO 40 J = 1, 35
        CIN(J,1) = 0.0D0
   40 CONTINUE
C
C     Load and mix all the inlet streams.
C     ----------------------------------
C     Conventional components - Load the component flow rates in
C     Mlbs/hr.
      OTHERS = 0.0
      DO 44 J = 1, NCC
        DO 42 K = 1, 55
        IF ( J .EQ. ICNUMB(K) )  THEN
          L = K
          IF ( K .GT. 35)   L = K - 20
          CIN(L,1) = CIN(L,1) + CF * XMW(J) * (SIN1(J)+SIN2(J)+SIN3(J))
          GO TO 44
        ENDIF
   42   CONTINUE
        OTHERS = OTHERS + CF * XMW(J) * (SIN1(J) + SIN2(J) + SIN3(J))
   44 CONTINUE
C
      IF ( KLASS .GE. 2 )  THEN
C       Non-conventional components.
        SOLIDS = CF * (SIN1(NCONV+1) + SIN1(NCONV+2) + SIN1(NCONV+3) +
     1                 SIN2(NCONV+1) + SIN2(NCONV+2) + SIN2(NCONV+3) +
     2                 SIN3(NCONV+1) + SIN3(NCONV+2) + SIN3(NCONV+3))
      ENDIF
C
      UNKNWN = OTHERS + SOLIDS
```

```
      IF ( UNKNWN .GE. 1.0D-3 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 513)  UNKNWN
  513   FORMAT ( / 1X, '* WARNING * - The feed to plant 5, the ',
     1    'gas-oil hydrotreater, contains one' /
     2    3X, 'or more components that this model cannot handle.  It ',
     3    'contains', F10.3 /
     4    3X, 'Mlbs/hr of these components.  These components will be',
     5    ' lost in the process.' /
     6    3X, 'Plant 5 will not be in mass balance.  Please remove',
     7    ' these component(s)' /
     8    3X, 'from the feed stream.' //
     9    3X, 'Execution is continuing.' / )
      ENDIF
C
C     If requested, write the inlet component information.
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 702)
  702   FORMAT ( / ' Inlet component flow rates and properties:' /
     1    '   No.  Name', 6X, 'Mlbs/hr', 2X, 'lbs/bbl', 4X, 'Wt% S',
     2    4X, 'Wt% N', 4X, 'Wt% O', 4X, 'Wt% C', 4X, 'Wt% H' )
        SUM1 = 0.0D0
        DO 50 J = 1, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 50
            WRITE (NHSTRY, 703)  J, CNAME(J), (CIN(J,K), K = 1, 7)
  703       FORMAT ( 1X, I5, 2X, A8, F9.3, F9.3, 5F9.4 )
          SUM1 = SUM1 + CIN(J,1)
   50   CONTINUE
        WRITE (NHSTRY, 704)  SUM1
  704   FORMAT ( 8X, 'Total ', F11.3 )
      ENDIF
C
C     Copy the inlet component mass flow rates to the COUT array.
      DO 60 J = 1, 35
        COUT(J,1) = CIN(J,1)
   60 CONTINUE
C
C
C     Call subroutine USR05C to do the desulfurization calculations.
      CALL USR05C (IPASS, KTEST, NHSTRY, PCTDES)
      H22H2S = CIN(1,1) - COUT(1,1)
C
C     If requested, write the outlet component information after
C     desulfurization.
      IF ( KTEST .GE. 4 )  THEN
        WRITE (NHSTRY, 705)
  705   FORMAT ( / ' COUT array after desulfurization:' /
     1    '   No.  Name  ', 6X, 'Mlbs/hr', 4X, 'lbs/bbl', 7X,
     2    'Wt S' )
        SUM1 = 0.0D0
        SUM3 = 0.0D0
        DO 70 J = 1, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 70
            WRITE (NHSTRY, 706)  J, CNAME(J), (COUT(J,K), K = 1, 3)
  706       FORMAT ( 1X, I5, 2X, A8, F11.3, F11.3, F11.4 )
```

```
            SUM1 = SUM1 + COUT(J,1)
            SUM3 = SUM3 + COUT(J,3)
   70     CONTINUE
          WRITE (NHSTRY, 707)  SUM1, SUM3
  707     FORMAT ( 8X, 'Total ', F13.3, F22.4 )
        ENDIF
C
C
C       Call subroutine USR05D to do the denitrogenation calculations.
        CALL USR05D (IPASS, KTEST, NHSTRY, PCTDEN)
        H22NH3 = CIN(1,1) - COUT(1,1) - H22H2S
C
C       If requested, write the outlet component information after
C       denitrogenation.
        IF ( KTEST .GE. 4 )  THEN
          WRITE (NHSTRY, 708)
  708     FORMAT ( / ' COUT array after denitrogenation:' /
     1      '   No.  Name  ', 6X, 'Mlbs/hr', 4X, 'lbs/bbl', 7X,
     2      'Wt S', 7X, 'Wt N' )
          SUM1 = 0.0D0
          SUM3 = 0.0D0
          SUM4 = 0.0D0
          DO 80 J = 1, 35
            IF ( CNAME(J) .EQ. BLANK8 )   GO TO 80
              WRITE (NHSTRY, 709)  J, CNAME(J), (COUT(J,K), K = 1, 4)
  709         FORMAT ( 1X, I5, 2X, A8, F11.3, F11.3, 2F11.4 )
              SUM1 = SUM1 + COUT(J,1)
              SUM3 = SUM3 + COUT(J,3)
              SUM4 = SUM4 + COUT(J,4)
   80     CONTINUE
          WRITE (NHSTRY, 710)  SUM1, SUM3, SUM4
  710     FORMAT ( 8X, 'Total ', F13.3, F22.4, F11.4 )
        ENDIF
C
C
C       Call subroutine USR05E to do the deoxygenation calculations.
        CALL USR05E (IPASS, KTEST, NHSTRY, PCTDEO)
        H22H2O = CIN(1,1) - COUT(1,1) - H22H2S - H22NH3
C
C       If requested, write the outlet component information after
C       deoxygenation.
        IF ( KTEST .GE. 4 )  THEN
          WRITE (NHSTRY, 711)
  711     FORMAT ( / ' COUT array after deoxygenation:' /
     1      '   No.  Name  ', 6X, 'Mlbs/hr', 4X, 'lbs/bbl', 7X,
     2      'Wt S', 7X, 'Wt N', 7X, 'Wt O' )
          SUM1 = 0.0D0
          SUM3 = 0.0D0
          SUM4 = 0.0D0
          SUM5 = 0.0D0
          DO 90 J = 1, 35
            IF ( CNAME(J) .EQ. BLANK8 )   GO TO 90
              WRITE (NHSTRY, 712)  J, CNAME(J), (COUT(J,K), K = 1, 5)
  712         FORMAT ( 1X, I5, 2X, A8, F11.3, F11.3, 3F11.4 )
                SUM1 = SUM1 + COUT(J,1)
```

```
                SUM3 = SUM3 + COUT(J,3)
                SUM4 = SUM4 + COUT(J,4)
                SUM5 = SUM5 + COUT(J,5)
   90     CONTINUE
          WRITE (NHSTRY, 713)  SUM1, SUM3, SUM4, SUM5
  713     FORMAT ( 8X, 'Total ', F13.3, F22.4, 2F11.4 )
C
          H2USED = H22H2S + H22NH3 + H22H2O
          WRITE (NHSTRY, 714) H22H2S, H22NH3, H22H2O, H2USED
  714     FORMAT ( / ' H2 consumed to H2S, NH3, H2O and total H2 ',
     1      'consumed in Mlbs/hr:' / 1X, 4F13.5 )
        ENDIF
C
C
C       Call subroutine USR05F to do the hydrogen consumption and yield
C       shift calculations.
        CALL USR05F (H2CONS, IPASS, KTEST, NHSTRY)
C
C       If the hydrogen consumption exceeds the makeup hydrogen, then
C       the leaving hydrogen flow rate will be negative.  If this is the
C       case, set the outlet hydrogen flow to zero and write a warning
C       message.
        IER1 = 0
        IF ( COUT(1,1) .LT. 0.0D0 )   THEN
          IER1 = 1
          IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
          X = - COUT(1,1)
          WRITE (NHSTRY, 721)  X
  721     FORMAT ( / ' * WARNING * - The hydrogen consumption exceeds ',
     1      'the makeup rate by ', F10.3 /
     2      3X, 'Mlbs/hr.  The outlet hydrogen flow rate will be set to',
     3      ' zero.  The gas-oil' /
     4      3X, 'hydrotreater will not be in mass balance.  Execution ',
     5      'is continuing.' )
          COUT(1,1) = 0.0D0
          COUT(1,7) = 0.0D0
        ENDIF
C
C       If requested, write the outlet component information.
        IF ( KTEST .GE. 3 )  THEN
          WRITE (NHSTRY, 722)
  722     FORMAT ( / ' Outlet component and elemental flow rates:' /
     1      '   No.  Name', 7X, 'Mlbs/hr', 2X, 'lbs/bbl', 5X, 'Wt S',
     2      5X, 'Wt N', 5X, 'Wt O', 5X, 'Wt C', 5X, 'Wt H' )
          SUM1 = 0.0D0
          SUM3 = 0.0D0
          SUM4 = 0.0D0
          SUM5 = 0.0D0
          SUM6 = 0.0D0
          SUM7 = 0.0D0
          DO 100 J = 1, 35
            IF ( CNAME(J) .EQ. BLANK8 )   GO TO 100
              WRITE (NHSTRY, 723)  J, CNAME(J), (COUT(J,K), K = 1, 7)
  723         FORMAT ( 1X, I5, 2X, A8, F10.3, F9.3, 5F9.3 )
              SUM1 = SUM1 + COUT(J,1)
```

```
            SUM3 = SUM3 + COUT(J,3)
            SUM4 = SUM4 + COUT(J,4)
            SUM5 = SUM5 + COUT(J,5)
            SUM6 = SUM6 + COUT(J,6)
            SUM7 = SUM7 + COUT(J,7)
  100     CONTINUE
          WRITE (NHSTRY, 724)  SUM1, SUM3, SUM4, SUM5, SUM6, SUM7
  724     FORMAT ( 8X, 'Total ', F12.3, F18.3, 4F9.3 )
        ENDIF
C
C
C       Convert the outlet sulfur, nitrogen, oxygen, carbon and hydrogen
C       flow rates in the COUT array from Mlbs/hr to wt%.
        DO 250 J = 1, 35
          IF ( COUT(J,1) .GT. 0.0D0 )  THEN
              DO 242 K = 3, 7
                COUT(J,K) = 100.0D0 * COUT(J,K) / COUT(J,1)
  242         CONTINUE
            ELSE
              DO 244 K = 3, 7
                COUT(J,K) = 0.0D0
  244         CONTINUE
          ENDIF
  250 CONTINUE
C
C       If requested, write the outlet component flow rates and
C       properties.
        IF ( KTEST .GE. 3 )  THEN
          WRITE (NHSTRY, 732)
  732     FORMAT ( / ' Outlet component flow rates and properties:' /
     1      '   No.  Name  ', 5X, 'Mlbs/hr', 2X, 'lbs/bbl', 4X, 'Wt% S',
     2      4X, 'Wt% N', 4X, 'Wt% O', 4X, 'Wt% C', 4X, 'Wt% H' )
          SUM1 = 0.0D0
          DO 252 J = 1, 35
            IF ( CNAME(J) .EQ. BLANK8 )   GO TO 252
              WRITE (NHSTRY, 733)  J, CNAME(J), (COUT(J,K), K = 1, 7)
  733         FORMAT ( 1X, I5, 2X, A8, F10.3, F9.3, 5F9.3 )
              SUM1 = SUM1 + COUT(J,1)
  252     CONTINUE
          WRITE (NHSTRY, 734)  SUM1
  734     FORMAT ( 8X, 'Total', F13.3 )
        ENDIF
C
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 ( IPASS .EQ. 4 .AND. INT(1) .LE. 2 )  THEN
          IF ( INT(2) .EQ. 0 )   THEN
C             Set the number of lines in the first page of the report.
              LINES = 55
              IF ( UNKNWN .GE. 0.001D0 )  LINES = LINES + 5
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 DCL05.REP to contain
C           this user block summary report.
            OPEN (UNIT=62, FILE='DCL05.REP', STATUS='UNKNOWN',
     1        ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2        BUFFERED='BUFFERED')
            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')
        ENDIF
C       Call subroutine USR05G to write the first page of the plant
C       summary report, the overall plant material balance.
        CALL USR05G (INT(1), INT(2), IPASS, NOUT, UNKNWN)
      ENDIF
C
C
C     If this is the report pass and the plant summary report is being
C     written, prepare for writing the second page.
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 2 )  THEN
        IF ( INT(2) .EQ. 0 )   THEN
C           Set the number of lines in the second page of the report.
            LINES = 51
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           If the summary report is going to a separate file, start
C           a new page.
            WRITE (NOUT, 800)
        ENDIF
      ENDIF
C
C     Call subroutine USR05H to distribute the net reactor yields
C     among the three product streams, load the outlet stream vectors,
C     and if this is the results pass, write the second page of the
C     plant summary report, the first page of the stream summary.
      KPAGE = 2
      CALL USR05H (IER1, INT(1), INT(2), IPASS,
     1  ITEMS, KPAGE, KTEST, NCC, NNCC, NCONV, NCCONV, NHSTRY, NOUT,
     2  SOUT1, SOUT2, SOUT3, SOUT4, SOUT5, SOUT6, SOUT7)
C
C     If this is the report pass and the plant sumamry report is being
C     written, prepare for writing the third page, the second stream
C     page containing the final 3 outlet streams.
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 2 )  THEN
        IF ( INT(2) .EQ. 0 )   THEN
C           Calculate the number of lines in the third page.
            LINES = 50
            IF ( IER1 .GE. 1 )   LINES = LINES + 4
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           If the summary report is going to a separate file, start
C           a new page.
            WRITE (NOUT, 800)
        ENDIF
        KPAGE = 3
        CALL USR05H (IER1, INT(1), INT(2), IPASS,
     1    ITEMS, KPAGE, KTEST, NCC, NNCC, NCONV, NCCONV, NHSTRY, NOUT,
     2    SOUT1, SOUT2, SOUT3, SOUT4, SOUT5, SOUT6, SOUT7)
      ENDIF
C
C     Calculate the total C6+ feed rate in Mlbs/hr for all of
C     the duplicate plants.
      FEEDIN = 0.0D0
      DO 260 J = 16, 35
        FEEDIN = FEEDIN + CIN(J,1)
  260 CONTINUE
C
C     If it has not been specified by the user in variable INT(3),
C     calculate the number of operating duplicate trains, excluding
C     spares (NPLNT), based on the total flow rate of the reference
C     stream.  However, if the maximum capacity of a single train
C     has not been specified, set the number of operating trains to 1.
      NPLNT = INT(3)
      IF ( (NPLNT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
          NPLNT = FEEDIN  / PMAXF
          IF ( (MOD(FEEDIN, PMAXF)) .GT. 0.0D0 )  NPLNT = NPLNT + 1
        ELSE
          IF ( NPLNT .EQ. 0 )   NPLNT = 1
      ENDIF
C
C     Calculate the feed rate for each of the duplicate plants (PFLOW)
C     in Mlbs/hr.
      XPLNT = NPLNT
      PFLOW = FEEDIN / XPLNT
C
C
C     If this is the report pass and the plant summary report is being
C     written, prepare for writing the fourth page of the plant summary
C     report, the utilities summary and capital cost information.
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 1 )  THEN
        IF ( INT(2) .EQ. 0 )  THEN
C           Find the number of lines in fourth page of the report.
            LSTRM = 4
            LUTIL = 16
            LCOST = 11
            NDUP = REAL(58) + 0.001D0
            IF ( (NPLNT + NDUP) .EQ. 1 )  LCOST = 9
            IF ( PFLOW .LT. PMINF )  LCOST = LCOST + 3
            IF ( PFLOW .GT .PMAXF )  LCOST = LCOST + 3
            IF ( NDUP .GE. 1 )  LCOST = LCOST + 1
            LINES = LSTRM + LUTIL + LCOST
C           Now, subtract the number of lines for those portions of
C           the user block summary report which will not be written.
            IF ( INT(1) .GE. 2 )   LINES = LINES - LUTIL
```

```
            IF ( INT(1) .GE. 1 )   LINES = LINES - LCOST
C           Call subroutine RPTHDR to tell ASPEN/SP system the number
C           of lines that will be written in the fourth page of this
C           user block summary report.
            CALL RPTHDR (LINES, 0, 3, ISUB)
          ELSE
            WRITE (NOUT, 800)
        ENDIF
        WRITE (NOUT, 801)
  801   FORMAT ( / 21X, 'PLANT 5 - SUMMARY REPORT (CONTINUED)' /
     1    29X, 'GAS-OIL HYDROTREATER' / )
      ENDIF
C
C     Call subroutine USRUCO to calculate, save and report the
C     utilities, capital and operating costs for the plant.
      ID = 5
      KUNITS = 2
      CALL USRUCO (NHSTRY, NOUT, IPASS, ID, PNAME, INT(1), INT(3),
     1  KTEST, REAL(21), FEEDIN, KUNITS)
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 USR05' )
C
C
      RETURN
      END
C
C$ USR05B
      SUBROUTINE USR05B (KTEST, NCC, NHSTRY)
C
C     This subroutine loads the inlet component densities and elemental
C     compositions into the CIN array, the outlet component densities
C     into the COUT array, and the outlet component molecular weights
C     into the CMWOUT vector.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - October 14, 1992.
C
C     Calling arguments:
C     KTEST  = Switch for controlling the printing to the history file.
C     NCC    = Number of conventional components.
C     NHSTRY = Logical unit number of the history file.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON/MW/XMW(1)
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
      COMMON /USR05M/ CIN(35,7), COUT(35,7), CUTWT(35), CMWOUT(35)
      COMMON /USR05N/ CNAME(35), ICNUMB(55)
C
C     In CIN(J,K) and COUT(J,K), subscript J designates the following
C     components.
C      1.  H2          16.  T125, P125        26   T625, P625
C      2.  NH3         17.  T175, P175        27.  T675, P675
C      3.  H2O         18.  T225, P225        28.  T725, P725
C      4.  H2S         19.  T275, P275        29.  T775, P775
C      5.  N2          20.  T325, P325        30.  T825, P825
C      6.  CH4         21.  T375, P375        31   T875, P875
C      7.  C2H6        22.  T425, P425        33.  T925, P925
C      8.  C3H8        23.  T475, P475        33.  T975, P975
C      9.  IC4H10      24.  T525, P525        34.  T1000+, P1000+
C     10.  NC4H10      25.  T575, P575        35.  Future use
C     11.  IC5H12
C     12.  NC5H12
C     13.  Future use
C     14.  Future use
C     15.  Future use
C     where T225 means the entering material in the 200-250 F boiling
C     range in the CIN array and P225 means the leaving (hydrotreated)
C     material in the same boiling range in the COUT array, and
C     subscript K designates
C      1.  Component flow rate in Mlbs/hr.
C      2.  Component standard liquid density at 60 F in lbs/barrel.
C      3.  Sulfur flow rate in Mlbs/hr or wt% sulfur.
C      4.  Nitrogen flow rate in Mlbs/hr or wt% nitrogen.
C      5.  Oxygen flow rate in Mlbs/hr or wt% oxygen.
C      6.  Carbon flow rate in Mlbs/hr or wt% carbon.
C      7.  Hydrogen flow rate in Mlbs/hr or wt% hydrogen.
C
      DIMENSION CMW(55), SVOL(55)
C
      CHARACTER * 8  BLANK8, CNAME
C
      DATA BLANK8 / '        ' /
C
C
C     Conventional components - Load the component molecular weights
C     and standard volumes in m**3/Kg.
      DO 10 J = 1, NCC
        DO 8 K = 1, 55
        IF ( J .EQ. ICNUMB(K) )  THEN
          CMW(K) = 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.
          SVOL(K) = XMW(J+NCC)
          L = K
          IF ( K .GT. 35)   L = K - 20
```

```
          CMWOUT(L) = XMW(J)
          GO TO 10
        ENDIF
    8   CONTINUE
   10 CONTINUE
C
      IF ( KTEST .GE. 5 )  THEN
        WRITE (NHSTRY, 501)
  501   FORMAT ( / ' Component number, name, molecular weight, ',
     1    'standard volume and relative number:')
        DO 20 J = 1, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 20
            WRITE (NHSTRY, 502) J, CNAME(J), CMW(J), SVOL(J), ICNUMB(J)
  502       FORMAT ( 1X, I5, 2X, A8, 2F12.4, I8 )
   20   CONTINUE
      ENDIF
C
C     Convert the component standard volumes from m**3/Kg-mole to
C     densities in lbs/bbl and load them in the CIN and COUT arrays.
C     X is the conversion factor from Kg/m**3 to 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     Load the inlet component densities in lbs/bbl.
      DO 30 J = 1, 35
        IF ( CNAME(J) .NE. BLANK8 )   THEN
            CIN(J,2) = X * CMW(J) / SVOL(J)
          ELSE
            CIN(J,2) = 1.0D0
        ENDIF
   30 CONTINUE
C
C     Load the outlet component densities in lbs/bbl.
      DO 32 J = 1, 15
        COUT(J,2) = CIN(J,2)
   32 CONTINUE
      DO 34 J = 16, 35
        IF ( CNAME(J) .NE. BLANK8 )  THEN
            COUT(J,2) = X * CMW(J+20) / SVOL(J+20)
          ELSE
            COUT(J,2) = 1.0D0
        ENDIF
   34 CONTINUE
C
C
C     Load the molecular weights of atomic carbon, hydrogen, sulfur,
C     nitrogen and oxygen.
      XMWH = 0.5D0 * CMW(1)
      XMWC = CMW(6) - 2.0D0 * CMW(1)
      XMWS = CMW(4) - CMW(1)
      XMWN = CMW(2) - 1.5D0 * CMW(1)
      XMWO = CMW(3) - CMW(1)
C
C     Zero all the pure component compositions.
      DO 38 J = 1, 15
```

```
      DO 36 K = 3, 7
        CIN(J,K) = 0.0D0
   36 CONTINUE
   38 CONTINUE
C
C     Load the pure component hydrogen, carbon, sulfur, nitrogen and
C     oxygen contents in wt%.
C     Hydrogen.
      CIN(1,7) = 100.0D0
C     Ammonia.
      CIN(2,7) = 100.0D0 * 3.0D0 * XMWH / CMW(2)
      CIN(2,4) = 100.0D0 * XMWN / CMW(2)
C     Water.
      CIN(3,7) = 100.0D0 * 2.0D0 * XMWH / CMW(3)
      CIN(3,5) = 100.0D0 * XMWO / CMW(3)
C     Hydrogen sulfide.
      CIN(4,7) = 100.0D0 * 2.0D0 * XMWH / CMW(4)
      CIN(4,3) = 100.0D0 * XMWS / CMW(4)
C     Nitrogen.
      CIN(5,4) = 100.0D0
C     Methane.
      CIN(6,6) = 100.0 * XMWC / CMW(6)
      CIN(6,7) = 100.0 * 4.0 * XMWH / CMW(6)
C     Ethane.
      CIN(7,6) = 100.0D0 * 2.0D0 * XMWC / CMW(7)
      CIN(7,7) = 100.0D0 * 6.0D0 * XMWH / CMW(7)
C     Propane.
      CIN(8,6) = 100.0D0 * 3.0D0 * XMWC / CMW(8)
      CIN(8,7) = 100.0D0 * 8.0D0 * XMWH / CMW(8)
C     Butanes.
      CIN(9,6) = 100.0 * 4.0 * XMWC / CMW(9)
      CIN(9,7) = 100.0 * 10.0 * XMWH / CMW(9)
      CIN(10,6) = CIN(9,6)
      CIN(10,7) = CIN(9,7)
C     Pentanes.
      CIN(11,6) = 100.0D0 * 5.0D0 * XMWC / CMW(11)
      CIN(11,7) = 100.0D0 * 12.0D0 * XMWH / CMW(11)
      CIN(12,6) = CIN(11,6)
      CIN(12,7) = CIN(11,7)
C
C     The following elemental compositions were taken from the
C     Aug. 20, 1990 letter to S. N. Habash from A. Basu and
C     A. B. Schachtschneider.  The 850+ F components were estimated.
C
C     Load the C5+ component sulfur contents in wt%.
      CIN(16,3) = 0.01
      CIN(17,3) = 0.01
      CIN(18,3) = 0.01
      CIN(19,3) = 0.01
      CIN(20,3) = 0.01
      CIN(21,3) = 0.01
      CIN(22,3) = 0.01
      CIN(23,3) = 0.02
      CIN(24,3) = 0.02
      CIN(25,3) = 0.02
```

```
      CIN(26,3) = 0.02
      CIN(27,3) = 0.06
      CIN(28,3) = 0.06
      CIN(29,3) = 0.06
      CIN(30,3) = 0.06
      CIN(31,3) = 0.10
      CIN(32,3) = 0.15
      CIN(33,3) = 0.20
      CIN(34,3) = 0.25
      CIN(35,3) = 0.0
C
C     Load the C5+ component nitrogen contents in wt%.
      CIN(16,4) = 0.17
      CIN(17,4) = 0.17
      CIN(18,4) = 0.17
      CIN(19,4) = 0.17
      CIN(20,4) = 0.17
      CIN(21,4) = 0.22
      CIN(22,4) = 0.22
      CIN(23,4) = 0.24
      CIN(24,4) = 0.24
      CIN(25,4) = 0.24
      CIN(26,4) = 0.24
      CIN(27,4) = 0.28
      CIN(28,4) = 0.28
      CIN(29,4) = 0.28
      CIN(30,4) = 0.28
      CIN(31,4) = 0.35
      CIN(32,4) = 0.40
      CIN(33,4) = 0.45
      CIN(34,4) = 0.50
      CIN(35,4) = 0.0
C
C     Load the C5+ component oxygen contents in wt%.
      CIN(16,5) = 0.50
      CIN(17,5) = 0.50
      CIN(18,5) = 0.50
      CIN(19,5) = 0.50
      CIN(20,5) = 0.50
      CIN(21,5) = 0.70
      CIN(22,5) = 0.70
      CIN(23,5) = 0.60
      CIN(24,5) = 0.60
      CIN(25,5) = 0.60
      CIN(26,5) = 0.60
      CIN(27,5) = 0.67
      CIN(28,5) = 0.67
      CIN(29,5) = 0.67
      CIN(30,5) = 0.67
      CIN(31,5) = 0.70
      CIN(32,5) = 0.72
      CIN(33,5) = 0.74
      CIN(34,5) = 0.76
      CIN(35,5) = 0.0
C
```

```
C     Load the C5+ component hydrogen contents in wt%.
      CIN(16,7) = 14.21
      CIN(17,7) = 14.21
      CIN(18,7) = 14.21
      CIN(19,7) = 14.21
      CIN(20,7) = 14.21
      CIN(21,7) = 12.16
      CIN(22,7) = 12.16
      CIN(23,7) = 10.95
      CIN(24,7) = 10.95
      CIN(25,7) = 10.95
      CIN(26,7) = 10.95
      CIN(27,7) = 9.97
      CIN(28,7) = 9.97
      CIN(29,7) = 9.97
      CIN(30,7) = 9.97
      CIN(31,7) = 9.90
      CIN(32,7) = 9.85
      CIN(33,7) = 9.80
      CIN(34,7) = 9.75
      CIN(35,7) = 0.0
C
C     If mode equals 18, load the High Space Velocity Factors.
C     The following elemental compositions were developed from the
C     June 30, 1992 FAX from A. Basu to S. Poddar.  The 850+ F
C     components were estimated.
      IF ( MODE .EQ. 18 )  THEN
C       Load the C6+ component sulfur contents in wt%.
        CIN(16,3) = 0.04D0
        CIN(17,3) = 0.04D0
        CIN(18,3) = 0.04D0
        CIN(19,3) = 0.04D0
        CIN(20,3) = 0.04D0
        CIN(21,3) = 0.03D0
        CIN(22,3) = 0.03D0
        CIN(23,3) = 0.02D0
        CIN(24,3) = 0.02D0
        CIN(25,3) = 0.02D0
        CIN(26,3) = 0.02D0
        CIN(27,3) = 0.02D0
        CIN(28,3) = 0.02D0
        CIN(29,3) = 0.02D0
        CIN(30,3) = 0.02D0
        CIN(31,3) = 0.10D0
        CIN(32,3) = 0.15D0
        CIN(33,3) = 0.20D0
        CIN(34,3) = 1.50D0
        CIN(35,3) = 1.50D0
C
C       Load the C6+ component nitrogen contents in wt%.
        CIN(16,4) = 0.03D0
        CIN(17,4) = 0.03D0
        CIN(18,4) = 0.03D0
        CIN(19,4) = 0.03D0
        CIN(20,4) = 0.03D0
```

```
      CIN(21,4) = 0.20D0
      CIN(22,4) = 0.20D0
      CIN(23,4) = 0.35D0
      CIN(24,4) = 0.35D0
      CIN(25,4) = 0.35D0
      CIN(26,4) = 0.35D0
      CIN(27,4) = 0.38D0
      CIN(28,4) = 0.38D0
      CIN(29,4) = 0.38D0
      CIN(30,4) = 0.38D0
      CIN(31,4) = 0.40D0
      CIN(32,4) = 0.45D0
      CIN(33,4) = 0.50D0
      CIN(34,4) = 1.20D0
      CIN(35,4) = 1.20D0
C
C     Load the C6+ component oxygen contents in wt%.
      CIN(16,5) = 0.50D0
      CIN(17,5) = 0.50D0
      CIN(18,5) = 0.50D0
      CIN(19,5) = 0.50D0
      CIN(20,5) = 0.50D0
      CIN(21,5) = 0.55D0
      CIN(22,5) = 0.55D0
      CIN(23,5) = 0.50D0
      CIN(24,5) = 0.50D0
      CIN(25,5) = 0.50D0
      CIN(26,5) = 0.50D0
      CIN(27,5) = 0.65D0
      CIN(28,5) = 0.65D0
      CIN(29,5) = 0.65D0
      CIN(30,5) = 0.65D0
      CIN(31,5) = 0.70D0
      CIN(32,5) = 0.75D0
      CIN(33,5) = 0.80D0
      CIN(34,5) = 3.30D0
      CIN(35,5) = 3.30D0
C
C     Load the C6+ component hydrogen contents in wt%.
      CIN(16,7) = 14.21D0
      CIN(17,7) = 14.21D0
      CIN(18,7) = 14.21D0
      CIN(19,7) = 14.21D0
      CIN(20,7) = 14.21D0
      CIN(21,7) = 12.16D0
      CIN(22,7) = 12.16D0
      CIN(23,7) = 11.03D0
      CIN(24,7) = 11.03D0
      CIN(25,7) = 11.03D0
      CIN(26,7) = 11.03D0
      CIN(27,7) = 10.00D0
      CIN(28,7) = 10.00D0
      CIN(29,7) = 10.00D0
      CIN(30,7) = 10.00D0
      CIN(31,7) = 9.90D0
```

```
        CIN(32,7) = 9.80D0
        CIN(33,7) = 9.70D0
        CIN(34,7) = 5.50D0
        CIN(35,7) = 5.50D0
      ENDIF
C
C     Calculate the C5+ component carbon contents in wt% by difference.
      DO 40 J = 16, 35
        CIN(J,6) = 100.0D0 - CIN(J,3) - CIN(J,4) - CIN(J,5) - CIN(J,7)
   40 CONTINUE
C
      IF ( KTEST .GE. 5 )  THEN
        WRITE (NHSTRY, 503) MODE
  503   FORMAT ( / ' Component properties:   (MODE = ', I5, ')'  /
     1    3X, 'No.', 2X, 'Name', 9X, 'MW', 4X, 'lbs/bbl', 4X, 'Wt% S',
     2    4X, 'Wt% N', 4X, 'Wt% O', 4X, 'Wt% C', 4X, 'Wt% H')
        DO 50 J = 1, 35
          IF ( CNAME(J) .EQ. BLANK8 )  GO TO 50
            WRITE (NHSTRY, 504) J, CNAME(J), CMW(J), (CIN(J,K), K = 2,7)
  504       FORMAT ( 1X, I5, 2X, A8, 2F9.3, 5F9.4 )
   50   CONTINUE
      ENDIF
C
C
      RETURN
      END
C
C$ USR05C
      SUBROUTINE USR05C (IPASS, KTEST, NHSTRY, PCTDES)
C
C     This subroutine does the gas-oil hydrotreater desulfurization
C     calculations.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - November 21, 1991.
C
C     Calling arguments:
C     IPASS  = The results pass flag.
C     KTEST  = Switch for controlling the printing to the history file.
C     NHSTRY = Logical unit number of the history file.
C     PCTDES = Overall percent desulfurization; i. e., percent
C              sulfur removed from the C6+ feed.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
C     See subroutine USR05A for a description of the items in named
C     COMMON block /USR05M/.
      COMMON /USR05M/ CIN(35,7), COUT(35,7), CUTWT(35), CMWOUT(35)
      COMMON /USR05N/ CNAME(35), ICNUMB(55)
C
      CHARACTER * 8  BLANK8, CNAME
C
      DATA BLANK8 / '        ' /
```

```
C
C     Local variable declarations.
      DIMENSION RELDES(20), QX(2), QY(2)
C
C     RELDES(J) is the relative desulfurability of component J compared
C     to the T625 cut (component 26 - the 600-650 F boiling range cut).
C     It is calculated as follows.
C                    100.0 - % Desulfurization of component 22
C       RELDES(K) = ------------------------------------------
C                    100.0 - % Desulfurization of component K
C
C     If the T675 cut (component 26) is 98.0% desulfurized and cut K is
C     only 96% desulfurized, then
C        RELDES(K) = (100. - 98.) / (100. - 96.) = 0.5
C
C     Load the RELDES vector with the relative desulfurability of
C     components 16 - 35 so that RELDES(J) corresponds to the relative
C     desulfurability of component J + 15.
      DATA RELDES / 1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0,
     1  1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0,
     2  1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0,
     3  1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0 /
C
C
C     Load the molecular weights of hydrogen and sulfur.
      XMWH2 = CMWOUT(1)
      XMWS = CMWOUT(4) - CMWOUT(1)
C
C     Calculate the entering amount of sulfur in the C6+ in Mlbs/hr.
      WTSIN = 0.0D0
      DO 10 J = 16, 35
        WTSIN = WTSIN + CIN(J,1) * CIN(J,3)
   10 CONTINUE
      WTSIN = 0.01D0 * WTSIN
C
C     If requested, write the entering amount of sulfur and desired
C     percent desulfurization of the C6+ feed.
      IF ( KTEST .GE. 3 )  WRITE (NHSTRY, 701)  WTSIN, PCTDES
  701 FORMAT ( / ' Entering sulfur in C6+, Mlbs/hr =', F10.4 /
     1  ' Target percent desulfurization =', F10.4 )
C
C     If requested, write the relative component desulfurabilities.
      IF ( KTEST .GE. 2 )  THEN
        WRITE (NHSTRY, 702)
  702   FORMAT ( / ' Relative component desulfurabilities:' )
        DO 20 J = 1, 10
          K = J + 15
          KP = J + 25
          JP = J + 10
          WRITE (NHSTRY, 703) K, CNAME(K), RELDES(J), KP, CNAME(KP),
     1      RELDES(JP)
  703     FORMAT ( 3X, I3, 3X, A8, F9.4, 10X, I3, 3X, A8, F9.4 )
   20   CONTINUE
      ENDIF
C
```

```
C     Initialize the component weights to zero,
      DO 30 J = 1, 35
        CUTWT(J) = 0.0D0
   30 CONTINUE
C
C     Converge on the specified overall percent desulfurization by
C     varying F, the fractional desulfurization of the reference
C     cut (component 26), the 600 - 650 F boiling range cut.
C
C     Initialize the iteration history.
      DO 40 J = 1, 2
        QX(J) = 0.0D0
        QY(J) = 0.0D0
   40 CONTINUE
C
C     For an initial guess, set F equal to the overall fractional
C     desulfurization.
      F = 0.01D0 * PCTDES
C
      DO 60 K = 1, 35
        ITER = K
C       Desulfurize the C6+ material and accumulate the total amount
C       of sulfur remaining in the C6+, SLEFT, in Mlbs/hr.
        SLEFT = 0.0D0
        DO 50 J = 16, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 50
C           CSIN is the weight of sulfur entering in this component.
            CSIN = 0.01D0 * CIN(J,1) * CIN(J,3)
C           CSLEFT is the weight of sulfur remaining in this component.
            CSLEFT = CSIN * (1.0D0 - F) / RELDES(J-15)
C           Adjust the weight flow rate for the amount of S removed.
            CUTWT(J) = COUT(J,1) - (CSIN - CSLEFT)
C           Load the remaining Mlbs/hr of sulfur in COUT(J,3).
            COUT(J,3) = CSLEFT
            SLEFT = SLEFT + COUT(J,3)
   50   CONTINUE
C       Calculate the overall percent desulfurization - SREM is the
C       amount of sulfur removed from the C6+ in Mlbs/hr.
        SREM = WTSIN - SLEFT
        CDES = 100.0D0 * SREM / WTSIN
C       Save the iteration results.
        QX(1) = QX(2)
        QY(1) = QY(2)
        QX(2) = F
        QY(2) = CDES
        IF ( KTEST .GE. 5 )  THEN
          IF ( K .EQ. 1 )  WRITE (NHSTRY, 704)
  704     FORMAT ( / ' Desulfurization iteration history:' )
          WRITE (NHSTRY, 705) K, QX(1), QX(2), QY(1), QY(2)
  705     FORMAT ( ' K, QX(1), QX(2), QY(1) & QY(2):', I5, 4F10.5 )
        ENDIF
C       Convergence check.
        IF ( DABS(PCTDES-QY(2)) .LT. 0.00001 )  THEN
C           Converged - Exit the convergence loop.
            GO TO 70
```

```
          ELSE
C           Make the guess for the next iteration.
            IF ( K .EQ. 1 )  THEN
C               First iteration - make a small move.
                IF ( CDES .LT. PCTDES )  THEN
C                   Calculated desulfurization is below target value.
                    F = 1.0D0 - 0.75D0 * (1.0D0 - F)
                  ELSE
C                   Calculated desulfurization is above target value.
                    F = 1.0D0 - 1.25D0 * (1.0D0 - F)
                ENDIF
              ELSE
C               Subsequent iterations - Use a damping factor for the
C               third and fourth iterations.
                DF = 0.25 * K
                IF ( DF .GT. 1.0D0 )  DF = 1.0D0
                F = QX(2) +
     1            DF * (PCTDES-QY(2))*(QX(2)-QX(1))/(QY(2)-QY(1))
            ENDIF
        ENDIF
   60 CONTINUE
C     End of desulfurization iteration loop.
C
C     The desulfurization loop did not converge, write a warning
C     message and continue using the last value.
      WRITE (NHSTRY, 706)  PCTDES, ITER, CDES
  706 FORMAT ( / ' * WARNING * - In subroutine USR05C, the overall',
     1  ' percent desulfurization did not' /
     2  3X, 'converge to the desired value of', F9.4, '% within', I3,
     3  ' iterations.  Execution' /
     4  3X, 'will continue using the calculated percent',
     5  ' desulfurization of', F10.4, '%.' )
C
C     If requested, write the calculated percent desulfurization.
   70 IF ( KTEST .GE. 4 )  WRITE (NHSTRY, 707)  CDES
  707 FORMAT ( / ' Calculated percent desulfurization =', F10.4 )
C
C     Load the adjusted component weights in the COUT array.
      DO 150 J = 16, 35
        COUT(J,1) = CUTWT(J)
  150 CONTINUE
C
C     Adjust the COUT array for the amount of sulfur converted to H2S.
      COUT(4,1) = COUT(4,1) + SREM * (XMWS + XMWH2) / XMWS
C     Load the Mlbs/hr of sulfur in COUT(4,3)
      COUT(4,3) = COUT(4,1) * XMWS / (XMWS + XMWH2)
C     Adjust the hydrogen for the amount used to make the H2S.
      COUT(1,1) = COUT(1,1) - SREM * XMWH2 / XMWS
C
C
      RETURN
      END
C
C$ USR05D
      SUBROUTINE USR05D (IPASS, KTEST, NHSTRY, PCTDEN)
```

```
C
C     This subroutine does the gas-oil hydrotreater denitrogenation
C     calculations.
C     NOTE: This subroutine is similar to subroutine USR05C.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - November 21, 1991.
C
C     Calling arguments:
C     IPASS  = The results pass flag.
C     KTEST  = Switch for controlling the printing to the history file.
C     NHSTRY = Logical unit number of the history file.
C     PCTDEN = Overall percent denitrogenation; i. e., percent
C              nitrogen removed from the C6+ feed.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
C     See subroutine USR05A for a description of the items in named
C     COMMON block /USR05M/.
      COMMON /USR05M/ CIN(35,7), COUT(35,7), CUTWT(35), CMWOUT(35)
      COMMON /USR05N/ CNAME(35), ICNUMB(55)
C
      CHARACTER * 8  BLANK8, CNAME
C
      DATA BLANK8 / '        ' /
C
C     Local variable declarations.
      DIMENSION RELDEN(20), QX(2), QY(2)
C
C     RELDEN(J) is the relative denitrogenability of component J
C     compared to the T625 cut (component 26 - the 600-650 F boiling
C     range cut).  It is calculated as follows.
C                    100.0 - % Denitrogenation of component 22
C       RELDEN(K) = ------------------------------------------
C                    100.0 - % Denitrogenation of component K
C     If the T625 cut (component 26) is 98.0% denitrogenated and cut K
C     is only 96% denitrogenated then
C        RELDEN(K) = (100. - 98.) / (100. - 96.) = 0.5
C
C     Load the RELDEN vector with the relative denitrogenability of
C     components 16 - 35 so that RELDEN(J) corresponds to the relative
C     denitrogenability of component J + 15.
      DATA RELDEN / 1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0,
     1  1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0,
     2  1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0,
     3  1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0 /
C
C
C     Load the molecular weights of 3 hydrogen atoms and 1 nitrogen
      XMWH3 = 1.5D0 * CMWOUT(1)
      XMWN = CMWOUT(2) - XMWH3
C
C     Calculate the entering amount of nitrogen in in C6+ Mlbs/hr.
```

```
      WTNIN = 0.0D0
      DO 10 J = 16, 35
        WTNIN = WTNIN + CIN(J,1) * CIN(J,4)
   10 CONTINUE
      WTNIN = 0.01D0 * WTNIN
C
C     If requested, write the entering amount of nitrogen and desired
C     percent denitrogenation of the C6+ feed.
      IF ( KTEST .GE. 3 )  WRITE (NHSTRY, 701)  WTNIN, PCTDEN
  701 FORMAT ( / ' Entering nitrogen in C6+, Mlbs/hr =', F10.4 /
     1  ' Target percent denitrogenation =', F10.4 )
C
C     If requested, write the relative component denitrogenabilities.
      IF ( KTEST .GE. 2 )  THEN
        WRITE (NHSTRY, 702)
  702   FORMAT ( / ' Relative component denitrogenabilities:' )
        DO 20 J = 1, 10
          K = J + 15
          KP = J + 25
          JP = J + 10
          WRITE (NHSTRY, 703) K, CNAME(K), RELDEN(J), KP, CNAME(KP),
     1      RELDEN(JP)
  703     FORMAT ( 3X, I3, 3X, A8, F9.4, 10X, I3, 3X, A8, F9.4 )
   20   CONTINUE
      ENDIF
C
C     Initialize the component weights to zero,
      DO 30 J = 1, 35
        CUTWT(J) = 0.0D0
   30 CONTINUE
C
C     Converge on the specified overall percent denitrogenation by
C     varying F, the fractional denitrogenation of the reference
C     cut (component 26), the 600 - 650 F boiling range cut.
C
C     Initialize the iteration history.
      DO 40 J = 1, 2
        QX(J) = 0.0D0
        QY(J) = 0.0D0
   40 CONTINUE
C
C     For an initial guess, set F equal to the overall fractional
C     denitrogenation.
      F = 0.01D0 * PCTDEN
C
      DO 60 K = 1, 35
        ITER = K
C       Desulfurize the C6+ material and accumulate the total amount
C       of nitrogen remaining in the C6+, XNLEFT, in Mlbs/hr.
        XNLEFT = 0.0D0
        DO 50 J = 16, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 50
C           CNIN is the weight of nitrogen entering in this component.
            CNIN = 0.01D0 * CIN(J,1) * CIN(J,4)
C           CNLEFT is the weight of nitrogen remaining in this
```

```
C           component.
            CNLEFT = CNIN * (1.0D0 - F) / RELDEN(J-15)
C           Adjust the weight flow rate for the amount of N removed.
            CUTWT(J) = COUT(J,1) - (CNIN - CNLEFT)
C           Load the remaining Mlbs/hr of nitrogen in COUT(J,4).
            COUT(J,4) = CNLEFT
            XNLEFT = XNLEFT + COUT(J,4)
   50     CONTINUE
C         Calculate the overall percent denitrogenation - XNREM is the
C         amount of nitrogen removed from the C6+ in Mlbs/hr.
          XNREM = WTNIN - XNLEFT
          CDEN = 100.0D0 * XNREM / WTNIN
C         Save the iteration results.
          QX(1) = QX(2)
          QY(1) = QY(2)
          QX(2) = F
          QY(2) = CDEN
          IF ( KTEST .GE. 5 )  THEN
            IF ( K .EQ. 1 )  WRITE (NHSTRY, 704)
  704       FORMAT ( / ' Denitrogenation iteration history:' )
            WRITE (NHSTRY, 705) K, QX(1), QX(2), QY(1), QY(2)
  705       FORMAT ( ' K, QX(1), QX(2), QY(1) & QY(2):', I5, 4F10.5 )
          ENDIF
C         Convergence check.
          IF ( DABS(PCTDEN-QY(2)) .LT. 0.00001 )  THEN
C             Converged - Exit the convergence loop.
              GO TO 70
            ELSE
C             Make the guess for the next iteration.
              IF ( K .EQ. 1 )  THEN
C                 First iteration - make a small move.
                  IF ( CDEN .LT. PCTDEN )  THEN
C                     Calculated denitrogenation is below target value.
                      F = 1.0D0 - 0.75D0 * (1.0D0 - F)
                    ELSE
C                     Calculated denitrogenation is above target value.
                      F = 1.0D0 - 1.25D0 * (1.0D0 - F)
                  ENDIF
                ELSE
C                 Subsequent iterations - Use a damping factor for the
C                 third and fourth iterations.
                  DF = 0.25 * K
                  IF ( DF .GT. 1.0D0 )  DF = 1.0D0
                  F = QX(2) +
     1              DF * (PCTDEN-QY(2))*(QX(2)-QX(1))/(QY(2)-QY(1))
              ENDIF
          ENDIF
   60   CONTINUE
C         End of denitrogenation iteration loop.
C
C         The denitrogenation loop did not converge, write a warning
C         message and continue using the last value.
          WRITE (NHSTRY, 706)  PCTDEN, ITER, CDEN
  706     FORMAT ( / ' * WARNING * - In subroutine USR05D, the overall',
     1  ' percent denitrogenation did not' /
```

```
     2  3X, 'converge to the desired value of', F9.4, '% within', I3,
     3  ' iterations.  Execution' /
     4  3X, 'will continue using the calculated percent',
     5  ' denitrogenation of', F10.4, '%.' )
C
C     If requested, write the calculated percent denitrogenation.
   70 IF ( KTEST .GE. 4 )  WRITE (NHSTRY, 707)  CDEN
  707 FORMAT ( / ' Calculated percent denitrogenation =', F10.4 )
C
C     Load the adjusted component weights in the COUT array.
      DO 150 J = 16, 35
        COUT(J,1) = CUTWT(J)
  150 CONTINUE
C
C     Adjust the COUT array for the amount of nitrogen converted to NH3.
      COUT(2,1) = COUT(2,1) + XNREM * (XMWN + XMWH3) / XMWN
C     Load the Mlbs/hr of nitrogen in COUT(2,4)
      COUT(2,4) = COUT(2,1) * XMWN / (XMWN + XMWH3)
C     Adjust the hydrogen for the amount used to make the NH3.
      COUT(1,1) = COUT(1,1) - XNREM * XMWH3 / XMWN
C     Adjust for any entering nitrogen.
      COUT(5,4) = COUT(5,1)
C
C
      RETURN
      END

C$ USR05E
      SUBROUTINE USR05E (IPASS, KTEST, NHSTRY, PCTDEO)
C
C     This subroutine does the gas-oil hydrotreater deoxygenation
C     calculations.
C     NOTE: This subroutine is similar to subroutine USR05C.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - November 21, 1991.
C
C     Calling arguments:
C     IPASS  = The results pass flag.
C     KTEST  = Switch for controlling the printing to the history file.
C     NHSTRY = Logical unit number of the history file.
C     PCTDEO = Overall percent desulfurization; i. e., percent
C              oxygen removed from the C6+ feed.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
C     See subroutine USR05A for a description of the items in named
C     COMMON block /USR05M/.
      COMMON /USR05M/ CIN(35,7), COUT(35,7), CUTWT(35), CMWOUT(35)
      COMMON /USR05N/ CNAME(35), ICNUMB(55)
C
      CHARACTER * 8  BLANK8, CNAME
C
```

```
      DATA BLANK8 / '        ' /
C
C     Local variable declarations.
      DIMENSION RELDEO(20), QX(2), QY(2)
C
C     RELDEO(J) is the relative deoxygenability of component J compared
C     to the T625 cut (component 26 - the 600-650 F boiling range cut).
C     It is calculated as follows.
C                     100.0 - % Deoxygenation of component 22
C       RELDEO(K) = ----------------------------------------
C                     100.0 - % Deoxygenation of component K
C     If the T625 cut (component 26) is 98.0% deoxygenated and cut K is
C     only 96% deoxygenated then
C        RELDEO(K) = (100. - 98.) / (100. - 96.) = 0.5
C
C     Load the RELDEO vector with the relative deoxygenability of
C     components 16 - 35 so that RELDEO(J) corresponds to the relative
C     deoxygenability of component J + 15.
      DATA RELDEO / 1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0,
     1  1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0,
     2  1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0,
     3  1.00D0, 1.00D0, 1.00D0, 1.00D0, 1.00D0 /
C
C
C     Load the molecular weight of H2 and an oxygen atom.
      XMWH2 = CMWOUT(1)
      XMWO = CMWOUT(3) - XMWH2
C
C     Calculate the entering amount of oxygen in the C6+ in Mlbs/hr.
      WTOIN = 0.0D0
      DO 10 J = 16, 35
        WTOIN = WTOIN + CIN(J,1) * CIN(J,5)
   10 CONTINUE
      WTOIN = 0.01D0 * WTOIN
C
C     If requested, write the entering amount of oxygen and desired
C     percent deoxygenation of the C6+ feed.
      IF ( KTEST .GE. 3 )  WRITE (NHSTRY, 701)  WTOIN, PCTDEO
  701 FORMAT ( / ' Entering oxygen in C6+, Mlbs/hr =', F10.4 /
     1  ' Target percent deoxygenation =', F10.4 )
C
C     If requested, write the relative component deoxygenabilities.
      IF ( KTEST .GE. 2 )  THEN
        WRITE (NHSTRY, 702)
  702   FORMAT ( / ' Relative component deoxygenabilities:' )
        DO 20 J = 1, 10
          K = J + 15
          KP = J + 25
          JP = J + 10
          WRITE (NHSTRY, 703) K, CNAME(K), RELDEO(J), KP, CNAME(KP),
     1      RELDEO(JP)
  703     FORMAT ( 3X, I3, 3X, A8, F9.4, 10X, I3, 3X, A8, F9.4 )
   20   CONTINUE
      ENDIF
C
```

```
C     Initialize the component weights to zero,
      DO 30 J = 1, 35
        CUTWT(J) = 0.0D0
   30 CONTINUE
C
C     Converge on the specified overall percent deoxygenation by
C     varying F, the fractional deoxygenation of the reference cut,
C     (component 26), the 600 - 650 F boiling range cut.
C
C     Initialize the iteration history.
      DO 40 J = 1, 2
        QX(J) = 0.0D0
        QY(J) = 0.0D0
   40 CONTINUE
C
C     For an initial guess, set F equal to the overall fractional
C     deoxygenation.
      F = 0.01D0 * PCTDEO
C
      DO 60 K = 1, 35
        ITER = K
C       Deoxygenate the C6+ material and accumulate the total amount
C       of oxygen remaining in the C6+, OLEFT, in Mlbs/hr.
        OLEFT = 0.0D0
        DO 50 J = 16, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 50
C           COIN is the weight of oxygen entering in this component.
            COIN = 0.01D0 * CIN(J,1) * CIN(J,5)
C           COLEFT is the weight of oxygen remaining in this component.
            COLEFT = COIN * (1.0D0 - F) / RELDEO(J-15)
C           Adjust the weight flow rate for the amount of O removed.
            CUTWT(J) = COUT(J,1) - (COIN - COLEFT)
C           Load the remaining Mlbs/hr of oxygen in COUT(J,5).
            COUT(J,5) = COLEFT
            OLEFT = OLEFT + COUT(J,5)
   50   CONTINUE
C       Calculate the overall percent deoxygenation - OREM is the
C       amount of oxygen removed from the C6+ in Mlbs/hr.
        OREM = WTOIN - OLEFT
        CDEO = 100.0D0 * OREM / WTOIN
C       Save the iteration results.
        QX(1) = QX(2)
        QY(1) = QY(2)
        QX(2) = F
        QY(2) = CDEO
        IF ( KTEST .GE. 5 )  THEN
          IF ( K .EQ. 1 )  WRITE (NHSTRY, 704)
  704     FORMAT ( / ' Deoxygenation iteration history:' )
          WRITE (NHSTRY, 705) K, QX(1), QX(2), QY(1), QY(2)
  705     FORMAT ( ' K, QX(1), QX(2), QY(1) & QY(2):', I5, 4F10.5 )
        ENDIF
C       Convergence check.
        IF ( DABS(PCTDEO-QY(2)) .LT. 0.00001 )  THEN
C           Converged - Exit the convergence loop.
            GO TO 70
```

```
          ELSE
C           Make the guess for the next iteration.
            IF ( K .EQ. 1 )  THEN
C               First iteration - make a small move.
                IF ( CDEO .LT. PCTDEO )  THEN
C                   Calculated deoxygenation is below target value.
                    F = 1.0D0 - 0.75D0 * (1.0D0 - F)
                  ELSE
C                   Calculated deoxygenation is above target value.
                    F = 1.0D0 - 1.25D0 * (1.0D0 - F)
                ENDIF
              ELSE
C               Subsequent iterations - Use a damping factor for the
C               third and fourth iterations.
                DF = 0.25 * K
                IF ( DF .GT. 1.0D0 )  DF = 1.0D0
                F = QX(2) +
     1            DF * (PCTDEO-QY(2))*(QX(2)-QX(1))/(QY(2)-QY(1))
            ENDIF
        ENDIF
   60 CONTINUE
C     End of deoxygenation iteration loop.
C
C     The deoxygenation loop did not converge, write a warning
C     message and continue using the last value.
      WRITE (NHSTRY, 706)  PCTDEO, ITER, CDEO
  706 FORMAT ( / ' * WARNING * - In subroutine USR05E, the overall',
     1  ' percent deoxygenation did not' /
     2  3X, 'converge to the desired value of', F9.4, '% within', I3,
     3  ' iterations.  Execution' /
     4  3X, 'will continue using the calculated percent',
     5  ' deoxygenation of', F10.4, '%.' )
C
C     If requested, write the calculated percent deoxygenation.
   70 IF ( KTEST .GE. 4 )  WRITE (NHSTRY, 707)  CDEO
  707 FORMAT ( / ' Calculated percent deoxygenation =', F10.4 )
C
C     Load the adjusted component weights in the COUT array.
      DO 150 J = 16, 35
        COUT(J,1) = CUTWT(J)
  150 CONTINUE
C
C     Adjust the COUT array for the amount of oxygen converted to H2O.
      COUT(3,1) = COUT(3,1) + OREM * (XMWO + XMWH2) / XMWO
C     Load the Mlbs/hr of oxygen in COUT(3,5)
      COUT(3,5) = COUT(3,1) * XMWO / (XMWO + XMWH2)
C     Adjust the hydrogen for the amount used to make the NH3.
      COUT(1,1) = COUT(1,1) - OREM * XMWH2 / XMWO
C
C
      RETURN
      END
C
C$ USR05F
      SUBROUTINE USR05F (H2CONS, IPASS, KTEST, NHSTRY)
```

```
C
C     This subroutine does the gas oil hydrotreater hydrogen
C     consumption and yield shift calculations.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - October 14, 1992.
C
C     Calling arguments:
C     H2CONS = Specified chemical hydrogen consumption in SCF/bbl of
C              C6+ feed.
C     IPASS  = The results pass flag.
C     KTEST  = Switch for controlling the printing to the history file.
C     NHSTRY = Logical unit number of the history file.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
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
C     See subroutine USR05A for a description of the items in named
C     COMMON block /USR05M/.
      COMMON /USR05M/ CIN(35,7), COUT(35,7), CUTWT(35), CMWOUT(35)
      COMMON /USR05N/ CNAME(35), ICNUMB(55)
C
      CHARACTER * 8  BLANK8, CNAME
C
C     Local variable declarations.
      DIMENSION DELYLD(35), DELY(35), DELY8(35)
C
      DATA BLANK8 / '        ' /
C
C     Load the DELY(35) vector with the net component productions
C     in wt % of C6+ feed for the Baseline Design Case ignoring the
C     pure non-hydrocarbon components since they have been previously
C     calculated.
C                          H2        NH3       H2O       H2S       N2
      DATA DELY    /  0.0D0,    0.0D0,    0.0D0,    0.0D0,    0.0D0,
C        CH4          C2H6         C3H8         IC4H10       NC4H10
     1   1.2195990,   1.1406180,   1.7694920,   1.6255810,   0.8753130,
C        IC5H12       NC5H12       Future       Future       Future
     2   1.4717454,   1.4717454,   0.00000D0,   0.00000D0,   0.00000D0,
C        T125         T175         T225         T275         T325
     3   0.4757990,   0.4757990,   0.4757990,   0.4757990,   0.4757990,
C        T375         T425         T475         T525         T575
     4   1.6887220,   1.6887220,  -0.6108429,  -0.6108429,  -0.6108429,
C        T625         T675         T725         T775         T825
     5  -0.6108429,  -3.3911540,  -3.3911540,  -3.3911540,  -3.3911540,
C        T875         T925         T975         T1000+       Future
     6   0.4036520,   0.4036520,   0.4036520,   0.00000D0,   0.00000D0 /
C
```

```
C     Load the DELY8(35) vector with the net component productions
C     in wt % of C6+ feed for the High Space Velocity Design Case
C     ignoring the pure non-hydrocarbon components since they have
C     been previously calculated.
C                        H2        NH3       H2O       H2S       N2
      DATA DELY8  /  0.0D0,    0.0D0,    0.0D0,    0.0D0,    0.0D0,
C        CH4          C2H6         C3H8         IC4H10       NC4H10
     1   0.238959 ,   0.268632 ,   0.318525 ,   0.152654 ,   0.076327 ,
C        IC5H12       NC5H12       Future       Future       Future
     2   0.0      ,   0.0      ,   0.00000D0,   0.00000D0,   0.00000D0,
C        T125         T175         T225         T275         T325
     3   0.260282 ,   0.260282 ,   0.260282 ,   0.260282 ,   0.260282 ,
C        T375         T425         T475         T525         T575
     4   0.228981 ,   0.228981 ,   0.090485 ,   0.090485 ,   0.090485 ,
C        T625         T675         T725         T775         T825
     5   0.090485 ,  -0.535404 ,  -0.535404 ,  -0.535404 ,  -0.535404 ,
C        T875         T925         T975         T1000+       Future
     6  -0.004639 ,  -0.004639 ,  -0.004639 ,   0.00000D0,   0.00000D0 /
C
C     Load the SCF per pound mole.
      DATA SCFPM / 379.495D0 /
C
C
C     Load the appropriate yield deltas in the DELYLD vector.
C     Baseline Design.
      DO 10 J = 1, 35
        DELYLD(J) = DELY(J)
   10 CONTINUE
C
C     The high space velocity Plant 2 option (MODE = 18).
      IF ( MODE .EQ. 18 )  THEN
        DO 18 J = 1, 35
          DELYLD(J) = DELY8(J)
   18   CONTINUE
      ENDIF
C
C     Calculate the C6+ density of the feed in lbs/bbl.
      C6PWT = 0.0D0
      C6PVOL = 0.0D0
      DO 30 J = 16, 35
        IF ( CNAME(J) .EQ. BLANK8 )   GO TO 30
          C6PWT = C6PWT + CIN(J,1)
          C6PVOL = C6PVOL + CIN(J,1) / CIN(J,2)
   30 CONTINUE
      C6PDEN = C6PWT / C6PVOL
C
C     Calculate the total weight of H2 that has to be consumed.
      TWTH2 = (H2CONS * CMWOUT(1) / SCFPM) * C6PVOL
C
      IF ( KTEST .GE. 4 )  THEN
        V = 1000.0D0 * C6PVOL
        WRITE (NHSTRY, 701) C6PWT, V, C6PDEN, H2CONS, TWTH2
  701   FORMAT ( / ' C6+ weight  =', F10.3, ' Mlbs/hr' /
     1    ' C6+ volume  =', F10.3, ' bbls/hr' /
     2    ' C6+ density =', F10.3, ' lbs/bbl' /
```

```
     3    ' Total H2 consumption =', F10.1, ' SCF/bbl or', F10.3,
     4    ' Mlbs/hr' )
      ENDIF
C
      IF ( KTEST .GE. 2 )  THEN
        WRITE (NHSTRY, 702) MODE, (J, DELYLD(J), J = 1, 35)
  702   FORMAT ( / ' Plant 2 Reactor MODE = ', I5 /
     1    ' Specified component productions in wt% of C5+ feed:',
     2    7 (/I4, F9.6, I7, F9.6, I7, F9.6, I7, F9.6, I7, F9.6 ) )
      ENDIF
C
C     If requested, write the component information.
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 722)
  722   FORMAT ( / ' Component flow rates entering USR05F:' )
        WRITE (NHSTRY, 723)
  723   FORMAT ( '   No.  Name', 7X, 'Mlbs/hr', 2X, 'lbs/bbl', 5X,
     1    'Wt S', 5X, 'Wt N', 5X, 'Wt O', 5X, 'Wt C', 5X, 'Wt H' )
  724   FORMAT ( 1X, I5, 2X, A8, F10.3, F9.3, 5F9.3 )
        SUM1 = 0.0D0
        SUM3 = 0.0D0
        SUM4 = 0.0D0
        SUM5 = 0.0D0
        SUM6 = 0.0D0
        SUM7 = 0.0D0
        DO 100 J = 1, 35
            IF ( CNAME(J) .EQ. BLANK8 )   GO TO 100
            WRITE (NHSTRY, 724)  J, CNAME(J), (COUT(J,K), K = 1, 7)
            SUM1 = SUM1 + COUT(J,1)
            SUM3 = SUM3 + COUT(J,3)
            SUM4 = SUM4 + COUT(J,4)
            SUM5 = SUM5 + COUT(J,5)
            SUM6 = SUM6 + COUT(J,6)
            SUM7 = SUM7 + COUT(J,7)
  100   CONTINUE
        WRITE (NHSTRY, 725)  SUM1, SUM3, SUM4, SUM5, SUM6, SUM7
  725   FORMAT ( 8X, 'Total ', F12.3, F18.3, 4F9.3 )
      ENDIF
C
C
C     Adjust the hydrogen for the total amount of hydrogen consumed as
C     specified by the supplied chemical hydrogen consumption.
      COUT(1,1) = CIN(1,1) - TWTH2
      COUT(1,7) = COUT(1,1)
C
C     Load the weight of hydrogen in the in the COUT array for H2, NH3,
C     H2O and H2S.
      DO 40 J = 2, 4
        COUT(J,7) = 0.01D0 * COUT(J,1) * CIN(J,7)
   40 CONTINUE
C
C     Calculate the net C1 - C5 productions in Mlbs/hr.
      DO 42 J = 6, 12
        WT = COUT(J,1) + 0.01D0 * C6PWT * DELYLD(J)
        COUT(J,6) = WT * CIN(J,6) / (CIN(J,6) + CIN(J,7))
```

```
        COUT(J,7) = WT - COUT(J,6)
        COUT(J,1) = WT
   42 CONTINUE
C
C     Calculate the pseudocomponents.
      DO 44 J = 16, 35
        IF ( CNAME(J) .EQ. BLANK8 )   GO TO 44
          WT = 0.01D0 * C6PWT * DELYLD(J)
          COUT(J,6) = 0.01D0 * CIN(J,1) * CIN(J,6) +
     1      WT * CIN(J,6) / (CIN(J,6) + CIN(J,7))
          COUT(J,7) = 0.01D0 * CIN(J,1) * CIN(J,7) +
     1      WT * CIN(J,7) / (CIN(J,6) + CIN(J,7))
          COUT(J,1) = COUT(J,3) + COUT(J,4) + COUT(J,5) + COUT(J,6) +
     1      COUT(J,7)
   44 CONTINUE
C
C     If requested, write the component information.
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 726)
  726   FORMAT ( / ' Component flow rates after first pass yields:' )
        WRITE (NHSTRY, 723)
        SUM1 = 0.0D0
        SUM3 = 0.0D0
        SUM4 = 0.0D0
        SUM5 = 0.0D0
        SUM6 = 0.0D0
        SUM7 = 0.0D0
        DO 110 J = 1, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 110
            WRITE (NHSTRY, 724)  J, CNAME(J), (COUT(J,K), K = 1, 7)
            SUM1 = SUM1 + COUT(J,1)
            SUM3 = SUM3 + COUT(J,3)
            SUM4 = SUM4 + COUT(J,4)
            SUM5 = SUM5 + COUT(J,5)
            SUM6 = SUM6 + COUT(J,6)
            SUM7 = SUM7 + COUT(J,7)
  110   CONTINUE
        WRITE (NHSTRY, 725)  SUM1, SUM3, SUM4, SUM5, SUM6, SUM7
      ENDIF
C
C     Calculate a carbon/hydrogen balance.
      CARIN = 0.0D0
      CAROUT = 0.0D0
      HIN = 0.0D0
      HOUT = 0.0D0
      DO 50 J = 1, 35
        CARIN = CARIN + 0.01D0 * CIN(J,1) * CIN(J,6)
        HIN = HIN + 0.01D0 * CIN(J,1) * CIN(J,7)
        CAROUT = CAROUT + COUT(J,6)
        HOUT = HOUT + COUT(J,7)
   50 CONTINUE
C     Calculate the carbon and hydrogen imbalance.
      DC = CARIN - CAROUT
      DH = HIN - HOUT
C
```

```
      IF ( KTEST .GE. 4 )  THEN
        WRITE (NHSTRY, 705) CARIN, CAROUT, HIN, HOUT
  705   FORMAT ( / ' Preliminary carbon and hydrogen balances' /
     1    2X, 'Carbon:     In =', F12.3, 10X, 'Out =', F12.3 /
     2    2X, 'Hydrogen    In =', F12.3, 10X, 'Out =', F12.3 )
      ENDIF
C
C     Now adjust the carbon and hydrogen in the C6+ pseudocomponents
C     in proportion to their amounts to make a 100% balance.
C     Calculate the C6+ carbon and hydrogen.
      CC6P = 0.0D0
      HC6P = 0.0D0
      DO 60 J = 16, 35
        CC6P = CC6P + COUT(J,6)
        HC6P = HC6P + COUT(J,7)
   60 CONTINUE
C
C     Adjust the C6+ pseudocomponents in proportion to their amount.
      DO 62 J = 16, 35
        COUT(J,6) = COUT(J,6) + DC*COUT(J,6)/CC6P
        COUT(J,7) = COUT(J,7) + DH*COUT(J,7)/HC6P
        COUT(J,1) = COUT(J,3) + COUT(J,4) + COUT(J,5) + COUT(J,6) +
     1    COUT(J,7)
   62 CONTINUE
C
C     If requested, write the component information.
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 727)
  727   FORMAT ( / ' Component flow rates leaving USR05F:' )
        WRITE (NHSTRY, 723)
        SUM1 = 0.0D0
        SUM3 = 0.0D0
        SUM4 = 0.0D0
        SUM5 = 0.0D0
        SUM6 = 0.0D0
        SUM7 = 0.0D0
        DO 120 J = 1, 35
          IF ( CNAME(J) .EQ. BLANK8 )   GO TO 120
            WRITE (NHSTRY, 724)  J, CNAME(J), (COUT(J,K), K = 1, 7)
            SUM1 = SUM1 + COUT(J,1)
            SUM3 = SUM3 + COUT(J,3)
            SUM4 = SUM4 + COUT(J,4)
            SUM5 = SUM5 + COUT(J,5)
            SUM6 = SUM6 + COUT(J,6)
            SUM7 = SUM7 + COUT(J,7)
  120   CONTINUE
        WRITE (NHSTRY, 725)  SUM1, SUM3, SUM4, SUM5, SUM6, SUM7
      ENDIF
C
      RETURN
      END
C
C$ USR05G
      SUBROUTINE USR05G (INT1, INT2, IPASS, NOUT, UNKNWN)
C
```

```
C     This subroutine writes the first part of the gas-oil hydrotreater
C     summary report.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - December 2, 1991.
C
C     Calling arguments:
C     INT1   = 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 report.
C              2 => Skip the capital cost and utilities portions of the
C                   summary report.
C              3 => Skip writing the entire user block summary report.
C     INT2   = User block summary report destination control switch.
C              0 => Write the user block summary report to the normal
C                   ASPEN/SP output report file.
C              1 => Write the user block summary report to a separate
C                   user block summary report file on logical unit 62.
C     IPASS  = The results pass flag.
C     NOUT   = Logical unit of the plant summary report file.
C     UNKNWN = Flow rate of unknown components in Mlbs/hr.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
C     See subroutine USR05A for a description of the items in named
C     COMMON block /USR05M/.
      COMMON /USR05M/ CIN(35,7), COUT(35,7), CUTWT(35), CMWOUT(35)
      COMMON /USR05N/ CNAME(35), ICNUMB(55)
C
      CHARACTER * 8,  BLANK8, CNAME
C
      DATA BLANK8 / '        '/
      DATA SCFM / 379.495D0 /
C
C
      IF ( IPASS .EQ. 4 .AND. INT1 .LE. 0 )  THEN
C       Write the first part of the plant summary report.
C       ================================================
        WRITE (NOUT, 801)
  801   FORMAT ( / 27X, 'PLANT 5 - SUMMARY REPORT' /
     1    29X, 'GAS-OIL HYDROTREATER' //
     2    31X, 'REACTOR SUMMARY' )
C
        WRITE (NOUT, 802)
  802   FORMAT ( 18X, 'REACTOR INLET', 11X, 'REACTOR OUTLET' /
     1    ' COMPONENT ', 5X, 'MLBS/HR', 3X, 'BBLS/HR', 8X, 'MLBS/HR',
     2    3X, 'BBLS/HR' )
C
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        SUM4 = 0.0D0
        DO 10 J = 1, 8
```

```
          SUM1 = SUM1 + CIN(J,1)
          SUM3 = SUM3 + COUT(J,1)
          WRITE (NOUT, 803)  CNAME(J), CIN(J,1), COUT(J,1)
  803     FORMAT ( 2X, A8, F13.3, F25.3 )
   10  CONTINUE
C
        X1 = 0.0D0
        X2 = 0.0D0
        X3 = 0.0D0
        X4 = 0.0D0
        DO 25 J = 9, 12
          BBLIN = 1.0D3 * CIN(J,1) / CIN(J,2)
          BBLOUT = 1.0D3 * COUT(J,1) / COUT(J,2)
          X1 = X1 + CIN(J,1)
          X2 = X2 + BBLIN
          X3 = X3 + COUT(J,1)
          X4 = X4 + BBLOUT
          WRITE (NOUT, 804)  CNAME(J), CIN(J,1), BBLIN, COUT(J,1),
     1      BBLOUT
  804     FORMAT ( 2X, A8, F13.3, F10.1, F15.3, F10.1)
   25  CONTINUE
C
C       Write the C6 - 300 F material.
        Y1 = 0.0D0
        Y2 = 0.0D0
        Y3 = 0.0D0
        Y4 = 0.0D0
        DO 20 J = 16, 19
          BBLIN = 1.0D3 * CIN(J,1) / CIN(J,2)
          BBLOUT = 1.0D3 * COUT(J,1) / COUT(J,2)
          Y1 = Y1 + CIN(J,1)
          Y2 = Y2 + BBLIN
          Y3 = Y3 + COUT(J,1)
          Y4 = Y4 + BBLOUT
   20  CONTINUE
       WRITE (NOUT, 805)  Y1, Y2, Y3, Y4
  805  FORMAT ( 2X, 'C6 - 300 F', F11.3, F10.1, F15.3, F10.1)
C
       DO 30 J = 20, 35
         IF ( CNAME(J) .EQ. BLANK8 )   GO TO 30
           BBLIN = 1.0D3 * CIN(J,1) / CIN(J,2)
           BBLOUT = 1.0D3 * COUT(J,1) / COUT(J,2)
           SUM1 = SUM1 + CIN(J,1)
           SUM2 = SUM2 + BBLIN
           SUM3 = SUM3 + COUT(J,1)
           SUM4 = SUM4 + BBLOUT
           WRITE (NOUT, 804)  CNAME(J), CIN(J,1), BBLIN, COUT(J,1),
     1       BBLOUT
   30  CONTINUE
C
       SUM1 = SUM1 + X1 + Y1
       SUM2 = SUM2 + X2 + Y2
       SUM3 = SUM3 + X3 + Y3
       SUM4 = SUM4 + X4 + Y4
       WRITE (NOUT, 806)  SUM1, SUM2, SUM3, SUM4
```

```
  806   FORMAT ( 2X, 'TOTAL', F16.3, F10.1, F15.3, F10.1)
C
C       Calculate and write the butanes.
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        SUM4 = 0.0D0
        X1 = CIN(9,1) + CIN(10,1)
        X2 = 1.0D3 * (CIN(9,1)/CIN(9,2) + CIN(10,1)/CIN(10,2))
        X3 = COUT(9,1) + COUT(10,1)
        X4 = 1.0D3 * (COUT(9,1)/COUT(9,2) + COUT(10,1)/COUT(10,2))
        SUM1 = SUM1 + X1
        SUM2 = SUM2 + X2
        SUM3 = SUM3 + X3
        SUM4 = SUM4 + X4
        WRITE (NOUT, 807)  X1, X2, X3, X4
  807   FORMAT ( / 2X, 'BUTANES', F14.3, F10.1, F15.3, F10.1 )
C
C       Calculate and write the pentanes.
        X1 = CIN(11,1) + CIN(12,1)
        X2 = 1.0D3 * (CIN(11,1)/CIN(11,2) + CIN(12,1)/CIN(12,2))
        X3 = COUT(11,1) + COUT(12,1)
        X4 = 1.0D3 * (COUT(11,1)/COUT(11,2) + COUT(12,1)/COUT(12,2))
        SUM1 = SUM1 + X1
        SUM2 = SUM2 + X2
        SUM3 = SUM3 + X3
        SUM4 = SUM4 + X4
        WRITE (NOUT, 808)  X1, X2, X3, X4
  808   FORMAT ( 2X, 'PENTANES', F13.3, F10.1, F15.3, F10.1 )
C
C       Calculate and write the C6 to 350 F material.
        X1 = 0.0D0
        X2 = 0.0D0
        X3 = 0.0D0
        X4 = 0.0D0
        DO 50 J = 16, 20
          X1 = X1 + CIN(J,1)
          X2 = X2 + 1.0D3 * CIN(J,1)/CIN(J,2)
          X3 = X3 +  COUT(J,1)
          X4 = X4 + 1.0D3 * COUT(J,1)/COUT(J,2)
   50   CONTINUE
        SUM1 = SUM1 + X1
        SUM2 = SUM2 + X2
        SUM3 = SUM3 + X3
        SUM4 = SUM4 + X4
        WRITE (NOUT, 809)  X1, X2, X3, X4
  809   FORMAT ( 2X, 'C6 - 350 F', F11.3, F10.1, F15.3, F10.1 )
        C6PBBL = X2
C
C       Calculate and write the 350 to 450 F material.
        X1 = 0.0D0
        X2 = 0.0D0
        X3 = 0.0D0
        X4 = 0.0D0
        DO 60 J = 21, 22
```

```
          X1 = X1 + CIN(J,1)
          X2 = X2 + 1.0D3 * CIN(J,1)/CIN(J,2)
          X3 = X3 +  COUT(J,1)
          X4 = X4 + 1.0D3 * COUT(J,1)/COUT(J,2)
   60   CONTINUE
        SUM1 = SUM1 + X1
        SUM2 = SUM2 + X2
        SUM3 = SUM3 + X3
        SUM4 = SUM4 + X4
        WRITE (NOUT, 810)  X1, X2, X3, X4
  810   FORMAT ( 2X, '350 - 450 F', F10.3, F10.1, F15.3, F10.1 )
        C6PBBL = C6PBBL + X2
C
C       Calculate and write the 450 to 650 F material.
        X1 = 0.0D0
        X2 = 0.0D0
        X3 = 0.0D0
        X4 = 0.0D0
        DO 70 J = 23, 26
          X1 = X1 + CIN(J,1)
          X2 = X2 + 1.0D3 * CIN(J,1)/CIN(J,2)
          X3 = X3 +  COUT(J,1)
          X4 = X4 + 1.0D3 * COUT(J,1)/COUT(J,2)
   70   CONTINUE
        SUM1 = SUM1 + X1
        SUM2 = SUM2 + X2
        SUM3 = SUM3 + X3
        SUM4 = SUM4 + X4
        WRITE (NOUT, 811)  X1, X2, X3, X4
  811   FORMAT ( 2X, '450 - 650 F', F10.3, F10.1, F15.3, F10.1 )
        C6PBBL = C6PBBL + X2
C
C       Calculate and write the 650 to 850 F material.
        X1 = 0.0D0
        X2 = 0.0D0
        X3 = 0.0D0
        X4 = 0.0D0
        DO 80 J = 27, 30
          X1 = X1 + CIN(J,1)
          X2 = X2 + 1.0D3 * CIN(J,1)/CIN(J,2)
          X3 = X3 +  COUT(J,1)
          X4 = X4 + 1.0D3 * COUT(J,1)/COUT(J,2)
   80   CONTINUE
        SUM1 = SUM1 + X1
        SUM2 = SUM2 + X2
        SUM3 = SUM3 + X3
        SUM4 = SUM4 + X4
        WRITE (NOUT, 812)  X1, X2, X3, X4
  812   FORMAT ( 2X, '650 - 850 F', F10.3, F10.1, F15.3, F10.1 )
        C6PBBL = C6PBBL + X2
C
C       Calculate and write the 850+ F material.
        X1 = 0.0D0
        X2 = 0.0D0
        X3 = 0.0D0
```

```
      X4 = 0.0D0
      DO 90 J = 31, 35
        IF ( CNAME(J) .EQ. BLANK8 )   GO TO 90
          X1 = X1 + CIN(J,1)
          X2 = X2 + 1.0D3 * CIN(J,1)/CIN(J,2)
          X3 = X3 +  COUT(J,1)
          X4 = X4 + 1.0D3 * COUT(J,1)/COUT(J,2)
   90 CONTINUE
      SUM1 = SUM1 + X1
      SUM2 = SUM2 + X2
      SUM3 = SUM3 + X3
      SUM4 = SUM4 + X4
      WRITE (NOUT, 813)  X1, X2, X3, X4
  813 FORMAT ( 2X, '850+ F', F15.3, F10.1, F15.3, F10.1 )
      C6PBBL = C6PBBL + X2
C
      WRITE (NOUT, 814)  SUM1, SUM2, SUM3, SUM4
  814 FORMAT ( 2X, 'TOTAL C4+', F12.3, F10.1, F15.3, F10.1 )
C
      WRITE (NOUT, 815)
  815 FORMAT ( / 1X, 'C6+ HETROATOM STATISTICS' /
     1  18X, 'REACTOR INLET', 11X, 'REACTOR OUTLET' /
     2  ' ELEMENT   ', 6X, 'LBS/HR', 3X, '   WT %', 9X, 'LBS/HR',
     3  3X, '   WT %', 4X, '% REMOVAL' )
C
C     Calculate and write the sulfur statistics.
      X1 = 0.0D0
      X2 = 0.0D0
      X3 = 0.0D0
      X4 = 0.0D0
      DO 100 J = 16, 35
        IF ( CNAME(J) .EQ. BLANK8 )   GO TO 100
          X1 = X1 + 0.01D0 * CIN(J,1) * CIN(J,3)
          X2 = X2 + CIN(J,1)
          X3 = X3 + 0.01D0 * COUT(J,1) * COUT(J,3)
          X4 = X4 + COUT(J,1)
  100 CONTINUE
      X2 = 100.0D0 * X1 / X2
      X4 = 100.0D0 * X3 / X4
      X1 = 1000.0D0 * X1
      X3 = 1000.0D0 * X3
      REMVAL = 100.0D0 * (X1 - X3) / X1
      WRITE (NOUT, 821)  X1, X2, X3, X4, REMVAL
  821 FORMAT ( 2X, 'SULFUR', F15.2, F10.5, F15.2, F10.5, F12.3 )
C
C     Calculate and write the nitrogen statistics.
      X1 = 0.0D0
      X2 = 0.0D0
      X3 = 0.0D0
      X4 = 0.0D0
      DO 110 J = 16, 35
        IF ( CNAME(J) .EQ. BLANK8 )   GO TO 110
          X1 = X1 + 0.01D0 * CIN(J,1) * CIN(J,4)
          X2 = X2 + CIN(J,1)
          X3 = X3 + 0.01D0 * COUT(J,1) * COUT(J,4)
```

```
            X4 = X4 + COUT(J,1)
  110    CONTINUE
         X2 = 100.0D0 * X1 / X2
         X4 = 100.0D0 * X3 / X4
         X1 = 1000.0D0 * X1
         X3 = 1000.0D0 * X3
         REMVAL = 100.0D0 * (X1 - X3) / X1
         WRITE (NOUT, 822)  X1, X2, X3, X4, REMVAL
  822    FORMAT ( 2X, 'NITROGEN', F13.2, F10.5, F15.2, F10.5, F12.3 )
C
C        Calculate and write the oxygen statistics.
         X1 = 0.0D0
         X2 = 0.0D0
         X3 = 0.0D0
         X4 = 0.0D0
         DO 120 J = 16, 35
           IF ( CNAME(J) .EQ. BLANK8 )   GO TO 120
             X1 = X1 + 0.01D0 * CIN(J,1) * CIN(J,5)
             X2 = X2 + CIN(J,1)
             X3 = X3 + 0.01D0 * COUT(J,1) * COUT(J,5)
             X4 = X4 + COUT(J,1)
  120    CONTINUE
         X2 = 100.0D0 * X1 / X2
         X4 = 100.0D0 * X3 / X4
         X1 = 1000.0D0 * X1
         X3 = 1000.0D0 * X3
         REMVAL = 100.0D0 * (X1 - X3) / X1
         WRITE (NOUT, 823)  X1, X2, X3, X4, REMVAL
  823    FORMAT ( 2X, 'OXYGEN', F15.2, F10.5, F15.2, F10.5, F12.3 )
C
C        Calculate and write the inlet hydrogen rate and chemical
C        hydrogen consumption in SCF/bbl of C6+ feed.
         H2IN = (1.0D3*SCFM / (CMWOUT(1)*C6PBBL)) * CIN(1,1)
         H2CONS = (1.0D3*SCFM / (CMWOUT(1)*C6PBBL)) * (CIN(1,1) -
     1     COUT(1,1))
         WRITE (NOUT, 830)  H2IN, H2CONS
  830    FORMAT ( / ' MAKEUP HYDROGEN RATE', F21.1, ' SCF/BBL OF C6+',
     1     ' FEED' /
     2     ' CHEMICAL HYDROGEN CONSUMPTION', F12.1, ' SCF/BBL OF C6+',
     3     ' FEED' )
C
         IF ( UNKNWN .GE. 1.0D-3 )  WRITE(NOUT, 835) UNKNWN
  835    FORMAT ( / ' *WARNING* THE FEED TO THIS PLANT CONTAINS', F8.3,
     1     ' MLBS/HR OF COMPONENT(S)' /
     2     2X, 'UNKNOWN TO THIS MODEL.  THEY ARE BEING IGNORED.  ',
     3     'THEREFORE, THE GAS-OIL' /
     3     2X, 'HYDROTREATER IS NOT IN MASS BALANCE.  PLEASE REMOVE ',
     4     'THESE EXTRA' /
     5     2X, 'COMPONENT(S) FROM THE FEED STREAM.' )
C
        WRITE (NOUT, 840)
  840   FORMAT ( 25X, '- CONTINUED ON NEXT PAGE -' )
      ENDIF
C
C
```

```
      RETURN
      END
C
C$ USR05H
      SUBROUTINE USR05H (IER1, INT1, INT2, IPASS,
     1  ITEMS, KPAGE, KTEST, NCC, NNCC, NCONV, NCCONV, NHSTRY, NOUT,
     2  SOUT1, SOUT2, SOUT3, SOUT4, SOUT5, SOUT6, SOUT7)
C
C     This subroutine splits the net gas-oil hydrotreater yields into
C     the six net product streams, loads the outlet stream vectors,
C     and writes the stream section of the summary report.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - October 19, 1992.
C
C     Calling arguments:
C     IER1    = Switch to specify if the insufficient hydrogen makeup
C               rate warning message is to be written.
C               0 => Normal - Do not write the warning message.
C               1 => Write the insufficient makeup hydrogen warning
C                    message.
C     INT1    = 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 report.
C               2 => Skip the capital cost and utilities portions of the
C                    summary report.
C               3 => Skip writing the entire user block summary report.
C     INT2    = User block summary report destination control switch.
C               0 => Write the user block summary report to the normal
C                    ASPEN/SP output report file.
C               1 => Write the user block summary report to a separate
C                    user block summary report file on logical unit 62.
C     IPASS     = The results pass flag.
C     ITEMS     = Total number of items in the SOUT1 - SOUT3 vectors.
C     KPAGE     = Switch to indicate which page of the summary report
C                 will be written when IPASS = 4.  Valid calling values
C                 are 2 (for the second page) and 3 for the third page).
C     KTEST     = Switch for controlling the printing to the history
C                 file.
C     NCC       = Number of conventional components.
C     NNCC      = Number of non-conventional components.
C     NCONV     = Offset for the conventional component substream.
C     NCCONV    = Offset for the non-conventional component substream.
C     NHSTRY    = Logical unit number of the hisory file.
C     NOUT      = Logical unit of the plant summary report file.
C     SOUT1()   = ASPEN/SP stream vector for outlet stream number 1 -
C                 the high pressure reactor purge gas stream.
C     SOUT2()   = ASPEN/SP stream vector for outlet stream number 2 -
C                 the other gas streams.
C     SOUT3()   = ASPEN/SP stream vector for outlet stream number 3 -
C                 the hydrotreated naphtha product stream.
C     SOUT4()   = ASPEN/SP stream vector for outlet stream number 4 -
C                 the hydrotreated 350 - 450 F product stream.
C     SOUT5()   = ASPEN/SP stream vector for outlet stream number 5 -
```

```
C                 the hydrotreated 450 - 650 F product stream.
C     SOUT6()  = ASPEN/SP stream vector for outlet stream number 6 -
C                the hydrotreated 650 - 850 F product stream.
C     SOUT7()  = ASPEN/SP stream vector for outlet stream number 7 -
C                the sour water stream.
C
C     Method of calculation:
C       The net yields are split into the seven net product streams
C       using component distribution factors for the last six product
C       streams (the final six streams), and all remaining material is
C       placed in the first net product stream, the reactor purge gas
C       stream.
C       The seven product streams, in order are:
C         Stream 1 - the high pressure reactor purge gas stream
C         Stream 2 - the other gas streams
C         Stream 3 - the hydrotreated naphtha product stream.
C         Stream 4 - the hydrotreated 350 - 450 F product stream.
C         Stream 5 - the hydrotreated 450 - 650 F product stream.
C         Stream 6 - the hydrotreated 650 - 850 F product stream.
C         Stream 7 - the sour water feed stream.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
C     See subroutine USR05A for a description of the items in named
C     COMMON block /USR05M/.
      COMMON /USR05M/ CIN(35,7), COUT(35,7), CUTWT(35), CMWOUT(35)
      COMMON /USR05N/ CNAME(35), ICNUMB(55)
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
      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 SOUT1(*), SOUT2(*), SOUT3(*),
     1  SOUT4(*), SOUT5(*), SOUT6(*), SOUT7(*)
C
C     Loacal variable declarations.
      DIMENSION CDF2(35), CDF3(35), CDF4(35), CDF5(35), CDF6(35),
     1  CDF7(35), S1(35), S2(35), S3(35), S4(35), S5(35), S6(35),
     2  S7(35)
      DIMENSION CDF2H(35), CDF3H(35), CDF4H(35), CDF5H(35),
     1  CDF6H(35), CDF7H(35)
C
      CHARACTER * 8  BLANK8, CNAME
C
      DATA BLANK8 / '        ' /
C
```

```
C     CDF2(J) are the component distribution factors for stream 2, the
C             lower pressure gas streams.
C     CDF3(J) are the component distribution factors for stream 3, the
C             naphtha stream.
C     CDF4(J) are the component distribution factors for stream 4, the
C             350 - 450 F stream.
C     CDF5(J) are the component distribution factors for stream 5, the
C             450 - 650 F stream.
C     CDF6(J) are the component distribution factors for stream 6, the
C             650 - 850 F stream.
C     CDF7(J) are the component distribution factors for stream 7, the
C             sour water stream.
C     S1(J) are the component flow rates in Mlbs/hr in the first
C           product stream, the high pressure reactor purge gas stream.
C     S2(J) are the component flow rates in Mlbs/hr in the second
C           product stream, the low pressure gas stream.
C     S3(J) are the component flow rates in Mlbs/hr in the third
C           product stream, the hydrotreated naphtha stream.
C     S4(J) are the component flow rates in Mlbs/hr in the fourth
C           product stream, the hydrotreated 350 - 450 F stream.
C     S5(J) are the component flow rates in Mlbs/hr in the fifth
C           product stream, the hydrotreated 450 - 650 F stream.
C     S6(J) are the component flow rates in Mlbs/hr in the sixth
C           product stream, the hydrotreated 650 - 850 F stream.
C     S7(J) are the component flow rates in Mlbs/hr in the seventh
C           product stream, the sour water stream.
C
C     Initialize the component distribution factors for the second
C     product stream, the low pressure gases stream (BASELINE).
C     Fraction of   H2       NH3       H2O       H2S       N2
      DATA CDF2 / 0.191754, 0.067045, 0.029375, 0.034783, 0.301370,
C       CH4       C2H6      C3H8      IC4H10    NC4H10
     1  0.286443, 0.488633, 0.645781, 0.750876, 0.786664,
C       IC5H12    NC5H12    Future    Future    Future
     2  0.590980, 0.590980, 0.000000, 0.000000, 0.000000,
C       T125      T175      T225      T275      T325
     3  0.073484, 0.073484, 0.073484, 0.073484, 0.073484,
C       T375      T425      T475      T525      T575
     4  0.001662, 0.001662, 0.000007, 0.000007, 0.000007,
C       T625      T675      T725      T775      T825
     5  0.000007, 0.000000, 0.000000, 0.000000, 0.000000,
C       T875      T925      T975      T1000+    Future
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for the third
C     product stream, the naphtha stream (BASELINE).
C     Fraction of   H2       NH3       H2O       H2S       N2
      DATA CDF3 / 0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CH4       C2H6      C3H8      IC4H10    NC4H10
     1  0.000000, 0.000000, 0.000000, 0.001782, 0.010749,
C       IC5H12    NC5H12    Future    Future    Future
     2  0.303005, 0.303005, 0.000000,  0.00000, 0.000000,
C       T125      T175      T225      T275      T325
     3  0.604022, 0.604022, 0.604022, 0.604022, 0.604022,
C       T375      T425      T475      T525      T575
```

```
     4  0.014920, 0.014920, 0.000000, 0.000000, 0.000000,
C       T625      T675      T725      T775      T825
     5  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T875      T925      T975      T1000+    Future
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for the fourth
C     product stream, the 350 - 450 F stream (BASELINE).
C     Fraction of   H2       NH3       H2O       H2S       N2
      DATA CDF4 / 0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CH4       C2H6      C3H8      IC4H10    NC4H10
     1  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       IC5H12    NC5H12    Future    Future    Future
     2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T125      T175      T225      T275      T325
     3  0.309746, 0.309746, 0.309746, 0.309746, 0.309746,
C       T375      T425      T475      T525      T575
     4  0.892861, 0.892861, 0.006152, 0.006152, 0.006152,
C       T625      T675      T725      T775      T825
     5  0.006152, 0.000000, 0.000000, 0.000000, 0.000000,
C       T875      T925      T975      T1000+    Future
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for the fifth
C     product stream, the 450 - 650 F stream (BASELINE).
C     Fraction of   H2       NH3       H2O       H2S       N2
      DATA CDF5 / 0.000000, 0.000000, 0.004079, 0.000000, 0.000000,
C       CH4       C2H6      C3H8      IC4H10    NC4H10
     1  0.000000, 0.004965, 0.000000, 0.000000, 0.000000,
C       IC5H12    NC5H12    Future    Future    Future
     2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
c       T125      T175      T225      T275      T325
     3  0.001293, 0.001293, 0.001293, 0.001293, 0.001293,
C       T375      T425      T475      T525      T575
     4  0.088954, 0.088954, 0.885586, 0.885586, 0.885586,
C       T625      T675      T725      T775      T825
     5  0.885586, 0.138759, 0.138759, 0.138759, 0.138759,
C       T875      T925      T975      T1000+    Future
     6  0.000488, 0.000488, 0.000488, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for the sixth
C     product stream, the 650 - 850 F stream (BASELINE).
C     Fraction of   H2       NH3       H2O       H2S       N2
      DATA CDF6 / 0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CH4       C2H6      C3H8      IC4H10    NC4H10
     1  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       IC5H12    NC5H12    Future    Future    Future
     2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T125      T175      T225      T275      T325
     3  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T375      T425      T475      T525      T575
     4  0.000000, 0.000000, 0.108168, 0.108168, 0.108168,
C       T625      T675      T725      T775      T825
     5  0.108168, 0.861241, 0.861241, 0.861241, 0.861241,
C       T875      T925      T975      T1000+    Future
```

```
     6  0.999512, 0.999512, 0.999512, 1.000000, 1.000000 /
C
C     Initialize the component distribution factors for the seventh
C     product stream, the sour water stream (BASELINE).
C     Fraction of   H2        NH3        H2O        H2S        N2
      DATA CDF7 / 0.000000, 0.901136, 0.949364, 0.956522, 0.000000,
C       CH4       C2H6       C3H8       IC4H10     NC4H10
     1  0.000486, 0.000261, 0.000168, 0.000000, 0.000000,
C       IC5H12    NC5H12     Future     Future     Future
     2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T125      T175       T225       T275       T325
     3  0.000462, 0.000462, 0.000462, 0.000462, 0.000462,
C       T375      T425       T475       T525       T575
     4  0.001388, 0.001388, 0.000086, 0.000086, 0.000086,
C       T625      T675       T725       T775       T825
     5  0.000086, 0.000000, 0.000000, 0.000000, 0.000000,
C       T875      T925       T975       T1000+     Future
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C     THE HIGH SPACE VELOCITY CASE DISTRIBUTION FACTORS.
C     Initialize the component distribution factors for the second
C     product stream, the low pressure gases stream (HIGH SPACE
C     VELOCITY CASE).
C     Fraction of   H2        NH3        H2O        H2S        N2
      DATA CDF2H/ 0.849268, 0.094931, 0.016593, 0.060000, 0.989899,
C       CH4       C2H6       C3H8       IC4H10     NC4H10
     1  0.893473, 0.954057, 0.971146, 0.975447, 0.975447,
C       IC5H12    NC5H12     Future     Future     Future
     2  0.150152, 0.150152, 0.000000, 0.000000, 0.000000,
C       T125      T175       T225       T275       T325
     3  0.150152, 0.150152, 0.150152, 0.150152, 0.150152,
C       T375      T425       T475       T525       T575
     4  0.000990, 0.000990, 0.000015, 0.000015, 0.000015,
C       T625      T675       T725       T775       T825
     5  0.000015, 0.000000, 0.000000, 0.000000, 0.000000,
C       T875      T925       T975       T1000+     Future
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for the third
C     product stream, the naphtha stream (HIGH SPACE VELOCITY CASE).
C     Fraction of   H2        NH3        H2O        H2S        N2
      DATA CDF3H/ 0.000000, 0.000000, 0.000052, 0.000000, 0.000000,
C       CH4       C2H6       C3H8       IC4H10     NC4H10
     1  0.000000, 0.000000, 0.000000, 0.007351, 0.007351,
C       IC5H12    NC5H12     Future     Future     Future
     2  0.805642, 0.805642, 0.000000,  0.00000, 0.000000,
C       T125      T175       T225       T275       T325
     3  0.805642, 0.805642, 0.805642, 0.805642, 0.805642,
C       T375      T425       T475       T525       T575
     4  0.002476, 0.002476, 0.000000, 0.000000, 0.000000,
C       T625      T675       T725       T775       T825
     5  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T875      T925       T975       T1000+     Future
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
```

```
C     Initialize the component distribution factors for the fourth
C     product stream, the 350 - 450 F stream (HIGH SPACE VELOCITY CASE).
C     Fraction of   H2        NH3        H2O        H2S        N2
      DATA CDF4H/ 0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CH4       C2H6       C3H8       IC4H10     NC4H10
     1  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       IC5H12    NC5H12     Future     Future     Future
     2  0.015984, 0.015984, 0.000000, 0.000000, 0.000000,
C       T125      T175       T225       T275       T325
     3  0.015984, 0.015984, 0.015984, 0.015984, 0.015984,
C       T375      T425       T475       T525       T575
     4  0.786979, 0.786979, 0.025110, 0.025110, 0.025110,
C       T625      T675       T725       T775       T825
     5  0.025110, 0.000000, 0.000000, 0.000000, 0.000000,
C       T875      T925       T975       T1000+     Future
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for the fifth
C     product stream, the 450 - 650 F stream (HIGH SPACE VELOCITY CASE).
C     Fraction of   H2        NH3        H2O        H2S        N2
      DATA CDF5H/ 0.000000, 0.000000, 0.004982, 0.000000, 0.000000,
C       CH4       C2H6       C3H8       IC4H10     NC4H10
     1  0.000000, 0.004965, 0.000000, 0.000000, 0.000000,
C       IC5H12    NC5H12     Future     Future     Future
     2  0.026099, 0.026099, 0.000000, 0.000000, 0.000000,
c       T125      T175       T225       T275       T325
     3  0.026099, 0.026099, 0.026099, 0.026099, 0.026099,
C       T375      T425       T475       T525       T575
     4  0.209495, 0.209495, 0.701948, 0.701948, 0.701948,
C       T625      T675       T725       T775       T825
     5  0.701948, 0.051711, 0.051711, 0.051711, 0.051711,
C       T875      T925       T975       T1000+     Future
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for the sixth
C     product stream, the 650 - 850 F stream (HIGH SPACE VELOCITY CASE).
C     Fraction of   H2        NH3        H2O        H2S        N2
      DATA CDF6H/ 0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CH4       C2H6       C3H8       IC4H10     NC4H10
     1  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       IC5H12    NC5H12     Future     Future     Future
     2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T125      T175       T225       T275       T325
     3  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T375      T425       T475       T525       T575
     4  0.000040, 0.000040, 0.272927, 0.272927, 0.272927,
C       T625      T675       T725       T775       T825
     5  0.272927. 0.948289. 0.948289, 0.948289, 0.948289,
C       T875      T925       T975       T1000+     Future
     6  1.000000, 1.000000, 1.000000, 1.000000, 1.000000 /
C
C     Initialize the component distribution factors for the seventh
C     product stream, the sour water stream (HIGH SPACE VELOCITY CASE).
C     Fraction of   H2        NH3        H2O        H2S        N2
      DATA CDF7H/ 0.000000, 0.903132, 0.978294, 0.940000, 0.000000,
```

```
C       CH4       C2H6      C3H8      IC4H10    NC4H10
     1  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       IC5H12    NC5H12    Future    Future    Future
     2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T125      T175      T225      T275      T325
     3  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T375      T425      T475      T525      T575
     4  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T625      T675      T725      T775      T825
     5  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T875      T925      T975      T1000+    Future
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
      DATA SCFM / 379.495D0 /
C
C
C     If this is the results pass, decide which page of the summary
C     report will be written.
      IF ( IPASS .EQ. 4 .AND. KPAGE .EQ. 3 )  GOTO 300
C                                             --------
C       KPAGE = 2 - Do the splitting calculations and write the second
C                   page of the sumary report.
C
        IF ( KTEST .GE. 3 )   WRITE (NHSTRY, 701)  MODE
  701   FORMAT ( / ' Starting the gas-oil hydrotreater separation',
     1    ' calculations in Subroutine USR05H.' /
     2    ' for Plant 2 reactor MODE = ', I5 )
C
C       If this is the HIGH SPACE VELOCITY Option, load the
C       appropriate separation factors.
        IF ( MODE .EQ. 18 )  THEN
          DO 10 J = 1, 35
            CDF2(J) = CDF2H(J)
            CDF3(J) = CDF3H(J)
            CDF4(J) = CDF4H(J)
            CDF5(J) = CDF5H(J)
            CDF6(J) = CDF6H(J)
            CDF7(J) = CDF7H(J)
   10     CONTINUE
        ENDIF
C
        IF ( KTEST .GE. 2 )   THEN
          WRITE (NHSTRY, 702)
  702     FORMAT ( / ' The component product distribution factors:' /
     1      ' No.', 3X, 'Component', 5X, 'LP Gas', 5X, 'C6-350F',
     2      4X, '350-450F', 4X, '450-650F', 4X, '650-850F',
     3      4X, 'Sour H2O')
          DO 20 J = 1, 35
            IF ( CNAME(J) .EQ. BLANK8 )   GO TO 20
              WRITE (NHSTRY, 703)  J, CNAME(J), CDF2(J), CDF3(J),
     1          CDF4(J), CDF5(J), CDF6(J), CDF7(J)
  703       FORMAT ( 1X, I3, 3X, A8, 6F12.6 )
   20       CONTINUE
          WRITE (NHSTRY, 704)
  704     FORMAT ( 2X, '* The gas stream component distribution',
```

```
     1      ' factors are calculated by difference.' )
          ENDIF
C
C         Distribute the net unit yields among the seven product streams.
          SUMC = 0.0D0
          SUM1 = 0.0D0
          SUM2 = 0.0D0
          SUM3 = 0.0D0
          SUM4 = 0.0D0
          SUM5 = 0.0D0
          SUM6 = 0.0D0
          SUM7 = 0.0D0
          DO 30 J = 1, 35
            X = CDF2(J) + CDF3(J) + CDF4(J) + CDF5(J) + CDF6(J) + CDF7(J)
            IF ( X .GT. 1.0000001D0 )  THEN
C             The component distributions factors for this component are
C             greater than 1.0.  Therefore, adjust the distribution so
C             that this component is distributed in the same ratio as the
C             specified component distribution factors, and write a
C             warning message.
              IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 705) IPASS
  705         FORMAT ( // 1X, 'Plant 5 - Supplementary data',
     1          ' from subroutine USR05' /
     2          2X, 'the gas-oil hydrotreater', 20X, 'IPASS =', I3 /)
              WRITE (NHSTRY, 706)  J, CNAME(J), CDF2(J), CDF3(J),
     1          CDF4(J), CDF5(J), CDF6(J), CDF7(J)
  706         FORMAT ( / 1X, '* WARNING * - The component product ',
     1          'distribution factors for component no.', I3 /
     2          3X, A8, ' sum to a total greater than 1.0.  They are' /,
     3          3X, 6F12.6 /
     4          3X, 'They will be normalized to 1.0.' //
     4          3X, 'Please correct this problem in the next run.  ',
     5          'Execution is continuing.' / )
              CDF2(J)  = CDF2(J) / X
              CDF3(J)  = CDF3(J) / X
              CDF4(J)  = CDF4(J) / X
              CDF5(J)  = CDF5(J) / X
              CDF6(J)  = CDF6(J) / X
              CDF7(J)  = CDF7(J) / X
            ENDIF
            CMLBS = COUT(J,1)
            S2(J) = CDF2(J) * CMLBS
            S3(J) = CDF3(J) * CMLBS
            S4(J) = CDF4(J) * CMLBS
            S5(J) = CDF5(J) * CMLBS
            S6(J) = CDF6(J) * CMLBS
            S7(J) = CDF7(J) * CMLBS
            S1(J) = CMLBS - S2(J) - S3(J) - S4(J) - S5(J) - S6(J) - S7(J)
            SUMC = SUMC + CMLBS
            SUM1 = SUM1 + S1(J)
            SUM2 = SUM2 + S2(J)
            SUM3 = SUM3 + S3(J)
            SUM4 = SUM4 + S4(J)
            SUM5 = SUM5 + S5(J)
            SUM6 = SUM6 + S6(J)
```

```
          SUM7 = SUM7 + S7(J)
   30   CONTINUE
C
        IF ( KTEST .GE. 3 )   THEN
          WRITE (NHSTRY, 707)
  707     FORMAT ( / ' Total net stream flows leaving plant 5 ',
     1      'in Mlbs/hr:' /
     2      ' No.', 1X, 'Component', 4X, 'Total', 4X, 'HP Gas',
     3      4X, 'LP Gas', 3X, 'C6-350F', 2X, '350-450F',
     4      2X, '450-650F', 2X, '650-850F', 2X, 'Sour H2O' )
          DO 40 J = 1, 35
            IF ( CNAME(J) .EQ. BLANK8 )   GO TO 40
              WRITE (NHSTRY, 708)  J, CNAME(J), COUT(J,1), S1(J),
     1          S2(J), S3(J), S4(J), S5(J), S6(J), S7(J)
  708         FORMAT ( 1X, I3, 1X, A8, 8F10.3 )
   40     CONTINUE
          WRITE (NHSTRY, 709)  SUMC, SUM1, SUM2, SUM3, SUM4, SUM5, SUM6
  709     FORMAT ( 5X, 'Total', 3X, 7F10.3 )
        ENDIF
C
C
        IF ( IPASS .NE. 4 )   THEN
C         Set up the product stream properties in the SOUT vectors.
C         ==========================================================
C         First, zero all the items in the product stream vectors.
          DO 200 J = 1, ITEMS
            SOUT1(J) = 0.0D0
            SOUT2(J) = 0.0D0
            SOUT3(J) = 0.0D0
            SOUT4(J) = 0.0D0
            SOUT5(J) = 0.0D0
            SOUT6(J) = 0.0D0
            SOUT7(J) = 0.0D0
  200     CONTINUE
C
C         CF is the conversion factor from Kg/sec to Mlbs/hr.
          CF = 0.001D0 * 3600.0D0 / 0.45359237D0
C
C         Set the molar flow rates of the conventional components.
          SUM1 = 0.0D0
          SUM2 = 0.0D0
          SUM3 = 0.0D0
          SUM4 = 0.0D0
          SUM5 = 0.0D0
          SUM6 = 0.0D0
          SUM7 = 0.0D0
          DO 210 J = 1, NCC
            DO 208 K = 1, 35
              K1 = K
              IF ( K .GE. 15 )  K1 = K + 20
              IF ( J .EQ. ICNUMB(K1) )  THEN
                SOUT1(J) = S1(K) / (CF * CMWOUT(K))
                SOUT2(J) = S2(K) / (CF * CMWOUT(K))
                SOUT3(J) = S3(K) / (CF * CMWOUT(K))
                SOUT4(J) = S4(K) / (CF * CMWOUT(K))
```

```
                SOUT5(J) = S5(K) / (CF * CMWOUT(K))
                SOUT6(J) = S6(K) / (CF * CMWOUT(K))
                SOUT7(J) = S7(K) / (CF * CMWOUT(K))
                SUM1 = SUM1 + SOUT1(J)
                SUM2 = SUM2 + SOUT2(J)
                SUM3 = SUM3 + SOUT3(J)
                SUM4 = SUM4 + SOUT4(J)
                SUM5 = SUM5 + SOUT5(J)
                SUM6 = SUM6 + SOUT6(J)
                SUM7 = SUM7 + SOUT7(J)
                GO TO 210
              ENDIF
  208       CONTINUE
  210     CONTINUE
C
C         Set the total molar flow rates of the conventional components.
          SOUT1(NCC+1) = SUM1
          SOUT2(NCC+1) = SUM2
          SOUT3(NCC+1) = SUM3
          SOUT4(NCC+1) = SUM4
          SOUT5(NCC+1) = SUM5
          SOUT6(NCC+1) = SUM6
          SOUT7(NCC+1) = SUM7
C
C         Since there are no non-conventional components leaving this
C         model, nothing needs to be done with them since their flow
C         rates and properties already have been set to zero.
C
C         Set the default temperature and pressure of the outlet
C         streams to 70 F and 15 PSIA.  Return these values to ASPEN/SP
C         in degrees Kelvin and Pascals.  These default values can be
C         overriden by the FLASH-SPECS sentence in the ASPEN/SP input
C         file.
          SOUT1(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
          SOUT1(NCC+3) = 15.0D0 * 6.8947573D+3
          SOUT2(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
          SOUT2(NCC+3) = 15.0D0 * 6.8947573D+3
          SOUT3(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
          SOUT3(NCC+3) = 15.0D0 * 6.8947573D+3
          SOUT4(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
          SOUT4(NCC+3) = 15.0D0 * 6.8947573D+3
          SOUT5(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
          SOUT5(NCC+3) = 15.0D0 * 6.8947573D+3
          SOUT6(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
          SOUT6(NCC+3) = 15.0D0 * 6.8947573D+3
          SOUT7(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
          SOUT7(NCC+3) = 15.0D0 * 6.8947573D+3
C
          IF ( NNCC .GT. 0 )   THEN
C           If present, set some overall stream properties of the
C           non-conventional component substream.
            SOUT1(NCONV+NNCC+9) = 1.0D0
            SOUT2(NCONV+NNCC+9) = 1.0D0
            SOUT3(NCONV+NNCC+9) = 1.0D0
            SOUT4(NCONV+NNCC+9) = 1.0D0
```

```
            SOUT5(NCONV+NNCC+9) = 1.0D0
            SOUT6(NCONV+NNCC+9) = 1.0D0
            SOUT7(NCONV+NNCC+9) = 1.0D0
            SOUT1(NCONV+NNCC+2) = SOUT1(NCC+2)
            SOUT1(NCONV+NNCC+3) = SOUT1(NCC+3)
            SOUT2(NCONV+NNCC+2) = SOUT2(NCC+2)
            SOUT2(NCONV+NNCC+3) = SOUT2(NCC+3)
            SOUT3(NCONV+NNCC+2) = SOUT3(NCC+2)
            SOUT3(NCONV+NNCC+3) = SOUT3(NCC+3)
            SOUT4(NCONV+NNCC+2) = SOUT4(NCC+2)
            SOUT4(NCONV+NNCC+3) = SOUT4(NCC+3)
            SOUT5(NCONV+NNCC+2) = SOUT5(NCC+2)
            SOUT5(NCONV+NNCC+3) = SOUT5(NCC+3)
            SOUT6(NCONV+NNCC+2) = SOUT6(NCC+2)
            SOUT6(NCONV+NNCC+3) = SOUT6(NCC+3)
            SOUT7(NCONV+NNCC+2) = SOUT7(NCC+2)
            SOUT7(NCONV+NNCC+3) = SOUT7(NCC+3)
          ENDIF
C
C         Call subroutine CPACK and funcion AVEMW to calculate the
C         average molecular weight of the conventional components in
C         all the product streams.
          CALL CPACK (SOUT1, NCP, IDX, XPACK, TMASS)
          SOUT1(NCC+9) = AVEMW (NCP, IDX, XPACK)
          CALL CPACK (SOUT2, NCP, IDX, XPACK, TMASS)
          SOUT2(NCC+9) = AVEMW (NCP, IDX, XPACK)
          CALL CPACK (SOUT3, NCP, IDX, XPACK, TMASS)
          SOUT3(NCC+9) = AVEMW (NCP, IDX, XPACK)
          CALL CPACK (SOUT4, NCP, IDX, XPACK, TMASS)
          SOUT4(NCC+9) = AVEMW (NCP, IDX, XPACK)
          CALL CPACK (SOUT5, NCP, IDX, XPACK, TMASS)
          SOUT5(NCC+9) = AVEMW (NCP, IDX, XPACK)
          CALL CPACK (SOUT6, NCP, IDX, XPACK, TMASS)
          SOUT6(NCC+9) = AVEMW (NCP, IDX, XPACK)
          CALL CPACK (SOUT7, NCP, IDX, XPACK, TMASS)
          SOUT7(NCC+9) = AVEMW (NCP, IDX, XPACK)
C
C         If requested, write the items of interest in the outlet
C         stream vectors to the history file.
          IF ( KTEST .GE. 5 )  THEN
            WRITE (NHSTRY, 711)
  711       FORMAT ( // ' The outlet stream vectors' /
     1        11X, 'SOUT1', 9X, 'SOUT2', 9X, 'SOUT3', 9X, 'SOUT4', 9X,
     2        'SOUT5', 9X, 'SOUT6', 9X, 'SOUT7')
            DO 230 J = 1, ITEMS
              WRITE (NHSTRY, 712) J, SOUT1(J), SOUT2(J), SOUT3(J),
     1          SOUT4(J), SOUT5(J), SOUT6(J), SOUT7(J)
  712         FORMAT ( 1X, I5, 7(1PE14.5) )
  230       CONTINUE
          ENDIF
        ENDIF
C
C
        IF ( IPASS .EQ. 4 .AND. INT1 .LE. 0 )  THEN
C         Write the stream section of the plant summary report.
```

```
C         ==================================================
          WRITE (NOUT, 801)
  801     FORMAT ( / 21X, 'PLANT 5 - SUMMARY REPORT (CONTINUED)' /
     1      29X, 'GAS-OIL HYDROTREATER' //
     2      32X, 'STREAM SUMMARY' )
C
          WRITE (NOUT, 802)
  802     FORMAT ( / '  INLET AND OUTLET STREAMS, MLBS/HR')
C
C         Write the net inlet and the first three outlet stream flow
C         rates in Mlbs/hr.
          WRITE (NOUT, 803)
  803     FORMAT ( / 19X, 'TOTAL' /
     1      4X, 'COMPONENT', 6X, 'INLET', 8X, 'RX GAS',
     2      7X, 'GASES', 5X, 'NAPHTHA' )
          DO 250 J = 1, 35
            IF ( CNAME(J) .EQ. BLANK8 )   GO TO 250
              WRITE (NOUT, 804) CNAME(J), CIN(J,1), S1(J), S2(J),
     1          S3(J)
  804         FORMAT ( 4X, A8, F12.3, F14.3, 2F12.3 )
  250     CONTINUE
C
C         Calculate and write the total flow rates in Mlbs/hr, the
C         total gas flow rate in MM SCF/hr, and the hydrocarbon flow
C         rates in bbl/hr.
          SUMC = 0.0D0
          SUM1 = 0.0D0
          SUM2 = 0.0D0
          SUM3 = 0.0D0
          GAS1 = 0.0D0
          GAS2 = 0.0D0
          X3 = 0.0D0
          DO 260 J = 1, 35
            IF ( CNAME(J) .EQ. BLANK8 )   GO TO 260
              SUMC = SUMC + CIN(J,1)
              SUM1 = SUM1 + S1(J)
              SUM2 = SUM2 + S2(J)
              SUM3 = SUM3 + S3(J)
              GAS1 = GAS1 + S1(J) / CMWOUT(J)
              GAS2 = GAS2 + S2(J) / CMWOUT(J)
              X3 = X3 + S3(J) / COUT(J,2)
  260     CONTINUE
C         Convert the gas flow rate from M lb-moles/hr to MM SCF/hr.
          SCF1 = 0.001D0 * SCFM * GAS1
          SCF2 = 0.001D0 * SCFM * GAS2
C         Convert the hydrocarbon stream flow rate to bbl/hr.
          X3 = 1.0D+3 * X3
C
          WRITE (NOUT, 805) SUMC, SUM1, SUM2, SUM3
  805     FORMAT ( 4X, 'TOTAL', 1X, 2F14.3, 2F12.3 )
          WRITE (NOUT, 806) SCF1, SCF2, X3
  806     FORMAT ( / 4X, 'FLOW, MM SCF/HR', F19.3, F12.3 /
     1      4X, 'FLOW, BBL/HR ', F45.3 )
C
C       Calculate and write the NAPHTHA product properties.
```

```
      TS3 = 0.0D0
      TN3 = 0.0D0
      TO3 = 0.0D0
      DO 270 J = 1, 35
        TS3 = TS3 + S3(J) * COUT(J,3)
        TN3 = TN3 + S3(J) * COUT(J,4)
        TO3 = TO3 + S3(J) * COUT(J,5)
  270 CONTINUE
      IF ( SUM3 .NE. 0.0D0 )  THEN
        TS3 = 1.0D+4 * TS3 / SUM3
        TN3 = 1.0D+4 * TN3 / SUM3
        TO3 = 1.0D+4 * TO3 / SUM3
      ENDIF
      WRITE (NOUT, 807) TS3, TN3, TO3
  807 FORMAT ( / 4X, 'SULFUR, WT PPM', F44.1 /
     1  4X, 'NITROGEN, WT PPM', F42.1 /
     2  4X, 'OXYGEN, WT PPM', F44.1 )
C
        WRITE (NOUT, 809)
  809   FORMAT (/16X,'- OUTLET STREAMS ARE CONTINUED ON NEXT PAGE -')
      ENDIF
      GOTO 999
C     --------
C
C    KPAGE = 3 - Only write the third page of the summary report, the
C    second page of the stream summaries.
C
  300 CONTINUE
      WRITE (NOUT, 801)
C
      WRITE (NOUT, 812)
  812 FORMAT ( / '  OUTLET STREAMS (CONTINUED), MLBS/HR')
C
C    Write the final three outlet stream flow rates in Mlbs/hr.
      WRITE (NOUT, 813)
  813 FORMAT ( / 4X, 'COMPONENT', 12X, '350-450F', 3X, '450-650F',
     1  3X, '650-850F', 3X, 'SOUR-H2O' )
C
      DO 310 J = 1, 35
        IF ( CNAME(J) .EQ. BLANK8 )   GO TO 310
          WRITE (NOUT, 814) CNAME(J), S4(J), S5(J), S6(J), S7(J)
  814     FORMAT ( 4X, A8, 2X, F19.3, 3F11.3 )
  310 CONTINUE
C
C    Calculate and write the total flow rates in Mlbs/hr, the
C    hydrocarbon flow rates in bbl/hr, and the sour water flow rate
C    in gal/min.
      SUM4 = 0.0D0
      SUM5 = 0.0D0
      SUM6 = 0.0D0
      SUM7 = 0.0D0
      X4 = 0.0D0
      X5 = 0.0D0
      X6 = 0.0D0
      SOUR = 0.0D0
```

```
      DO 360 J = 1, 35
        IF ( CNAME(J) .EQ. BLANK8 )   GO TO 360
          SUM4 = SUM4 + S4(J)
          SUM5 = SUM5 + S5(J)
          SUM6 = SUM6 + S6(J)
          SUM7 = SUM7 + S7(J)
          X4 = X4 + S4(J) / COUT(J,2)
          X5 = X5 + S5(J) / COUT(J,2)
          X6 = X6 + S6(J) / COUT(J,2)
          SOUR = SOUR + S7(J) / COUT(J,2)
  360 CONTINUE
C     Convert the hydrocarbon stream flow rates to bbl/hr.
      X4 = 1.0D+3 * X4
      X5 = 1.0D+3 * X5
      X6 = 1.0D+3 * X6
C     Convert the sour water flow rate from Mbbls/hr to gal/min.
      SOUR = 42.0D0 * 1.0D+3 * SOUR / 60.0D0
C
      WRITE (NOUT, 815) SUM4, SUM5, SUM6, SUM7
  815 FORMAT ( 4X, 'TOTAL', 5X, F19.3, 3F11.3 )
      WRITE (NOUT, 816) X4, X5, X6, SOUR
  816 FORMAT ( / 4X, 'FLOW, BBL/HR', F17.3, 2F11.3 /
     1  4X, 'FLOW, GAL/MIN', F49.3 )
C
C     Calculate and write the 350-450, 450-650 and 650-850 F product
C     properties.
      TS2 = 0.0D0
      TN2 = 0.0D0
      TO2 = 0.0D0
      TS3 = 0.0D0
      TN3 = 0.0D0
      TO3 = 0.0D0
      TS4 = 0.0D0
      TN4 = 0.0D0
      TO4 = 0.0D0
      DO 370 J = 1, 35
        IF ( CNAME(J) .EQ. BLANK8 )   GO TO 370
          TS2 = TS2 + S4(J) * COUT(J,3)
          TN2 = TN2 + S4(J) * COUT(J,4)
          TO2 = TO2 + S4(J) * COUT(J,5)
          TS3 = TS3 + S5(J) * COUT(J,3)
          TN3 = TN3 + S5(J) * COUT(J,4)
          TO3 = TO3 + S5(J) * COUT(J,5)
          TS4 = TS4 + S6(J) * COUT(J,3)
          TN4 = TN4 + S6(J) * COUT(J,4)
          TO4 = TO4 + S6(J) * COUT(J,5)
  370 CONTINUE
      TS2 = 1.0D+4 * TS2 / SUM4
      TN2 = 1.0D+4 * TN2 / SUM4
      TO2 = 1.0D+4 * TO2 / SUM4
      TS3 = 1.0D+4 * TS3 / SUM5
      TN3 = 1.0D+4 * TN3 / SUM5
      TO3 = 1.0D+4 * TO3 / SUM5
      TS4 = 1.0D+4 * TS4 / SUM6
      TN4 = 1.0D+4 * TN4 / SUM6
```

```
      TO4 = 1.0D+4 * TO4 / SUM6
      WRITE (NOUT, 817) TS2, TS3, TS4, TN2, TN3, TN4, TO2, TO3, TO4
  817 FORMAT ( / 4X, 'SULFUR, WT PPM', F15.1, 2F11.1 /
     1  4X, 'NITROGEN, WT PPM', F13.1, 2F11.1 /
     2  4X, 'OXYGEN, WT PPM', F15.1, 2F11.1 )
C
C
      IF ( IER1 .GE. 1 )   WRITE (NOUT, 821)
  821 FORMAT ( / ' *WARNING* INSUFFICIENT MAKEUP HYDROGEN HAS BEEN ',
     1  'SUPPLIED TO THE' /
     2  2X, 'GAS-OIL HYDROTREATER.  SUFFICIENT MAKEUP HYDROGEN HAS ',
     3  'BEEN ASSUMED. ' /
     4  2X, 'THE GAS OIL HYDROTREATER IS NOT IN MASS BALANCE.' )
C
C
      WRITE (NOUT, 831)
  831 FORMAT ( / 25X, '- CONTINUED ON NEXT PAGE -' )
C
  999 RETURN
      END
C
C$  Subroutine USR61
C
C     This file contains the following subroutines:
C       USR61    Main routine for Plant 6.1, hydrogen purification by
C                membrane permeation, the high pressure section of
C                Plant 6.
C       USR61A   Subroutine to simulate the high pressure section of
C                the hydrogen purification plant, hudrogen purification
C                by membrane permeation.
C       USR61B   Subroutine to load the three product streams into the
C                outlet stream vectors.
C       USR61S   Subroutine to write the first part of the plant
C                summary report for hydrogen purification by membrane
C                permeation plant.
C
C     NOTE:  To save space, this model uses named common block COMMON
C            /USR02M/.
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 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       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$ USR61
      SUBROUTINE USR61 (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:  USR61
C
C  BLOCK DESCRIPTION:  Plant 6.1, Hydrogen Purification by Membrane
C                      Permeation Plant.
C
C        Hydrogen Purification by Membrane Permeation Plant
C
C                      --------------------
C                      |                  |
C                      |    Plant 6.1     |
C           Total      |                  |-----> H2-rich gas
C            Gas ---->|     Hydrogen     |
C           Feed       |   Purification   |-----> Sour gas
C                      |    by Membrane   |
C                      |    Permeation    |-----> Reject gas
C                      |                  |       (non-permeate gas)
C                      --------------------
C
C
C  Prepared under DOE contract no. DE-AC22 90PC89857.
C
C  FUNCTION (MODEL, REPORT, OR BOTH):  Both
C
C  Last revision - May 29, 1992.
C
C  ASSUMPTIONS, SPECIAL FEATURES AND LIMITATIONS:
C     1.  The model has a single inlet stream, the high pressure
C         off-gas from the coal liquefaction plant.
C     2.  The three outlet streams are 1. The H2-rich Product Gas
C                                          Stream.
C                                      2. The Sour Gas Stream.
C                                      3. The Reject (non-permeate) Gas
C                                          Stream.
C     3.  This user block model will work with any number of
C         conventional and non-conventional components.
C     4.  The input stream to this model and all output streams from
C         this model must be of the same ASPEN/SP stream class.  Only
C         the following three ASPEN/SP stream classes can be used;
C         CONVENTIONAL, MIXNC or MIXNCPSD.
C     5.  All non-conventional components must have the PROXANAL,
C         ULTANAL, SULFANAL AND AOXANAL component attributes.
C     6.  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, any ATTR-COMPS statements in
C         the input file must be like to the following one for COAL.
C           ATTR-COMPS COAL   PROXANAL ULTANAL SULFANAL AOXANAL
C     7.  Any non-conventional components entering in the input stream
C         will be ignored and lost in the process.  In this case,
C         Plant 6.1 will not be in mass balance.
C     8.  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 DCL61.REP.
C          INT(3)  = Number of operating duplicate trains, excluding
C                    spares.
C                    If INT(3) = 0, the minimum number of duplicate
C                      trains will be determined so that the capacity
C                      each train does not exceed the maximum train
C                      capacity specified by variable REAL(52).
C                    If INT(3) > 0, this number of duplicate trains will
C                      be used.
C          INT(4)  = History file additional output control switch.
C                    0 => Write no additional output to the history 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      9.  The 70 real parameters are:
C          REAL(1)   = Percent hydrogen recovery to the hydrogen-rich
C                      product gas stream from the inlet gas stream.
C          REAL(2)   = Concentration of hydrogen in the hydrogen-rich
C                      product gas stream, mole % or vol%.
C          REAL(3) -
C           REAL(20) = Future use.
C          REAL(21)  = Constant factor for the power consumption, kw.
C          REAL(22)  = Power consumption per MM SCF/hr of H2 recovered,
C                      kw/(MM SCF/hr of H2 recovered)
C          REAL(23)  = Constant factor for the 900 psig / 750 F steam
C                      consumption, Mlbs/hr.
C          REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr
C                      of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2
C                      recovered).
C          REAL(25)  = Constant factor for the 900 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr
C                      of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2
C                      recovered).
C          REAL(27)  = Constant factor for the 600 psig / 720 F steam
C                      consumption, Mlbs/hr.
C          REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr
C                      of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2
C                      recovered).
```

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

```
C          REAL(70) = 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.  200+ F       All conventional components not listed above.
C
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5)
C
C     In COMMON /USR02M/
C       CIN(J) contains the component flow rates entering Plant 6.1.
C       COUT(J) contains the component flow rates leaving Plant 6.1.
C       CPROP(J,K) contains the conventional component properties.
C         Note to save space, the CPROP(40,7) array in nammed COMMON
C          /USR02M/ is used to store the following
C         CPROP(J,1) = Vector of component molecular weights.
C         CPROP(J,2) = Not used.
C         CPROP(J,3) = Vector of component flow rates in the sour gas
```

```
C                       product stream that is produced by combining the
C                       material removed in the water washing and amine
C                       scrubbing steps in lbs/hr.
C          CPROP(J,4) = Vector of component flow rates in the non-
C                       permeate product stream; i.e., all the other
C                       entering material not leaving in the H2-rich and
C                       sour gas product gas streams in lbs/hr.
C          CPROP(J,5) = Not used.
C          CPROP(J,6) = Not used.
C          CPROP(J,7) = Not used.
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
C     Local variable declaration statements.
      DIMENSION ICN(2), ICNAME(100)
C
      CHARACTER * 4  BLANK4, ICN, ICNAME
      CHARACTER * 6  PNAME
C
C     Initialize the component identifications.
      DATA KMAXC / 20 /
      DATA KOMPS / 19 /
      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  '200+', ' F  ',  60 * '    ' /
C
      DATA PNAME / '6.1   ' /
C
C
C     PARAMETER INITIALIZATION SECTION
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)
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 6.1 - Supplementary data from ',
     1    'subroutine USR61' /
     2    2X, 'The Hydrogen Purification by Membrane Permeation Plant',
     3    10X, '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 Hydrogen Purification by ',
     1    'Membrane Permeation Plant' /
     2    3X, 'requires only one inlet stream.  It currently has', I4,
     3    ' inlet streams.' //
     4    3X, 'Please correct this problem and try again.' //
     5    3X, 'EXECUTION IS BEING TERMINATED.' / )
        STOP
      ENDIF
C
C     Check to insure that there are exactly 3 outlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSOUT .NE. 3 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501) IPASS
        WRITE (NHSTRY, 503)  NSOUT
  503   FORMAT ( / 1X, '* ERROR * - The Hydrogen Purification by ',
     1    'Membrane Permeation Plant' /
     2    3X, 'requires exactly three outlet streams.  It currently ',
     3    'has', I4, ' outlet streams.' //
     4    3X, 'Please correct this problem and try again.' //
     5    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 = 1

C     Set CF, the conversion factor from Kg/sec to lbs/hr.
      CF = 3600.0D0 / 0.45359237D0
C
      IER1 = 0
      IF ( NSUBS .GE. 2 .AND. ITYPE(2) .EQ. 3 )  THEN
        KLASS = 2
        IF ( NNCC .GE. 1 )  THEN
          K = NCC + 9 + NNCC + 1
          SOLIDS = CF * SIN1(K)
          IF ( SOLIDS .GE. 1.0D0)  THEN
            IER1 = 1
            IF ( KTEST .LE. 0 )  WRITE (NHSTRY, 501)  IPASS
            WRITE (NHSTRY, 504) SOLIDS
  504       FORMAT (/ 1X, '* WARNING * The feed stream to the ',
     1        'hydrogen purification by membrane' /
     2        3x, 'permeation plant contains solids, ', F10.1,
     3        ' lbs/hr.  These solids' /
     3        3X, 'will be lost in the process.  Please ',
     4        'remove these solids from the feed' /
```

```
     5        3X, 'stream to the hydrogen purification plant.')
            ENDIF
          ENDIF
        ENDIF
C
C     Check for a substream PSD attribute on the second substream of the
C     first inlet stream.
      NUMPSD = 0
      IF ( KLASS .EQ. 2 )  THEN
        CALL GETSTR (IDS(1,4), NB, LB, NBD, LBD)
        NUMATT = NPAT (LBD, 2)
        IF ( NUMATT .GT. 0 )   THEN
          NUMPSD = NAVAR (LBD, 2, 1)
          KLASS = 3
        ENDIF
      ENDIF
C
C     Set the offset variable for the conventional substream.
      NCONV = (NCC + 9)
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
C     Find the number of items in the whole inlet stream vector.
      ITEMS = NCONV
      IF ( KLASS .EQ. 2 )  ITEMS = ITEMS + ( NNCC + 9 )
     1                            + NITEMS * NNCC
      IF ( KLASS .EQ. 2 )  ITEMS = ITEMS + NUMPSD
C
C     Calculate the total gas inlet flow rate in lbs/hr.
      FLOWIN = CF * SIN1(NCC+1)*SIN1(NCC+9)
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 plant 6.1, the ',
     1    'hydrogen purification' /
     2    ' by membrane permeation plant.' )
        GO TO 999
C       ---------
      ENDIF
C
C     Find the relative component numbers of the required conventional
C     components, and save them 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, 506)  ICN(1), ICN(2)
  506     FORMAT ( / 1X, '* ERROR * - The following component is ',
```

```
     1      'missing from your component list' / 5X, 2A4 /
     2      3X, 'The hydrogen purification by membrane permeation ',
     3      'plant requires this component.' /
     4      3X, 'Please add 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 hydrogen recovery to the hydrogen-rich product
C     gas stream from the inlet gas stream.
      RECVY = REAL(1)
C     Load the concentration of hydrogen in the hydrogen-rich product
C     gas stream, mole % or vol%.
      PURITY = REAL(2)
C
C     Set up the maximum and minimum train flow rates in Mlbs/hour
C     of H2 recovered in the H2-rich product gas stream.
      PMAXF = REAL(52)
      PMINF = REAL(53)
C
C     Check the supplied value of the percent hydrogen recovery to the
C     hydrogen-rich product gas stream to make sure that a realistic
C     value has been supplied.
      IF ( RECVY .LE. 40.0D0 .OR. RECVY .GE. 99.9D0 )   THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 507)  RECVY
  507   FORMAT ( / 1X, '* WARNING * - The supplied hydrogen recovery ',
     1    'to the hydrogen-rich gas stream' /
     2    3X, 'from the feed stream has an invalid value of',
     3    F10.3, '%.  A value of 65.0%' /
     4    3X, 'will be assumed, and execution will continue ',
     5    'using this value.' )
        RECVY = 65.0D0
      ENDIF
C
C     Check the supplied value of the hydrogen purity in the hydrogen-
C     rich product gas stream to make sure that a realistic value has
C     been supplied.
      IF ( PURITY .LE. 70.0D0 .OR. PURITY .GE. 99.995D0 )   THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 508)  PURITY
  508   FORMAT ( / 1X, '* WARNING * - The supplied hydrogen purity ',
     1    'of the hydrogen-rich gas stream' /
     2    3X, 'has an invalid value of', F10.3, '%.  A value of ',
     3    '99.0% will be assumed, and' /
```

```
     4    3X, 'execution will continue using this value.' )
        PURITY = 99.0D0
      ENDIF
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 and CPROP array.
      DO 42 J = 1, KMAXC
        CIN(J) = 0.0D0
        DO 40 K = 1, 7
          CPROP(J,K) = 0.0D0
   40   CONTINUE
   42 CONTINUE
C
C     Conventional components - Load the component flow rates and MWs.
      DO 46 J = 1, NCC
        DO 44 K = 1, KOMPS
        IF ( J .EQ. ICNUMB(K) )  THEN
          CPROP(K,1) = XMW(J)
          CIN(K) = CF * XMW(J) * SIN1(J)
          GO TO 46
        ENDIF
   44   CONTINUE
        CIN(20) = CIN(20) + CF * XMW(J) * SIN1(J)
   46 CONTINUE
C
C     Set the molecular weight of the 200+ F component.
      CPROP(20,1) = 110.0D0
C
C     Ignore any non-conventional components.
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', 9X, 'ID' )
        DO 50 J = 1, KMAXC
          K = 2 * J - 1
          IF ( ICNAME(K) .NE. BLANK4 )  THEN
            SUM = SUM + CIN(J)
            WRITE (NHSTRY, 514) J, ICNAME(K), ICNAME(K+1), CIN(J),
     1        CPROP(J,1), ICNUMB(J)
  514         FORMAT ( 1X, I3, 2X, 2A4, F10.1, F10.4, I8 )
          ENDIF
```

```
   50   CONTINUE
        WRITE (NHSTRY, 515) SUM
  515   FORMAT ( 6X, 'Total', F13.1 )
      ENDIF
C
C
C     Call subroutine USR61A to calculate the product streams.
      CALL USR61A (ICNAME, IER2, KMAXC, KTEST, NHSTRY,
     1  PURITY, RECVY)
C
C
      IF ( IPASS .NE. 4 )   THEN
C       Call Subroutine USR61B to load the three product streams into
C       the SOUT1, SOUT2 and SOUT3 stream vectors.
        CALL USR61B (ITEMS, KOMPS, KTEST, NCC, NCONV,
     1    NHSTRY, NNCC, SIN1, SOUT1, SOUT2, SOUT3)
      ENDIF
C
C
C     Calculate the total H2 recovery rate in MM SCF/hr of hydrogen
C     recovered in the hydrogen-rich product gas.
      H2RATE = 379.495D-6 * COUT(1) / CPROP(1,1)
C
C     If it has not been specified by the user in variable INT(3),
C     calculate the number of operating duplicate trains, excluding
C     spares (NPLNT), based on the total flow rate of the reference
C     stream.  However, if the maximum capacity of a single train
C     has not been specified, set the number of operating trains to 1.
      NPLNT = INT(3)
      IF ( (NPLNT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
          NPLNT = H2RATE  / PMAXF
          IF ( (MOD(H2RATE, PMAXF)) .GT. 0.0D0 )  NPLNT = NPLNT + 1
        ELSE
          IF ( NPLNT .EQ. 0 )   NPLNT = 1
      ENDIF
C
C     Calculate the hydrogen recovery rate in MM SCF/hr of hydrogen
C     recovered in the hydrogen-rich product gas stream (PFLOW) for
C     each of the duplicate trains.
      XPLNT = NPLNT
      PFLOW = H2RATE / XPLNT
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 USR61S.
      X = 1.8D0
      X1 = 459.67D0
      ST1(1,2) = X * SIN1(NCC+2) - X1
      ST2(1,2) = X * SOUT1(NCC+2) - X1
      ST2(2,2) = X * SOUT2(NCC+2) - X1
      ST2(3,2) = X * SOUT3(NCC+2) - X1
      X = 1.0D0 / 6.8947573D+3
      ST1(1,3) = X * SIN1(NCC+3)
      ST2(1,3) = X * SOUT1(NCC+3)
      ST2(2,3) = X * SOUT2(NCC+3)
```

```
      ST2(3,3) = X * SOUT3(NCC+3)
C
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.
            LSTRM = 16
C           Count the number of non-zero components to be reported.
            L = 0
            DO 60 J = 1, KMAXC
              IF ( CIN(J) .GE. 0.1D0 )   L = L + 1
   60       CONTINUE
            IF ( IER1 .GE. 1 )   LSTRM = LSTRM + 4
            IF ( IER2 .GE. 1 )   LSTRM = LSTRM + 4
            LINES = LSTRM + L
C           Call subroutine RPTHDR to tell ASPEN/SP system the number
C           of lines that will be written on this page.
            CALL RPTHDR (LINES, 0, 3, ISUB)
          ELSE
C           Open the separate output file called DCL61.REP to contain
C           this user block summary report.
            OPEN (UNIT=62, FILE='DCL61.REP', STATUS='UNKNOWN',
     1        ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2        BUFFERED='BUFFERED')
            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' )
        ENDIF
      ENDIF
C
      IF ( IPASS .EQ. 4 )   THEN
C       Call Subroutine USR61S to write the first part of the stream
C       summary report.
        CALL USR61S (ICNAME, IER1, IER2, INT(1), KMAXC, NOUT)
      ENDIF
C
C     If this is the report pass, set up to write the second page of
C     the summary report.
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 1 )  THEN
        IF ( INT(2) .EQ. 0 )   THEN
C           Calculate the number of lines in the second page.
            LSTRM = 3
            LUTIL = 16
            LCOST = 11
            NDUP = REAL(58) + 0.001D0
            IF ( (NPLNT + NDUP) .EQ. 1 )  LCOST = 9
            IF ( PFLOW .LT. PMINF )  LCOST = LCOST + 3
            IF ( PFLOW .GT .PMAXF )  LCOST = LCOST + 3
```

```
            IF ( NDUP .GE. 1 )  LCOST = LCOST + 1
            LINES = LSTRM + LUTIL + LCOST
C           Now, subtract the number of lines for those portions of
C           the user block summary report which will not be written.
            IF ( INT(1) .GE. 2 )   LINES = LINES - LUTIL
            IF ( INT(1) .GE. 1 )   LINES = LINES - LCOST
C           Call subroutine RPTHDR to tell ASPEN/SP system the number
C           of lines that will be written on this page.
            CALL RPTHDR (LINES, 0, 3, ISUB)
          ELSE
            WRITE (NOUT, 800)
        ENDIF
        WRITE (NOUT, 801)
  801   FORMAT ( / 18X, 'PLANT 6.1 - SUMMARY REPORT (CONTINUED)' /
     1    15X, 'HYDROGEN PURIFICATION BY MEMBRANE PERMEATION' )
      ENDIF
C
C
C     Call subroutine USRUCO to calculate, save and report the
C     utilities, capital and operating costs for the plant.
      ID = 6
      KUNITS = 5
      CALL USRUCO (NHSTRY, NOUT, IPASS, ID, PNAME, INT(1), INT(3),
     1  KTEST, REAL(21), H2RATE, KUNITS)
C
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 USR61' )
C
C
      RETURN
      END
C
C$ USR61A
      SUBROUTINE USR61A (ICNAME, IER2, KMAXC, KTEST, NHSTRY,
     1  PURITY, RECVY)
C
C     This subroutine simulates the high pressure portion of the
C     hydrogen recovery plant which recovers hydrogen from the
C     high pressure purge gas from the plant 2 coal liquefaction
C     reactors by membrane permeation.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - April 2, 1992.
C
C     This subroutine calculates the component flow rates in the
C     purified hydrogen-rich product gas stream by following procedure.
C       1.  All ammonia, carbon dioxide and hydrogen sulfide are first
C           removed in water and amine scrubbers and put in the sour
```

```
C           gas stream which is stored in the CPROP(J,3) vector.  The
C           mole fraction of water in the remaining gases is set to
C           the values specified by the variable H2OMF as given in a
C           following data statement.  All water removed leaves in
C           the sour gas stream.
C       2.  The total amount of hydrogen leaving in the purified
C           hydrogen-rich product gas stream is calculated from the
C           specified hydrogen recovery, RECVY.
C       3.  The total amount of non-hydrogen gases is calculated from
C           the specified purity (PURITY) of the hydrogen-rich
C           product gas stream.
C       4.  The amount of each impurity in the hydrogen-rich product
C           gas stream is calculated using the specified composition
C           of the non-hydrogen components stored in the YC vector.
C       5.  All remaining gases leaves in the non-permeate product
C           gas stream, called the reject gas stream, which goes to
C           further processing.
C
C     Calling arguments:
C     ICNAME() = Vector of component identifications (CHARACTER * 4)
C     IER2     = Switch to indicate whether the warning message
C                indicating that the composition of the non-hydrogen
C                components in the hydrogen-rich product gas stream had
C                to be adjusted to maintain the individual component
C                balance should be written.
C                0 => Do not write the warning message.
C                1 => Write the warning message.
C     KMAXC    = Total number of components in the component vectors.
C                (KMAXC must be < or = to 20)
C     KTEST    = Switch for controlling the printing to the history
C                file.
C     NHSTRY   = Logical unit number of the history file.
C     PURITY   = Concentration of hydrogen in the hydrogen-rich
C                product gas stream, mole % or vol%.
C     RECVY    = Percent hydrogen recovery from the inlet gas stream.
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)
C
C     Note to save space, the CPROP(40,7) array in nammed COMMON
C     /USRO2M/ is used to store the following
C       CPROP(J,1) = Vector of component molecular weights.
C       CPROP(J,2) = Not used.
C       CPROP(J,3) = Vector of component flow rates in the sour gas
C                    product stream that is produced by combining the
C                    material removed in the water washing and amine
C                    scrubbing steps in lbs/hr.
C       CPROP(J,4) = Vector of component flow rates in the non-permeate
C                    product stream; i.e., all the other entering
C                    material not leaving in the H2-rich and sour gas
C                    product gas streams in lbs/hr.
C       CPROP(J,5) = Not used.
```

```
C       CPROP(J,6) = Not used.
C       CPROP(J,7) = Not used.
C
      DIMENSION ICNAME(*)
      CHARACTER * 4  ICNAME
C
C     Local variable declarations.
C
C     YC(J) is the composition of the non-hydrogen components in the
C     hydrogen-rich product gas stream, mole or vol %.
      DIMENSION YC(20)
C
      CHARACTER * 4  BLANK4
C
      DATA BLANK4 / '    ' /
C
C     Initialize the composition of the non-hydrogen components
C     contained in the hydrogen-rich product gas stream in mole %.
C     Mole % of        H2      N2      O2      H2S      CO
      DATA YC  /       0.0,    0.0,    0.0,    0.0,     0.0,
C       CO2         NH3         H2O         HCL         COS
     1  0.0,        0.0,        0.0,        0.0,        0.0,
C       CH4         C2H6        C3H8        IC4H10      N C4H10
     2  100.0,      0.0,        0.0,        0.0,        0.0,
C       IC5H12      N C5H12     T125        T175        200+ F
     3  0.0,        0.0,        0.0,        0.0,        0.0 /
C
C     Initialize the mole-fraction of water remaining in the inlet
C     gas after the water washing and amine scrubbing; i.e., the gas
C     feed to the membrane permeation unit.
      DATA H2OMF / 0.00070354 /
C
C
      IF ( KTEST .GE. 2 )  WRITE (NHSTRY, 501)
  501 FORMAT ( / ' Starting the hydrogen purification calculations ',
     1  'in Subroutine USR61A.' )
C
C     Do the water washing and amine scrubbing to remove all ammonia,
C     carbon dioxide, hydrogen sulfide and some water.
      DO 10 J = 1, KMAXC
        CPROP(J,3) = 0.0D0
   10 CONTINUE
      CPROP(4,3) = CIN(4)
      CPROP(6,3) = CIN(6)
      CPROP(7,3) = CIN(7)
C
C     Now remove the required amount of water so that the feed gas to
C     the membrane peremeation unit has the specified amount of water.
C     Calculate the total moles of remaining DRY gas.
      TMOLES = 0.0D0
      DO 20 J = 1, KMAXC
        IF ( J .NE. 8 )   THEN
          X = (CIN(J) - CPROP(J,3)) / CPROP(J,1)
          TMOLES = TMOLES + X
        ENDIF
```

```
   20 CONTINUE
C
C     Calculate the weight of water that has to remain in the membrane
C     unit feed gas.
      WTH2O = H2OMF * TMOLES * CPROP(8,1) / (1.0D0 - H2OMF)
      CPROP(8,3) = CIN(8) - WTH2O
C
C     Calculate the total composition of the non-hydrogen components in
C     the H2-rich product gas stream.
      SUMYC = 0.0D0
      DO 120 J = 1, KMAXC
        SUMYC = SUMYC + YC(J)
  120 CONTINUE
C
      IF ( KTEST .GE. 2 )   THEN
        WRITE (NHSTRY, 502)
  502   FORMAT ( / ' The composition of the non-hydrogen components ',
     1    'in the hydrogen-rich' /
     2    ' product gas stream, mole %.' )
        DO 130 J = 1, KMAXC
          IF ( YC(J) .GT. 0.0D0 )  THEN
            K = 2 * J - 1
            IF ( YC(J) .GE. 0.0D0 )  THEN
              WRITE (NHSTRY, 503)  J, ICNAME(K), ICNAME(K+1), YC(J)
  503         FORMAT ( 1X, I5, 5X, 2A4, 5X, F11.3 )
            ENDIF
          ENDIF
  130   CONTINUE
        WRITE (NHSTRY, 504)  SUMYC
  504   FORMAT ( 11X, 'Total', 8X, F11.3 )
C
        WRITE (NHSTRY, 505)  PURITY, RECVY
  505   FORMAT ( / ' Specified hydrogen purity   =', F10.3, ' mole %' /
     1    ' Specified hydrogen recovery =', F10.3, '%' )
      ENDIF
C
C     Zero the component flow rates in the H2-rich product gas stream.
      DO 140 J = 1, KMAXC
        COUT(J) = 0.0D0
  140 CONTINUE
C
C     Load the specified amount of hydrogen in the H2-rich product gas
C     stream in lbs/hr.
      COUT(1) = 0.01D0 * RECVY * CIN(1)
C
C     Calculate the total moles of H2 in the H2-rich product gas stream
C     in lb-moles/hr.
      H2MOLS = COUT(1) / CPROP(1,1)
C
C     Calculate the total molar flow of non-hydrogen components in the
C     H2-rich product gas stream in lb-moles/hr.
      TMOLES = (100.0D0 - PURITY) * H2MOLS / PURITY
C
C     Calculate the flow rate in lbs/hr of each non-hydrogen component
C     in the H2-rich product gas stream in lbs/hr.
```

```
      DO 150 J = 2, KMAXC
        COUT(J) = CPROP(J,1) * YC(J) * TMOLES / SUMYC
  150 CONTINUE
C
C     If necessary, adjust the above component flow rates in case more
C     of a component has been specified to appear in the outlet stream
C     than is in present in the inlet stream.  In this case substitute
C     carbon monoxide (CO), component number 5, for the missing amount
C     of this component to maintain the component balance and the
C     specified hydrogen purity in the hydrogen-rich product gas stream.
      IER2 = 0
      K = 5
      LK = 2 * K - 1
      DO 160 J = 2, KMAXC
        X = COUT(J) - ( CIN(J) - CPROP(J,3) )
        IF ( X .GT. 0.1D0 )  THEN
          COUT(J) = COUT(J) - X
          COUT(K) = COUT(K) + X * CPROP(K,1) / CPROP(J,1)
          L = 2 * J - 1
          IF ( IER2 .EQ. 0 .AND. KTEST .LE. 0 )  WRITE (NHSTRY, 506)
     1      IPASS
  506     FORMAT ( // 1X, 'Plant 6.1 - Supplementary data from ',
     1      'subroutine USR61' /
     2      2X, 'The Hydrpgen Purification by Membrane Permeation ',
     3      'Plant', 10X, 'IPASS =', I3)
          WRITE (NHSTRY, 507) ICNAME(L), ICNAME(L+1), X, ICNAME(LK),
     1      ICNAME(LK+1)
  507     FORMAT ( / ' * WARNING * - The flow rate of ', 2A4,
     1      ' in the hydrogen-rich product gas' /
     2      3X, 'stream has been adjusted by', F8.1, ' lbs/hr to ',
     3      'maintain the component balance.' /
     4      3X, 2A4, ' has been substituted for it in the hydrogen-',
     5      'rich product gas stream to' /
     6      3X, 'to maintain the specified hydrogen purity.' )
          IER2 = IER2 + 1
        ENDIF
  160 CONTINUE
C
C     Calculate the component flow rates in the non-permeate product
C     gas stream, the reject gas stream.
      DO 170 J = 1, KMAXC
        CPROP(J,4) = CIN(J) - CPROP(J,3) - COUT(J)
  170 CONTINUE
C
      IF ( KTEST .GE. 3 )   THEN
        WRITE (NHSTRY, 510)
  510   FORMAT ( / ' Hydrogen purification plant flow rates, lbs/hr' /
     1    4X, 'No', 1X, 'Component', 12X, ' Feed', 4X, 'H2-rich gas',
     2    3X, 'Sour gas', 3X, 'Reject gas' )
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        SUM4 = 0.0D0
        DO 180 J = 1, KMAXC
          IF ( CIN(J) .GT. 0.0D0 )  THEN
```

```
            K = 2 * J - 1
            IF ( ICNAME(K) .NE. BLANK4 )  THEN
              SUM1 = SUM1 + CIN(J)
              SUM2 = SUM2 + COUT(J)
              SUM3 = SUM3 + CPROP(J,3)
              SUM4 = SUM4 + CPROP(J,4)
              WRITE (NHSTRY, 511)  J, ICNAME(K), ICNAME(K+1), CIN(J),
     1          COUT(J), CPROP(J,3), CPROP(J,4)
  511         FORMAT ( 1X, I5, 1X, 2A4, 5X, 4F13.1)
            ENDIF
          ENDIF
  180   CONTINUE
        WRITE (NHSTRY, 512)  SUM1, SUM2, SUM3, SUM4
  512   FORMAT ( 7X, 'Total', 8X, 4F13.1)
      ENDIF
C
C     If requested calculate and write to the history file the component
C     flow rates and composition of the H2-rich product gas stream.
      IF ( KTEST .GE. 3 )   THEN
        SUMWT  = 0.0D0
        SUMMOL = 0.0D0
        DO 190 J = 1, KMAXC
          SUMWT  = SUMWT  + COUT(J)
          SUMMOL = SUMMOL + COUT(J) / CPROP(J,1)
  190   CONTINUE
        WRITE (NHSTRY, 513)
  513   FORMAT ( / ' Hydrogen-rich product gas stream properties.' /
     1    4X, 'No', 1X, 'Component', 11X, 'lbs/hr', 9X, 'Wt %',
     2    7X, 'Mole %' )
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        DO 192 J = 1, KMAXC
          IF ( COUT(J) .GT. 0.0D0 )  THEN
            K = 2 * J - 1
            X = 100.0D0 * COUT(J) / SUMWT
            Y = 100.0D0 * COUT(J) / (CPROP(J,1) * SUMMOL)
            SUM1 = SUM1 + COUT(J)
            SUM2 = SUM2 + X
            SUM3 = SUM3 + Y
            WRITE (NHSTRY, 514)  J, ICNAME(K), ICNAME(K+1), COUT(J),
     1        X, Y
  514       FORMAT ( 1X, I5, 1X, 2A4, 5X, F13.1, 2F13.3 )
          ENDIF
  192   CONTINUE
        WRITE (NHSTRY, 515) SUM1, SUM2, SUM3
  515   FORMAT ( 7X, 'Total', 8X, F13.1, 2F13.3 )
      ENDIF
C
      RETURN
      END
C
C$ USR61B
      SUBROUTINE USR61B (ITEMS, KOMPS, KTEST, NCC, NCONV,
     1  NHSTRY, NNCC, SIN1, SOUT1, SOUT2, SOUT3)
```

```
C
C     This subroutine loads the three product streams from the hydrogen
C     purification by membrane permeation plant into the SOUT1, SOUT2
C     and SOUT3 stream vectors.  This subroutine is only called when
C     IPASS is not equat to 4.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - April 2, 1992.
C
C     Calling arguments:
C     ITEMS    = Total number of items in the SOUT1 vector.
C     KOMPS    = Number of conventional components used in this unit
C                model.  (KOMPS must be < or = to 19)
C     KTEST    = Switch for controlling the printing to the history
C                file.
C     NCC      = Number of conventional components.
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 inlet stream.
C     SOUT1()  = ASPEN/SP stream vector for the first outlet stream,
C                the hydrogen-rich product gas stream.
C     SOUT2()  = ASPEN/SP stream vector for the second outlet stream,
C                the sour gas stream.
C     SOUT3()  = ASPEN/SP stream vector for the third outlet stream,
C                the reject (non-permeate) gas stream.
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)
C
      COMMON /USRCO2/ 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 /USRCO2/
C     only to save space since all block models use these variables.
C
      DIMENSION SIN1(*), SOUT1(*), SOUT2(*), SOUT3(*)
C
C
C     Set up the properties of the product streams.
C
C     Conventional components.
C     ------------------------
C     First, zero all the items in the product stream vectors.
      DO 200 J = 1, ITEMS
        SOUT1(J) = 0.0D0
        SOUT2(J) = 0.0D0
        SOUT3(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
      SUM2 = 0.0D0
      SUM3 = 0.0D0
      DO 210 J = 1, NCC
        IF ( SIN1(J) .LE. 1.0D-25 )  GO TO 210
          DO 206 K = 1, KOMPS
            IF ( J .EQ. ICNUMB(K) )  THEN
C             The hydrogen-rich product gas stream.
              SOUT1(J) = COUT(K) / (CF * CPROP(K,1))
C             The sour gas stream.
              SOUT2(J) = CPROP(K,3) / (CF * CPROP(K,1))
C             The reject (non-permeate) gas stream.
              SOUT3(J) = CPROP(K,4) / (CF * CPROP(K,1))
              SUM1 = SUM1 + SOUT1(J)
              SUM2 = SUM2 + SOUT2(J)
              GO TO 208
            ENDIF
  206     CONTINUE
C         Put all the 200+ F components in the reject gas stream.
          SOUT3(J) = SIN1(J)
  208     SUM3 = SUM3 + SOUT3(J)
  210 CONTINUE
C
C     Set the total molar flow rate of the conventional components.
      SOUT1(NCC+1) = SUM1
      SOUT2(NCC+1) = SUM2
      SOUT3(NCC+1) = SUM3
C
C     Set the temperature and pressure of the product streams.
C     Return these values to ASPEN/SP in degrees Kelvin 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) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT1(NCC+3) = 15.0D0 * 6.8947573D+3
      SOUT2(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT2(NCC+3) = 15.0D0 * 6.8947573D+3
      SOUT3(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT3(NCC+3) = 15.0D0 * 6.8947573D+3
C
C     Call subroutine CPACK and funcion AVEMW to calculate the
C     average molecular weight of the conventional components in
C     all the product streams.
      CALL CPACK (SOUT1, NCP, IDX, XPACK, TMASS)
      SOUT1(NCC+9) = AVEMW (NCP, IDX, XPACK)
      CALL CPACK (SOUT2, NCP, IDX, XPACK, TMASS)
      SOUT2(NCC+9) = AVEMW (NCP, IDX, XPACK)
      CALL CPACK (SOUT3, NCP, IDX, XPACK, TMASS)
      SOUT3(NCC+9) = AVEMW (NCP, IDX, XPACK)
C
C
C     Non-conventional components.
C     ---------------------------
```

```
      IF ( NNCC .GE. 1 )   THEN
C       If present, set the temperature and pressure of the non-
C       conventional portion of the stream but ingnore any component
C       flows since they previously have been set to zero.
        SOUT1(NCONV+NNCC+2) = SOUT1(NCC+2)
        SOUT1(NCONV+NNCC+3) = SOUT1(NCC+3)
        SOUT2(NCONV+NNCC+2) = SOUT2(NCC+2)
        SOUT2(NCONV+NNCC+3) = SOUT2(NCC+3)
        SOUT3(NCONV+NNCC+2) = SOUT3(NCC+2)
        SOUT3(NCONV+NNCC+3) = SOUT3(NCC+3)
      ENDIF
C
C     If requested, write the items of interest in the inlet and
C     outlet stream vectors to the history file.
      IF ( KTEST .GE. 5 )  THEN
        WRITE (NHSTRY, 531)
  531   FORMAT ( // ' The inlet and outlet stream vectors' /
     1    14X, ' SIN1', 10X, 'SOUT1', 10X, 'SOUT2', 10X, 'SOUT3' )
        DO 290 J = 1, ITEMS
          WRITE (NHSTRY, 532) J, SIN1(J), SOUT1(J), SOUT2(J), SOUT3(J)
  532     FORMAT ( 2X, I5, 4(1PE15.5) )
  290   CONTINUE
      ENDIF
C
      RETURN
      END
C
C$ USR61S
      SUBROUTINE USR61S (ICNAME, IER1, IER2, INT1, KMAXC, NOUT)
C
C     This subroutine writes the first part of the plant summary report
C     for the hydrogen recovery by membrane permeation plant, Plant 6.1.
C     This subroutine is only called when IPASS equals 4.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - April 2, 1992.
C
C     Calling arguments:
C     ICNAME() = Vector of component identifications (CHARACTER * 4)
C     IER1     = Switch to indicate whether the warning message
C                indicating that solids are present in the inlet
C                stream should be written.
C                0 => Do not write the warning message.
C                1 => Write the warning message.
C     IER2     = Switch to indicate whether the warning message
C                indicating that the composition of the non-hydrogen
C                components in the H2-rich product gas stream had to
C                be adjusted to maintain the individual component
C                balance 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     KMAXC     = Total number of components in the component vectors.
C                 (KMAXC must be < or = to 20)
C     NOUT      = Logical unit number of the plant output report file.
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)
C
C     Note to save space, the CPROP(40,7) array in nammed COMMON
C     /USR02M/ is used to store the following
C       CPROP(J,1) = Vector of component molecular weights.
C       CPROP(J,2) = Not used.
C       CPROP(J,3) = Vector of component flow rates in the sour gas
C                    product stream that is produced by combining the
C                    material removed in the water washing and amine
C                    scrubbing steps in lbs/hr.
C       CPROP(J,4) = Vector of component flow rates in the non-permeate
C                    product stream; i.e., all other material entering
C                    the plant and not leaving in either the hydrogen-
C                    rich or sour gas product streams in lbs/hr.
C       CPROP(J,5) = Not used.
C       CPROP(J,6) = Not used.
C       CPROP(J,7) = Not used.
C
      DIMENSION ICNAME(*)
C
      CHARACTER * 4  ICNAME
C
C
      IF ( INT1 .LE. 2 )  THEN
C
C       Write the first part of the plant summary report.
C       ================================================
        WRITE (NOUT, 801)
  801   FORMAT ( / 24X, 'PLANT 6.1 - SUMMARY REPORT' /
     1    15X, 'HYDROGEN PURIFICATION BY MEMBRANE PERMEATION' )
C
        WRITE (NOUT, 802)
  802   FORMAT ( / '  COMPONENT FLOW RATES, LBS/HR' /
     1    2X, 'COMPONENT', 14X, 'INLET', 6X, 'H2-RICH', 5X,
     2    'SOUR GAS', 3X, 'REJECT GAS' )
C
C       Write the component flow rates in lbs/hr.
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        SUM4 = 0.0D0
        DO 20 J = 1, KMAXC
          IF ( CIN(J) .GE. 0.1D0 ) THEN
            K = 2 * J - 1
```

```
            SUM1 = SUM1 + CIN(J)
            SUM2 = SUM2 + COUT(J)
            SUM3 = SUM3 + CPROP(J,3)
            SUM4 = SUM4 + CPROP(J,4)
            WRITE (NOUT, 803) ICNAME(K), ICNAME(K+1), CIN(J),
     1        COUT(J), CPROP(J,3), CPROP(J,4)
  803       FORMAT ( 2X, 2A4, F20.1, 3F13.1 )
          ENDIF
   20   CONTINUE
C
        WRITE (NOUT, 804) SUM1, SUM2, SUM3, SUM4
  804   FORMAT ( 2X, 'TOTAL', F23.1, 3F13.1 )
C
C       Calculate the total stream flow rates in MM SCF/hr.
        SUMM1 = 0.0D0
        SUMM2 = 0.0D0
        SUMM3 = 0.0D0
        SUMM4 = 0.0D0
        DO 30 J = 1, KMAXC
          SUMM1 = SUMM1 + CIN(J) / CPROP(J,1)
          SUMM2 = SUMM2 + COUT(J) / CPROP(J,1)
          SUMM3 = SUMM3 + CPROP(J,3) / CPROP(J,1)
          SUMM4 = SUMM4 + CPROP(J,4) / CPROP(J,1)
   30   CONTINUE
        SCF1 = 379.495D-6 * SUMM1
        SCF2 = 379.495D-6 * SUMM2
        SCF3 = 379.495D-6 * SUMM3
        SCF4 = 379.495D-6 * SUMM4
        WRITE (NOUT, 811) SCF1, SCF2, SCF3, SCF4
  811   FORMAT ( / 2X, 'FLOW, MM SCF/HR', F13.3, 3F13.3 )
C
        WRITE (NOUT, 812) ST1(1,2), ST2(1,2), ST2(2,2), ST2(3,2),
     1    ST1(1,3), ST2(1,3), ST2(2,3), ST2(3,3)
  812   FORMAT ( 2X, 'TEMPERATURE, F', F14.1, 3F13.1 /
     1    2X, 'PRESSURE, PSIA', F14.1, 3F13.1 )
C
C       Calculate and report the hydrogen flow rate in MM SCF/hr and
C       the mole percent hydrogen in each product stream.
        XMH1 = CIN(1) / CPROP(1,1)
        XMH2 = COUT(1) / CPROP(1,1)
        XMH4 = CPROP(1,4) / CPROP(1,1)
        SCF1 = 379.495D-6 * XMH1
        SCF2 = 379.495D-6 * XMH2
        SCF4 = 379.495D-6 * XMH4
        PH1 = 100.0D0 * XMH1 / SUMM1
        PH2 = 100.0D0 * XMH2 / SUMM2
        PH4 = 100.0D0 * XMH4 / SUMM4
        WRITE (NOUT, 813) SCF1, SCF2, SCF4, PH1, PH2, PH4
  813   FORMAT ( / 2X, 'H2 FLOW, MM SCF/HR', F10.3, F13.3, F26.3 /
     1    2X, 'MOLE % HYDROGEN', F13.3, F13.3, F26.3 )
C
C
        IF ( IER1 .GE. 1 )  WRITE (NOUT, 821)
  821   FORMAT ( / 1X, '*WARNING* THE FEED TO THIS HYDROGEN ',
     1    'PURIFICATION PLANT CONTAINS SOLIDS.' /
```

```
     2    2X, 'THEY WILL BE LOST IN THE PROCESS.',
     3    '  PLANT 6.1 IS NOT IN MASS BALANCE.' )
C
        IF ( IER2 .GE. 1 )  WRITE (NOUT, 822) IER2
  822   FORMAT  (/ 1X, '*WARNING* THE COMPOSITION OF', I3,
     1    ' NON-HYDROGEN COMPONENT(S) IN THE HYDROGEN-' /
     2    2X, 'RICH GAS STREAM HAS BEEN ADJUSTED TO MAINTAIN THE ',
     3    'INDIVIDUAL COMPONENT' /
     4    2X, 'BALANCE AND THE SPECIFIED HYDROGEN PURITY.' )
C
        IF ( INT1 .LE. 1 )   WRITE (NOUT, 831)
  831   FORMAT ( / 25X, '- CONTINUED ON NEXT PAGE -' )
C
      ENDIF
C
C
  999 RETURN
      END
C
C$  Subroutine USR62
C
C     This file contains the following subroutines:
C       USR62    Main routine for Plant 6.2, hydrogen purification by
C                pressure swing absorption, the low pressure hydrogen
C                recovery section of Plant 6
C       USR62A   Subroutine to simulate the high pressure section of
C                the hydrogen purification plant, hudrogen purification
C                by pressure swing absorption.
C       USR62B   Subroutine to load the four product streams into the
C                outlet stream vectors.
C       USR62S   Subroutine to write the first part of the plant
C                summary report for hydrogen purification by pressure
C                swing absorption plant.
C
C     NOTE:  To save space, this model uses named common block COMMON
C            /USR02M/.
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 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       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 /USRC01/.
C
C$ USR62
      SUBROUTINE USR62 (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:  USR62
C
C  BLOCK DESCRIPTION:  Plant 6.2, Hydrogen Purification by Pressure
C                      Swing Absorption Plant.
C
C        Hydrogen Purification by Pressure Swing Absorption Plant
C
C                      --------------------
C                      |                  |
C          Mixed Gas   |    Plant 6.2     |-----> H2-rich gas
C            Feed ---->|                  |
C                      |    Hydrogen      |-----> Sour gas
C          Reject Gas  |  Purification    |
C           from ----->|   by Pressure    |-----> Reject gas
C          Plant 6.1   |      Swing       |
C                      |    Absorption    |-----> Naphtha
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 - May 29, 1992.
C
C  ASSUMPTIONS, SPECIAL FEATURES AND LIMITATIONS:
C     1.  The model has a two inlet streams;
C              1. The combined low pressure off-gases from various
C                 sources.
C              2. The reject gas stream from Plant 6.1, the hydrogen
C                 recovery by membrane permeation plant.
C     2.  The four outlet streams are 1. The H2-rich Product Gas
C                                        Stream.
C                                     2. The Sour Gas Stream.
C                                     3. The Reject Gas Stream
C                                     4. The Liquid Naphtha Stream
C     3.  This user block model will work with any number of
C         conventional and non-conventional components.
C     4.  The input stream to this model and all output streams from
C         this model must be of the same ASPEN/SP stream class.  Only
C         the following three ASPEN/SP stream classes can be used;
C         CONVENTIONAL, MIXNC or MIXNCPSD.
C     5.  All non-conventional components must have the PROXANAL,
C         ULTANAL, SULFANAL AND AOXANAL component attributes.
C     6.  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, any ATTR-COMPS statements in
C         the input file must be like to the following one for COAL.
C           ATTR-COMPS COAL   PROXANAL ULTANAL SULFANAL AOXANAL
C     7.  Any non-conventional solid components entering in either
C         input stream will be ignored and lost in the process.  When
C         solids are present, Plant 6.2 will not be in mass balance.
C     8.  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 DCL62.REP.
C         INT(3)  = Number of operating duplicate trains, excluding
C                   spares.
C                   If INT(3) = 0, the minimum number of duplicate
C                     trains will be determined so that the capacity
C                     each train does not exceed the maximum train
C                     capacity specified by variable REAL(52).
C                   If INT(3) > 0, this number of duplicate trains will
C                     be used.
C         INT(4)  = History file additional output control switch.
C                   0 => Write no additional output to the history 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     9.  The 70 real parameters are:
C         REAL(1)   = Percent hydrogen recovery to the hydrogen-rich
C                     product gas stream from the inlet gas stream.
C         REAL(2)   = Concentration of hydrogen in the hydrogen-rich
C                     product gas stream, mole % or vol%.
C         REAL(3) -
C          REAL(20) = Future use.
C         REAL(21)  = Constant factor for the power consumption, kw.
C         REAL(22)  = Power consumption per MM SCF/hr of H2 recovered,
C                     kw/(MM SCF/hr of H2 recovered)
C         REAL(23)  = Constant factor for the 900 psig / 750 F steam
C                     consumption, Mlbs/hr.
C         REAL(24)  = 900 psig / 750 F steam consumption per MM SCF/hr
C                     of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2
C                     recovered).
C         REAL(25)  = Constant factor for the 900 psig saturated steam
C                     consumption, Mlbs/hr.
C         REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr
C                     of H2 recovered, (Mlbs/hr)/(MM SCF/hr of H2
C                     recovered).
C         REAL(27)  = Constant factor for the 600 psig / 720 F steam
C                     consumption, Mlbs/hr.
C         REAL(28)  = 600 psig / 720 F steam consumption per MM SCF/hr
```

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

```
C         REAL(58)  = Number of spare trains.
C         REAL(59) -
C          REAL(70) = 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.   -           Future use
C      29.   -           Future use
C      30.  HEAVIES      All conventional components not listed above.
C
```

```
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5)
C
C     In COMMON /USR02M/
C       CIN(J) contains the component flow rates entering Plant 6.2.
C       COUT(J) contains the component flow rates leaving Plant 6.2.
C       CPROP(J,K) contains the conventional component properties.
C         Note to save space, the CPROP(40,7) array in nammed COMMON
C          /USR02M/ is used to store the following
C         CPROP(J,1) = Vector of component molecular weights.
C         CPROP(J,2) = Vector of component flow rates in the total gas
C                      feed stream after water washing and amine
C                      scrubbing to the PSA unit itself.
C         CPROP(J,3) = Vector of component flow rates in the sour gas
C                      product stream that is produced by combining the
C                      material removed in the water washing and amine
C                      scrubbing steps in lbs/hr.
C         CPROP(J,4) = Vector of component flow rates in the reject gas
C                      product stream.
C         CPROP(J,5) = Vector of component flow rates in the liquid
C                      naphtha product stream.
C         CPROP(J,6) = The mixed gas feed stream.
C         CPROP(J,7) = The reject gas stream from plant 6.1, the
C                      hydrogen purification by membrane permeation
C                      plant.
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
C     Local variable declaration statements.
      DIMENSION ICN(2), ICNAME(100)
C
      CHARACTER * 4  BLANK4, ICN, ICNAME
      CHARACTER * 6  PNAME
C
C     Initialize the component identifications.
      DATA KMAXC / 30 /
      DATA KOMPS / 27 /
      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  '    ', '    ', '    ', '    ', 'HEAV', 'IES ',  40 * '    ' /
C
      DATA PNAME / '6.2   ' /
```

```
C
C
C     PARAMETER INITIALIZATION SECTION
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)
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 6.2 - Supplementary data from ',
     1    'subroutine USR62' /
     2    2X, 'The Hydrogen Purification by Pressure Swing Absorption',
     3    ' Plant', 5X, 'IPASS =', I3)
      ENDIF
C
C     Check to insure that there are exactly two inlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSIN .NE. 2 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 502)  NSIN
  502   FORMAT ( / 1X, '* ERROR * - The Hydrogen Purification by ',
     1    'Pressure Swing Absorption Plant' /
     2    3X, 'requires two inlet streams.  It currently has', I4,
     3    ' inlet streams.' //
     4    3X, 'Please correct this problem and try again.' //
     5    3X, 'EXECUTION IS BEING TERMINATED.' / )
        STOP
      ENDIF
C
C     Check to insure that there are exactly 4 outlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSOUT .NE. 4 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501) IPASS
        WRITE (NHSTRY, 503)  NSOUT
  503   FORMAT ( / 1X, '* ERROR * - The Hydrogen Purification by ',
     1    'Pressure Swing Absorption Plant' /
     2    3X, 'requires exactly four outlet streams.  It currently ',
     3    'has', I4, ' outlet streams.' //
     4    3X, 'Please correct this problem and try again.' //
     5    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 = 1

C     Set CF, the conversion factor from Kg/sec to lbs/hr.
      CF = 3600.0D0 / 0.45359237D0
```

```
C
      IER1 = 0
      IF ( NSUBS .GE. 2 .AND. ITYPE(2) .EQ. 3 )  THEN
        KLASS = 2
        IF ( NNCC .GE. 1 )  THEN
          K = NCC + 9 + NNCC + 1
          SOLIDS = CF * SIN1(K)
          IF ( SOLIDS .GE. 1.0D0)  THEN
            IER1 = 1
            IF ( KTEST .LE. 0 )  WRITE (NHSTRY, 501)  IPASS
            WRITE (NHSTRY, 504) SOLIDS
  504       FORMAT (/ 1X, '* WARNING * The feed to the ',
     1        'hydrogen purification by pressure' /
     2        3x, 'swing absorption plant contains solids, ', F10.1,
     3        ' lbs/hr.  These solids' /
     3        3X, 'will be lost in the process.  Please remove these',
     4        'solids from the feed stream' /
     5        3X, 'to the hydrogen purification plant.')
            ENDIF
          ENDIF
      ENDIF
C
C     Check for a substream PSD attribute on the second substream of the
C     first inlet stream.
      NUMPSD = 0
      IF ( KLASS .EQ. 2 )  THEN
        CALL GETSTR (IDS(1,4), NB, LB, NBD, LBD)
        NUMATT = NPAT (LBD, 2)
        IF ( NUMATT .GT. 0 )   THEN
          NUMPSD = NAVAR (LBD, 2, 1)
          KLASS = 3
        ENDIF
      ENDIF
C
C     Set the offset variable for the conventional substream.
      NCONV = (NCC + 9)
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
C     Find the number of items in the whole inlet stream vector.
      ITEMS = NCONV
      IF ( KLASS .EQ. 2 )  ITEMS = ITEMS + ( NNCC + 9 )
     1                           + NITEMS * NNCC
      IF ( KLASS .EQ. 2 )  ITEMS = ITEMS + NUMPSD
C
C     Calculate the total gas inlet flow rate in lbs/hr.
      FLOWIN = CF * SIN1(NCC+1)*SIN1(NCC+9)
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 plant 6.2, the ',
     1    'hydrogen purification' /
```

```
     2    ' by pressure swing absorption plant.' )
        GO TO 999
C       ---------
      ENDIF
C
C     Find the relative component numbers of the required conventional
C     components, and save them 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, 506)  ICN(1), ICN(2)
  506     FORMAT ( / 1X, '* ERROR * - The following component is ',
     1      'missing from your component list' / 5X, 2A4 /
     2      3X, 'The hydrogen purification by pressure swing ',
     3      'absorption plant requires this' /
     4      3X, 'component.  Please add it to your component list ',
     5      '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 hydrogen recovery to the hydrogen-rich product
C     gas stream from the inlet gas stream.
      RECVY = REAL(1)
C     Load the concentration of hydrogen in the hydrogen-rich product
C     gas stream, mole % or vol%.
      PURITY = REAL(2)
C
C     Set up the maximum and minimum plant flow rates in Mlbs/hour
C     of H2 recovered in the H2-rich product gas stream.
      PMAXF = REAL(52)
      PMINF = REAL(53)
C
C     Check the supplied value of the percent hydrogen recovery to the
C     hydrogen-rich product gas stream to make sure that a realistic
C     value has been supplied.
      IF ( RECVY .LE. 50.0D0 .OR. RECVY .GE. 99.9D0 )   THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 507)  RECVY
  507   FORMAT ( / 1X, '* WARNING * - The supplied hydrogen recovery ',
```

```
     1    'to the hydrogen-rich gas stream' /
     2    3X, 'from the feed stream has an invalid value of',
     3    F10.3, '%.  A value of 65.0%' /
     4    3X, 'will be assumed, and execution will continue ',
     5    'using this value.' )
        RECVY = 65.0D0
      ENDIF
C
C     Check the supplied value of the hydrogen purity in the hydrogen-
C     rich product gas stream to make sure that a realistic value has
C     been supplied.
      IF ( PURITY .LE. 50.0D0 .OR. PURITY .GE. 99.9D0 )   THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 508)  PURITY
  508   FORMAT ( / 1X, '* WARNING * - The supplied hydrogen purity ',
     1    'of the hydrogen-rich gas stream' /
     2    3X, 'has an invalid value of', F10.3, '%.  A value of ',
     3    '99.0% will be assumed, and' /
     4    3X, 'execution will continue using this value.' )
        PURITY = 99.0D0
      ENDIF
C
C     If requested, write the items of interest in the inlet
C     stream vectors to the history file.
      IF ( KTEST .GE. 5 )  THEN
        WRITE (NHSTRY, 509)
  509   FORMAT ( / '  The inlet stream vectors:'/
     1    3X, 'Item', 8X, 'SIN1', 11X, 'SIN2' )
        DO 30 J = 1, ITEMS
          WRITE (NHSTRY, 510) J, SIN1(J), SIN2(J)
  510     FORMAT ( 1X, I6, 1X, 2(1PE15.5) )
   30   CONTINUE
      ENDIF
C
C     Load the total entering component flow rates in the CIN vector.
C     First, zero the CIN vector and CPROP array.
      DO 42 J = 1, KMAXC
        CIN(J) = 0.0D0
        DO 40 K = 1, 7
          CPROP(J,K) = 0.0D0
   40   CONTINUE
   42 CONTINUE
C
C     Conventional components - Load the component flow rates and MWs.
      DO 46 J = 1, NCC
        DO 44 K = 1, KOMPS
        IF ( J .EQ. ICNUMB(K) )  THEN
          CPROP(K,1) = XMW(J)
          CPROP(K,6) = CF * XMW(J) * SIN1(J)
          CPROP(K,7) = CF * XMW(J) * SIN2(J)
          CIN(K) = CPROP(K,6) + CPROP(K,7)
          GO TO 46
        ENDIF
   44   CONTINUE
C       Other components which are called HEAVIES.
```

```
          CPROP(30,6) = CPROP(30,6) + CF * XMW(J) * SIN1(J)
          CPROP(30,7) = CPROP(30,7) + CF * XMW(J) * SIN2(J)
   46 CONTINUE
      CIN(30) = CPROP(30,6) + CPROP(30,7)
C
C     Set the molecular weight of the HEAVIES component.
      CPROP(30,1) = 180.0D0
C
C     Ignore any non-conventional components.
C
      IF ( KTEST .GE. 4 )  THEN
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        WRITE (NHSTRY, 513)
  513   FORMAT ( / ' Component properties:' /
     1    19X, 'Total', 5X, 'First', 4X, 'Second' /
     2    1X, 'No.', 2X, 'Name', 8X, 'lbs/hr', 4X, 'lbs/hr', 4X,
     3    'lbs/hr', 5X, 'MW', 9X, 'ID' )
        DO 50 J = 1, KMAXC
          K = 2 * J - 1
          IF ( ICNAME(K) .NE. BLANK4 )  THEN
            SUM1 = SUM1 + CIN(J)
            SUM2 = SUM2 + CPROP(J,6)
            SUM3 = SUM3 + CPROP(J,7)
            WRITE (NHSTRY, 514) J, ICNAME(K), ICNAME(K+1), CIN(J),
     1        CPROP(J,6), CPROP(J,7), CPROP(J,1), ICNUMB(J)
  514         FORMAT ( 1X, I3, 2X, 2A4, 3F10.1, F10.4, I8 )
          ENDIF
   50   CONTINUE
        WRITE (NHSTRY, 515) SUM1, SUM2, SUM3
  515   FORMAT ( 6X, 'Total', F13.1, 2F10.1)
      ENDIF
C
C
C     Call subroutine USR62A to calculate the product streams.
      CALL USR62A (ICNAME, IER2, KOMPS, KMAXC, KTEST, NHSTRY,
     1  PURITY, RECVY)
C
C
      IF ( IPASS .NE. 4 )   THEN
C       Call Subroutine USR62B to load the four product streams into
C       the SOUT1, SOUT2, SOUT3 and SOUT4 stream vectors.
        CALL USR62B (ITEMS, KOMPS, KTEST, NCC, NCONV,
     1    NHSTRY, NNCC, SIN1, SIN2, SOUT1, SOUT2, SOUT3, SOUT4)
      ENDIF
C
C
C     Calculate the total H2 recovery rate in MM SCF/hr of hydrogen
C     recovered in the hydrogen-rich product gas.
      H2RATE = 379.495D-6 * COUT(1) / CPROP(1,1)
C
C     If it has not been specified by the user in variable INT(3),
C     calculate the number of operating duplicate trains, excluding
C     spares (NPLNT), based on the total flow rate of the reference
```

```
C     stream.  However, if the maximum capacity of a single train
C     has not been specified, set the number of operating trains to 1.
      NPLNT = INT(3)
      IF ( (NPLNT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
          NPLNT = H2RATE  / PMAXF
          IF ( (MOD(H2RATE, PMAXF)) .GT. 0.0D0 )  NPLNT = NPLNT + 1
        ELSE
          IF ( NPLNT .EQ. 0 )   NPLNT = 1
      ENDIF
C
C     Calculate the hydrogen recovery rate in MM SCF/hr of hydrogen
C     recovered in the hydrogen-rich product gas stream (PFLOW) for
C     each of the duplicate trains.
      XPLNT = NPLNT
      PFLOW = H2RATE / XPLNT
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 USR62S.
      X = 1.8D0
      X1 = 459.67D0
      ST1(1,2) = X * SIN1(NCC+2) - X1
      ST1(2,2) = X * SIN2(NCC+2) - X1
      ST2(1,2) = X * SOUT1(NCC+2) - X1
      ST2(2,2) = X * SOUT2(NCC+2) - X1
      ST2(3,2) = X * SOUT3(NCC+2) - X1
      ST2(4,2) = X * SOUT4(NCC+2) - X1
      X = 1.0D0 / 6.8947573D+3
      ST1(1,3) = X * SIN1(NCC+3)
      ST1(2,3) = X * SIN2(NCC+3)
      ST2(1,3) = X * SOUT1(NCC+3)
      ST2(2,3) = X * SOUT2(NCC+3)
      ST2(3,3) = X * SOUT3(NCC+3)
      ST2(4,3) = X * SOUT4(NCC+3)
C
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.
            LSTRM = 16
C           Count the number of non-zero components boiling below 200 F
C           to be reported.
            L = 0
            DO 60 J = 1, 19
              IF ( CIN(J) .GE. 0.1D0 )   L = L + 1
   60       CONTINUE
C           Do any components boiling above 200 F?
            X = 0.0D0
            DO 62 J = 20, KMAXC
              X = X + CIN(J)
```

```
   62       CONTINUE
            IF ( X .GE. 0.1D0 )   L = L + 1
            IF ( IER1 .GE. 1 )   LSTRM = LSTRM + 4
            IF ( IER2 .GE. 1 )   LSTRM = LSTRM + 4
            LINES = LSTRM + L
C           Call subroutine RPTHDR to tell ASPEN/SP system the number
C           of lines that will be written on this page.
            CALL RPTHDR (LINES, 0, 3, ISUB)
          ELSE
C           Open the separate output file called DCL62.REP to contain
C           this user block summary report.
            OPEN (UNIT=62, FILE='DCL62.REP', STATUS='UNKNOWN',
     1        ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2        BUFFERED='BUFFERED')
            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' )
        ENDIF
      ENDIF
C
      IF ( IPASS .EQ. 4 )   THEN
C       Call Subroutine USR62S to write the first part of the stream
C       summary report.
        CALL USR62S (ICNAME, IER1, IER2, INT(1), KOMPS, KMAXC, NOUT)
      ENDIF
C
C     If this is the report pass, set up to write the second page of
C     the summary report.
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 1 )  THEN
        IF ( INT(2) .EQ. 0 )   THEN
C           Calculate the number of lines in the second page.
            LSTRM = 3
            LUTIL = 16
            LCOST = 11
            NDUP = REAL(58) + 0.001D0
            IF ( (NPLNT + NDUP) .EQ. 1 )  LCOST = 9
            IF ( PFLOW .LT. PMINF )  LCOST = LCOST + 3
            IF ( PFLOW .GT .PMAXF )  LCOST = LCOST + 3
            IF ( NDUP .GE. 1 )  LCOST = LCOST + 1
            LINES = LSTRM + LUTIL + LCOST
C           Now, subtract the number of lines for those portions of
C           the user block summary report which will not be written.
            IF ( INT(1) .GE. 2 )   LINES = LINES - LUTIL
            IF ( INT(1) .GE. 1 )   LINES = LINES - LCOST
C           Call subroutine RPTHDR to tell ASPEN/SP system the number
C           of lines that will be written on this page.
            CALL RPTHDR (LINES, 0, 3, ISUB)
          ELSE
            WRITE (NOUT, 800)
        ENDIF
        WRITE (NOUT, 801)
  801   FORMAT ( / 17X, 'PLANT 6.2 - SUMMARY REPORT (CONTINUED)' /
     1    11X, 'HYDROGEN PURIFICATION BY PRESSURE SWING ABSORPTION' )
```

```
      ENDIF
C
C
C     Call subroutine USRUCO to calculate, save and report the
C     utilities, capital and operating costs for the plant.
      ID = 7
      KUNITS = 5
      CALL USRUCO (NHSTRY, NOUT, IPASS, ID, PNAME, INT(1), INT(3),
     1  KTEST, REAL(21), H2RATE, KUNITS)
C
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 USR62' )
C
C
      RETURN
      END
C
C$ USR62A
      SUBROUTINE USR62A (ICNAME, IER2, KOMPS, KMAXC, KTEST, NHSTRY,
     1  PURITY, RECVY)
C
C     This subroutine simulates the low pressure portion of the
C     hydrogen recovery plant which recovers hydrogen from many
C     gas streams by pressure swing absorption.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - January 28, 1992.
C
C     This subroutine calculates the component flow rates in the
C     purified hydrogen-rich product gas stream by following procedure.
C       1.  All ammonia, carbon dioxide and hydrogen sulfide are first
C           removed in water and amine scrubbers and put in the sour
C           gas stream which is stored in the CPROP(J,3) vector.  The
C           mole fraction of water in the remaining gases is set to
C           the values specified by the variable H2OMF as given in a
C           following data statement.  All water removed leaves in the
C           sour gas stream.
C       2.  The total amount of hydrogen leaving in the purified
C           hydrogen-rich product gas stream is calculated from the
C           specified hydrogen recovery, RECVY.
C       3.  The total amount of non-hydrogen gases is calculated from
C           the specified purity (PURITY) of the hydrogen-rich
C           product gas stream.
C       4.  The amount of each impurity in the hydrogen-rich product
C           gas stream is calculated using the specified composition
C           of the non-hydrogen components stored in the YC vector.
C       5.  The remaining material leaves either in the reject gas
C           gas stream or in the liquid naphtha stream.
```

```
C
C     Calling arguments:
C     ICNAME() = Vector of component identifications (CHARACTER * 4)
C     IER2     = Switch to indicate whether the warning message
C                indicating that the composition of the non-hydrogen
C                components in the hydrogen-rich product gas stream had
C                to be adjusted to maintain the individual component
C                balance should be written.
C                0 => Do not write the warning message.
C                1 => Write the warning message.
C     KOMPS    = Total number of known conventional components in the
C                component vectors. (KOMPS must be < or = to 29)
C     KMAXC    = Component number of the component used to lump all
C                unknown components.
C     KTEST    = Switch for controlling the printing to the history
C                file.
C     NHSTRY   = Logical unit number of the history file.
C     PURITY   = Concentration of hydrogen in the hydrogen-rich
C                product gas stream, mole % or vol%.
C     RECVY    = Percent hydrogen recovery from the inlet gas stream.
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)
C
C     Note to save space, the CPROP(40,7) array in nammed COMMON
C     /USR02M/ is used to store the following
C       CPROP(J,1) = Vector of component molecular weights.
C       CPROP(J,2) = Vector of component flow rates in the total gas
C                    feed stream after water washing and amine
C                    scrubbing to the PSA unit itself.
C       CPROP(J,3) = Vector of component flow rates in the sour gas
C                    product stream that is produced by combining the
C                    material removed in the water washing and amine
C                    scrubbing steps in lbs/hr.
C       CPROP(J,4) = Vector of component flow rates in the reject gas
C                    product stream.
C       CPROP(J,5) = Vector of component flow rates in the liquid
C                    naphtha product stream.
C       CPROP(J,6) = The mixed gas feed stream.
C       CPROP(J,7) = The reject gas stream from plant 6.1, the hydrogen
C                    purification by membrane permeation plant.
C
      DIMENSION ICNAME(*)
      CHARACTER * 4  ICNAME
C
C     Local variable declarations.
C
C     FC(J) is the fraction of component J that is condensed in the PSA
C       unit exit gas when it is compressed and leaves the unit in the
C       liquid naphtha product stream.
C     YC(J) is the composition of the non-hydrogen components in the
C       hydrogen-rich product gas stream, mole or vol %.
```

```
      DIMENSION FC(30), YC(30)
C
      CHARACTER * 4  BLANK4
C
      DATA BLANK4 / '    ' /
C
C     Initialize the fraction of component J that is condensed in the
C     PSA unit exit gas when it is compressed and leaves the unit in
C     the liquid naphtha product stream.
C     Fraction of     H2      N2      O2      H2S     CO
      DATA FC  /      0.0,    0.0,    0.0,    0.0,    0.0,
C       CO2         NH3         H2O         HCL         COS
     1  0.0,        0.0,        0.0,        0.0,        0.0,
C       CH4         C2H6        C3H8        IC4H10      N C4H10
     2  0.0000924,  0.0004925,  0.0015416,  0.0040010,  0.0040010,
C       IC5H12      N C5H12     T125        T175        T225
     3  0.0633788,  0.0633788,  0.0633788,  0.0633788,  0.0633788,
C       T275        T325        T375        T425        T475
     4  0.0633788,  0.0633788,  0.7263158,  0.7263158,  1.0,
C       T525        T575        -           -           HEAVIES
     5  1.0,        1.0,        1.0,        1.0,        1.0 /
C
C     Initialize the composition of the non-hydrogen components
C     contained in the hydrogen-rich product gas stream in mole %.
C     Mole % of     H2          N2          O2      H2S     CO
      DATA YC  /    0.0,        1.182078,   0.0,    0.0,    0.709323,
C       CO2         NH3         H2O         HCL         COS
     1  0.0,        0.0,        29.50964,   0.0,        0.0,
C       CH4         C2H6        C3H8        IC4H10      N C4H10
     2  44.64421,   13.55171,   7.161916,   1.183397,   1.183397,
C       IC5H12      N C5H12     T125        T175        T225
     3  0.123800,   0.123800,   0.123800,   0.123800,   0.123800,
C       T275        T325        T375        T425        T475
     4  0.123800,   0.123800,   0.003854,   0.003854,   0.0,
C       T525        T575        -           -           HEAVIES
     5  0.0,        0.0,        0.0,        0.0,        0.0 /
C
C     Initialize the mole-fraction of water remaining in the inlet
C     gas after the water washing and amine scrubbing; i.e., the gas
C     feed to the pressure swing absorption separation unit.
C     Set H2OMF to a value greater than 1.0 to remove no water.
      DATA H2OMF / 1.1 /
C
C
      IF ( KTEST .GE. 2 )  WRITE (NHSTRY, 501)
  501 FORMAT ( / ' Starting the hydrogen purification calculations ',
     1  'in Subroutine USR62A.' )
C
C     Do the water washing and amine scrubbing to remove all ammonia,
C     carbon dioxide, hydrogen sulfide and some water.
      DO 10 J = 1, KMAXC
        CPROP(J,3) = 0.0D0
   10 CONTINUE
      CPROP(4,3) = CPROP(4,6)
      CPROP(6,3) = CPROP(6,6)
```

```
      CPROP(7,3) = CPROP(7,6)
C
      IF ( H2OMF .LE. 0.000 )  THEN
C       Now remove the required amount of water so that the feed gas to
C       the pressure swing absorption unit has the specified amount of
C       water.
C       Calculate the total moles of remaining DRY gas.
        TMOLES = 0.0D0
        DO 20 J = 1, KMAXC
          IF ( J .NE. 8 )   THEN
            IF ( CPROP(J,1) .GE. 1.0D-20 )  THEN
              X = (CPROP(J,6) - CPROP(J,3)) / CPROP(J,1)
            ENDIF
            TMOLES = TMOLES + X
          ENDIF
   20   CONTINUE
C
C       Calculate the weight of water that has to remain in the mixed
C       gas stream after water washing and amine scrubbing; i.e., the
C       remaing gas going to the pressure swing absorption unit.
        WTH2O = H2OMF * TMOLES * CPROP(8,1) / (1.0D0 - H2OMF)
        CPROP(8,3) = CPROP(8,6) - WTH2O
      ENDIF
C
C     Calculate the total feed stream to the PSA unit itself.
      DO 30 J = 1, KMAXC
        CPROP(J,2) = CIN(J) - CPROP(J,3)
   30 CONTINUE
C
C     Calculate the total composition of the non-hydrogen components in
C     the H2-rich product gas stream.
      SUMYC = 0.0D0
      DO 120 J = 1, KMAXC
        SUMYC = SUMYC + YC(J)
  120 CONTINUE
C
      IF ( KTEST .GE. 2 )   THEN
        WRITE (NHSTRY, 502)
  502   FORMAT ( / ' The composition of the non-hydrogen components ',
     1    'in the hydrogen-rich' /
     2    ' product gas stream, mole %.' )
        DO 130 J = 1, KMAXC
          IF ( YC(J) .GT. 0.0D0 )  THEN
            K = 2 * J - 1
            IF ( YC(J) .GE. 0.0D0 )  THEN
              WRITE (NHSTRY, 503)  J, ICNAME(K), ICNAME(K+1), YC(J)
  503         FORMAT ( 1X, I5, 5X, 2A4, 5X, F11.4 )
            ENDIF
          ENDIF
  130   CONTINUE
        WRITE (NHSTRY, 504)  SUMYC
  504   FORMAT ( 11X, 'Total', 8X, F11.4 )
C
        WRITE (NHSTRY, 505)  PURITY, RECVY
  505   FORMAT ( / ' Specified hydrogen purity   =', F10.3, ' mole %' /
```

```
     1    ' Specified hydrogen recovery =', F10.3, ' %' )
      ENDIF
C
C     Zero the component flow rates in the H2-rich product gas stream.
      DO 140 J = 1, KMAXC
        COUT(J) = 0.0D0
  140 CONTINUE
C
C     Load the specified amount of hydrogen in the H2-rich product gas
C     stream in lbs/hr.
      COUT(1) = 0.01D0 * RECVY * CPROP(1,2)
C
C     Calculate the total moles of H2 in the H2-rich product gas stream
C     in lb-moles/hr.
      H2MOLS = COUT(1) / CPROP(1,1)
C
C     Calculate the total molar flow of non-hydrogen components in the
C     H2-rich product gas stream in lb-moles/hr.
      TMOLES = (100.0D0 - PURITY) * H2MOLS / PURITY
C
C     Calculate the flow rate in lbs/hr of each non-hydrogen component
C     in the H2-rich product gas stream in lbs/hr.
      DO 150 J = 2, KMAXC
        COUT(J) = CPROP(J,1) * YC(J) * TMOLES / SUMYC
  150 CONTINUE
C
C     If necessary, adjust the above component flow rates in case more
C     of a component has been specified to appear in the outlet stream
C     than is in present in the inlet stream.  In this case substitute
C     methane (CO), component number 11, for the missing amount of this
C     component to maintain the component balance and the specified
C     hydrogen purity in the hydrogen-rich product gas stream.
      IER2 = 0
      K = 11
      LK = 2 * K - 1
      DO 160 J = 2, KMAXC
        X = COUT(J) - CPROP(J,2)
        IF ( X .GT. 0.1D0 )  THEN
          COUT(J) = COUT(J) - X
          IF ( CPROP(J,1) .GE. 1.0D-20 )  THEN
            COUT(K) = COUT(K) + X * CPROP(K,1) / CPROP(J,1)
          ENDIF
          L = 2 * J - 1
          IF ( IER2 .EQ. 0 .AND. KTEST .LE. 0 )  WRITE (NHSTRY, 506)
     1      IPASS
  506     FORMAT ( // 1X, 'Plant 6.2 - Supplementary data from ',
     1      'subroutine USR62' /
     2      2X, 'The Hydrpgen Purification by Pressure Swing ',
     3      'Absorption Plant', 10X, 'IPASS =', I3)
          WRITE (NHSTRY, 507) ICNAME(L), ICNAME(L+1), X, ICNAME(LK),
     1      ICNAME(LK+1)
  507     FORMAT ( / ' * WARNING * - The flow rate of ', 2A4,
     1      ' in the hydrogen-rich product gas' /
     2      3X, 'stream has been adjusted by', F8.1, ' lbs/hr to ',
     3      'maintain the component balance.' /
```

```
     4      3X, 2A4, ' has been substituted for it in the hydrogen-',
     5      'rich product gas stream to' /
     6      3X, 'to maintain the specified hydrogen purity.' )
          IER2 = IER2 + 1
        ENDIF
  160 CONTINUE
C
C     Calculate the component flow rates in all the product streams.
C     The reject gas stream.
      DO 170 J = 1, KMAXC
C       The total PSA unit low pressure exit gas stream.
        CPROP(J,4) = CIN(J) - CPROP(J,3) - COUT(J)
C       Remove the material that is condensed from this stream when
C       it is compressed to make the liquid naphtha product stream.
        CPROP(J,5) = FC(J) * CPROP(J,4)
C       The remaining vapor; i.e., the off-gas product stream.
        CPROP(J,4) = CPROP(J,4) - CPROP(J,5)
  170 CONTINUE
C
      IF ( KTEST .GE. 3 )   THEN
        WRITE (NHSTRY, 510)
  510   FORMAT ( / ' Hydrogen purification plant flow rates, lbs/hr' /
     1    33X, 'H2-rich', 8X, 'Sour', 6X, 'Reject'  /
     2    4X, 'No', 1X, 'Component', 7X, ' Feed', 9X, 'gas',
     3    9X, 'gas', 9X, 'gas', 5X, 'Naphtha' )
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        SUM4 = 0.0D0
        SUM5 = 0.0D0
        DO 180 J = 1, KMAXC
          IF ( CIN(J) .GT. 0.0D0 )  THEN
            K = 2 * J - 1
            IF ( ICNAME(K) .NE. BLANK4 )  THEN
              SUM1 = SUM1 + CIN(J)
              SUM2 = SUM2 + COUT(J)
              SUM3 = SUM3 + CPROP(J,3)
              SUM4 = SUM4 + CPROP(J,4)
              SUM5 = SUM5 + CPROP(J,5)
              WRITE (NHSTRY, 511)  J, ICNAME(K), ICNAME(K+1), CIN(J),
     1          COUT(J), CPROP(J,3), CPROP(J,4), CPROP(J,5)
  511         FORMAT ( 1X, I5, 1X, 2A4, 1X, 5F12.1)
            ENDIF
          ENDIF
  180   CONTINUE
        WRITE (NHSTRY, 512)  SUM1, SUM2, SUM3, SUM4, SUM5
  512   FORMAT ( 7X, 'Total', 4X, 5F12.1)
      ENDIF
C
C     If requested calculate and write to the history file the component
C     flow rates and composition of the H2-rich product gas stream.
      IF ( KTEST .GE. 3 )   THEN
        SUMWT  = 0.0D0
        SUMMOL = 0.0D0
        DO 190 J = 1, KMAXC
```

```
          SUMWT  = SUMWT  + COUT(J)
          IF ( CPROP(J,1) .GE. 1.0D-20)  THEN
            SUMMOL = SUMMOL + COUT(J) / CPROP(J,1)
          ENDIF
  190   CONTINUE
        WRITE (NHSTRY, 513)
  513   FORMAT ( / ' Hydrogen-rich product gas stream properties.' /
     1    4X, 'No', 1X, 'Component', 11X, 'lbs/hr', 9X, 'Wt %',
     2    7X, 'Mole %' )
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        DO 192 J = 1, KOMPS
          IF ( COUT(J) .GT. 0.0D0 )  THEN
            K = 2 * J - 1
            X = 100.0D0 * COUT(J) / SUMWT
            Y = 100.0D0 * COUT(J) / (CPROP(J,1) * SUMMOL)
            SUM1 = SUM1 + COUT(J)
            SUM2 = SUM2 + X
            SUM3 = SUM3 + Y
            WRITE (NHSTRY, 514)  J, ICNAME(K), ICNAME(K+1), COUT(J),
     1        X, Y
  514       FORMAT ( 1X, I5, 1X, 2A4, 5X, F13.1, 2F13.3 )
          ENDIF
  192   CONTINUE
        WRITE (NHSTRY, 515) SUM1, SUM2, SUM3
  515   FORMAT ( 7X, 'Total', 8X, F13.1, 2F13.3 )
      ENDIF
C
      RETURN
      END
C
C$ USR62B
      SUBROUTINE USR62B (ITEMS, KOMPS, KTEST, NCC, NCONV,
     1  NHSTRY, NNCC, SIN1, SIN2, SOUT1, SOUT2, SOUT3, SOUT4)
C
C     This subroutine loads the four product streams from the hydrogen
C     purification by pressure swing absorption plant into the SOUT1,
C     SOUT2, SOUT3, and SOUT4 stream vectors.  This subroutine is only
C     called when IPASS is not equat to 4.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - June 14, 1992.
C
C     Calling arguments:
C     ITEMS    = Total number of items in the SOUT1 vector.
C     KOMPS    = Total number of known conventional components in the
C                component vectors. (KOMPS must be < or = to 29)
C     KTEST    = Switch for controlling the printing to the history
C                file.
C     NCC      = Number of conventional components.
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 the first inlet stream.
C     SIN2()   = ASPEN/SP stream vector for the second inlet stream.
C     SOUT1()  = ASPEN/SP stream vector for the first outlet stream,
C                the hydrogen-rich product gas stream.
C     SOUT2()  = ASPEN/SP stream vector for the second outlet stream,
C                the sour gas stream.
C     SOUT3()  = ASPEN/SP stream vector for the third outlet stream,
C                the reject gas stream.
C     SOUT4()  = ASPEN/SP stream vector for the fourth outlet stream,
C                the liquid naphtha stream.
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)
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 SIN1(*), SIN2(*), SOUT1(*), SOUT2(*), SOUT3(*), SOUT4(*)
C
C
C     Set up the properties of the product streams.
C
C     Conventional components.
C     ------------------------
C     First, zero all the items in the product stream vectors.
      DO 200 J = 1, ITEMS
        SOUT1(J) = 0.0D0
        SOUT2(J) = 0.0D0
        SOUT3(J) = 0.0D0
        SOUT4(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
      SUM2 = 0.0D0
      SUM3 = 0.0D0
      SUM4 = 0.0D0
      DO 210 J = 1, NCC
        IF ( (SIN1(J) + SIN2(J)) .LE. 1.0D-25 )  GO TO 210
          DO 206 K = 1, KOMPS
            IF ( J .EQ. ICNUMB(K) )  THEN
C             The hydrogen-rich product gas stream.
              SOUT1(J) = COUT(K) / (CF * CPROP(K,1))
C             The sour gas stream.
              SOUT2(J) = CPROP(K,3) / (CF * CPROP(K,1))
C             The reject gas stream.
```

```
              SOUT3(J) = CPROP(K,4) / (CF * CPROP(K,1))
C             The liquid naphtha stream.
              SOUT4(J) = CPROP(K,5) / (CF * CPROP(K,1))
              SUM1 = SUM1 + SOUT1(J)
              SUM2 = SUM2 + SOUT2(J)
              SUM3 = SUM3 + SOUT3(J)
              GO TO 208
            ENDIF
  206     CONTINUE
C         Put all other components in the liquid naphtha stream.
          SOUT4(J) = SIN1(J) + SIN2(J)
  208     SUM4 = SUM4 + SOUT4(J)
  210 CONTINUE
C
C     Set the total molar flow rate of the conventional components.
      SOUT1(NCC+1) = SUM1
      SOUT2(NCC+1) = SUM2
      SOUT3(NCC+1) = SUM3
      SOUT4(NCC+1) = SUM4
C
C     Set the temperature and pressure of the product streams.
C     Return these values to ASPEN/SP in degrees Kelvin 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) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT1(NCC+3) = 15.0D0 * 6.8947573D+3
      SOUT2(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT2(NCC+3) = 15.0D0 * 6.8947573D+3
      SOUT3(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT3(NCC+3) = 15.0D0 * 6.8947573D+3
      SOUT4(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT4(NCC+3) = 15.0D0 * 6.8947573D+3
C
C     Call subroutine CPACK and funcion AVEMW to calculate the
C     average molecular weight of the conventional components in
C     all the product streams.
      CALL CPACK (SOUT1, NCP, IDX, XPACK, TMASS)
      SOUT1(NCC+9) = AVEMW (NCP, IDX, XPACK)
      CALL CPACK (SOUT2, NCP, IDX, XPACK, TMASS)
      SOUT2(NCC+9) = AVEMW (NCP, IDX, XPACK)
      CALL CPACK (SOUT3, NCP, IDX, XPACK, TMASS)
      SOUT3(NCC+9) = AVEMW (NCP, IDX, XPACK)
      CALL CPACK (SOUT4, NCP, IDX, XPACK, TMASS)
      SOUT4(NCC+9) = AVEMW (NCP, IDX, XPACK)
C
C
C     Non-conventional components.
C     ---------------------------
      IF ( NNCC .GE. 1 )   THEN
C       If present, set the temperature and pressure of the non-
C       conventional portion of the stream but ingnore any component
C       flows since they previously have been set to zero.
        SOUT1(NCONV+NNCC+2) = SOUT1(NCC+2)
        SOUT1(NCONV+NNCC+3) = SOUT1(NCC+3)
        SOUT2(NCONV+NNCC+2) = SOUT2(NCC+2)
```

```
          SOUT2(NCONV+NNCC+3) = SOUT2(NCC+3)
          SOUT3(NCONV+NNCC+2) = SOUT3(NCC+2)
          SOUT3(NCONV+NNCC+3) = SOUT3(NCC+3)
          SOUT4(NCONV+NNCC+2) = SOUT4(NCC+2)
          SOUT4(NCONV+NNCC+3) = SOUT4(NCC+3)
        ENDIF
C
C       If requested, write the items of interest in the outlet stream
C       vectors to the history file.
        IF ( KTEST .GE. 5 )  THEN
          WRITE (NHSTRY, 531)
  531     FORMAT ( // ' The outlet stream vectors' /
     1      14X, 'SOUT1', 10X, 'SOUT2', 10X, 'SOUT3', 10X, 'SOUT4' )
          DO 290 J = 1, ITEMS
            WRITE (NHSTRY, 532) J, SOUT1(J), SOUT2(J), SOUT3(J), SOUT4(J)
  532       FORMAT ( 2X, I5, 4(1PE15.5) )
  290     CONTINUE
        ENDIF
C
        RETURN
        END
C
C$ USR62S
        SUBROUTINE USR62S (ICNAME, IER1, IER2, INT1, KOMPS, KMAXC, NOUT)
C
C       This subroutine writes the first part of the plant summary report
C       for the hydrogen recovery by pressure swing absorption plant,
C       Plant 6.2.
C       This subroutine is only called when IPASS equals 4.
C
C       Prepared under DOE contract no. DE-AC22 90PC89857.
C
C       Last revision - June 14, 1991.
C
C       Calling arguments:
C       ICNAME() = Vector of component identifications (CHARACTER * 4)
C       IER1     = Switch to indicate whether the warning message
C                  indicating that solids are present in the inlet
C                  stream should be written.
C                  0 => Do not write the warning message.
C                  1 => Write the warning message.
C       IER2     = Switch to indicate whether the warning message
C                  indicating that the composition of the non-hydrogen
C                  components in the H2-rich product gas stream had to
C                  be adjusted to maintain the individual component
C                  balance 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       KOMPS    = Total number of known conventional components in the
```

```
C                 component vectors. (KOMPS must be < or = to 29)
C     KMAXC     = Component number of the component used to lump all
C                 unknown components.
C     NOUT      = Logical unit number of the plant output report file.
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)
C
C     Note to save space, the CPROP(40,7) array in nammed COMMON
C     /USR02M/ is used to store the following
C       CPROP(J,1) = Vector of component molecular weights.
C       CPROP(J,2) = Vector of component flow rates in the total gas
C                    feed stream after water washing and amine
C                    scrubbing to the PSA unit itself.
C       CPROP(J,3) = Vector of component flow rates in the sour gas
C                    product stream that is produced by combining the
C                    material removed in the water washing and amine
C                    scrubbing steps in lbs/hr.
C       CPROP(J,4) = Vector of component flow rates in the reject gas
C                    product stream.
C       CPROP(J,5) = Vector of component flow rates in the liquid
C                    naphtha product stream.
C       CPROP(J,6) = The mixed gas feed stream.
C       CPROP(J,7) = The reject gas stream from plant 6.1, the hydrogen
C                    purification by membrane permeation plant.
C
      DIMENSION ICNAME(*)
C
      CHARACTER * 4  ICNAME
C
C
      IF ( INT1 .LE. 2 )  THEN
C
C       Write the first part of the plant summary report.
C       ================================================
        WRITE (NOUT, 801)
  801   FORMAT ( / 23X, 'PLANT 6.2 - SUMMARY REPORT' /
     1    11X, 'HYDROGEN PURIFICATION BY PRESSURE SWING ABSORPTION' )
C
        WRITE (NOUT, 802)
  802   FORMAT ( / ' INLET STREAM COMPONENT FLOW RATES, LBS/HR' /
     1    2X, 'COMPONENT', 10X, 'MIXED GAS', 4X, 'FROM P6.1', 8X,
     2    'TOTAL' )
C
C       Write the component flow rates in lbs/hr.
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        DO 10 J = 1, 19
          IF ( CIN(J) .GE. 0.1D0 ) THEN
            K = 2 * J - 1
            SUM1 = SUM1 + CPROP(J,6)
```

```
            SUM2 = SUM2 + CPROP(J,7)
            SUM3 = SUM3 + CIN(J)
            WRITE (NOUT, 803) ICNAME(K), ICNAME(K+1), CPROP(J,6),
     1        CPROP(J,7), CIN(J)
  803       FORMAT ( 2X, 2A4, F20.1, 3F13.1 )
          ENDIF
   10   CONTINUE
C
C       The 200+ F components.
        X1 = CPROP(30,6)
        X2 = CPROP(30,7)
        X3 = CIN(30)
        DO 20 J = 20, KOMPS
          X1 = X1 + CPROP(J,6)
          X2 = X2 + CPROP(J,7)
          X3 = X3 + CIN(J)
   20   CONTINUE
        IF ( X3 .GE. 1.0D0 )   WRITE (NOUT, 804)  X1, X2, X3
  804   FORMAT ( 2X, '200+ F', F22.1, 3F13.1 )
        SUM1 = SUM1 + X1
        SUM2 = SUM2 + X2
        SUM3 = SUM3 + X3
C
        WRITE (NOUT, 805) SUM1, SUM2, SUM3
  805   FORMAT ( 2X, 'TOTAL', F23.1, 3F13.1 )
C
C       Calculate the total stream flow rates in MM SCF/hr.
        SUMM1 = 0.0D0
        SUMM2 = 0.0D0
        SUMM3 = 0.0D0
        DO 30 J = 1, KOMPS
          IF ( CPROP(J,1) .GE. 1.0D-20 )  THEN
            SUMM1 = SUMM1 + CPROP(J,6) / CPROP(J,1)
            SUMM2 = SUMM2 + CPROP(J,7) / CPROP(J,1)
            SUMM3 = SUMM3 + CIN(J) / CPROP(J,1)
          ENDIF
   30   CONTINUE
        SCF1 = 379.495D-6 * SUMM1
        SCF2 = 379.495D-6 * SUMM2
        SCF3 = 379.495D-6 * SUMM3
        WRITE (NOUT, 806) SCF1, SCF2, SCF3
  806   FORMAT ( / 2X, 'FLOW, MM SCF/HR', F13.3, 3F13.3 )
C
        WRITE (NOUT, 807) ST1(1,2), ST1(2,2), ST1(1,3), ST1(2,3)
  807   FORMAT ( 2X, 'TEMPERATURE, F', F14.1, F13.1 /
     1    2X, 'PRESSURE, PSIA', F14.1, F13.1 )
C
        WRITE (NOUT, 812)
  812   FORMAT ( / ' OUTLET STREAM COMPONENT FLOW RATES, LBS/HR' /
     1    2X, 'COMPONENT', 12X, 'H2-RICH', 5X,
     2    'SOUR GAS', 3X, 'REJECT GAS', 6X, 'NAPHTHA' )
C
C       Write the component flow rates in lbs/hr.
        SUM1 = 0.0D0
        SUM2 = 0.0D0
```

```
      SUM3 = 0.0D0
      SUM4 = 0.0D0
      DO 40 J = 1, 19
        IF ( CIN(J) .GE. 0.1D0 ) THEN
          K = 2 * J - 1
          SUM1 = SUM1 + COUT(J)
          SUM2 = SUM2 + CPROP(J,3)
          SUM3 = SUM3 + CPROP(J,4)
          SUM4 = SUM4 + CPROP(J,5)
          WRITE (NOUT, 803) ICNAME(K), ICNAME(K+1),
     1      COUT(J), CPROP(J,3), CPROP(J,4), CPROP(J,5)
        ENDIF
   40 CONTINUE
C
C     The 200+ F components.
      X1 = COUT(30)
      X2 = CPROP(30,3)
      X3 = CPROP(30,4)
      X4 = CPROP(30,5)
      DO 50 J = 20, KOMPS
        X1 = X1 + COUT(J)
        X2 = X2 + CPROP(J,3)
        X3 = X3 + CPROP(J,4)
        X4 = X4 + CPROP(J,5)
   50 CONTINUE
      IF ( X4 .GE. 1.0D0 )   WRITE (NOUT, 804)  X1, X2, X3, X4
      SUM1 = SUM1 + X1
      SUM2 = SUM2 + X2
      SUM3 = SUM3 + X3
      SUM4 = SUM4 + X4
C
      WRITE (NOUT, 805) SUM1, SUM2, SUM3, SUM4
C
C     Calculate the total stream flow rates in MM SCF/hr.  Ignore
C     the HEAVIES component in this calculation.
      SUMM1 = 0.0D0
      SUMM2 = 0.0D0
      SUMM3 = 0.0D0
      DO 60 J = 1, KOMPS
        IF ( CPROP(J,1) .GE. 1.0D-20 )  THEN
          SUMM1 = SUMM1 + COUT(J) / CPROP(J,1)
          SUMM2 = SUMM2 + CPROP(J,3) / CPROP(J,1)
          SUMM3 = SUMM3 + CPROP(J,4) / CPROP(J,1)
        ENDIF
   60 CONTINUE
      SCF1 = 379.495D-6 * SUMM1
      SCF2 = 379.495D-6 * SUMM2
      SCF3 = 379.495D-6 * SUMM3
      WRITE (NOUT, 806) SCF1, SCF2, SCF3
C
      WRITE (NOUT, 816) ST2(1,2), ST2(2,2), ST2(3,2), ST2(4,2),
     1  ST2(1,3), ST2(2,3), ST2(3,3), ST2(4,3)
  816 FORMAT ( 2X, 'TEMPERATURE, F', F14.1, 3F13.1 /
     1  2X, 'PRESSURE, PSIA', F14.1, 3F13.1 )
C
```

```
C       Calculate and report the hydrogen flow rate in MM SCF/hr and
C       the mole percent hydrogen in each vapor product stream.
        XMH1 = COUT(1) / CPROP(1,1)
        XMH3 = CPROP(1,4) / CPROP(1,1)
        SCF1 = 379.495D-6 * XMH1
        SCF3 = 379.495D-6 * XMH3
        PH1 = 100.0D0 * XMH1 / SUMM1
        PH3 = 100.0D0 * XMH3 / SUMM3
        WRITE (NOUT, 817) SCF1, SCF3, PH1, PH3
  817   FORMAT ( / 2X, 'H2 FLOW, MM SCF/HR', F10.3, F26.3 /
     1    2X, 'MOLE % HYDROGEN', F13.3, F26.3 )
C
        IF ( IER1 .GE. 1 )  WRITE (NOUT, 821)
  821   FORMAT ( / 1X, '*WARNING* THE FEED TO THIS HYDROGEN ',
     1    'PURIFICATION PLANT CONTAINS SOLIDS.' /
     2    2X, 'THEY WILL BE LOST IN THE PROCESS.',
     3    '  PLANT 6.2 IS NOT IN MASS BALANCE.' )

C
        IF ( IER2 .GE. 1 )  WRITE (NOUT, 822) IER2
  822   FORMAT  (/ 1X, '*WARNING* THE COMPOSITION OF', I3,
     1    ' NON-HYDROGEN COMPONENT(S) IN THE HYDROGEN-' /
     2    2X, 'RICH GAS STREAM HAS BEEN ADJUSTED TO MAINTAIN THE ',
     3    'INDIVIDUAL COMPONENT' /
     4    2X, 'BALANCE AND THE SPECIFIED HYDROGEN PURITY.' )
C
        IF ( INT1 .LE. 1 )   WRITE (NOUT, 831)
  831   FORMAT ( / 25X, '- CONTINUED ON NEXT PAGE -' )
C
      ENDIF
C
C
  999 RETURN
      END
C
C$  Subroutine USR07
C
C     This file contains the following subroutines:
C       USR07    Main routine for naphtha reformer plant model.
C       USR07R   Subroutine which does the yields calculations and
C                splits the yields into the three product streams.
C       USR07S   Subroutine to load the outlet streams into the
C                product stream vectors.
C
C     NOTE:  This model common block COMMON /USR02M/.
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 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       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 /USRC01/.
C
C$ USR07
      SUBROUTINE USR07 (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:  USR07
C
C  BLOCK DESCRIPTION:  Naphtha Reformer Plant Model
C
C                        -----------------------
C                        |       Plant 7       | ---> Hydrogen Rich Gas
C                        |                     |
C     Naphtha Feed---->|   Naphtha Reformer  | ---> Light Gases
C                        |        Plant        |
C                        |                     | ---> Reformate Product
C                        -----------------------
C
C  Prepared under DOE contract no. DE-AC22-90PC 89857.
C
C  FUNCTION (MODEL, REPORT, OR BOTH):  Both
C
C  Last revision - May 29, 1992.
C
C  ASSUMPTIONS, SPECIAL FEATURES AND LIMITATIONS:
C     1.  The single inlet stream is the naphtha feed stream.
C     2.  There are 3 product streams.
C           1.  The hydrogen rich product gas stream.
C           2.  The light hydrocarbon product gas stream.
C           3.  The reformate product stream.
C     3.  This user block model will work with any number of
C         conventional components, but requires that 7 specific
C         conventional components must be available in the component
C         list.
C     4.  This user block Fortran model requires that all inupt and
C         output streams are of the ASPEN/SP stream class
C         conventional, MIXNC, or MIXNCPSD.
C     5.  If the inlet stream is of class MIXNC or MIXNCPSD, then
C         the order of the items in the ATTR-COMPS statement must be
C         PROXANAL, ULTANAL, SULFANAL AND AOXANAL because it is in
C         this order that ASPEN/SP stores these items, and this
C         subroutine assumes this order.  Therefore, the three
C         ATTR-COMPS 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 non-conventional (solid) components in the input stream
C         will be ignored, and the plant will not be in mass balance.
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 DCL07.REP.
C          INT(3)  = Number of operating duplicate trains, excluding
C                    spares.
C                    If INT(3) = 0, the minimum number of duplicate
C                      trains will be determined so that the capacity
C                      each train does not exceed the maximum train
C                      capacity specified by variable REAL(52).
C                    If INT(3) > 0, this number of duplicate trains will
C                      be used.
C          INT(4)  = History file additional output control switch.
C                    0 => Write no additional output to the history 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     8.   The 70 real parameters are:
C          REAL(1) -
C           REAL(20) = Future use.
C          REAL(21)  = Constant factor for the power consumption, kw.
C          REAL(22)  = Power consumption per Mlbs/hr of feed,
C                      kw/(Mlbs/hr of feed)
C          REAL(23)  = Constant factor for the 900 psig / 750 F steam
C                      consumption, Mlbs/hr.
C          REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr
C                      of feed, (Mlbs/hr)/(Mlbs/hr of feed).
C          REAL(25)  = Constant factor for the 900 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr
C                      of feed, (Mlbs/hr)/(Mlbs/hr of feed).
C          REAL(27)  = Constant factor for the 600 psig / 720 F steam
C                      consumption, Mlbs/hr.
C          REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr
C                      of feed, (Mlbs/hr)/(Mlbs/hr of feed).
C          REAL(29)  = Constant factor for the 600 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr
C                      of feed, (Mlbs/hr)/(Mlbs/hr of feed).
C          REAL(31)  = Constant factor for the 150 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr
C                      of feed, (Mlbs/hr)/(Mlbs/hr of feed).
```

```
C         REAL(33)  = Constant factor for the 50 psig saturated steam
C                     consumption, Mlbs/hr.
C         REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr
C                     of feed, (Mlbs/hr)/(Mlbs/hr of feed).
C         REAL(35)  = Constant factor for the plant fuel consumption,
C                     MM BTU/hr.
C         REAL(36)  = Plant fuel consumption per Mlbs/hr of feed,
C                     (MM BTU/hr)/(Mlbs/hr of feed).
C         REAL(37)  = Constant factor for the cooling water consumption,
C                     Mgal/hr.
C         REAL(38)  = Cooling water consumption per Mlbs/hr of feed,
C                     (Mgal/hr)/(Mlbs/hr of feed).
C         REAL(39)  = Constant factor for the process water consumption,
C                     Mgal/hr.
C         REAL(40)  = Process water consumption per Mlbs/hr of feed,
C                     (Mgal/hr)/(Mlbs/hr of feed).
C         REAL(41)  = Constant factor for the nitrogen consumption,
C                     MM SCF/hr of N2.
C         REAL(42)  = Nitrogen consumption per Mlbs/hr of feed,
C                     (MM SCF/hr of N2)/(Mlbs/hr of feed).
C         REAL(43) -
C          REAL(48) = Future use.
C         REAL(49)  = Constant factor for the number of operators per
C                     day, operators/day.
C         REAL(50)  = Number of operators per day per train,
C                     (operators/day)/train.
C         REAL(51)  = Reference feed rate to a single train in
C                     Mlbs/hr for the calculation of the ISBL field cost
C                     of a single train as a function of train capacity.
C         REAL(52)  = Maximum size of a single train as defined by the
C                     feed rate in Mlbs/hr of feed.
C         REAL(53)  = Minimum size of a single train as defined by the
C                     feed rate in Mlbs/hr of feed.
C         REAL(54)  = Constant A in the plant ISBL field cost equation.
C         REAL(55)  = Constant B in the plant ISBL field cost equation.
C         REAL(56)  = Constant E in the plant ISBL field cost equation.
C         REAL(57)  = Constant F in the plant ISBL field cost equation.
C         REAL(58)  = Number of spare trains.
C         REAL(59) -
C          REAL(70) = 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.   CH4          Methane
C       3.   C2H6         Ethane
C       4.   C3H8         Propane
C       5.   IC4H10       Iso-butane
C       6.   NC4H10       Normal butane
C       7.   REFORMAT     Reformate product
C       8.-
C        10. blank        Future use
C
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(2,5), ST2(3,5)
C
C     In COMMON /USR02M/
C       CIN(J) is not used.
C       COUT(J) contains the component flow rates leaving the
C         naphtha reformer reactors in lbs/hr.
C       CPROP(J,K) is not used.  This storage space is used by the
C         STRM(J,K) vector in subroutines USR07R and USR07S to
C         save space via an EQUIVALNCE statement.
C       ICNUMB(J) contains the relative component numbers.
C       ST1(J,K) and ST2(J,K) contain the properties of up to 2 inlet
C         and 3 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
C     Local variable declaration statements.
      DIMENSION ICN(2), ICNAME(20)
C
      CHARACTER * 4  ICN, ICNAME
      CHARACTER * 6  PNAME
C
C     Initialize the component identifications.
      DATA KOMPS / 7 /
      DATA ICNAME / 'H2  ', '    ', 'CH4 ', '    ', 'C2H6', '    ',
     1  'C3H8', '    ', 'IC4H', '10  ', 'NC4H', '10  ', 'REFO', 'RMAT',
     2  '    ', '    ', '    ', '    ', '    ', '    ' /
C
      DATA PNAME / '7     ' /
C
C
C     PARAMETER INITIALIZATION SECTION
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)
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 7 - Supplementary data from ',
     1    'subroutine USR07' /
     2    2X, 'Naphtha Reformer Plant', 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 naphtha reformer plant ',
     1    'requires 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 are exactly 3 outlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSOUT .NE. 3 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501) IPASS
        WRITE (NHSTRY, 503)  NSOUT
  503   FORMAT ( / 1X, '* ERROR * - The naphtha reformer plant ',
     1    'requires exactly 3 outlet streams.' /
     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     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 = 1
C
C     Can the inlet stream contain non-conventional components?
      NUMPSD = 0
      IF ( NSUBS .EQ. 2 .AND. ITYPE(2) .EQ. 3 )   THEN
        KLASS = 2
C       Check for a substream PSD attribute on the second substream of
C       the first inlet stream.
        CALL GETSTR (IDS(1,4), NB, LB, NBD, LBD)
        NUMATT = NPAT (LBD, 2)
        IF ( NUMATT .GT. 0 )   THEN
          NUMPSD = NAVAR (LBD, 2, 1)
          KLASS = 3
```

```
        ENDIF
      ENDIF
C
C     Set the offset variable for the conventional substream.
      NCONV = (NCC + 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 = NCONV
      IF ( KLASS .EQ. 2 )  ITEMS = ITEMS + ( NNCC + 9 )
     1                             + NITEMS * NNCC
      IF ( KLASS .EQ. 3 )  ITEMS = ITEMS + NUMPSD
C
C     Calculate the total inlet flow rate of all conventional
C     components in lbs/hr, and save it in ST1(1,1).
C     CF is the conversion factor from Kg/sec to lbs/hr.
      CF = 3600.0D0 / 0.45359237D0
      J = NCC + 1
      K = NCC + 9
      ST1(1,1) = CF * SIN1(J)*SIN1(K)
C
      IF ( ST1(1,1) .LE. 1.0D0 )   THEN
C       Skip all remaing calculations if this plant has no flow.
        IF ( KTEST .GE. 1 )  WRITE (NHSTRY, 504)
  504   FORMAT ( / ' There is no material entering plant 7, the ',
     1    'naphtha reformer plant.' )
        GO TO 999
C       ---------
      ENDIF
C
C     Calculate the total unit feed rate of conventional components
C     in Mlbs/hr.
      FLOWIN = 0.001D0 * ST1(1,1)
C
      SOLIDS = 0.0D0
      IF ( KLASS .GE. 2 )   THEN
        J = NCC + 9 + NNCC + 1
        SOLIDS = CF * SIN1(J)
        IF ( SOLIDS .GE. 1.0D0 )  THEN
          IF ( KTEST .LE. 0 )  WRITE (NHSTRY, 501)  IPASS
          WRITE (NHSTRY, 505) SOLIDS
  505     FORMAT (/ 1X, '* WARNING * The feed stream to the ',
     1      'naphtha reformer plant' /
     2      3X, 'contains solids, ', F10.1, ' lbs/hr.' /
     3      3X, 'These solids are being ignored.  The plant will ',
     4      'NOT be in mass balance.' /
     5      3X, 'Please remove these solids from the feed stream to ',
     6      'this plant plant.' )
        ENDIF
      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 naphtha reformer plant model 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     Set up the maximum and minimum train flow rates in Mlbs/hour
C     of unit feed.
      PMAXF = REAL(52)
      PMINF = REAL(53)
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     If it has not been specified by the user in variable INT(3),
C     calculate the number of operating duplicate trains, excluding
C     spares (NPLNT), based on the total flow rate of the reference
C     stream.  However, if the maximum capacity of a single train
C     has not been specified, set the number of operating trains to 1.
      NPLNT = INT(3)
      IF ( (NPLNT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
          NPLNT = FLOWIN  / PMAXF
          IF ( (MOD(FLOWIN, PMAXF)) .GT. 0.0D0 )  NPLNT = NPLNT + 1
```

```
          ELSE
            IF ( NPLNT .EQ. 0 )   NPLNT = 1
        ENDIF
C
C       Calculate the feed rate for each of the duplicate trains (PFLOW)
C       in Mlbs/hr.
        XPLNT = NPLNT
        PFLOW = FLOWIN / XPLNT
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 plant summary report.
              LSTRM = 17
              LUTIL = 16
              LCOST = 11
              IF (SOLIDS .GE. 1.0D0 )  LSTRM = LSTRM + 4
              NDUP = REAL(58) + 0.001D0
              IF ( (NPLNT + NDUP) .EQ. 1 )  LCOST = 9
              IF ( PFLOW .LT. PMINF )  LCOST = LCOST + 3
              IF ( PFLOW .GT .PMAXF )  LCOST = LCOST + 3
              IF ( NDUP .GE. 1 )  LCOST = LCOST + 1
              LINES = LSTRM + LUTIL + LCOST
C             Now, subtract the number of lines for those portions of
C             the user block summary report which will not be written.
              IF ( INT(1) .GE. 2 )   LINES = LINES - LUTIL
              IF ( INT(1) .GE. 1 )   LINES = LINES - LCOST
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 DCL07.REP to contain
C             this user block summary report.
              OPEN (UNIT=62, FILE='DCL07.REP', STATUS='UNKNOWN',
     1          ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2          BUFFERED='BUFFERED')
              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' )
          ENDIF
      ENDIF
C
C     Load the entering inlet and outlet stream temperatures (in
C     degrees Fahrenheit) and stream pressures (in PSIA) in the ST1
C     and ST2 arrays.  The outlet stream cconditions will be reset
C     later in the calculations.
      X = 1.8D0
      X1 = 459.67D0
      ST1(1,2) = X * SIN1(NCC+2) - X1
```

```
      ST2(1,2) = X * SOUT1(NCC+2) - X1
      ST2(2,2) = X * SOUT2(NCC+2) - X1
      ST2(3,2) = X * SOUT3(NCC+2) - X1
      X = 1.0D0 / 6.8947573D+3
      ST1(1,3) = X * SIN1(NCC+3)
      ST2(1,3) = X * SOUT1(NCC+3)
      ST2(2,3) = X * SOUT2(NCC+3)
      ST2(3,3) = X * SOUT3(NCC+3)
C
C     Call Subroutine USR07R to calculate the net naphtha reformer
C     yields, distribute them among the 3 product streams, and write
C     the first part of the plant summary report.
      CALL USR07R (ICNAME, INT(1), IPASS, KOMPS, KTEST, NHSTRY, NOUT)
C
C     If appropriate, write the following warning message to the plant
C     summary report.
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 2 )  THEN
        IF ( SOLIDS .GE. 1.0D0 )  WRITE (NOUT, 811)
  811   FORMAT (/ 1X, '*WARNING* THE FEED STREAM TO THIS ',
     1    'PLANT CONTAINS SOLIDS.' /
     2    2X, 'THEY ARE BEING IGNORED.  '
     3    'THIS PLANT IS NOT IN MASS BALANCE.' /
     4    2X, 'PLEASE REMOVE THESE SOLIDS FROM THE ',
     5    'FEED STREAM.' )
       ENDIF
C
      IF ( IPASS .NE. 4 )   THEN
C       Call Subroutine USR07S to load the product streams into the
C       SOUT1, SOUT2 AND SOUT3 vectors for transfer to ASPEN/SP.
        CALL USR07S (ICNAME, ITEMS, KLASS, KOMPS, KTEST,
     1    NCC, NHSTRY, NNCC, SIN1, SOUT1, SOUT2, SOUT3 )
      ENDIF
C
C     Call subroutine USRUCO to calculate, save and report the
C     utilities, capital and operating costs for the plant.
      ID = 9
      KUNITS = 2
      CALL USRUCO (NHSTRY, NOUT, IPASS, ID, PNAME, INT(1), INT(3),
     1  KTEST, REAL(21), FLOWIN, KUNITS)
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 USR07' )
C
      RETURN
      END
C
C$ USR07R
      SUBROUTINE USR07R (ICNAME, INT1, IPASS, KOMPS, KTEST, NHSTRY,
     1  NOUT)
C
```

```
C     This subroutine calculates the net naphtha reformer yields,
C     and distributes them among the three product streams.
C
C     Prepared under DOE contract no. DE-AC22 91PC90027.
C
C     Last revision - January 30, 1992.
C
C     Method of calculation:
C     ----------------------
C       1.  This is a very simplistic naphtha reformer model because
C           of proprietary considerations.  Therefore, this plant is
C           NOT in elemental balance.
C       2.  This model assumes all entering maaterial is naphtha which
C           is reformed to produce the yield slate given in the YLDS
C           vector.  The reformate product has a 95.0 clear Research
C           octane number.
C       3.  The net reformer yields are saved in the COUT vector.
C       4.  The net reformer yields are split into the three product
C           streams.  One set of splitting factors is used to
C           distribute the hydrogen and light hydrocarbon gases bewteen
C           the 2 gaseous product streams.  All the reformate goes to
C           the reformate product stream.  It is the only component in
C           this stream.
C
C     Calling arguments:
C     ICNAME() = Vector of component identifications (CHARACTER * 4)
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     KOMPS    = Number of conventional components used in this model.
C     KTEST    = Switch for controlling the printing to the history
C                file.
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
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON /USRO2M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(2,5), ST2(3,5)
C
      DIMENSION ICNAME(*)
C
C     Local variable declarations.
      DIMENSION FH2(10), STRM(10,3), YLDS(10)
      EQUIVALENCE (STRM(1,1), CPROP(1,1))
C
C     The STRM(J,K) array contains the flow rates of component J in
C     product stream K.  In order to save space, thus array is
C     equivalenced to the CPROP() array in COMMON /USRO2M/.
```

```
C
      CHARACTER * 4  ICNAME
C
C     The YLDS vector contains the net naphtha reformer weight
C     percent yields based on total plant feed.
C                   H2       ,  CH4      ,  C2H6     ,  C3H8
      DATA YLDS /  3.089318,  0.428465,  1.280491,  1.325076,
C       IC4H10  ,  NCH10   ,  REFORMAT,  future,  future,  future
     1  0.339294,  0.452095,  93.08526,  0.0    ,  0.0    ,  0.0   /
C
C     The FH2 vector contains the fraction of component J leaving the
C     naphtha reformer in the H2 rich product gas stream, the first
C     product stream.  All other light hydrocarbon gases leave in the
C     light hydrovarbon product gas stream, the second product stream.
C     All REFORMAT leaves in the reformate stream, the third product
C     stream.
C                   H2       ,  CH4      ,  C2H6     ,  C3H8
      DATA FH2  /  0.994515,  0.965660,  0.832520,  0.429004,
C       IC4H10  ,  NCH10   ,  REFORMAT,  future,  future,  future
     1  0.366622,  0.366863,  0.0      ,  0.0    ,  0.0    ,  0.0    /
C
C
      IF ( KTEST .GE. 2 )  WRITE (NHSTRY, 501)
  501 FORMAT ( / ' Starting the naphtha reformer yield ',
     1  'calculations in Subroutine USR07R.' )
C
C     Calculate the net naphtha reformer yields and save them in the
C     COUT vector.  Note that ST1(1,1) contains the total plant feed
C     rate in lbs/hr.
      SUM = 0.0
      DO 30 J = 1, 6
        COUT(J) = 0.01 * ST1(1,1) * YLDS(J)
        SUM = SUM + COUT(J)
   30 CONTINUE
C     Calculate the reformate yield by difference.
      COUT(8) = ST1(1,1) - SUM
C
C     If requested, write the total naphtha reformer product rates to
C     the history file.
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 721)
  721   FORMAT ( / '  Total naphtha reformer product rates in lbs/hr.')
        DO 450 J = 1, KOMPS
          K = 2 * J - 1
          WRITE (NHSTRY, 722) ICNAME(K), ICNAME(K+1), COUT(J)
  722     FORMAT ( 4X, 2A4, F16.1, F14.1 )
  450   CONTINUE
        WRITE (NHSTRY, 723)  ST1(1,1)
  723   FORMAT ( 4X, 'Total', 3X, F16.1 )
      ENDIF
C
C     Split the above yields into the three product streams.
      ST2(1,1) = 0.0D0
      ST2(2,1) = 0.0D0
C     The hydrogen and light hydrocarbon gases.
```

```
      DO 40 J = 1, 6
        STRM(J,1) = FH2(J) * COUT(J)
        STRM(J,2) = COUT(J) - STRM(J,1)
        STRM(J,3) = 0.0D0
        ST2(1,1) = ST2(1,1) + STRM(J,1)
        ST2(2,1) = ST2(2,1) + STRM(J,2)
   40 CONTINUE
C     Load all the REFORMAT in the reformate stream.
      STRM(7,1) = 0.0D0
      STRM(7,2) = 0.0D0
      STRM(7,3) = COUT(8)
      ST2(3,1) = STRM(7,3)
C
C     If requested, write the product stream rates to the history file.
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 731)
  731   FORMAT ( / '  Product stream flow rates in lbs/hr.' /
     1    4X, 'Component', 8X, 'H2 Rich', 9X, 'Gases', 5X, 'Reformate')
        DO 460 J = 1, 7
          K = 2 * J - 1
          WRITE (NHSTRY, 732) ICNAME(K), ICNAME(K+1), STRM(J,1),
     1      STRM(J,2), STRM(J,3)
  732     FORMAT ( 4X, 2A4, F16.1, 3F14.1 )
  460   CONTINUE
        WRITE (NHSTRY, 733)  ST2(1,1), ST2(2,1), ST2(3,1)
  733   FORMAT ( 4X, 'Total', 3X, F16.1, 2F14.1 )
      ENDIF
C
C
      IF ( IPASS .EQ. 4 .AND. INT1 .LE. 2 )  THEN
C
C       Write the plant summary output report.
C       ======================================
        WRITE (NOUT, 801)
  801   FORMAT ( / 27X, 'PLANT 7 - SUMMARY REPORT' /
     1    28X, 'NAPHTHA REFORMER PLANT')
C
        WRITE (NOUT, 821)
  821   FORMAT ( / '  PRODUCT STREAM FLOW RATES, MLBS/HR' /
     1    4X, 'COMPONENT', 8X, 'H2 RICH', 8X, 'HC GAS', 5X,
     2    'REFORMATE' )
C
C       Write the individual stream component flow rates in Mlbs/hr.
        DO 210 J = 1, KOMPS
          K = 2 * J - 1
          X1= 0.001D0 * STRM(J,1)
          X2= 0.001D0 * STRM(J,2)
          X3= 0.001D0 * STRM(J,3)
          WRITE (NOUT, 831) ICNAME(K), ICNAME(K+1), X1, X2, X3
  831     FORMAT ( 4X, 2A4, F16.3, 2F14.3 )
  210   CONTINUE
        X1 = 0.001D0 * ST2(1,1)
        X2 = 0.001D0 * ST2(2,1)
        X3 = 0.001D0 * ST2(3,1)
        WRITE (NOUT, 832)  X1, X2, X3
```

```
  832   FORMAT ( 4X, 'TOTAL', 3X, F16.3, 2F14.3 )
C
        WRITE (NOUT, 841) ST2(1,2), ST2(2,2), ST2(3,2), ST2(1,3),
     1    ST2(2,3), ST2(3,3)
  841   FORMAT ( / 4X, 'TEMPERATURE, F', F10.1, 2F14.1 /
     1    4X, 'PRESSURE, PSIA', F10.1, 2F14.1 )
C
      ENDIF
C
  999 RETURN
      END
C
C$ USR07S
      SUBROUTINE USR07S (ICNAME, ITEMS, KLASS, KOMPS, KTEST,
     1  NCC, NHSTRY, NNCC, SIN1, SOUT1, SOUT2, SOUT3 )
C
C     This subroutine loads the three product stream properties into
C     the SOUT1, SOUT2 and SOUT3 vectors for transfer to ASPEN/SP.
C     This subroutine is not called when IPASS = 4.
C
C     Prepared under DOE contract no. DE-AC22 91PC90027.
C
C     Last revision - January 30, 1992.
C
C     Calling arguments:
C     ICNAME() = Vector of component identifications (CHARACTER * 4)
C     ITEMS    = Total number of items in the SOUT1 vector.
C     KLASS    = Stream class identification switch
C                1 => Conventional (MIXED)
C                2 => MIXNC
C                3 => MIXNCPSD
C     KOMPS    = Number of conventional components used in this model.
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     NNCC     = Number of non-conventional components.
C     SIN1()   = ASPEN/SP stream vector for reactor inlet stream.
C     SOUT1()  = ASPEN/SP stream vector for hydrogen rich product gas
C                stream.
C     SOUT2()  = ASPEN/SP stream vector for light hydrocarbon product
C                gas stream.
C     SOUT3()  = ASPEN/SP stream vector for reformate product stream.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON/MW/XMW(1)
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(2,5), ST2(3,5)
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(*), SIN1(*), SOUT1(*), SOUT2(*), SOUT3(*)
C
C     Local variable declarations.
      DIMENSION STRM(10,3)
      EQUIVALENCE (STRM(1,1), CPROP(1,1))
C
      CHARACTER * 4  ICNAME
C
C
C     First, zero all the items in the product stream vectors.
      DO 200 J = 1, ITEMS
        SOUT1(J) = 0.0D0
        SOUT2(J) = 0.0D0
        SOUT3(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     Load the molar flow rates of the conventional components.
      SUM1 = 0.0D0
      SUM2 = 0.0D0
      SUM3 = 0.0D0
      DO 210 J = 1, NCC
        DO 208 K = 1, KOMPS
          IF ( J .EQ. ICNUMB(K) )  THEN
            SOUT1(J) = STRM(K,1) / (CF * XMW(J))
            SOUT2(J) = STRM(K,2) / (CF * XMW(J))
            SOUT3(J) = STRM(K,3) / (CF * XMW(J))
            SUM1 = SUM1 + SOUT1(J)
            SUM2 = SUM2 + SOUT2(J)
            SUM3 = SUM3 + SOUT3(J)
            GO TO 210
          ENDIF
  208   CONTINUE
  210 CONTINUE
C     Load the total molar flow rate of the conventional components.
      SOUT1(NCC+1) = SUM1
      SOUT2(NCC+1) = SUM2
      SOUT3(NCC+1) = SUM3
C
C     Set the outlet stream temperatures and pressures to the
C     default values of 70 F and 1 atmosphere.  These default values
C     may be overridden by a FLASH-SPECS sentence in the input file.
      SOUT1(NCC+2) = ( 70.0D0 + 459.67D0 ) / 1.8D0
      SOUT1(NCC+3) = 6.8947573D+3 * 14.696D0
      SOUT2(NCC+2) = SOUT1(NCC+2)
      SOUT2(NCC+3) = SOUT1(NCC+3)
      SOUT3(NCC+2) = SOUT1(NCC+2)
      SOUT3(NCC+3) = SOUT1(NCC+3)
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)
      CALL CPACK (SOUT2, NCP, IDX, XPACK, TMASS)
      SOUT2(NCC+9) = AVEMW (NCP, IDX, XPACK)
      CALL CPACK (SOUT3, NCP, IDX, XPACK, TMASS)
      SOUT3(NCC+9) = AVEMW (NCP, IDX, XPACK)
C
C     If requested, write the items of interest in the inlet and
C     outlet stream vectors to the history file.
      IF ( KTEST .GE. 5 )  THEN
        WRITE (NHSTRY, 531)
  531   FORMAT ( // ' The inlet and outlet stream vectors:' /
     1    14X, ' SIN1', 10X, 'SOUT1', 10X, 'SOUT2', 10X, 'SOUT3' )
        DO 290 J = 1, ITEMS
          WRITE (NHSTRY, 532) J, SIN1(J), SOUT1(J), SOUT2(J), SOUT3(J)
  532     FORMAT ( 2X, I5, 6(1PE15.5) )
  290   CONTINUE
      ENDIF
C
      RETURN
      END
C
C$  Subroutine USR81
C
C     This file contains the following subroutines:
C       USR81    Main routine for the ROSE-SR Critical Solvent
C                Deashing Unit.
C       USR81A   Subroutine to calculate the component flow rates in
C                the ash concentrate stream.
C       USR81B   Subroutine to load the two product streams into the
C                outlet stream vectors.
C       USR81S   Subroutine to write the first part of the plant
C                summary report for the ROSE-SR unit.
C *del  USR02A   Subroutine to load the pure component properties in
C                the CPROP array in named COMMON /USR02M/.
C
C     NOTE:  This model contains some USR02 sumbroutines and uses named
C            common block COMMON /USR02M/.
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 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       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 /USRC01/.
C
C$ USR81
      SUBROUTINE USR81 (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:  USR81
C
C  BLOCK DESCRIPTION:  Plant 8.1, ROSE-SR Critical Solvent Deashing Unit
C
C        ROSE-SR Critical Solvent Deashing Unit Block Model
C
C                      ---------------------
C                      |                   |
C                      |     Plant 8.1     |-----> Deashed Residuum
C                      |                   |          (Extract)
C            Feed---->|    ROSE-SR Unit   |
C                      |                   |-----> Ash Concentrate
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 - July 3, 1992.
C
C  ASSUMPTIONS, SPECIAL FEATURES AND LIMITATIONS:
C     1.  The model has a single inlet stream, the Plant 2 vacuum
C         tower bottoms stream.
C     2.  The two outlet streams are 1. The Deashed Residuum Stream.
C                                    2. The Ash Concentrate 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), unreacted coal (URCOAL), SLAG or
C         unknown components (OTHERS) present in the input stream
C         leaves the ROSE-SR unit unchanged in the ash concentrate
C         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 DCL81.REP.
C        INT(3)  = Number of operating duplicate trains, excluding
C                  spares.
C                  If INT(3) = 0, the minimum number of duplicate
C                    trains will be determined so that the capacity
C                    each train does not exceed the maximum train
C                    capacity specified by variable REAL(52).
C                  If INT(3) > 0, this number of duplicate trains will
C                    be used.
C        INT(4)  = History file additional output control switch.
C                  0 => Write no additional output to the history 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     8. The 70 real parameters are:
C        REAL(1)   = Hydrocarbon rejection factor.
C        REAL(2) -
C         REAL(20) = Future use.
C        REAL(21)  = Constant factor for the power consumption, kw.
C        REAL(22)  = Power consumption per Mlbs/hr of extract,
C                    kw/(Mlbs/hr of extract)
C        REAL(23)  = Constant factor for the 900 psig / 750 F steam
C                    consumption, Mlbs/hr.
C        REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
C                    extract, (Mlbs/hr)/(Mlbs/hr of extract).
C        REAL(25)  = Constant factor for the 900 psig saturated steam
C                    consumption, Mlbs/hr.
C        REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr
C                    of extract, (Mlbs/hr)/(Mlbs/hr of extract).
C        REAL(27)  = Constant factor for the 600 psig / 720 F steam
C                    consumption, Mlbs/hr.
C        REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
C                    extract, (Mlbs/hr)/(Mlbs/hr of extract).
C        REAL(29)  = Constant factor for the 600 psig saturated steam
C                    consumption, Mlbs/hr.
C        REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr
C                    of extract, (Mlbs/hr)/(Mlbs/hr of extract).
C        REAL(31)  = Constant factor for the 150 psig saturated steam
C                    consumption, Mlbs/hr.
C        REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr
C                    of extract, (Mlbs/hr)/(Mlbs/hr of extract).
C        REAL(33)  = Constant factor for the 50 psig saturated steam
```

```
C                       consumption, Mlbs/hr.
C          REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr
C                      of extract, (Mlbs/hr)/(Mlbs/hr of extract).
C          REAL(35)  = Constant factor for the plant fuel consumption,
C                      MM BTU/hr.
C          REAL(36)  = Plant fuel consumption per Mlbs/hr of extract,
C                      (MM BTU/hr)/(Mlbs/hr of extract).
C          REAL(37)  = Constant factor for the cooling water consumption,
C                      Mgal/hr.
C          REAL(38)  = Cooling water consumption per Mlbs/hr of extract,
C                      (Mgal/hr)/(Mlbs/hr of extract).
C          REAL(39)  = Constant factor for the process water consumption,
C                      Mgal/hr.
C          REAL(40)  = Process water consumption per Mlbs/hr of extract,
C                      (Mgal/hr)/(Mlbs/hr of extract).
C          REAL(41)  = Constant factor for the nitrogen consumption,
C                      MM SCF/hr of N2.
C          REAL(42)  = Nitrogen consumption per Mlbs/hr of extract,
C                      (MM SCF/hr of N2)/(Mlbs/hr of extract).
C          REAL(43) -
C           REAL(48) = Future use.
C          REAL(49)  = Constant factor for the number of operators per
C                      day, operators/day.
C          REAL(50)  = Number of operators per day per train,
C                      (operators/day)/train.
C          REAL(51)  = Reference feed rate to a single train in Mlbs/hr
C                      of unit feed for the calculation of the ISBL field
c                      cost of a single train as a function of train
C                      capacity.
C          REAL(52)  = Maximum size of a single train as defined by the
C                      feed rate in Mlbs/hr of unit feed.
C          REAL(53)  = Minimum size of a single train as defined by the
C                      feed rate in Mlbs/hr of unit feed.
C          REAL(54)  = Constant A in the plant ISBL field cost equation.
C          REAL(55)  = Constant B in the plant ISBL field cost equation.
C          REAL(56)  = Constant E in the plant ISBL field cost equation.
C          REAL(57)  = Constant F in the plant ISBL field cost equation.
C          REAL(58)  = Number of spare trains.
C          REAL(59) -
C           REAL(70) = 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 in the plant 2
C                        reactors.
```

```
C       47.  URCOAL        Unreacted coal which leaves the coal
C                          liquefaction 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 /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5)
C
C     In COMMON /USR02M/
C       CIN(J) contains the component flow rates entering the ROSE-SR
C         unit in lbs/hr.
C       COUT(J) contains the component flow rates leaving the ROSE-SR
C         unit in the ash concentrate stream 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
C     Local variable declaration statements.
      DIMENSION ICN(2), ICNAME(100)
C
      DIMENSION OXIN1(10), OXIN1N(10), UANAME(8), UIN1(7), UIN2(7),
     1  UIN3(7), UIN1N(7), UIN2N(7), UIN3N(7), ULTAC(7), WTAC(7),
     2  WTUC(7), WTUCC(7)
C
      CHARACTER * 4  BLANK4, ICN, ICNAME
      CHARACTER * 6  PNAME
      CHARACTER * 8  UANAME
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 UANAME / 'Ash     ', 'Carbon  ', 'Hydrogen', 'Nitrogen',
     1              'Chlorine', 'Sulfur  ', 'Oxygen  ', 'Total   ' /
C
      DATA PNAME / '8.1   ' /
C
C
C     PARAMETER INITIALIZATION SECTION
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)
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 8.1 - Supplementary data from ',
     1    'subroutine USR81' /
     2    2X, 'The ROSE-SR Critical Solvent Deashing Unit', 10X,
     3   '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 ROSE-SR unit requires ',
     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 are exactly 2 outlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSOUT .NE. 2 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501) IPASS
        WRITE (NHSTRY, 503)  NSOUT
  503   FORMAT ( / 1X, '* ERROR * - The ROSE-SR unit requires ',
     1    'exactly two outlet streams.' /
     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 ROSE-SR ',
     1    'unit is not of stream' /
     2    3X, 'class MIXNC or MIXNCPSD.  This model will not work.  ',
     3    'Please set all' /
     4    3X, 'input streams to one of these stream classes and try ',
     5    '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 ROSE-SR unit.' )
        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 ROSE-SR ',
     1    'unit must allow for' /
     2    3X, 'three non-conventional components, COAL, URCOAL and ',
     3    'SLAG.  Please' /
     4    3X, 'adjust your component list to contain them in the ',
     5    '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 them 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 ROSE-SR unit requires this component.  Please ',
     3      'add it to your component list' /
     4      3X, 'and try again.' //
     5      3X, 'EXECUTION IS BEING TERMINATED.' / )
          STOP
        ENDIF
   20 CONTINUE
C
C
C     INPUT SECTION
C     -------------
C     User specified parameters.
C
C     Load the hydrocarbon rejection factor (HRF).
      HRF = REAL(1)
C
      IF ( KTEST .GE. 2 )   WRITE (NHSTRY, 508) HRF
  508 FORMAT ( 2X, 'Hydrocarbon rejection factor = ', F11.6 )
```

```
C
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     Set up the maximum and minimum train flow rates in Mlbs/hour
C     of unit feed.
      PMAXF = REAL(52)
      PMINF = REAL(53)
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)
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
      IF ( CIN(50) .GE. 1.0D0 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 511)  CIN(50)
  511   FORMAT ( / 1X, '* WARNING * - The feed to the ROSE-SR unit ',
     1    'contains one or more' /
```

```
     2    3X, 'components that this model cannot handle.  It contains',
     3    F10.1, ' lbs/hr' /
     4    3X, 'of these components.  These components will leave in' /
     5    'the ash concentrate' /
     6    3X, 'stream.   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,L), L = 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     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)  (UANAME(J), UIN1(J), UIN2(J), UIN3(J),
     1    J = 1, 7), UANAME(8), SUMIN1, SUMIN2, SUMIN3
  518   FORMAT ( ' Component', 9X, 'Coal', 7X, 'URCOAL', 9X, 'SLAG',
     1    8( / 2X, A8, 3F13.2 ) )
C
        WRITE (NHSTRY, 519)
  519   FORMAT ( / ' Normalized non-conventional component Ultimate ',
     1    'analyses:')
        WRITE (NHSTRY, 518)  (UANAME(J), UIN1N(J), UIN2N(J), UIN3N(J),
     1    J = 1, 7), UANAME(8), SUM1, SUM2, SUM3
      ENDIF
C
C     Load the ash oxide (AOXANAL) analyses of the fresh inlet coal and
C     normalize to 100%.
      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, 520)
  520   FORMAT ( / ' Supplied and normalized ash oxide (AOXANAL) ',
     1    'analyses of the fresh coal:')
        WRITE (NHSTRY, 521)  (OXIN1(J), OXIN1N(J), J = 1, 10)
  521   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, 522)  SUM, SUM1
  522   FORMAT ( 2X, 'Total   ', 2F13.2 )
      ENDIF
C
C     Calculate the total lbs/hr of the Ultimate analyses components in
C     the feed stream entering the ROSR-SR unit (WTUC).
      N1 = NCCONV + 4
      N2 = N1 + 24
      N3 = N2 + 24
      DO 70 J = 1, 7
        WTUC(J) = 0.01D0 * (CIN(46)*UIN1N(J) + CIN(47)*UIN2N(J)
     1   + CIN(48)*UIN3N(J))
   70 CONTINUE
      TSOLID = CIN(46) + CIN(47) + CIN(48)
C
      IF ( KTEST .GE. 2 )  THEN
        WRITE (NHSTRY, 523)  (UANAME(J), WTUC(J), J = 1, 7), UANAME(8),
     1    TSOLID
  523   FORMAT ( / ' Amount of entering Ultimate analysis components,',
     1    ' lbs/hr.',
     2    8( / 2X, A8, F13.1 ) )
      ENDIF
C
C     Call subroutine USR81A to calculate the component flow rates of
C     the ash concentrate stream.
      CALL USR81A (EXTRCT, HRF, ICNAME, KMAXC, KOMPS, KTEST, NHSTRY)
C
C     If requested, write the properties of the solids in the ash
C     concentrate stream to the history file.
      IF ( KTEST .GE. 3 )   THEN
        SUM1 = 0.0D0
        DO 80 J = 1, 7
          WTAC(J) = 0.01D0 * (COUT(46)*UIN1N(J) + COUT(47)*UIN2N(J)
     1      + COUT(48)*UIN2N(J))
          SUM1 = SUM1 + WTAC(J)
   80   CONTINUE
        SUM2 = 0.0D0
        DO 82 J = 1, 7
          ULTAC(J) = 100.0D0 * WTAC(J) / SUM1
          SUM2 = SUM2 + ULTAC(J)
   82   CONTINUE
        WRITE (NHSTRY, 524) (UANAME(J), WTAC(J), ULTAC(J), J = 1, 7),
     1    UANAME(8), SUM1, SUM2
  524   FORMAT ( / ' Properties of the solids in the ash concentrate ',
     1    'stream' /
     2    16X, 'lbs/hr', 8X, 'Wt %',
     3    8( / 2X, A8,  F12.1, F12.3 ) )
      ENDIF
C
      IF ( IPASS .NE. 4 )   THEN
C       Call Subroutine USR81B to load the two ROSE-SR unit product
C       streams into the SOUT1 and SOUT2 stream vectors.
        CALL USR81B (ITEMS, KOMPS, KTEST, NCC, NCCONV, NCONV,
     1    NHSTRY, NNCC, SIN1, SOUT1, SOUT2)
      ENDIF
```

```
C
C
C     Calculate the total unit feed rate in Mlbs/hr.
      FLOWIN = 0.001D0 * FLOWIN
C
C     If it has not been specified by the user in variable INT(3),
C     calculate the number of operating duplicate trains, excluding
C     spares (NPLNT), based on the total flow rate of the reference
C     stream.  However, if the maximum capacity of a single train
C     has not been specified, set the number of operating trains to 1.
      NPLNT = INT(3)
      IF ( (NPLNT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
         NPLNT = FLOWIN  / PMAXF
         IF ( (MOD(FLOWIN, PMAXF)) .GT. 0.0D0 )  NPLNT = NPLNT + 1
        ELSE
         IF ( NPLNT .EQ. 0 )   NPLNT = 1
      ENDIF
C
C     Calculate the feed rate for each of the duplicate trains (PFLOW)
C     in Mlbs/hr.
      XPLNT = NPLNT
      PFLOW = FLOWIN / XPLNT
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 USR81S.
      X = 1.8D0
      X1 = 459.67D0
      ST1(1,2) = X * SIN1(NCC+2) - X1
      ST2(1,2) = X * SOUT1(NCC+2) - X1
      ST2(2,2) = X * SOUT2(NCC+2) - X1
      X = 1.0D0 / 6.8947573D+3
      ST1(1,3) = X * SIN1(NCC+3)
      ST2(1,3) = X * SOUT1(NCC+3)
      ST2(2,3) = X * SOUT2(NCC+3)
C
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.
            LSTRM = 21
            IF ( CIN(46) .GE. 1.0D0 )   LSTRM = LSTRM + 1
            IF ( CIN(48) .GE. 1.0D0 )   LSTRM = LSTRM + 1
            IF ( CIN(50) .GE. 1.0D0 )   LSTRM = LSTRM + 4
            LUTIL = 16
            LCOST = 11
            NDUP = REAL(58) + 0.001D0
            IF ( (NPLNT + NDUP) .EQ. 1 )  LCOST = 9
            IF ( PFLOW .LT. PMINF )  LCOST = LCOST + 3
            IF ( PFLOW .GT .PMAXF )  LCOST = LCOST + 3
```

```
            IF ( NDUP .GE. 1 )  LCOST = LCOST + 1
            LINES = LSTRM + LUTIL + LCOST
C           Now, subtract the number of lines for those portions of
C           the user block summary report which will not be written.
            IF ( INT(1) .GE. 2 )   LINES = LINES - LUTIL
            IF ( INT(1) .GE. 1 )   LINES = LINES - LCOST
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 DCL81.REP to contain
C           this user block summary report.
            OPEN (UNIT=62, FILE='DCL81.REP', STATUS='UNKNOWN',
     1        ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2        BUFFERED='BUFFERED')
            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' )
        ENDIF
      ENDIF
C
      IF ( IPASS .EQ. 4 )   THEN
C       Call Subroutine USR81S to write the first part of the plant
C       summary report.
      CALL USR81S (INT(1), KMAXC, NOUT)
      ENDIF
C
C     Call subroutine USRUC1 to calculate, save and report the
C     utilities, capital and operating costs for the plant.  This
C     special routine is necessary because the utilities are based on
C     the extract production and the capital cost is based on the
C     inlet feed rate.
      ID = 8
      KUNITS = 2
      CALL USRUC1 (NHSTRY, NOUT, IPASS, ID, PNAME, INT(1), INT(3),
     1  KTEST, REAL(21), FLOWIN, EXTRCT, KUNITS)
C
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 USR81' )
C
C
      RETURN
      END
C
C$ USR81A
      SUBROUTINE USR81A (EXTRCT, HRF, ICNAME, KMAXC, KOMPS, KTEST,
     1  NHSTRY)
```

```
C
C     This subroutine simulates the splitting of the feed stream in the
C     ROSE-SR Critical Solvent Deashing Unit.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - July 3, 1992.
C
C     This subroutine calculates the component flow rates in the ash
C     concentrate stream by the following procedure.
C       1.  All the entering non-conventional components; i.e., the
C           solid components (COAL, unreacted coal (URCOAL) and SLAG),
C           and any unknown components (OTHERS) leave in the ash
C           concentrate stream.
C       2.  The amount of each conventional component leaving in the
C           ash concentrate stream is calculated based on the percent
C           of the entering material stored in the YC vector.
C       3.  All remaining material leaves in the deashed residuum
C           stream.
C
C     Calling arguments:
C     EXTRCT   = Calculated flow rate of deashed residuum (extract)
C                stream in Mlbs/hr.
C     HRF      = Overall hydrocarbon rejection factor; i.e., a
C                direct multiplier on the basic amount of hydrocarbon
C                rejected, if possible.
C     ICNAME() = Vector of component identifications (CHARACTER * 4)
C     KMAXC    = Total number of components (conventional and non-
C                conventional) in the component vectors.
C     KOMPS    = Number of conventional components used in this ROSE-SR
C                unit model.  (KOMPS must be < or = to 40)
C     KTEST    = Switch for controlling the printing to the history
C                file.
C     NHSTRY   = Logical unit number of the history file.
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)
C
      DIMENSION ICNAME(*)
      CHARACTER * 4  ICNAME
C
C     Local variable declarations.
C
C     YC(J) is the composition of the conventional hydrocarbon portion
C     of the material leaving the ROSE-SR unit in the ash concentrate
C     stream.
      DIMENSION YC(40)
C
      CHARACTER * 4  BLANK4
C
      DATA BLANK4 / '    ' /
C
```

```
C     Initialize the percent of the conventional components entering
C     in the feed that leaves in the ash concentrate stream.
C     Weight % of     H2      N2      O2      H2S     CO
      DATA YC  /      0.0,    0.0,    0.0,    0.0,    0.0,
C       CO2         NH3         H2O         HCL         COS
     1  0.0,        0.0,        0.0,        0.0,        0.0,
C       CH4         C2H6        C3H8        IC4H10      N C4H10
     2  0.0,        0.0,        0.0,        0.0,        0.0,
C       IC5H12      N C5H12     T125        T175        T225
     3  0.0,        0.0,        0.0,        0.0,        0.0,
C       T275        T325        T375        T425        T475
     4  0.0,        0.0,        0.0,        0.0,        0.0,
C       T525        T575        T625        T675        T725
     5  0.0,        0.0,        0.0,        0.0,        0.0,
C       T775        T825        T875        T925        T975
     6  0.0,        0.0,        82.5161,    82.5161,    82.5161,
C       T1000+      I1000+      Future      Future      Future
     7  16.47702,   0.0,        0.0,        0.0,        0.0 /
C
C
      IF ( KTEST .GE. 2 )  WRITE (NHSTRY, 501)  HRF
  501 FORMAT ( / ' Starting the ROSE-SR unit separation calculations ',
     1  'in Subroutine USR81A.' /
     2  2X, 'Hydrocarbon rejection factor = ', F11.6 )
C
      IF ( KTEST .GE. 2 )   THEN
        WRITE (NHSTRY, 502)
  502   FORMAT ( / ' Amount of entering conventional ',
     1    'components leaving in the' /
     2    ' ash concentrate stream, percent of entering amount.' /
     3    11X, 'Component', 9X, 'Basic', 6X, 'Adjusted' )
        DO 20 J = 1, KOMPS
          IF ( YC(J) .GT. 0.0D0 )  THEN
            K = 2 * J - 1
            IF ( YC(J) .GE. 0.0D0 )  THEN
              X = HRF * YC(J)
              IF ( X .GT. 100.0D0 )   X = 100.0D0
              WRITE (NHSTRY, 503)  J, ICNAME(K), ICNAME(K+1), YC(J), X
  503         FORMAT ( 1X, I5, 5X, 2A4, 5X, F11.4, F13.4 )
            ENDIF
          ENDIF
   20   CONTINUE
      ENDIF
C
C     Zero the component flow rates in the ash concentrate stream.
      DO 30 J = 1, KMAXC
        COUT(J) = 0.0D0
   30 CONTINUE
C
C     Load all the entering solid and unknown components (OTHERS) into
C     the ash concentrate stream.
      COUT(46) = CIN(46)
      COUT(47) = CIN(47)
      COUT(48) = CIN(48)
      COUT(50) = CIN(50)
```

```
C
C     Calculate the amount of each conventional component in the ash
C     concentrate stream.
      SUMIN = 0.0D0
      AC = 0.0D0
      DO 40 J = 1, KOMPS
        X = HRF * YC(J)
        IF ( X .GT. 100.0D0 )   X = 100.0D0
        COUT(J) = 0.01D0 * X * CIN(J)
        SUMIN = SUMIN + CIN(J)
        AC = AC + COUT(J)
   40 CONTINUE
      EXT = SUMIN - AC
      EXTRCT = 0.001D0 * EXT
C
      IF ( KTEST .GE. 3 )   THEN
        WRITE (NHSTRY, 506)
  506   FORMAT ( / ' ROSE-SR unit flow rates, lbs/hr' /
     1    38X, 'Deashed', 9X, 'Ash' /
     2    4X, 'No', 1X, 'Component', 12X, 'Inlet', 5X, 'Residuum',
     3    4X, 'Concentrate' )
        DO 60 J = 1, KMAXC
          IF ( CIN(J) .GT. 0.0D0 )  THEN
            K = 2 * J - 1
            IF ( ICNAME(K) .NE. BLANK4 )  THEN
              X = CIN(J) - COUT(J)
              WRITE (NHSTRY, 507)  J, ICNAME(K), ICNAME(K+1), CIN(J),
     1          X, COUT(J)
  507         FORMAT ( 1X, I5, 1X, 2A4, 5X, 3F13.1)
            ENDIF
          ENDIF
   60   CONTINUE
        WRITE (NHSTRY, 508)  SUMIN, EXT, AC
  508   FORMAT ( 7X, 'Total', 8X, 3F13.1)
      ENDIF
C
      RETURN
      END
C
C$ USR81B
      SUBROUTINE USR81B (ITEMS, KOMPS, KTEST, NCC, NCCONV, NCONV,
     1  NHSTRY, NNCC, SIN1, SOUT1, SOUT2)
C
C     This subroutine loads the ROSE-SR Critical Solvent Deashing Unit
C     outlet streams into the SOUT1 and SOUT2 stream vectors.  This
C     subroutine is only called when IPASS is not equal to 4.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - March 26, 1991.
C
C
C     Calling arguments:
C     ITEMS    = Total number of items in the SOUT1 vector.
C     KOMPS    = Number of conventional components used in this ROSE-SR
```

```
C                 unit model.  (KOMPS must be < or = to 40)
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 ROSE-SR unit inlet stream.
C     SOUT1()   = ASPEN/SP stream vector for the first ROSE-SR unit
C                 outlet stream, the deashed residuum stream.
C     SOUT2()   = ASPEN/SP stream vector for the second ROSE-SR unit
C                 outlet stream, the ash concentrate stream.
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)
C
      COMMON /USRCO2/ 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 /USRCO2/
C     only to save space since all block models use these variables.
C
      DIMENSION SIN1(*), SOUT1(*), SOUT2(*)
C
C
C     Set up the properties of the product streams.
C     ---------------------------------------------
C
C     First, zero all the base items in the product stream vectors.
      DO 200 J = 1, NCCONV
        SOUT1(J) = 0.0D0
        SOUT2(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
      SUM2 = 0.0D0
      DO 210 J = 1, NCC
        IF (SIN1(J) .LE. 1.0D-25)  GO TO 210
          DO 208 K = 1, KOMPS
            IF ( J .EQ. ICNUMB(K) )  THEN
C             The ash concentrate stream.
              SOUT2(J) = COUT(K) / (CF * CPROP(K,1))
C             The deashed residuum stream.
              SOUT1(J) = SIN1(J) - SOUT2(J)
              SUM1 = SUM1 + SOUT1(J)
              SUM2 = SUM2 + SOUT2(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
      SOUT2(NCC+1) = SUM2
C
C     Set the mass flow rates of the non-conventional components.
      SUM1 = 0.0D0
      SUM2 = 0.0D0
      DO 220 J = 1, 3
        SOUT1(NCONV+J) = 0.0D0
        SOUT2(NCONV+J) = COUT(J+45) / CF
        SUM2 = SUM2 + SOUT2(NCONV+J)
  220 CONTINUE
C
C     Set the total mass flow rates of the non-conventionals.
      SOUT1(NCONV+NNCC+1) = SUM1
      SOUT2(NCONV+NNCC+1) = SUM2
C
C     Set the temperature and pressure of the ROSE-SR unit product
C     streams.  Return these values to ASPEN/SP in degrees Kelvin
C     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) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT1(NCC+3) = 15.0D0 * 6.8947573D+3
      SOUT1(NCONV+NNCC+2) = SOUT1(NCC+2)
      SOUT1(NCONV+NNCC+3) = SOUT1(NCC+3)
      SOUT2(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT2(NCC+3) = 15.0D0 * 6.8947573D+3
      SOUT2(NCONV+NNCC+2) = SOUT2(NCC+2)
      SOUT2(NCONV+NNCC+3) = SOUT2(NCC+3)
C
      SOUT1(NCONV+NNCC+9) = 1.0D0
      SOUT2(NCONV+NNCC+9) = 1.0D0
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)
      CALL CPACK (SOUT2, NCP, IDX, XPACK, TMASS)
      SOUT2(NCC+9) = AVEMW (NCP, IDX, XPACK)
C
C     Set the properties of the of the COAL, unconverted coal (URCOAL)
C     and SLAG to their entering values.
      JS = (NCONV+NNCC+9) + 1
      DO 230 J = JS, ITEMS
        SOUT1(J) = SIN1(J)
        SOUT2(J) = SIN1(J)
  230 CONTINUE
C
C     If requested, write the items of interest in the inlet and
```

```
C     outlet stream vectors to the history file.
      IF ( KTEST .GE. 5 )  THEN
        WRITE (NHSTRY, 531)
  531   FORMAT ( // ' The inlet and outlet stream vectors' /
     1    14X, ' SIN1', 10X, 'SOUT1', 10X, 'SOUT2' )
        DO 290 J = 1, ITEMS
          WRITE (NHSTRY, 532) J, SIN1(J), SOUT1(J), SOUT2(J)
  532     FORMAT ( 2X, I5, 3(1PE15.5) )
  290   CONTINUE
      ENDIF
C
      RETURN
      END
C
C$ USR81S
      SUBROUTINE USR81S (INT1, KMAXC, NOUT)
C
C     This subroutine writes the first part of the plant summary report
C     for the ROSE-SR Critical Solvent Deashing Unit.  This subroutine
C     is only called when IPASS equals 4.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - July 25, 1991.
C
C     Calling arguments:
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     KMAXC     = Total number of components (conventional and non-
C                 conventional) in the component vectors.  (KMAXC must
C                 be < or = to 50)
C     NOUT      = Logical unit number of the plant output report file.
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)
C
C
      IF ( INT1 .LE. 2 )  THEN
C
C       Write the first part of the plant summary report.
C       ================================================
        WRITE (NOUT, 801)
  801   FORMAT ( / 15X, 'PLANT 8.1 - ROSE-SR UNIT SUMMARY REPORT' )
C
        WRITE (NOUT, 802)
  802   FORMAT ( / '  COMPONENT FLOW RATES, LBS/HR' /
     1    34X, 'DEASHED', 10X, 'ASH' /
     2    4X, 'COMPONENT', 10X, 'INLET', 6X, 'RESIDUUM', 5X,
```

```
     3    'CONCENTRATE' )
C
C       Write the ROSE-SR unit component flow rates in lbs/hr.
C       Water.
        X = CIN(8) - COUT(8)
        WRITE (NOUT, 811) CIN(8), X, COUT(8)
  811   FORMAT ( 4X, 'H2O     ', F16.1, 2F14.1 )
C
C       C5- material excluding water.
        SUM1 = 0.0D0
        SUM3 = 0.0D0
        DO 210 J = 1, 17
          IF ( J .NE. 8 )   THEN
            SUM1 = SUM1 + CIN(J)
            SUM3 = SUM3 + COUT(J)
          ENDIF
  210   CONTINUE
        X = SUM1 - SUM3
        WRITE (NOUT, 812) SUM1, X, SUM3
  812   FORMAT ( 4X, 'C5-     ', F16.1, 2F14.1 )
C
C       C6 - 350 F material.
        SUM1 = CIN(18) + CIN(19) + CIN(20) + CIN(21) + CIN(22)
        SUM3 = COUT(18) + COUT(19) + COUT(20) + COUT(21) + COUT(22)
        X = SUM1 - SUM3
        WRITE (NOUT, 813) SUM1, X, SUM3
  813   FORMAT ( 4X, 'C6-350F ', F16.1, 2F14.1 )
C
C       350 - 450 F material.
        SUM1 = CIN(23) + CIN(24)
        SUM3 = COUT(23) + COUT(24)
        X = SUM1 - SUM3
        WRITE (NOUT, 814) SUM1, X, SUM3
  814   FORMAT ( 4X, '350-450F', F16.1, 2F14.1 )
C
C       450 - 650 F material.
        SUM1 = CIN(25) + CIN(26) + CIN(27) + CIN(28)
        SUM3 = COUT(25) + COUT(26) + COUT(27) + COUT(28)
        X = SUM1 - SUM3
        WRITE (NOUT, 815) SUM1, X, SUM3
  815   FORMAT ( 4X, '450-650F', F16.1, 2F14.1 )
C
C       650 - 850 F material.
        SUM1 = CIN(29) + CIN(30) + CIN(31) + CIN(32)
        SUM3 = COUT(29) + COUT(30) + COUT(31) + COUT(32)
        X = SUM1 - SUM3
        WRITE (NOUT, 816) SUM1, X, SUM3
  816   FORMAT ( 4X, '650-850F', F16.1, 2F14.1 )
C
C       850 - 900 F material.
        X = CIN(33) - COUT(33)
        WRITE (NOUT, 817) CIN(33), X, COUT(33)
  817   FORMAT ( 4X, '850-900F', F16.1, 2F14.1 )
C
C       900 - 950 F material.
```

```
      X = CIN(34) - COUT(34)
      WRITE (NOUT, 818) CIN(34), X, COUT(34)
  818 FORMAT ( 4X, '900-950F', F16.1, 2F14.1 )
C
C     950 - 1000 F material.
      X = CIN(35) - COUT(35)
      WRITE (NOUT, 819) CIN(35), X, COUT(35)
  819 FORMAT ( 4X, '950-1000F', F15.1, 2F14.1 )
C
C     1000+ F material.
      SUM1 = CIN(36) + CIN(37)
      SUM3 = COUT(36) + COUT(37)
      X = SUM1 - SUM3
      WRITE (NOUT, 820) SUM1, X, SUM3
  820 FORMAT ( 4X, '1000+F  ', F16.1, 2F14.1 )
C
C     COAL.
      IF ( CIN(46) .GE. 1.0D0 )   THEN
        X = CIN(46) - COUT(46)
        WRITE (NOUT, 821) CIN(46), X, COUT(46)
  821   FORMAT ( 4X, 'COAL    ', F16.1, 2F14.1 )
      ENDIF
C
C     Unreacted coal (URCOAL).
      X = CIN(47) - COUT(47)
      WRITE (NOUT, 822) CIN(47), X, COUT(47)
  822 FORMAT ( 4X, 'URCOAL  ', F16.1, 2F14.1 )
C
C     SLAG.
      IF ( CIN(48) .GE. 1.0D0 )   THEN
        X = CIN(48) - COUT(48)
        WRITE (NOUT, 823) CIN(48), X, COUT(48)
  823   FORMAT ( 4X, 'SLAG    ', F16.1, 2F14.1 )
      ENDIF
C
C     Other components.
      IF ( CIN(50) .GE. 1.0D0 )  THEN
        X = CIN(50) - COUT(50)
        WRITE (NOUT, 824) CIN(50), X, COUT(50)
  824   FORMAT ( 4X, 'OTHERS  ', F16.1, 2F14.1 )
      ENDIF
C
C     Calculate the stream weight flow rates.
      SUM1 = 0.0D0
      SUM3 = 0.0D0
      DO 220 J = 1, KMAXC
        SUM1 = SUM1 + CIN(J)
        SUM3 = SUM3 + COUT(J)
  220 CONTINUE
      X = SUM1 - SUM3
      WRITE (NOUT, 831) SUM1, X, SUM3
  831 FORMAT ( 4X, 'TOTAL', 3X, F16.1, 2F14.1 )
C
       WRITE (NOUT, 841) ST1(1,2), ST2(1,2), ST2(2,2),
     1   ST1(1,3), ST2(1,3), ST2(2,3)
```

```
  841   FORMAT ( / 4X, 'TEMPERATURE, F', F10.1, 2F14.1 /
     1    4X, 'PRESSURE, PSIA', F10.1, 2F14.1 )
C
        IF ( CIN(50) .GE. 1.0D0 )  WRITE (NOUT, 852)
  852     FORMAT (/ 1X, '*WARNING* THE FEED TO THE ROSE-SR UNIT ',
     1      'CONTAINS SOME COMPONENTS UNKNOWN' /
     2      2X, 'TO THE MODEL.  THEY ARE LEAVING THE UNIT IN THE ASH ',
     3      'CONCENTRATE STREAM.' )
C
      ENDIF
C
C
  999 RETURN
      END
C
C$  Subroutine USR82
C
C     This file contains the following subroutines:
C       USR82    Main routine for Plant 8.2, the fluid bed coking plant.
C del-> USR02A   Subroutine to load the pure component properties in
C                the CPROP array in named COMMON /USR02M/.
C       USR82B   Subroutine to write the coker elemental balance to
C                the history file.
C       USR82R   Subroutine to calculate the net coker yields.
C       USR82S   Subroutine to distribute the net yields from plant 8.2,
C                into the six product streams.
C       USR82Z   Subroutine to write the overall material balance for
C                Plant 8.2 and any warning messages.
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 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       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$ USR82
      SUBROUTINE USR82 (NSIN,NINFI,SIN1,SIN2,SIN3,SIN4,
     1 SIN5, SIN6, SIN7, SIN8, SINFI,NSOUT,
     2 NINFO,SOUT1,SOUT2,SOUT3,SOUT4, SOUT5, SOUT6, SOUT7, SOUT8,
     3 SINFO,NSUBS,IDXSUB,ITYPE,NINT,
     4 INT,NREAL,REAL,IDS,NPO,NBOPST,NIW,IW,NW,W,NSIZE,SIZE)
C
C  ASPEN USER UNIT OPERATION BLOCK:  USR82
C
C  BLOCK DESCRIPTION:  Plant 8.2, the Fluid Bed Coking Plant
C
C                 Simplified Fortran Block Model
C
```

```
C                    ----------------------
C                    |                     |-----> Fuel Gases
C     Main Feed  -->|                     |
C                    |     Plant 8.2       |-----> Naphtha
C     Air  -------->|                     |
C                    |       Fluid         |-----> Gas-oil
C     Steam  ------>|      Bed Coker      |
C                    |       Plant         |-----> Bottoms
C     Water ------->|                     |
C                    |                     |-----> Coke
C                    |                     |
C                    |                     |-----> Sour water
C                    ----------------------
C
C
C  Prepared under DOE contract no. DE-AC22 90PC89857.
C
C  FUNCTION (MODEL, REPORT, OR BOTH):  Both
C
C  Last revision - June 26, 1992.
C
C  ASSUMPTIONS, SPECIAL FEATURES AND LIMITATIONS:
C     1.  The four inlet stream are:   1. Hydrocarbon and ash feed
C                                      2. Air
C                                      3. Steam
C                                      4.
C     2.  The six outlet streams are:  1. Fuel gases
C                                      2. Naphtha hydrotreater feed
C                                      3. Gas-oil hydrotreater feed
C                                      4. Bottoms
C                                      4. Coke
C                                      6. Sour water & H2S 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 solids present in the input streams ends up in the
C         coke product 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 DCL82.REP.
C        INT(3)   = Number of operating duplicate trains, excluding
C                   spares.
C                   If INT(3) = 0, the minimum number of duplicate
C                     trains will be determined so that the capacity
C                     each train does not exceed the maximum train
C                     capacity specified by variable REAL(52).
C                   If INT(3) > 0, this number of duplicate trains will
C                     be used.
C        INT(4)   = History file additional output control switch.
C                   0 => Write no additional output to the history 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     8. The 70 real parameters are:
C        REAL(1) -
C         REAL(20) = Future use.
C        REAL(21)  = Constant factor for the power consumption, kw.
C        REAL(22)  = Power consumption per Mlbs/hr of main feed,
C                    kw/(Mlbs/hr of main)
C        REAL(23)  = Constant factor for the 900 psig / 750 F steam
C                    consumption, Mlbs/hr.
C        REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr
C                    of main feed, (Mlbs/hr)/(Mlbs/hr of main).
C        REAL(25)  = Constant factor for the 900 psig saturated steam
C                    consumption, Mlbs/hr.
C        REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr
C                    of main feed, (Mlbs/hr)/(Mlbs/hr of main).
C        REAL(27)  = Constant factor for the 600 psig / 720 F steam
C                    consumption, Mlbs/hr.
C        REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr
C                    of main feed, (Mlbs/hr)/(Mlbs/hr of main).
C        REAL(29)  = Constant factor for the 600 psig saturated steam
C                    consumption, Mlbs/hr.
C        REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr
C                    of main feed, (Mlbs/hr)/(Mlbs/hr of main).
C        REAL(31)  = Constant factor for the 150 psig saturated steam
C                    consumption, Mlbs/hr.
C        REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr
C                    of main feed, (Mlbs/hr)/(Mlbs/hr of main).
C        REAL(33)  = Constant factor for the 50 psig saturated steam
C                    consumption, Mlbs/hr.
```

```
C         REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr
C                     of main feed, (Mlbs/hr)/(Mlbs/hr of main).
C         REAL(35)  = Constant factor for the plant fuel consumption,
C                     MM BTU/hr.
C         REAL(36)  = Plant fuel consumption per Mlbs/hr of main feed,
C                     (MM BTU/hr)/(Mlbs/hr of main).
C         REAL(37)  = Constant factor for the cooling water consumption,
C                     Mgal/hr.
C         REAL(38)  = Cooling water consumption per Mlbs/hr of main
C                     feed, (Mgal/hr)/(Mlbs/hr of main).
C         REAL(39)  = Constant factor for the process water consumption,
C                     Mgal/hr.
C         REAL(40)  = Process water consumption per Mlbs/hr of main
C                     feed, (Mgal/hr)/(Mlbs/hr of main).
C         REAL(41)  = Constant factor for the nitrogen consumption,
C                     MM SCF/hr of N2.
C         REAL(42)  = Nitrogen consumption per Mlbs/hr of main feed,
C                     (MM SCF/hr of N2)/(Mlbs/hr of dry coal).
C         REAL(43) -
C          REAL(48) = Future use.
C         REAL(49)  = Constant factor for the number of operators per
C                     day, operators/day.
C         REAL(50)  = Number of operators per day per train,
C                     (operators/day)/train.
C         REAL(51)  = Reference main feed rate to a single plant in
C                     Mlbs/hr for the calculation of the ISBL field cost
C                     of a single plant as a function of plant capacity.
C         REAL(52)  = Maximum size of a single plant as defined by the
C                     main feed rate in Mlbs/hr of main feed.
C         REAL(53)  = Minimum size of a single plant as defined by the
C                     main feed rate in Mlbs/hr of main feed.
C         REAL(54)  = Constant A in the plant ISBL field cost equation.
C         REAL(55)  = Constant B in the plant ISBL field cost equation.
C         REAL(56)  = Constant E in the plant ISBL field cost equation.
C         REAL(57)  = Constant F in the plant ISBL field cost equation.
C         REAL(58)  = Number of spare plants.
C         REAL(59) -
C          REAL(70) = 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)
      DIMENSION SIN5(1),SIN6(1),SIN7(1),SIN8(1),SOUT5(1),
     1 SOUT6(1),SOUT7(1),SOUT8(1)
      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 make conventional
C                        components and unreacted coal (URCOAL)
```

```
C       47.  URCOAL        Unreacted coal which leaves in the bottoms
C                          product stream, the ROSE-SR unit feed stream.
C       48.  SLAG          Slag, i.e., Gasifier solid bottoms product
C       49.  blank         Future use
C       50.  OTHERS        Other components not listed above.
C
C       NOTE:  In this model, the coke will be called URCOAL.
C
      COMMON /USRO2M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5)
C
C     In COMMON /USRO2M/
C       CIN(J) contains the component flow rates entering the plant.
C       COUT(J) contains the component flow rates leaving the plant.
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 the 4 inlet and
C         6 outlet streams, in order, where J designates the stream 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
C     Local variable declaration statements.
      DIMENSION OXIN1(10), OXIN1N(10), UIN1(7), UIN2(7),
     1  UIN1N(7), UIN2N(7), ULTOUT(7), WTUC(7)
C
      DIMENSION ICN(2), ICNAME(100)
C
      CHARACTER * 4  BLANK4, ICN, ICNAME
      CHARACTER * 6  PNAME
C
      DATA KMAXC / 50 /
      DATA KOMPS / 37 /
      DATA BLANK4 / '    ' /
C     Initialize the component identifications.
      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 / '8.2   ' /
C
C
C     PARAMETER INITIALIZATION SECTION
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)
C
C     If requested, write the subroutine heading to the history file.
      IF ( KTEST .GE. 1 )  THEN
        WRITE (NHSTRY, 501) IPASS, (INT(K), K = 1, NINT)
  501   FORMAT ( // 1X, 'Plant 8.2 - Supplementary data from ',
     1    'subroutine USR82' /
     2    2X, 'Fluid Coking Plant', 20X, 'IPASS =', I3 /
     3    2X, 'Integer Parameters: ', 8I4 )
      ENDIF
C
C     Check to insure that there are exactly 4 inlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSIN .NE. 4 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS,
     1    (INT(K), K = 1, NINT)
        WRITE (NHSTRY, 502)  NSIN
  502   FORMAT ( / 1X, '* ERROR * - Plant 8.2 requires exactly ',
     1    '4 inlet streams.' /
     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 are exactly 6 outlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSOUT .NE. 6 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501) IPASS,
     1    (INT(K), K = 1, NINT)
        WRITE (NHSTRY, 503)  NSOUT
  503   FORMAT ( / 1X, '* ERROR * - Plant 8.2 requires exactly ',
     1    '6 outlet streams.' /
     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,
     1   (INT(K), K = 1, NINT)
      WRITE (NHSTRY, 504)
  504 FORMAT ( / 1X, '* ERROR * - The input streams to Plant 8.2, ',
     1   'the fluid coking plant, are' /
     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 MAIN FEED and total inlet flows 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) + SIN2(J)*SIN2(K) + SIN3(J)*SIN3(K)
     FEEDIN = SIN1(J)*SIN1(K)
     J = NCC + 9 + NNCC + 1
     FLOWIN = CF * (X + SIN1(J) + SIN2(J) + SIN3(J) )
     FEEDIN = CF * (FEEDIN + SIN1(J))
C    Convert Feedin to Mlbs/hr.
     FEEDIN = 0.001D0 * FEEDIN
```

```
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 Plant 8.2, the ',
     1    'fluid coking plant.' )
        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,
     1    (INT(K), K = 1, NINT)
        WRITE (NHSTRY, 506)
  506   FORMAT ( / 1X, '* ERROR * - The input streams to Plant 8.2, ',
     1    'the fluid coking plant,' /
     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
        ICNUMB(J) = 0
   20 CONTINUE
      DO 22 J = 1, KOMPS
        K = 2 * J - 1
        ICN(1) = ICNAME(K)
        ICN(2) = ICNAME(K+1)
        CALL USRCCN (ICN, ICNUMB(J))
        IF ( ICNUMB(J) .EQ. 0 ) THEN
          IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS,
     1    (INT(K), K = 1, NINT)
          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 fluid coking 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
   22 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     Set up the maximum and minimum train flow rates in Mlbs/hr of
C     dry coal feed.
      PMAXF = REAL(52)
      PMINF = REAL(53)
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)
C
C     If requested, write the items of interest in the inlet
C     stream vectors to the history file.
      IF ( KTEST .GE. 5 )  THEN
        WRITE (NHSTRY, 509)
  509   FORMAT ( / '  The inlet stream vectors:'/
     1    3X, 'Item', 8X, 'SIN1', 11X, 'SIN2', 11X, 'SIN3', 11X,
     2    'SIN4' )
        DO 30 J = 1, ITEMS
          WRITE (NHSTRY, 510) J, SIN1(J), SIN2(J), SIN3(J), SIN4(J)
  510     FORMAT ( 1X, I6, 1X, 4(1PE15.5) )
   30   CONTINUE
      ENDIF
C
C     Load the total entering component flow rates from all the inlet
C     streams in the CIN vector in lbs/hr.
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) + SIN2(J) + SIN3(J)
     1      + SIN4(J))
          GO TO 44
        ENDIF
   42   CONTINUE
        CIN(50) = CIN(50) + CF * XMW(J) * (SIN1(J) + SIN2(J) + SIN3(J)
     1    + SIN4(J))
   44 CONTINUE
C
C     Non-conventional components.
      CIN(46) = CF * (SIN1(NCONV+1) + SIN2(NCONV+1) + SIN3(NCONV+1)
     1  + SIN4(NCONV+1))
      CIN(47) = CF * (SIN1(NCONV+2) + SIN2(NCONV+2) + SIN3(NCONV+2)
     1  + SIN4(NCONV+2))
      CIN(48) = CF * (SIN1(NCONV+3) + SIN2(NCONV+3) + SIN3(NCONV+3)
     1  + SIN4(NCONV+3))
```

```
C
      IER1 = 0
      IF ( CIN(50) .GE. 1.0D0 ) THEN
        IER1 = 1
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS,
     1    (INT(K), K = 1, NINT)
        WRITE (NHSTRY, 511)  CIN(50)
  511   FORMAT ( / 1X, '* WARNING * - The feed to plant 8.2, the ',
     1    'fluid coking plant, ' /
     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 be' /
     6    3X, 'lost in the process.  Plant 2 will not be in mass ',
     7    'balance.  Please remove' /
     8    3X, 'these component(s) from the feed stream(s).' //
     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,L), L = 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     Load the Ultimate analyses of the fresh inlet coal and the URCOAL
C     from the first inlet stream, and normalize both to 100 wt%.
      N1 = NCCONV + 4
      N2 = N1 + 24
      SUMIN1 = 0.0D0
      SUMIN2 = 0.0D0
      DO 50 J = 1, 7
        UIN1(J) = SIN1(J+N1)
        UIN2(J) = SIN1(J+N2)
```

```
        SUMIN1 = SUMIN1 + UIN1(J)
        SUMIN2 = SUMIN2 + UIN2(J)
   50 CONTINUE
      SUM1 = 0.0D0
      SUM2 = 0.0D0
      DO 52 J = 1, 7
        UIN1N(J) =  100.0D0 * UIN1(J) / SUMIN1
        UIN2N(J) =  100.0D0 * UIN2(J) / SUMIN2
        SUM1 = SUM1 + UIN1N(J)
        SUM2 = SUM2 + UIN2N(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), J = 1, 7)
  518   FORMAT ( ' Component', 9X, 'Coal', 7X, 'URCOAL' /
     1    2X, 'Ash      ', 2F13.3 /
     2    2X, 'Carbon   ', 2F13.3 /
     3    2X, 'Hydrogen', 2F13.3 /
     4    2X, 'Nitrogen', 2F13.3 /
     5    2X, 'Chlorine', 2F13.3 /
     6    2X, 'Sulfur   ', 2F13.3 /
     7   2X, 'Oxygen   ', 2F13.3 )
        WRITE (NHSTRY, 519)  SUMIN1, SUMIN2
  519   FORMAT ( 2X, 'Total    ', 2F13.3 )
C
        WRITE (NHSTRY, 520)
  520   FORMAT ( / ' Normalized non-conventional component Ultimate ',
     1    'analyses:')
        WRITE (NHSTRY, 518)  (UIN1N(J), UIN2N(J), J = 1, 7)
        WRITE (NHSTRY, 519)  SUM1, SUM2
      ENDIF
C
C     Calculate the lbs/hr of the Ultimate analyses components in the
C     feed, and normalize to match the total entering weights.
      N1 = NCCONV + 4
      N2 = N1 + 24
      N3 = N2 + 24
      SUM1 = 0.0D0
      DO 70 J = 1, 7
        WTUC(J) = SIN1(NCONV+1)*SIN1(J+N1) + SIN2(NCONV+1)*SIN2(J+N1)
     1          + SIN3(NCONV+1)*SIN3(J+N1) + SIN4(NCONV+1)*SIN4(J+N1)
     2          + SIN1(NCONV+2)*SIN1(J+N2) + SIN1(NCONV+3)*SIN1(J+N3)
     3          + SIN2(NCONV+2)*SIN2(J+N2) + SIN2(NCONV+3)*SIN2(J+N3)
     4          + SIN3(NCONV+2)*SIN3(J+N2) + SIN3(NCONV+3)*SIN3(J+N3)
     5          + SIN4(NCONV+2)*SIN4(J+N2) + SIN4(NCONV+3)*SIN4(J+N3)
        SUM1 = SUM1 + WTUC(J)
   70 CONTINUE
      TSOLID = CIN(46) + CIN(47) + CIN(48)
      DO 72 J = 1, 7
        WTUC(J) = TSOLID * WTUC(J) / SUM1
   72 CONTINUE
```

```
C
      IF ( KTEST .GE. 2 )  THEN
        WRITE (NHSTRY, 523)  (WTUC(J), J = 1, 7), TSOLID
  523   FORMAT ( / ' Amount of entering Ultimate analysis components,',
     1    ' lbs/hr.' /
     2    2X, 'Ash     ', F13.1 /
     3    2X, 'Carbon  ', F13.1 /
     4    2X, 'Hydrogen', F13.1 /
     5    2X, 'Nitrogen', F13.1 /
     6    2X, 'Chlorine', F13.1 /
     7    2X, 'Sulfur  ', F13.1 /
     8    2X, 'Oxygen  ', F13.1 /
     9    2X, 'Total   ', F13.1 )
      ENDIF
C
C     If it has not been specified by the user in variable INT(3),
C     calculate the number of operating duplicate trains, excluding
C     spares (NPLNT), based on the total flow rate of the reference
C     stream.  However, if the maximum capacity of a single train
C     has not been specified, set the number of operating trains to 1.
      NPLNT = INT(3)
      IF ( (NPLNT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
          NPLNT = FEEDIN  / PMAXF
          IF ( (MOD(FEEDIN, PMAXF)) .GT. 0.0D0 )  NPLNT = NPLNT + 1
        ELSE
          IF ( NPLNT .EQ. 0 )   NPLNT = 1
      ENDIF
C
C     Calculate the feed rate for each of the duplicate plants (PFLOW)
C     in Mlbs/hr.
      XPLNT = NPLNT
      PFLOW = FEEDIN / XPLNT
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           Set the number of lines in the first page of the report.
            LINES = 54
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 DCL82.REP to contain
C           this user block summary report.
            OPEN (UNIT=62, FILE='DCL82.REP', STATUS='UNKNOWN',
     1        ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2        BUFFERED='BUFFERED')
            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' )
          ENDIF
        ENDIF
C
C       Call Subroutine USR82R to calculate the net yields from the
C       coal liquefaction reactor.
        CALL USR82R (ICNAME, IER1, IER2, INT(1), IPASS, KMAXC,
       1  KOMPS, KTEST, NHSTRY, NOUT, WTUC, ULTOUT)
C
C       If requested, call subroutine USR82B to write the reactor
C       elemental balance to the history file.
        IF ( KTEST .GE. 3 )  THEN
          CALL USR82B (ICNAME, KMAXC, KOMPS, NHSTRY, ULTOUT, WTUC)
        ENDIF
C
C       If this is the report pass and the plant sumamry report is being
C       written to a separate file, start a new page.
        IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 2 )  THEN
          IF ( INT(2) .EQ. 0 )   THEN
C             Set the number of lines in the second page of the report.
              LINES = 51
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
              WRITE (NOUT, 800)
          ENDIF
        ENDIF
C
C       Call Subroutine USR82S to distribute the net yields from plant 8.2
C       into the six product streams.
        CALL USR82S (ICNAME, INT(1), IPASS, ITEMS, KMAXC, KOMPS,
       1  KTEST, NCC, NCCONV, NCONV, NHSTRY, NNCC, NOUT, SIN1,
       2  SOUT1, SOUT2, SOUT3, SOUT4, SOUT5, SOUT6, ULTOUT)
C
C       If this is the report pass and the plant sumamry report is being
C       written to a separate file, start a new page.
        IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 2 )  THEN
          IF ( INT(2) .EQ. 0 )  THEN
C             Calculate the number of lines in third page of the report.
              LSTRM = 23
              IF ( IER1 .GE. 1 )  LSTRM = LSTRM + 4
              IF ( IER2 .GE. 1 )  LSTRM = LSTRM + 4
              LUTIL = 16
              LCOST = 11
              NDUP = REAL(58) + 0.001D0
              IF ( (NPLNT + NDUP) .EQ. 1 )  LCOST = 9
              IF ( PFLOW .LT. PMINF )  LCOST = LCOST + 3
              IF ( PFLOW .GT .PMAXF )  LCOST = LCOST + 3
              IF ( NDUP .GE. 1 )  LCOST = LCOST + 1
              LINES = LSTRM + LUTIL + LCOST
C             Now, subtract the number of lines for those portions of
C             the user block summary report which will not be written.
              IF ( INT(1) .GE. 2 )   LINES = LINES - LUTIL
              IF ( INT(1) .GE. 1 )   LINES = LINES - LCOST
```

```
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
            WRITE (NOUT, 800)
        ENDIF
C
C       Load the overall stream properties in the ST1 and ST2 arrays.
C
C       Load the total stream flow rates in Mlbs/hr.
C       CF is the conversion factor from Kg/sec to Mlbs/hr.
        CF = 0.001D0 * 3600.0D0 / 0.45359237D0
        J = NCONV + NNCC + 1
        ST1(1,1) = CF * (SIN1(NCC+1)*SIN1(NCC+9) + SIN1(J))
        ST1(2,1) = CF * (SIN2(NCC+1)*SIN2(NCC+9) + SIN2(J))
        ST1(3,1) = CF * (SIN3(NCC+1)*SIN3(NCC+9) + SIN3(J))
        ST1(4,1) = CF * (SIN4(NCC+1)*SIN4(NCC+9) + SIN4(J))
        ST1(5,1) = CF * (SIN5(NCC+1)*SIN5(NCC+9) + SIN5(J))
        ST2(1,1) = CF * (SOUT1(NCC+1)*SOUT1(NCC+9) + SOUT1(J))
        ST2(2,1) = CF * (SOUT2(NCC+1)*SOUT2(NCC+9) + SOUT2(J))
        ST2(3,1) = CF * (SOUT3(NCC+1)*SOUT3(NCC+9) + SOUT3(J))
        ST2(4,1) = CF * (SOUT4(NCC+1)*SOUT4(NCC+9) + SOUT4(J))
        ST2(5,1) = CF * (SOUT5(NCC+1)*SOUT5(NCC+9) + SOUT5(J))
        ST2(6,1) = CF * (SOUT6(NCC+1)*SOUT6(NCC+9) + SOUT6(J))
C
C       Load the stream temperatures in degrees Fahrenheit.
        X = 1.8D0
        X1 = 459.67D0
        ST1(1,2) = X * SIN1(NCC+2) - X1
        ST1(2,2) = X * SIN2(NCC+2) - X1
        ST1(3,2) = X * SIN3(NCC+2) - X1
        ST1(4,2) = X * SIN4(NCC+2) - X1
        ST1(5,2) = X * SIN5(NCC+2) - X1
        ST2(1,2) = X * SOUT1(NCC+2) - X1
        ST2(2,2) = X * SOUT2(NCC+2) - X1
        ST2(3,2) = X * SOUT3(NCC+2) - X1
        ST2(4,2) = X * SOUT4(NCC+2) - X1
        ST2(5,2) = X * SOUT5(NCC+2) - X1
        ST2(6,2) = X * SOUT6(NCC+2) - X1
C
C       Load the stream pressures in PSIA.
        X = 1.0D0 / 6.8947573D+3
        ST1(1,3) = X * SIN1(NCC+3)
        ST1(2,3) = X * SIN2(NCC+3)
        ST1(3,3) = X * SIN3(NCC+3)
        ST1(4,3) = X * SIN4(NCC+3)
        ST1(5,3) = X * SIN5(NCC+3)
        ST2(1,3) = X * SOUT1(NCC+3)
        ST2(2,3) = X * SOUT2(NCC+3)
        ST2(3,3) = X * SOUT3(NCC+3)
        ST2(4,3) = X * SOUT4(NCC+3)
        ST2(5,3) = X * SOUT5(NCC+3)
        ST2(6,3) = X * SOUT6(NCC+3)
C
C       Load the vapor stream flow rates in MM SCF/hr.
```

```
        ST1(2,4) = CF * SIN2(NCC+1) * 379.495D-3
        ST2(1,4) = CF * SOUT1(NCC+1) * 379.495D-3
C
C       Call Subroutine USR82Z to write the overall material balance
C       and any warning messages.
        CALL USR82Z (IER1, IER2, INT(1), IPASS, NOUT)
C
      ENDIF
C
C     Call subroutine USRUCO to calculate, save and report the
C     utilities, capital and operating costs for the plant.
      ID = 10
      KUNITS = 9
      CALL USRUCO (NHSTRY, NOUT, IPASS, ID, PNAME, INT(1), INT(3),
     1  KTEST, REAL(21), FEEDIN, KUNITS)
C
C
C     Call subroutine USR31T to check to insure that the Utilities
C     summary table output is correct.
C     IF ( IPASS .EQ. 4 .AND. INT(2) .EQ. 1 )  THEN
C       WRITE (NOUT, 800)
C       CALL USR31T (NHSTRY, NOUT, IPASS, INT(1), INT(2), KTEST)
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 USR82' )
C
C
      RETURN
      END
C
C$ USR82B
      SUBROUTINE USR82B (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 - June 26, 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 /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(5,5), ST2(6,5)
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  ICNAME
      CHARACTER * 8  ENAME
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
          EINC(K)  = EINC(K)  + CIN(J)  * CPROP(J,L)
          EOUTC(K) = EOUTC(K) + COUT(J) * CPROP(J,L)
   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$ USR82R
      SUBROUTINE USR82R (ICNAME, IER1, IER2, INT1, IPASS, KMAXC,
     1  KOMPS, KTEST, NHSTRY, NOUT, WTUC, ULTOUT)
C
C     This subroutine calculates the fluid coking reactor yields and
C     and the total reactor outlet stream.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - June 26, 1992.
C
C     Method of calculation:
C       1.  The entering T1000+ and I1000+ are converted to liquid
C           yields by the yield distribution factors in the YF array.
C       2.  The properties of the liquid yields producted in the
C           fluid coker are the same as that prodiuced in Plant 2.
C       3.  All O2 is converted.  The YF factor for N2 is based on
C           the amount of entering N2.
C       4.  All remaining material goes to the coke stream as COKE
C           and is called URCOAL.
C       5.  The net yields are loaded in the COUT vector.
C
C     Calling arguments:
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 a future warning message
C                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     NHSTRY   = Logical unit number of the history file.
C     NOUT     = Logical unit number of the plant output report file.
C                liquefaction reactor model.
C     WTUC()   = Weight of Ultimate anmalysis components entering
C                the reactor.
C     ULTOUT() = Ultimate analysis of the coke (called URCOAL) leaving
C                the reactor.
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)
C
      DIMENSION ICNAME(*), WTUC(*), ULTOUT(*)
C
C     Local variable declarations.
C
C     YF(J) is the yield factor for the T1000+ and I1000+ components
C     going to liquid products.
C
      DIMENSION YF(50)
C
      DIMENSION ENAME(5), EYLD(5), SUME(5), UANAME(8),
     1  WTEIN(5), WTUOUT(7)
C
      CHARACTER * 4  BLANK4, ICNAME
      CHARACTER * 8  ENAME, UANAME
C
      DATA BLANK4 / '    ' /
C
C     Initialize the reactor yield distribution factors in lbs/lb of
C     T1000+ and I1000+ converted.  The N2 factor isd based on the
C     entering N2, and all )2 is converted.
C
C     The following factors are based on the yields in Volume III of
C     the Task II Topical report of March 1992.
C
C     Wt fraction to  H2      N2          O2          H2S         CO
      DATA YF / 0.0200882, 0.979915, 0.000000, 0.0018524, 0.0018193,
C       CO2         NH3         H2O         HCL         COS
     1  0.0089137, 0.0015822, 0.0072925, 0.0000000, 0.0000000,
C       CH4         C2H6        C3H8        IC4H10      N C4H10
     2  0.0324726, 0.0106370, 0.0053200, 0.0004068, 0.0004068,
C       IC5H12      N C5H12     T125        T175        T225
     3  0.0000000, 0.0000000, 0.0019172, 0.0019172, 0.0019172,
C       T275        T325        T375        T425        T475
     4  0.0019173, 0.0019173, 0.0043382, 0.0043383, 0.0090000,
C       T525        T575        T625        T675        T725
     5  0.0090000, 0.0090000, 0.0090000, 0.0001953, 0.0001952,
C       T775        T825        T875        T925        T975
     6  0.0001952, 0.0001952, 0.0141667, 0.0141668, 0.0141668,
C       T1000+      I1000+      Future      Future      Future
     7  -0.655998, -0.655998, 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
      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)
  501 FORMAT ( / ' Starting the fluid coking plant yield ',
     1  'calculations in Subroutine USR82R.')
C
      IF ( KTEST .GE. 2 )   THEN
        WRITE (NHSTRY, 502)
  502   FORMAT ( / ' The yield distribution factors ')
        DO 20 J = 1, KOMPS
          K = 2 * J - 1
          WRITE (NHSTRY, 503)  J, ICNAME(K), ICNAME(K+1), YF(J)
  503     FORMAT ( 1X, I5, 5X, 2A4, 5X, F11.7 )
   20   CONTINUE
      ENDIF
C
C     Calculate the amount of MAF solids entering the reactors and put
C     them in the WTEIN vector in the order of C, H, S, N an O.
C     Include the chlorine with the carbon.
      WTEIN(1) = WTUC(2) + WTUC(5)
      WTEIN(2) = WTUC(3)
      WTEIN(3) = WTUC(6)
      WTEIN(4) = WTUC(4)
      WTEIN(5) = WTUC(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 total lbs of elements entering the reactor.
      DO 28 J = 1, 45
        DO 27 K = 1, 5
          L = K + 2
          WTEIN(K) = WTEIN(K) + 0.01D0 * CIN(J) * CPROP(J,L)
   27   CONTINUE
   28 CONTINUE
C
      IF ( KTEST .GE. 3 )   THEN
        TOTAL = WTEIN(1) + WTEIN(2) + WTEIN(3) + WTEIN(4) + WTEIN(5)
        WRITE (NHSTRY, 507) (ENAME(J), WTEIN(J), J = 1, 5), UANAME(8),
     1    TOTAL
  507   FORMAT ( / ' Total entering elemental weights, lbs/hr.',
     1    6( / 2X, A8, F12.1 ))
      ENDIF
C
C     Reactor Yield Calculations.
      X = CIN(36) + CIN(37)
      DO 30 J = 1, 45
        COUT(J) = CIN(J) + YF(J) * X
C       Recalculate special components; O2, N2, T1000+ and I1000+.
   30 CONTINUE
```

```
C     Recalculate special components; N2, O2, T1000+ and I1000+.
      COUT(2) = 0.979915D0 * CIN(2)
      COUT(3) = 0.0D0
      COUT(36) = CIN(36) * (1.0D0 + YF(36))
      COUT(37) = CIN(37) * (1.0D0 + YF(37))
C
C     Calculate the elemental weights in the above products.
      DO 32 K = 1, 5
        EYLD(K) = 0.0D0
   32 CONTINUE
      DO 36 J = 1, 45
        DO 34 K = 1, 5
          L = K + 2
          EYLD(K) = EYLD(K) + 0.01D0 * COUT(J) * CPROP(J,L)
   34   CONTINUE
   36 CONTINUE
C
C     Calculate the Ultimate analysis of the coke (called URCOAL) that
C     is produced by difference.
      WTUOUT(1) = WTUC(1)
      WTUOUT(2) = WTEIN(1) - EYLD(1)
      WTUOUT(3) = WTEIN(2) - EYLD(2)
      WTUOUT(4) = WTEIN(4) - EYLD(4)
      WTUOUT(5) = 0.0D0
      WTUOUT(6) = WTEIN(3) - EYLD(3)
      WTUOUT(7) = WTEIN(5) - EYLD(5)
C
C     Check for errors in the elemental balance as evidenced by a
C     negative component weight flow rate.
      IER2 = 0
      SUM = 0.0
      DO 40 J = 1, 7
        IF ( WTUOUT(J) .LE. 1.0D-10 )  IER2 = 1
        SUM = SUM + WTUOUT(J)
   40 CONTINUE
C
      IF ( IER2 .GE. 1 )  THEN
C       An error exists in the elemental balance.  Write a message and
C       adjust.
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 500)
  500   FORMAT ( // 1X, 'Plant 8.2 - Supplementary data from ',
     1    'subroutine USR82R' / )
        WRITE (NHSTRY, 521)  (UANAME(J), WTUOUT(J), J = 1, 7),
     1    UANAME(8), SUM
  521   FORMAT ( / 2X, 'The fluid coking plant has an elemental ',
     1    'balance problem.  The composition' /
     2    2X, 'of the coke will be adjusted to maintain the weight ',
     3    'balance.  The erroneous' /
     4    2X, 'coke weights that maintains the elemental balance are:'/
     5    16X, 'lbs/hr' /  7(3X, A8, F11.1 /),  3X, A8, F11.1 )
C
C       Adjustment - Assume the Ash is correct and adjust the other
C       weights as appropriate.  Take all error in the carbon.
        DO 42 J = 3, 7
          IF ( WTUOUT(J) .LT. 0.0D0 )   THEN
```

```
            WTUOUT(2) = WTUOUT(2) + WTUOUT(J)
            WTUOUT(J) = 0.0D0
           ENDIF
   42    CONTINUE
C
         SUM = 0.0D0
         DO 44 J = 1, 7
           SUM = SUM + WTUOUT(J)
   44    CONTINUE
         WRITE (NHSTRY, 522)  (UANAME(J), WTUOUT(J), J = 1, 7),
     1     UANAME(8), SUM
  522    FORMAT ( / 2X, 'The adjusted coke weights:' /
     1     16X, 'lbs/hr' /  7(3X, A8, F11.1 /),  3X, A8, F11.1 )
       ENDIF
C
       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
C      Set the coke flow rate (called URCOAL).
       COUT(47) = SUM
C
       IF ( KTEST .GE. 4 )  WRITE (NHSTRY, 530)
     1  (UANAME(J), ULTOUT(J), WTUOUT(J), J = 1, 7), UANAME(8), SUM
  530 FORMAT ( / ' Ultimate analysis of the coke (called URCOAL)',
     1  ' that is produced.'  /   16X, 'Wt %', 5X, 'lbs/hr' /
     2  7(3X, A8, F9.2, F11.1 / ),
     3  3X, A8, F20.1 )
C
       IF ( KTEST .GE. 3 )   THEN
         WRITE (NHSTRY, 531)
  531    FORMAT ( / ' Plant 8.2 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
             X = COUT(J) - CIN(J)
             WRITE (NHSTRY, 532)  J, ICNAME(K), ICNAME(K+1), CIN(J),
     1         X,  COUT(J)
  532        FORMAT ( 1X, I5, 1X, 2A4, 5X, 3F13.2)
             SUME(1) = SUME(1) + CIN(J)
             SUME(2) = SUME(2) + X
             SUME(3) = SUME(3) + COUT(J)
           ENDIF
  170    CONTINUE
         WRITE (NHSTRY, 533)  SUME(1), SUME(2), SUME(3)
  533    FORMAT ( 11X, 'Total', F17.2, 2F13.2 )
```

```
      ENDIF
C
C
      IF ( IPASS .EQ. 4 .AND. INT1 .LE. 2 )  THEN
C
C       Write the reactor portion of the output report.
C       ===============================================
        WRITE (NOUT, 801)
  801   FORMAT ( / 22X, 'PLANT 8.2 - SUMMARY REPORT' /
     1    26X, 'FLUID COKING PLANT')
C
C       Convert the total flow rates to Mlbs/hr.
        TOTIN = 0.001D0 * TOTIN
        SUM = 0.001D0 * SUM
C
        WRITE (NOUT, 821)
  821   FORMAT ( / '  INLET AND OUTLET COMPONENT FLOW RATES, MLBS/HR' /
     1    4X, 'COMPONENT', 9X, 'INLET', 6X, 'OUTLET' )
C
C       Write the 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
      ENDIF
C
  999 RETURN
      END
C
C$ USR82S
      SUBROUTINE USR82S (ICNAME, INT1, IPASS, ITEMS, KMAXC, KOMPS,
     1  KTEST, NCC, NCCONV, NCONV, NHSTRY, NNCC, NOUT, SIN1,
     2  SOUT1, SOUT2, SOUT3, SOUT4, SOUT5, SOUT6, ULTOUT)
C
C     This subroutine splits the net yields produced by the fluid
C     coking plant into the six product streams by a very simple
C     model, and loads them in the SOUT1 through SOUT6 vectors.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - June 26, 1992.
C
C     Method of calculation:
```

```
C       1.  The net yields are split into the six net product streams
C           using component distribution factors for the last five
C           product streams.
C           Stream 1 - the fuel gases stream
C           Stream 2 - the naphtha stream
C           Stream 3 - the gas-oil stream
C           Stream 4 - the bottoms stream
C           Stream 5 - the coke stream
C           Stream 6 - the sour water and H2S stream
C       2.  All remaining material is placed in the first net product
C           stream, the fuel gases stream.ream going to plant 6.1
C
C     Calling arguments:
C     ICNAME() = Vector of component identifications (CHARACTER * 4)
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     ITEMS    = Total number of items in the SOUT1 - SOUT5 vectors.
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     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     NOUT     = Logical unit number of the plant output report file.
C     SIN1()   = ASPEN/SP stream vector for inlet stream nunber 2 -
C                the fresh wet coal stream.
C     SOUT1()  = ASPEN/SP stream vector for outlet stream number 1 -
C                the high pressure gas stream going to plant 6.1.
C     SOUT2()  = ASPEN/SP stream vector for outlet stream number 2 -
C                the low pressure gas stream going to plant 6.2.
C     SOUT3()  = ASPEN/SP stream vector for outlet stream number 3 -
C                the naphtha stream.
C     SOUT4()  = ASPEN/SP stream vector for outlet stream number 4 -
C                the gas-oil hydrotreater feed stream.
C     SOUT5()  = ASPEN/SP stream vector for outlet stream number 5 -
C                the bottoms strean going to the ROSE-SR unit.
C     SOUT6()  = ASPEN/SP stream vector for outlet stream number 6 -
C                the sour water stream.
C     ULTOUT() = Ultimate analysis of the URCOAL (unconverted coal and
C                ash) leaving the ROSE-SR unit.
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)
C
      COMMON /USRCO2/ 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 /USRCO2/
C     only to save space since all block models use these variables.
C
      DIMENSION ICNAME(*), ULTOUT(*), SIN1(*),
     1  SOUT1(*), SOUT2(*), SOUT3(*), SOUT4(*), SOUT5(*), SOUT6(*)
C
C     Local variable declarations.
C
C     CDF2(J) are the component distribution factors for stream 2.
C     CDF3(J) are the component distribution factors for stream 3.
C     CDF4(J) are the component distribution factors for stream 4.
C     CDF5(J) are the component distribution factors for stream 5.
C     CDF6(J) are the component distribution factors for stream 6.
      DIMENSION CDF2(50), CDF3(50), CDF4(50), CDF5(50), CDF6(50)
C
      DIMENSION S1(50), S2(50), S3(50), S4(50), S5(50), S6(50)
C
      CHARACTER * 4  BLANK4, ICNAME
C
      DATA BLANK4 / '    ' /
C
C
C     BASELINE DESIGN COMPONENT DISTRIBUTION FACTORS.
C     ==============================================
C
C     The following component distribution factors were calculated in
C     Lotus spreadsheed P82A.WK1 based on the data in the Task II
C     topical report of March, 1992.
C
C     Initialize the component distribution factors for stream 2,
C     the naphtha stream.
C     Fraction of   H2        N2        O2        H2S       CO
      DATA CDF2 / 0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CO2       NH3       H2O       HCL       COS
     1  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CH4       C2H6      C3H8      IC4H10    N C4H10
     2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       IC5H12    N C5H12   T125      T175      T225
     3  1.000000, 1.000000, 0.881616, 0.881616, 0.881616,
C       T275      T325      T375      T425      T475
     4  0.881616, 0.881616, 0.029066, 0.029066, 0.000000,
C       T525      T575      T625      T675      T725
     5  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T775      T825      T875      T925      T975
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T1000+    I1000+    Future    Future    Future
     7  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Future    Future    Future    Future    Future
     8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Coal      URCOAL    Slag      Future    OTHERS
```

```
     9  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for stream 3,
C     the gas-oil stream.
C     Fraction of   H2        N2        O2        H2S       CO
      DATA CDF3 / 0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CO2       NH3       H2O       HCL       COS
     1  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CH4       C2H6      C3H8      IC4H10    N C4H10
     2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       IC5H12    N C5H12   T125      T175      T225
     3  0.000000, 0.000000, 0.092390, 0.092390, 0.092390,
C       T275      T325      T375      T425      T475
     4  0.092390, 0.092390, 0.970934, 0.970934, 1.000000,
C       T525      T575      T625      T675      T725
     5  1.000000, 1.000000, 1.000000, 1.000000, 1.000000,
C       T775      T825      T875      T925      T975
     6  1.000000, 1.000000, 0.000000, 0.000000, 0.000000,
C       T1000+    I1000+    Future    Future    Future
     7  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Future    Future    Future    Future    Future
     8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Coal      URCOAL    Slag      Future    OTHERS
     9  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for stream 4,
C     the 850-1000 F stream.
C     Fraction of   H2        N2        O2        H2S       CO
      DATA CDF4 / 0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CO2       NH3       H2O       HCL       COS
     1  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CH4       C2H6      C3H8      IC4H10    N C4H10
     2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       IC5H12    N C5H12   T125      T175      T225
     3  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T275      T325      T375      T425      T475
     4  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T525      T575      T625      T675      T725
     5  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T775      T825      T875      T925      T975
     6  0.000000, 0.000000, 1.000000, 1.000000, 1.000000,
C       T1000+    I1000+    Future    Future    Future
     7  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Future    Future    Future    Future    Future
     8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Coal      URCOAL    Slag      Future    OTHERS
     9  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for stream 5,
C     the Coke stream.
C     Fraction of   H2        N2        O2        H2S       CO
      DATA CDF5 / 0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CO2       NH3       H2O       HCL       COS
     1  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       CH4       C2H6      C3H8      IC4H10    N C4H10
```

```
     2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       IC5H12    N C5H12   T125      T175      T225
     3  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T275      T325      T375      T425      T475
     4  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T525      T575      T625      T675      T725
     5  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T775      T825      T875      T925      T975
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T1000+    I1000+    Future    Future    Future
     7  1.000000, 1.000000, 0.000000, 0.000000, 0.000000,
C       Future    Future    Future    Future    Future
     8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Coal      URCOAL    Slag      Future    OTHERS
     9  1.000000, 1.000000, 1.000000, 0.000000, 0.000000 /
C
C     Initialize the component distribution factors for stream 6,
C     the sour water stream.
C     Fraction of   H2       N2        O2        H2S       CO
      DATA CDF6 / 0.000000, 0.000000, 0.000000, 1.000000, 0.000000,
C       CO2       NH3       H2O       HCL       COS
     1  0.000000, 0.774194, 1.000000, 0.000000, 0.000000,
C       CH4       C2H6      C3H8      IC4H10    N C4H10
     2  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       IC5H12    N C5H12   T125      T175      T225
     3  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T275      T325      T375      T425      T475
     4  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T525      T575      T625      T675      T725
     5  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T775      T825      T875      T925      T975
     6  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       T1000+    I1000+    Future    Future    Future
     7  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Future    Future    Future    Future    Future
     8  0.000000, 0.000000, 0.000000, 0.000000, 0.000000,
C       Coal      URCOAL    Slag      Future    OTHERS
     9  0.000000, 0.000000, 0.000000, 0.000000, 0.000000 /
C
C
      IF ( KTEST .GE. 2 )   WRITE (NHSTRY, 501)
  501 FORMAT ( / ' Starting the product separation calculations ',
     1  'in Subroutine USR82S' )
C
      IF ( KTEST .GE. 2 )   THEN
        WRITE (NHSTRY, 502)
  502   FORMAT ( / ' The component product distribution factors:' /
     1    ' No.', 3X, 'Component', 4X, 'Fuel gases',
     2    5X, 'Naphtha', 6X, 'Gas-oil', 6X, '1000+ F', 6X,
     3    ' Coke',5X, 'S H2O & H2S' )
        DO 12 J = 1, KMAXC
          K = 2 * J - 1
          IF ( ICNAME(K) .NE. BLANK4 )  THEN
            X = 1.0D0 - CDF2(J) - CDF3(J) - CDF4(J) - CDF5(J) - CDF6(J)
            WRITE (NHSTRY, 503)  J, ICNAME(K), ICNAME(K+1), X,
```

```
     1        CDF2(J), CDF3(J), CDF4(J), CDF5(J), CDF6(J)
  503       FORMAT ( 1X, I3, 3X, 2A4, 1X, 6F13.6 )
          ENDIF
   12   CONTINUE
        WRITE (NHSTRY, 504)
  504   FORMAT ( ' The distribution factors for the fuel gases ',
     1    'are calculated by difference.' )
      ENDIF
C
C     Zero the component flow rates in the six net product streams.
      DO 20 J = 1, KMAXC
        S1(J) = 0.0D0
        S2(J) = 0.0D0
        S3(J) = 0.0D0
        S4(J) = 0.0D0
        S5(J) = 0.0D0
        S6(J) = 0.0D0
   20 CONTINUE
C
C     Distribute the net unit yields among the six product streams.
      SUMC = 0.0D0
      SUM1 = 0.0D0
      SUM2 = 0.0D0
      SUM3 = 0.0D0
      SUM4 = 0.0D0
      SUM5 = 0.0D0
      SUM6 = 0.0D0
      DO 30 J = 1, KMAXC
        IF ( ICNAME(2*J-1) .NE. BLANK4 )  THEN
          X = CDF2(J) + CDF3(J) + CDF4(J) + CDF5(J) + CDF6(J)
          IF ( X .GT. 1.000001D0 )  THEN
C           The component distributions factors for this component are
C           greater than 1.0.  Therefore, adjust the distribution so
C           that this component is distributed in the same ratio as the
C           specified component distribution factors, and write a
C           warning message.
            IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 505) IPASS
  505       FORMAT ( // 1X, 'Plant 2 - Supplementary data',
     1        ' from subroutine USR82' /
     2        2X, 'Coal Liquefaction plant', 20X, 'IPASS =', I3 /)
            WRITE (NHSTRY, 506)  J, ICNAME(2*J-1), ICNAME(2*J),
     1        CDF2(J), CDF3(J), CDF4(J), CDF5(J), CDF6(J)
  506       FORMAT ( / 1X, '* WARNING * - The component product ',
     1        'distribution factors for component no.', I3 /
     2        3X, 2A4, ' sum to a total greater than 1.0.  They are' /,
     3        3X, 5F10.6, '  They will be normalized to 1.0' //
     4        3X, 'Please correct this problem in the next run.  ',
     5        'Execution is continuing.' / )
            CDF2(J) = CDF2(J) / X
            CDF3(J) = CDF3(J) / X
            CDF4(J) = CDF4(J) / X
            CDF5(J) = CDF5(J) / X
            CDF6(J) = CDF6(J) / X
          ENDIF
          CMLBS = 0.001D0 * COUT(J)
```

```
          S2(J) = CDF2(J) * CMLBS
          S3(J) = CDF3(J) * CMLBS
          S4(J) = CDF4(J) * CMLBS
          S5(J) = CDF5(J) * CMLBS
          S6(J) = CDF6(J) * CMLBS
          S1(J) = CMLBS - S2(J) - S3(J) - S4(J) - S5(J) - S6(J)
          SUMC = SUMC + CMLBS
          SUM1 = SUM1 + S1(J)
          SUM2 = SUM2 + S2(J)
          SUM3 = SUM3 + S3(J)
          SUM4 = SUM4 + S4(J)
          SUM5 = SUM5 + S5(J)
          SUM6 = SUM6 + S6(J)
        ENDIF
   30 CONTINUE
C
      IF ( KTEST .GE. 3 )   THEN
        WRITE (NHSTRY, 507)
  507   FORMAT ( / ' Total net stream flows leaving plant 8.2, ',
     1    'in Mlbs/hr:' /
     2    ' No.', 3X, 'Component', 5X, 'Total', 3X,
     3    'Fuel gases', 3X, 'Naphtha', 4X, 'Gas-oil', 4X,
     4    '1000+ F', 4X, ' Coke', 3X, 'S H2O & H2S' )
        DO 40 J = 1, KMAXC
          K = 2 * J - 1
          IF ( ICNAME(K) .NE. BLANK4 )  THEN
            CMLBS = 0.001D0 * COUT(J)
            WRITE (NHSTRY, 508)  J, ICNAME(K), ICNAME(K+1), CMLBS,
     1        S1(J), S2(J), S3(J), S4(J), S5(J), S6(J)
  508       FORMAT ( 1X, I3, 3X, 2A4, 7F11.3 )
          ENDIF
   40   CONTINUE
        WRITE (NHSTRY, 509)  SUMC, SUM1, SUM2, SUM3, SUM4, SUM5, SUM6
  509   FORMAT ( 1X, 'Total', 9X, 7F11.3 )
      ENDIF
C
      IF ( IPASS .EQ. 4 .AND. INT1 .LE. 0 )  THEN
C
C       Write the output report.
C       ========================
        WRITE (NOUT, 801)
  801   FORMAT ( / 20X, 'PLANT 8.2 - SUMMARY REPORT (CONTINUED)'
     1    / 30X, 'FLUID COKING PLANT')
C
        WRITE (NOUT, 802)
  802   FORMAT ( / ' PRIMARY OUTLET STREAMS, MLBS/HR')
C
C       Write the net outlet stream flow rates in Mlbs/hr.
        WRITE (NOUT, 803)
  803   FORMAT ( / 4X, 'COMPONENT', 3X, 'FUEL GAS', 6X, 'NAPHTHA',
     1    5X, 'GAS-OIL', 5X, 'BOTTOMS', 8X, 'COKE' )
        DO 110 J = 1, KMAXC
          K = 2 * J - 1
          IF ( ICNAME(K) .NE. BLANK4 )  THEN
            WRITE (NOUT, 804) ICNAME(K), ICNAME(K+1), S1(J), S2(J),
```

```
     1        S3(J), S4(J), S5(J)
  804       FORMAT ( 4X, 2A4, 5F12.3 )
          ENDIF
  110   CONTINUE
        WRITE (NOUT, 805) SUM1, SUM2, SUM3, SUM4, SUM5
  805   FORMAT ( 4X, 'TOTAL', 3X, 5F12.3 )
C
        WRITE (NOUT, 806)
  806   FORMAT ( / 25X, '- CONTINUED ON NEXT PAGE -' )
      ENDIF
C
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 vectors.
        DO 200 J = 1, NCCONV
          SOUT1(J) = 0.0D0
          SOUT2(J) = 0.0D0
          SOUT3(J) = 0.0D0
          SOUT4(J) = 0.0D0
          SOUT5(J) = 0.0D0
          SOUT6(J) = 0.0D0
  200   CONTINUE
C
C       CF is the conversion factor from Kg/sec to Mlbs/hr.
        CF = 0.001D0 * 3600.0D0 / 0.45359237D0
C
C       Set the molar flow rates of the conventional components.
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        SUM4 = 0.0D0
        SUM5 = 0.0D0
        SUM6 = 0.0D0
        DO 210 J = 1, NCC
          DO 208 K = 1, KOMPS
            IF ( J .EQ. ICNUMB(K) )  THEN
              SOUT1(J) = S1(K) / (CF * CPROP(K,1))
              SOUT2(J) = S2(K) / (CF * CPROP(K,1))
              SOUT3(J) = S3(K) / (CF * CPROP(K,1))
              SOUT4(J) = S4(K) / (CF * CPROP(K,1))
              SOUT5(J) = S5(K) / (CF * CPROP(K,1))
              SOUT6(J) = S6(K) / (CF * CPROP(K,1))
              SUM1 = SUM1 + SOUT1(J)
              SUM2 = SUM2 + SOUT2(J)
              SUM3 = SUM3 + SOUT3(J)
              SUM4 = SUM4 + SOUT4(J)
              SUM5 = SUM5 + SOUT5(J)
              SUM6 = SUM6 + SOUT6(J)
              GO TO 210
            ENDIF
  208     CONTINUE
  210   CONTINUE
C
```

```
C       Set the total molar flow rates of the conventional components.
        SOUT1(NCC+1) = SUM1
        SOUT2(NCC+1) = SUM2
        SOUT3(NCC+1) = SUM3
        SOUT4(NCC+1) = SUM4
        SOUT5(NCC+1) = SUM5
        SOUT6(NCC+1) = SUM6
C
C       Set the mass flow rates of the non-conventional components.
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        SUM4 = 0.0D0
        SUM5 = 0.0D0
        SUM6 = 0.0D0
        DO 220 J = 1, 3
          SOUT1(NCONV+J) = S1(J+45) / CF
          SOUT2(NCONV+J) = S2(J+45) / CF
          SOUT3(NCONV+J) = S3(J+45) / CF
          SOUT4(NCONV+J) = S4(J+45) / CF
          SOUT5(NCONV+J) = S5(J+45) / CF
          SOUT6(NCONV+J) = S6(J+45) / CF
          SUM1 = SUM1 + SOUT1(NCONV+J)
          SUM2 = SUM2 + SOUT2(NCONV+J)
          SUM3 = SUM3 + SOUT3(NCONV+J)
          SUM4 = SUM4 + SOUT4(NCONV+J)
          SUM5 = SUM5 + SOUT5(NCONV+J)
          SUM6 = SUM6 + SOUT6(NCONV+J)
  220   CONTINUE
C
C       Set the total mass flow rates of the non-conventionals.
        SOUT1(NCONV+NNCC+1) = SUM1
        SOUT2(NCONV+NNCC+1) = SUM2
        SOUT3(NCONV+NNCC+1) = SUM3
        SOUT4(NCONV+NNCC+1) = SUM4
        SOUT5(NCONV+NNCC+1) = SUM5
        SOUT6(NCONV+NNCC+1) = SUM6
C
C       Set the default temperature and pressure of the outlet streams
C       to 70 F and 15 PSIA.  Return these values to ASPEN/SP in degrees
C       Kelvin and Pascals.  These default values can be overriden by
C       the FLASH-SPECS sentence in the ASPEN/SP input file.
        SOUT1(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT1(NCC+3) = 15.0D0 * 6.8947573D+3
        SOUT1(NCONV+NNCC+2) = SOUT1(NCC+2)
        SOUT1(NCONV+NNCC+3) = SOUT1(NCC+3)
        SOUT2(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT2(NCC+3) = 15.0D0 * 6.8947573D+3
        SOUT2(NCONV+NNCC+2) = SOUT2(NCC+2)
        SOUT2(NCONV+NNCC+3) = SOUT2(NCC+3)
        SOUT3(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT3(NCC+3) = 15.0D0 * 6.8947573D+3
        SOUT3(NCONV+NNCC+2) = SOUT3(NCC+2)
        SOUT3(NCONV+NNCC+3) = SOUT3(NCC+3)
        SOUT4(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
```

```
      SOUT4(NCC+3) = 15.0D0 * 6.8947573D+3
      SOUT4(NCONV+NNCC+2) = SOUT4(NCC+2)
      SOUT4(NCONV+NNCC+3) = SOUT4(NCC+3)
      SOUT5(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT5(NCC+3) = 15.0D0 * 6.8947573D+3
      SOUT5(NCONV+NNCC+2) = SOUT5(NCC+2)
      SOUT5(NCONV+NNCC+3) = SOUT5(NCC+3)
      SOUT6(NCC+2) = (70.0D0 - 32.0D0)/1.8D0 + 273.15D0
      SOUT6(NCC+3) = 15.0D0 * 6.8947573D+3
      SOUT6(NCONV+NNCC+2) = SOUT6(NCC+2)
      SOUT6(NCONV+NNCC+3) = SOUT6(NCC+3)
C
      SOUT1(NCONV+NNCC+9) = 1.0D0
      SOUT2(NCONV+NNCC+9) = 1.0D0
      SOUT3(NCONV+NNCC+9) = 1.0D0
      SOUT4(NCONV+NNCC+9) = 1.0D0
      SOUT5(NCONV+NNCC+9) = 1.0D0
      SOUT6(NCONV+NNCC+9) = 1.0D0
C
C     Set the Ultiminate analysis of the coke (called URCOAL) to
C     that calculated in subroutine USR82R.
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 coke (called 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 coke (called 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 coke (called 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       Copy the URCOAL properties from the first outlet strean to
C       all the others.
        DO 250 J = 25, 48
          SOUT2(J+NCCONV) = SOUT1(J+NCCONV)
          SOUT3(J+NCCONV) = SOUT1(J+NCCONV)
          SOUT4(J+NCCONV) = SOUT1(J+NCCONV)
          SOUT5(J+NCCONV) = SOUT1(J+NCCONV)
          SOUT6(J+NCCONV) = SOUT1(J+NCCONV)
  250   CONTINUE
C
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)
        CALL CPACK (SOUT2, NCP, IDX, XPACK, TMASS)
        SOUT2(NCC+9) = AVEMW (NCP, IDX, XPACK)
        CALL CPACK (SOUT3, NCP, IDX, XPACK, TMASS)
        SOUT3(NCC+9) = AVEMW (NCP, IDX, XPACK)
        CALL CPACK (SOUT4, NCP, IDX, XPACK, TMASS)
        SOUT4(NCC+9) = AVEMW (NCP, IDX, XPACK)
        CALL CPACK (SOUT5, NCP, IDX, XPACK, TMASS)
        SOUT5(NCC+9) = AVEMW (NCP, IDX, XPACK)
        CALL CPACK (SOUT6, NCP, IDX, XPACK, TMASS)
        SOUT6(NCC+9) = AVEMW (NCP, IDX, XPACK)
C
C       If requested, write the items of interest in the outlet stream
C       vectors to the history file.
        IF ( KTEST .GE. 5 )  THEN
          WRITE (NHSTRY, 531)
  531     FORMAT ( // ' The outlet stream vectors' /
     1      12X, 'SOUT1', 10X, 'SOUT2', 10X, 'SOUT3', 10X, 'SOUT4',
     2      10X, 'SOUT5', 10X, 'SOUT6' )
          DO 290 J = 1, ITEMS
            WRITE (NHSTRY, 532) J, SOUT1(J), SOUT2(J), SOUT3(J),
     1        SOUT4(J), SOUT5(J), SOUT6(J)
  532       FORMAT ( 1X, I4, 6(1PE15.5) )
  290     CONTINUE
        ENDIF
C
      ENDIF
C
      RETURN
      END
C
C$ USR82Z
      SUBROUTINE USR82Z (IER1, IER2, INT1, IPASS, NOUT)
C
C     This subroutine writes the overall material balance summary for
```

```
C     plant 8.2, the fluid coking plant, and any warning messages.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - June 26, 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 a future warning
C                 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
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)
C
C     ST1(J,K) and ST2(J,K) contain the properties of the five inlet and
C     six outlet streams, in order, where J designates the stream 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
C
      IF ( IPASS .EQ. 4 .AND. INT1 .LE. 0 )  THEN
C
        SUMIN = ST1(1,1) + ST1(2,1) + ST1(3,1) + ST1(4,1)
        SUMOUT = ST2(1,1) + ST2(2,1) + ST2(3,1) + ST2(4,1) + ST2(5,1)
     1    + ST2(6,1)
C
C       Write the input/output stream summary report.
C       ============================================
        WRITE (NOUT, 801)
  801   FORMAT ( / 20X, 'PLANT 8.2 - SUMMARY REPORT (CONTINUED)'
     1    / 30X, 'FLUID COKING PLANT')
C
        WRITE (NOUT, 802)
  802   FORMAT ( / ' OVERALL STREAM BALANCE' /
     1    23X, 'FLOW,', 10X, 'FLOW',  9X, 'TEMP,', 7X, 'PRESS,' /
     2    21X, 'MM SCF/HR', 6X, 'MLBS/HR', 8X, 'DEG F', 8X, 'PSIA' )
```

```
C
      WRITE (NOUT, 803)  (ST1(1,J), J = 1, 3), ST1(2,4),
     1   ((ST1(K,J), J = 1, 3), K = 2, 4), ST1(2,4), SUMIN
  803 FORMAT ( 2X, 'INLET STREAMS' /
     1   2X, 'MAIN FEED      ', F26.3, F13.1, F13.1 /
     2   2X, 'AIR            ', F11.3, F15.3, F13.1, F13.1 /
     3   2X, 'STEAM          ', F26.3, F13.1, F13.1 /
     4   2X, 'WATER          ', F26.3, F13.1, F13.1 /
     5   2X, 'TOTAL INPUT    ', F11.3, F15.3 )
C
      WRITE (NOUT, 804) ST2(1,4),
     1   ((ST2(K,J), J = 1, 3), K = 1, 6), ST2(1,4), SUMOUT
  804 FORMAT ( / 2X, 'OUTLET STREAMS' /
     1   2X, 'FUEL GASES     ', F11.3, F15.3, F13.1, F13.1 /
     2   2X, 'NAPHTHA        ', F26.3, F13.1, F13.1 /
     3   2X, 'GAS OIL        ', F26.3, F13.1, F13.1 /
     4   2X, '1000+ F        ', F26.3, F13.1, F13.1 /
     5   2X, 'COKE           ', F26.3, F13.1, F13.1 /
     6   2X, 'SOUR WATER     ', F26.3, F13.1, F13.1 /
     7   2X, 'TOTAL OUTPUT   ', F11.3, F15.3 )
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* THIS PLANT IS NOT IN ELEMENTAL ',
     1     'BALANCE.  THE COMPOSITION OF' /
     2     2X, 'THE COKE HAS BEEN ADJUSTED TO MAINTAIN THE MASS ',
     3     'BALANCE AT THE' /
     4     2X, 'EXPENSE OF THE ELEMENTAL BALANCE.')
C
      ENDIF
C
      RETURN
      END
C
C$  Subroutine USR09
C
C     This file contains the following subroutines:
C       USR09    Main routine for Plant 9 - Hydrogen prodiction by
C                coal gasification.
C       USR09A   Subroutine to load the pseudocomponent properties.
C       USR09G   Subroutine for the coal gasification section.
C       USR09R   Subroutine for the Rectisol product recovery section.
C       USR09S   Subroutine for the shift reactor section.
C       USR09Z   Subroutine to write the overall plant material
C                balance.
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 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       GETSTR   Subroutine for finding the stream bead information.
C
C     This model uses the named common /USRCO9/.
C
C$ USRO9
      SUBROUTINE USRO9 (NSIN,NINFI,SIN1,SIN2,SIN3,SIN4,
     1 SIN5, SIN6, SIN7, SIN8, SINFI,NSOUT,
     1 NINFO,SOUT1,SOUT2,SOUT3,SOUT4, SOUT5, SOUT6, SOUT7, SOUT8,
     2 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:  USRO9
C
C  BLOCK DESCRIPTION:  DOE Hydrogen production by coal gasification
C                      Plant Fortran Block Model
C
C                     -----------------------
C       Wet Solids -->|                       |-----> Hydrogen
C                     |       Plant 9         |
C       Water ------->|                       |-----> Acid gas (H2S)
C                     |   H2 Production by    |-----> Vent Gas (mixed tail
C       Oxygen ------>|  Coal Gasification    |        and medium BTU gas)
C                     |        Plant          |-----> Sour Water
C       Steam ------->|                       |-----> Dry Slag
C                     -----------------------
C
C   The wet solids, water and oxygen streams go to the gasifier.
C   The steam goes to the shift reactor.
C
C
C  Prepared under DOE contract no. DE-AC22 90PC89857.
C
C  FUNCTION (MODEL, REPORT, OR BOTH):  Both
C
C  Last revision - May 29, 1992.
C
C  ASSUMPTIONS, SPECIAL FEATURES AND LIMITATIONS:
C     1.  The four inlet stream are:    1. Wet coal stream
C                                       2. Water to the gasifier
C                                       3. Oxygen stream
C                                       4. Steam to the shift reactor
C     2.  The five outlet streams are:  1. Hydrogen-rich gas stream
C                                       2. Acid gas stream
C                                       3. Vent gas stream (the mixed
C                                          tail and medium BTU gas
C                                          streams)
C                                       4. Sour water stream
C                                       5. Slag (dry basis)
C     3.  This user block model ignores any N2 used as a stripping gas.
C     4.  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     5.  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     6.  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     7.  Any COAL AND URCOAL present in the first input stream is
C         gasified and and the products are shifted.  Any SLAG present
C         in the input stream is ignored.  A warning message will be
C         written to the History file if the first input stream contains
C         any SLAG.
C     8.  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 DCL09.REP.
C         INT(3)  = Number of operating duplicate trains, excluding
C                   spares.
C                   If INT(3) = 0, the minimun number of duplicate
C                     trains will be determined so that the capacity
C                     each train does not exceed the maximum train
C                     capacity specified by variable REAL(52).
C                   If INT(3) > 0, this number of duplicate trains will
C                     be used.
C         INT(4)  = History file additional output control switch.
C                   0 => Write no additional output to the history 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    10.  The 70 real parameters are:
C         REAL(1)   = Molar CO/CO2 ratio in the gasifier product gas.
C         REAL(2)   = Fraction of carbon entering the gasifier that
C                     goes to carbonyl sulfide (COS).
```

```
C          REAL(3)    = Fraction of carbon entering the gasifier that
C                       goes to methane (CH4).
C          REAL(4)    = Fraction of nitrogen entering the gasifier that
C                       goes to ammonia (NH3).
C          REAL(5)    = Carbon content of the slag produced by the
C                       gasifier, wt %.
C          REAL(6)    = Fraction of carbon monoxide (CO) entering the
C                       shift reactors that is shifted; i.e., converted
C                       to carbon dioxide (CO2) by the reaction
C                           CO + H2O -----> CO2 + H2
C          REAL(7)    = Fraction of carbonyl sulfide (COS) entering the
C                       shift reactor section that is hydrolyzed; i.e.,
C                       converted to carbon dioxide (CO2) and hydrogen
C                       sulfide (H2S) by the reaction
C                           COS + H2O -----> CO2 + H2S
C          REAL(8)    = Future use.
C          REAL(9)-
C           REAL(20)  = Rectisol section component distribution factors,
C                        where
C          REAL(9)    = Fraction of inlet H2 going to the hydrogen-rich
C                       gas stream.
C          REAL(10)   = Fraction of inlet H2 going to the acid gas stream.
C          REAL(11)   = Fraction of inlet CO going to the hydrogen-rich
C                       gas stream.
C          REAL(12)   = Fraction of inlet CO going to the acid gas stream.
C          REAL(13)   = Fraction of inlet CO2 going to the hydrogen-rich
C                       gas stream.
C          REAL(14)   = Fraction of inlet CO2 going to the acid gas
C                       stream.
C          REAL(15)   = Fraction of inlet CH4 going to the hydrogen-rich
C                       gas stream.
C          REAL(16)   = Fraction of inlet CH4 going to the acid gas
C                       stream.
C          REAL(17)   = Fraction of inlet N2 going to the hydrogen-rich
C                       gas stream.
C          REAL(18)   = Fraction of inlet N2 going to the acid gas stream.
C          REAL(19)   = Fraction of inlet H2S going to the hydrogen-rich
C                       gas stream.
C          REAL(20)   = Fraction of inlet H2S going to the acid gas
C                       stream.
C          REAL(21)   = Constant factor for the power consumption, kw.
C          REAL(22)   = Power consumption per MM SCF/hr of hydrogen
C                       produced, kw/(MM SCF/hr of H2).
C          REAL(23)   = Constant factor for the 900 psig / 750 F steam
C                       consumption, Mlbs/hr.
C          REAL(24)   = 900 psig / 750 F steam consumption per MM SCF/hr
C                       of hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
C          REAL(25)   = Constant factor for the 900 psig saturated steam
C                       consumption, Mlbs/hr.
C          REAL(26)   = 900 psig saturated steam consumption per MM SCF/hr
C                       of hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
C          REAL(27)   = Constant factor for the 600 psig / 720 F steam
C                       consumption, Mlbs/hr.
C          REAL(28)   = 600 psig / 720 F steam consumption per MM SCF/hr
C                       of hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
```

```
C          REAL(29)  = Constant factor for the 600 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr
C                      of hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
C          REAL(31)  = Constant factor for the 150 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr
C                      of hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
C          REAL(33)  = Constant factor for the 50 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr
C                      of hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
C          REAL(35)  = Constant factor for the plant fuel consumption,
C                      MM BTU/hr.
C          REAL(36)  = Plant fuel consumption per MM SCF/hr of hydrogen
C                      produced, (MM BTU/hr)/(MM SCF/hr of H2).
C          REAL(37)  = Constant factor for the cooling water consumption,
C                      Mgal/hr.
C          REAL(38)  = Cooling water consumption per MM SCF/hr of
C                      hydrogen produced, (Mgal/hr)/(MM SCF/hr of H2).
C          REAL(39)  = Constant factor for the process water consumption,
C                      Mgal/hr.
C          REAL(40)  = Process water consumption per MM SCF/hr of
C                      hydrogen produced, (Mgal/hr)/(MM SCF/hr of H2).
C          REAL(41)  = Constant factor for the nitrogen consumption,
C                      MM SCF/hr of N2.
C          REAL(42)  = Nitrogen consumption per MM SCF/hr of hydrogen
C                      produced, (MM SCFl/hr of N2)/(MM SCF/hr of H2).
C          REAL(43) -
C           REAL(48) = Future use.
C          REAL(49)  = Constant factor for the number of operators per
C                      day, operators/day.
C          REAL(50)  = Number of operators per day per operating train,
C                      (operators/day)/train.
C          REAL(51)  = Reference hydrogen production rate for a single
C                      train in MM SCF/hr of H2 for the calculation of
C                      the ISBL field cost of a single train as a
C                      function of train capacity.
C          REAL(52)  = Maximum size of a single train as defined by the
C                      hydrogen production rate in MM SCF/hr of H2.
C          REAL(53)  = Minimum size of a single train as defined by the
C                      hydrogen production rate in MM SCF/hr of H2.
C          REAL(54)  = Constant A in the plant ISBL field cost equation.
C          REAL(55)  = Constant B in the plant ISBL field cost equation.
C          REAL(56)  = Constant E in the plant ISBL field cost equation.
C          REAL(57)  = Constant F in the plant ISBL field cost equation.
C          REAL(58)  = Number of spare trains.
C          REAL(59) -
C           REAL(70) = Future use.
C
C  NOTE:   MM SCF/hr of hydrogen produced means MM SCF/hr of hydrogen
C          in the hydrogen-rich product gas stream and NOT the total
C          flow rate of the hydrogen-rich product gas stream.
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)
      DIMENSION SIN5(1),SIN6(1),SIN7(1),SIN8(1),SOUT5(1),
     1 SOUT6(1),SOUT7(1),SOUT8(1)
      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
      COMMON /USRC01/ PLNTID(32), UTIL(32,15), CAPCST(32,7), OPCST(32,5)
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
      COMMON /USRC09/ CWT(15), CMOLES(15), CMPCT(15), CMW(15),
     1  CWPCT(15), EWT(7), EMW(7), SLAG(2), SLAGPC(2), UANAL(7),
     2  GSA(10,10), SWT(10), SMOLES(10), SMPCT(10), SWPCT(10),
     3  SH2(11,4), SH2S(11,4), SVG(11,4), SSW(11,4), CPROP(5,7),
     4  CIN(15), KOMPS
C
C     Element and component ordering in the various vectors.
C     Elements          Components      Slag          ULTANAL
C     1.  Carbon         1.  H2         1.  Carbon    1.  Ash
C     2.  Hydrogen       2.  CO         2.  Ash       2.  Carbon
C     3.  Nitrogen       3.  CO2                      3.  Hydrogen
C     4.  Chlorine       4.  CH4                      4.  Nitrogen
C     5.  Sulfur         5.  N2                       5.  Chlorine
C     6.  Oxygen         6.  H2S                      6.  Sulfur
C     7.  Ash            7.  COS                      7.  Oxygen
C                        8.  H2O
C                        9.  HCl
C                       10.  NH3
C                       11.  O2
C                       12.  T875
C                       13.  T925
C                       14.  T975
C                       15.  T1000+
C
C    GSA(J,K) is the Gasifier Stream Array, where
C      J = Stream number identifier
C          1 => The total inlet COAL/URCOAL stream
C          2 => The water stream
```

```
C           3 => The oxygen stream
C           4 => Gasifier gas stream
C           5 => Slag stream (dry basis)
C           6 => Shift reactor outlet stream
C           7 => Hydrogen-rich product gas stream
C           8 => Acig gas product stream
C           9 => Vent gas stream (the mixed tail and medium BTU gas
C                streams)
C          10 => Sour water stream
C       K = Stream property identifier
C           1 => Total stream flow rate, Mlbs/hr
C           2 => Total stream flow rate, MM SCF/hr
C           3 => Stream temperature, degrees Fahrenheit
C           4 => Stream pressure, PSIA
C           5 => Stream H2 flow rate in MM SCF/hr of H2
C           6 - 10 => Future use
C
C     Local variable declaration statements.
      DIMENSION STIN(5), ULTIN(7), UIN1(7), UIN2(7), OXIN1(10),
     1  OXIN2(10), AVGOX(10)
C     STIN(J) contains the inlet stream flow rates to the entire plant
C     in Mlbs/hr, as follows.
C      J => 1   Total COAL/URCOAL stream
C           2   Water/steam to gasifier
C           3   Oxygen stream to gasifier from the O2 plant
C           4   Steam to the shift reactor(s)
C           5   Future use
C
C     CDF(12) are the component distribution factors for the Rectisol
C     product recovery section.
      DIMENSION CDF(12)
C
      DIMENSION ICN(2), ICNAME(30), ICNUMB(15)
C
      CHARACTER * 4  ICN, ICNAME
      CHARACTER * 6  PLNTID, PNAME
C
C     Initialize the component identifications.
      DATA ICNAME / 'H2  ', '    ', 'CO  ', '    ', 'CO2 ', '    ',
     1  'CH4 ', '    ', 'N2  ', '    ', 'H2S ', '    ', 'COS ', '    ',
     2  'H2O ', '    ', 'HCL ', '    ', 'NH3 ', '    ', 'O2  ', '    ',
     3  'T875', '    ', 'T925', '    ', 'T975', '    ', 'T100', '0+  '/
C
      DATA PNAME / '9     ' /
C
C
C     PARAMETER INITIALIZATION SECTION
C     -------------------------------
C     Set the total number of components of interest.
      KOMPS = 15
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)
```

```
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 9 - Supplementary data from subroutine',
     1    ' USR09' /
     2    2X, 'Hydrogen Production by Coal Gasification', 10X,
     3    'IPASS =', I3 )
      ENDIF
C
C     Check to insure that there are exactly 4 inlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSIN .NE. 4 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 502)  NSIN
  502   FORMAT ( / 1X, '* ERROR * - The hydrogen production plant ',
     1    'requires exactly 4 inlet streams.' /
     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 are exactly 5 outlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSOUT .NE. 5 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501) IPASS
        WRITE (NHSTRY, 503)  NSOUT
  503   FORMAT ( / 1X, '* ERROR * - The hydrogen production plant ',
     1    'requires exactly 5 outlet streams.' /
     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 streams to Plant 9, ',
     1    'Hydrogen Production by Coal Gasification,' /
     2    3X, 'are not of stream class MIXNC or MIXNCPSD.  This ',
     3    'model will not work.' /
     4    3X, 'Please 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     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, 505)
  505   FORMAT ( / 1X, '* ERROR * - The input streams to Plant 9, ',
     1    'Hydrogen Production by Coal Gasification,' /
     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     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) + SIN2(J)*SIN2(K) + SIN3(J)*SIN3(K) +
     1  SIN4(J)*SIN4(K)
      J = NCC + 9 + NNCC + 1
      FLOWIN = CF * (X + SIN1(J) + SIN2(J) + SIN3(J) + SIN4(J))
C
      IF ( FLOWIN .LE. 0.09D0 )   THEN
C       Skip all remaing calculations if this plant has no flow.
```

```
          IF ( KTEST .GE. 1 )  WRITE (NHSTRY, 507)
  507     FORMAT ( / ' There is no material entering plant 9, the ',
     1      'coal gasification plant.' )
          GO TO 999
C         ---------
        ENDIF
C
C       Find the relative component numbers of the required components.
        DO 20 J = 1, KOMPS
          K = 2 * J - 1
          ICN(1) = ICNAME(K)
          ICN(2) = ICNAME(K+1)
          CALL USRCCN (ICN, ICNUMB(J))
          IF ( ICNUMB(J) .EQ. 0 ) THEN
            IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
            WRITE (NHSTRY, 506)  ICN(1), ICN(2)
  506       FORMAT ( / 1X, '* ERROR * - The following component is ',
     1        'missing from your component list' / 5X, 2A4 /
     2        3X, 'The gasifier requires this component.  Please ',
     3        'add it to your' /
     4        3X, 'component list and try again.' //
     5        3X, 'EXECUTION IS BEING TERMINATED.' / )
            STOP
          ENDIF
   20   CONTINUE
C       Save some relative component numbers in some specific variables.
        KH2   = ICNUMB(1)
        KN2   = ICNUMB(5)
        KH2O  = ICNUMB(8)
        KO2   = ICNUMB(11)
C
C       Load the component and element molecular weights in the CMW and
C       EMW vectors.
        DO 22 J = 1, KOMPS
          K = ICNUMB(J)
          CMW(J) = XMW(K)
   22   CONTINUE
        EMW(6) = CMW(3) - CMW(2)
        EMW(1) = CMW(2) - EMW(6)
        EMW(2) = 0.5D0 * CMW(1)
        EMW(3) = 0.5D0 * CMW(5)
        EMW(4) = CMW(9) - EMW(2)
        EMW(5) = CMW(6) - CMW(1)
        EMW(7) = 1.0
C
        IF ( KTEST .GE. 4)  THEN
          WRITE (NHSTRY, 508)
  508     FORMAT ( / ' Element and component molecular weights:')
          WRITE (NHSTRY, 509)  (EMW(J), CMW(J), J = 1, 7)
  509     FORMAT ( 2X, 'Carbon  ', F12.4, 5X, 'H2 ', F13.4 /
     1      2X, 'Hydrogen', F12.4, 5X, 'CO ', F13.4 /
     2      2X, 'Nitrogen', F12.4, 5X, 'CO2', F13.4 /
     3      2X, 'Chlorine', F12.4, 5X, 'CH4', F13.4 /
     4      2X, 'Sulfur  ', F12.4, 5X, 'N2 ', F13.4 /
     5      2X, 'Oxygen  ', F12.4, 5X, 'H2S', F13.4 /
```

```
     6    2X, 'Ash      ', F12.4, 5X, 'COS', F13.4 )
        WRITE (NHSTRY, 510)  (CMW(K), K = 8, KOMPS)
  510   FORMAT ( 27X, 'H2O', F13.4 /
     1    27X, 'HCl', F13.4 /
     2    27X, 'NH3', F13.4 /
     3    27X, 'O2 ', F13.4 /
     4    27X, 'T875', F12.4 /
     5    27X, 'T925', F12.4 /
     6    27X, 'T975', F12.4 /
     7    27X, 'T1000+', F10.4 )
        ENDIF
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       The gasifier parameters; molar CO/CO2 ratio, fraction carbon to
C       COS, fraction carbon to methane, fraction nitrogen to ammonia,
C       and wt% carbon in the slag.
        RCOCO2 = REAL(1)
        FCOS = REAL(2)
        FCH4 = REAL(3)
        FNH3 = REAL(4)
        PCSLAG = REAL(5)
C       Fraction of CO shifted to CO2 and H2 in the shift reactor.
        FCO = REAL(6)
C       Fraction of COS hydrolyzed to CO2 and H2S in the shift reactor
C       section.
        FCOSH = REAL(7)
C
C       Load the Rectisol section component distribution parameters.
        DO 30 J = 1, 12
          CDF(J) = REAL(J+8)
   30 CONTINUE
C
C       Set up the maximum train flow rate in Mlbs/hr of dry clean coal.
        PMAXF = REAL(52)
C       Set up the minimum train flow rate in Mlbs/hr of dry clean coal.
        PMINF = REAL(53)
C
C       If requested, write the items of interest in the inlet stream
C       vectors to the history file.
        IF ( KTEST .GE. 5 )  THEN
          WRITE (NHSTRY, 511)
  511     FORMAT ( / '  The inlet stream vectors:'/
     1      3X, 'Item', 10X, 'SIN1', 11X, 'SIN2', 11X, 'SIN3', 11X,
     2      'SIN4' )
          DO 40 J = 1, ITEMS
            WRITE (NHSTRY, 512) J, SIN1(J), SIN2(J), SIN3(J), SIN4(J)
  512       FORMAT ( 1X, I6, 3X, 4(1PE15.5) )
   40     CONTINUE
```

```
      ENDIF
C
C     Set up the main components in the inlet streams in lbs/hr.
C     The first inlet stream, the coal.
C     CF is the conversion factor from Kg/sec to lbs/hr.
      COALIN = SIN1(NCONV+1) * CF
      CHARIN = SIN1(NCONV+2) * CF
      WH2OIN = SIN1(KH2O) * XMW(KH2O) * CF
C     The second inlet stream, the water to the gasifier.
      WH2OIN = WH2OIN + SIN2(KH2O) * XMW(KH2O) * CF
C     The third inlet stream, the oxugen stream from the air separation
C     plant.
      WO2IN = SIN3(KO2) * XMW(KO2) * CF
      WN2IN = SIN3(KN2) * XMW(KN2) * CF
C     The fourth inlet stream, the steam to the shift reactors.
      STEAM = SIN4(KH2O) * XMW(KH2O) * CF
C
C
C     Check for any SLAG present in the first input stream, and if
C     found, write a warining message to the History file.
      SLAGIN = SIN1(NCONV+3) * CF
      IF ( SLAGIN .GE. 1.0D0 )  THEN
        WRITE (NHSTRY, 513)
  513   FORMAT ( / 1X, '* WARNING * - The first input stream to Plant ',
     1    '9, Hydrogen Production by Coal' /
     2    3X, 'Gasification, contains some SLAG.  It is being ignored.',
     3    '  Please remove it' /
     4    3X, 'from the first input stream and try again.'/)
      ENDIF
C
C     Write the model parameters.
      IF ( KTEST .GE. 2 )  THEN
        WRITE (NHSTRY, 514) RCOCO2, FCOS, FCH4, FNH3, PCSLAG, STEAM,
     1    FCO, FCOSH
  514   FORMAT ( /
     1    ' User specified gasifier section process conditions:' /
     2    3X, 'Molar CO/CO2 ratio in gasifier product gas', F10.4 /
     3    3X, 'Fraction of carbon in coal going to COS   ', F10.6 /
     4    3X, 'Fraction of carbon in coal going to CH4   ', F10.6 /
     5    3X, 'Fraction of nitrogen in coal going to NH3 ', F10.6 /
     6    3X, 'Carbon content of the gasifier slag, wt % ', F10.4 /
     7    ' Shift reactor section parameters:' /
     8    3X, 'Steam to shift reactors, lbs/hr          ', F12.2 /
     9    3X, 'Fraction CO shifted to CO2 and H2        ', F12.4 /
     A    3X, 'Fraction COS hydrolyzed to CO2 and H2S   ', F12.4 )
C
      WRITE (NHSTRY, 515)  (CDF(J), J = 1, 12)
  515 FORMAT (/ ' Rectisol section component distribution factors:' /
     1    18X, ' To H2  ', 5X, ' To H2S ' /
     2    3X, 'Component', 6X, 'Rich Gas', 5X, 'Rich Gas' /
     3    3X, 'H2 ', F19.5, F13.5 /
     4    3X, 'CO ', F19.5, F13.5 /
     5    3X, 'CO2', F19.5, F13.5 /
     6    3X, 'CH4', F19.5, F13.5 /
     7    3X, 'N2 ', F19.5, F13.5 /
```

```
     8    3X, 'H2S', F19.5, F13.5 )
      ENDIF
C
C     Load the Ultimate analyses of the inlet coal and URCOAL, and
C     calculate a weighted average analysis.
      N1 = NCCONV + 4
      N2 = N1 + 24
      SUMIN1 = 0.0D0
      SUMIN2 = 0.0D0
      DO 50 J = 1, 7
        UIN1(J) = SIN1(J+N1)
        UIN2(J) = SIN1(J+N2)
        SUMIN1 = SUMIN1 + UIN1(J)
        SUMIN2 = SUMIN2 + UIN2(J)
   50 CONTINUE
      SUMUIN = 0.0D0
      DO 52 J = 1, 7
        ULTIN(J) =  COALIN * UIN1(J) + CHARIN * UIN2(J)
        SUMUIN = SUMUIN + ULTIN(J)
   52 CONTINUE
      SUMUN = 0.0D0
      DO 54 J = 1, 7
        UANAL(J) = 100.0D0 * ULTIN(J) / SUMUIN
        SUMUN = SUMUN + UANAL(J)
   54 CONTINUE
C
      IF (KTEST .GE. 3)  THEN
C       Write the supplied and normalized Ultimate analyses.
        WRITE (NHSTRY, 517)
  517   FORMAT ( / ' Supplied and weighted normalized average ',
     1    'Ultimate analyses:')
        WRITE (NHSTRY, 518)  (UIN1(J), UIN2(J), UANAL(J), J = 1, 7)
  518   FORMAT ( ' Component', 8X, 'Coal', 7X, 'URCOAL', 8X, 'Average' /
     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, SUMUN
  519   FORMAT ( 2X, 'Total   ', 3F13.2 )
      ENDIF
C
C
C     Load the ash oxide (AOXANAL) analyses of the inlet coal and
C     URCOAL, and calculate a weighted average analysis.
      N1 = NCCONV + 14
      N2 = N1 + 24
      SUMOX1 = 0.0D0
      SUMOX2 = 0.0D0
      DO 60 J = 1, 10
        OXIN1(J) = SIN1(J+N1)
        OXIN2(J) = SIN1(J+N2)
        SUMOX1 = SUMOX1 + OXIN1(J)
```

```
          SUMOX2 = SUMOX2 + OXIN2(J)
   60 CONTINUE
      AVGSUM = 0.0D0
      DO 62 J = 1, 10
        AVGOX(J) = COALIN*UIN1(1)*OXIN1(J) + CHARIN*UIN2(1)*OXIN2(J)
        AVGSUM = AVGSUM + AVGOX(J)
   62 CONTINUE
      SUMAOX = 0.0D0
      DO 64 J = 1, 10
        AVGOX(J) = 100.0D0 * AVGOX(J) / AVGSUM
        SUMAOX = SUMAOX + AVGOX(J)
   64 CONTINUE
C
      IF (KTEST .GE. 3)  THEN
C       Write the supplied and normalized ash oxide (AOXANAL) analyses.
        WRITE (NHSTRY, 520)
  520   FORMAT ( / ' Supplied and weighted normalized average ash ',
     1    'oxide (AOXANAL) analyses:')
        WRITE (NHSTRY, 521)  (OXIN1(J), OXIN2(J), AVGOX(J), J = 1, 10)
  521   FORMAT ( ' Component', 8X, 'Coal', 7X, 'URCOAL', 8X, 'Average' /
     1    2X, 'SiO2     ', 3F13.2 /
     2    2X, 'Al2O3    ', 3F13.2 /
     3    2X, 'FeOx     ', 3F13.2 /
     4    2X, 'TiO2     ', 3F13.2 /
     5    2X, 'P2O5     ', 3F13.2 /
     6    2X, 'CaO      ', 3F13.2 /
     7    2X, 'MgO      ', 3F13.2 /
     8    2X, 'Na2O     ', 3F13.2 /
     9    2X, 'K2O      ', 3F13.2 /
     A    2X, 'SO3      ', 3F13.2 )
        WRITE (NHSTRY, 519)  SUMOX1, SUMOX2, SUMAOX
      ENDIF
C
C
C     Load the pseudocomponent flows entering in the solids feed
C     CF is the conversion factor from Kg/sec to lbs/hr.
      DO 68 J = 1, NCC
        DO 66 K = 10, KOMPS
        IF ( J .EQ. ICNUMB(K) )  THEN
          CIN(K) = CF * XMW(J) * SIN1(J)
          GO TO 68
        ENDIF
   66   CONTINUE
   68 CONTINUE
C
C     Load the inlet stream flow rates in Mlbs/hr in the STIN vector.
C       Hydrocarbons in the solids feed.
        HCIN = CIN(12) + CIN(13) + CIN(14) + CIN(15)
      STIN(1) = 0.001D0 * (COALIN + CHARIN + CF*SIN1(KH2O)*XMW(KH2O)
     1  + HCIN)
      STIN(2) = 0.001D0 * CF * SIN2(KH2O) * XMW(KH2O)
      STIN(3) = 0.001D0 * (WO2IN + WN2IN)
      STIN(4) = 0.001D0 * STEAM
      STIN(5) = 0.0D0
C
```

```
C     Call subroutine USR09A to load the pseudocomponent properties
C     in the CPROP(J,K) array.
      CALL USR09A (KTEST, NHSTRY)
C
      IF ( KTEST .GE. 4 )  THEN
        SUM = 0.0D0
        WRITE (NHSTRY, 523)
  523   FORMAT ( / ' Pseudocomponent properties:' /
     1    1X, 'No.', 2X, 'Name', 8X, 'lbs/hr', 5X, 'MW',
     2    7X, 'Wt% C', 4X, 'Wt% H', 4X, 'Wt% S', 4X, 'Wt% N',
     3    4X, 'Wt% O', 3X, 'ID' )
        DO 70 J = 12, KOMPS
          K = 2*J - 1
          L = J - 11
          SUM = SUM + CIN(J)
          WRITE (NHSTRY, 524) J, ICNAME(K), ICNAME(K+1), CIN(J),
     1      CPROP(L,1), (CPROP(L,K1), K1 = 3, 7), ICNUMB(J)
  524     FORMAT ( 1X, I3, 2X, 2A4, F10.1, F10.3, 5F9.4, I5 )
   70   CONTINUE
        WRITE (NHSTRY, 525) SUM
  525   FORMAT ( 6X, 'Total', F13.1 )
      ENDIF
C
      IF ( KTEST .GE. 3 )  THEN
C       Write the gasifier inlet conditions.
        TOTIN = COALIN + CHARIN + HCIN + WH2OIN + WO2IN + WN2IN
        WRITE (NHSTRY, 526)  COALIN, CHARIN, HCIN, WH2OIN, WN2IN,
     1    WO2IN, TOTIN
  526   FORMAT ( / ' Gasifier section inlet flow rates, lbs/hr:' /
     1    3X, 'Coal (dry basis)  ', F12.2 /
     2    3X, 'URCOAL (dry basis)', F12.2 /
     3    3X, 'Hydrocarbons      ', F12.2 /
     4    3X, 'Water (total)     ', F12.2 /
     5    3X, 'Nitrogen (gaseous)', F12.2 /
     6    3X, 'Oxygen (gaseous)  ', F12.2 /
     7    3X, 'Total             ', F12.2 )
      ENDIF
C
C
C     Get the useable hydrogen flow rate in the hydrogen-rich
C     product gas stream in MM SCF/hr from the last iteration.
      IF ( SOUT1(KH2) .NE. 0.0D0 ) THEN
          H2PROD = SOUT1(KH2) * CF * 379.495D-6
        ELSE
          H2PROD = 0.5D0 * (PMAXF + PMINF)
      ENDIF
C
C     If it has not been specified by the user in variable INT(3),
C     calculate the number of operating duplicate trains, excluding
C     spares (NPLNT), based on the total flow rate of the reference
C     stream.  However, if the maximum capacity of a single train
C     has not been specified, set the number of operating trains to 1.
      NPLNT = INT(3)
      IF ( (NPLNT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
          NPLNT = H2PROD  / PMAXF
```

```
          IF ( (MOD(H2PROD, PMAXF)) .GT. 0.0D0 )  NPLNT = NPLNT + 1
        ELSE
          IF ( NPLNT .EQ. 0 )   NPLNT = 1
      ENDIF
C
C     Calculate the useable hydrogen flow rate in the hydrogen-rich
C     product gas stream in MM SCF/hr (PFLOW) for each of the
C     individual duplicate trains.
      XPLANT = NPLNT
      PFLOW = H2PROD / XPLANT
C
C     If this is the results pass, set up to write the first page of
C     the summary report.
      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           Set the number of lines in the first page.
            LINES = 53
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 DCL09.REP to contain
C           this user block summary report.
            OPEN (UNIT=62, FILE='DCL09.REP', STATUS='UNKNOWN',
     1        ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2        BUFFERED='BUFFERED')
            WRITE (NOUT, 800)
C           FORMAT statement 800 will print across a page because it
C           contains the PC top-of-form character (ASCII character 012)
C           between two quote marks ( i.e., 'TOF').
  800       FORMAT ( 'TOF' )
        ENDIF
      ENDIF
C
C     Call Subroutine USR09G to do the coal gasification section
C     calculations.
      CANDC = COALIN + CHARIN
      CALL USR09G (INT(1), IPASS, KTEST, NHSTRY, NOUT, CANDC,
     1  WH2OIN, WN2IN, WO2IN, RCOCO2, FCOS, FCH4, FNH3, PCSLAG)
C
C     Call Subroutine USR09S to do the shift section calculations.
      CALL USR09S (INT(1), IPASS, KTEST, NHSTRY, NOUT, FCO, FCOSH,
     1  STEAM)
C
C     Call Subroutine USR09R to do the Rectisol product recovery
C     section caculations.
      CALL USR09R (CDF, INT(1), IPASS, KTEST, NHSTRY, NOUT)
C
C     Set up the properties of the product streams.
C     ---------------------------------------------
```

```
      IF ( IPASS .NE. 4 )   THEN
C       First, zero all the items in the product stream vectors.
        DO 200 J = 1, ITEMS
          SOUT1(J) = 0.0D0
          SOUT2(J) = 0.0D0
          SOUT3(J) = 0.0D0
          SOUT4(J) = 0.0D0
          SOUT5(J) = 0.0D0
  200   CONTINUE
C
C       Set the weight flow rate of the Slag stream in kg/sec.  Note
C       that SLAG is the third non-conventional component.
        SOUT5(NCONV+3) = 1000.0D0 * GSA(5,1) / CF
        SOUT5(NCONV+NNCC+1) = SOUT5(NCONV+3)
C       The Proximate analysis (PROXANAL).
C       NBASE is the last item of the 2nd non-conventional component.
        NBASE = NCCONV + 2 * NITEMS
        SOUT5(NBASE+2) = SLAGPC(1)
        SOUT5(NBASE+4) = SLAGPC(2)
C       The Ultimate analysis (ULTANAL).
        SOUT5(NBASE+5) = SLAGPC(2)
        SOUT5(NBASE+6) = SLAGPC(1)
C       Set the ash oxide analysis (AOXANAL) of the slag to the weighted
C       average of that of the entering coal and URCOAL.
        N1 = NBASE + 14
        DO 210 J = 1, 10
          SOUT5(J+N1) = AVGOX(J)
  210   CONTINUE
C
C       Set the molar flow rates of the components in the H2 rich gas
C       stream (SOUT1), Acid gas stream (SOUT2), Vent gas stream
C       (SOUT3), and the sour water stream (SOUT4).
        DO 222 J = 1, NCC
          DO 220 K = 1, 10
            IF ( J .EQ. ICNUMB(K))  THEN
              SOUT1(J) = SH2(K,3) / CF
              SOUT2(J) = SH2S(K,3) / CF
              SOUT3(J) = SVG(K,3) / CF
              SOUT4(J) = SSW(K,3) / CF
C             Put 0..1 lbs/hr of water in the slag stream.
              IF ( K .EQ. 8 )   SOUT5(J) = 1.0D-3 / ( CF * XMW(KH2O))
              GO TO 222
            ENDIF
  220     CONTINUE
  222   CONTINUE
C
C       Set the total molar flow rates of the conventional components.
        SOUT1(NCC+1) = SH2(11,3) / CF
        SOUT2(NCC+1) = SH2S(11,3) / CF
        SOUT3(NCC+1) = SVG(11,3) / CF
        SOUT4(NCC+1) = SSW(11,3) / CF
        SOUT5(NCC+1) = 1.0D-3 / ( CF * XMW(KH2O))
C
C       Set the default temperature and pressure of the outlet streams
C       to 70 F and 15 PSIA.  Return these values to ASPEN/SP in degrees
```

```
C       Kelvin and Pascals.  These default values can be overriden by
C       the FLASH-SPECS sentence in the ASPEN/SP input file.
        SOUT1(NCC+2) = (70.0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT1(NCC+3) = 15.0 * 6.8947573D+3
        SOUT1(NCONV+NNCC+2) = SOUT1(NCC+2)
        SOUT1(NCONV+NNCC+3) = SOUT1(NCC+3)
        SOUT2(NCC+2) = (70.0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT2(NCC+3) = 15.0 * 6.8947573D+3
        SOUT2(NCONV+NNCC+2) = SOUT2(NCC+2)
        SOUT2(NCONV+NNCC+3) = SOUT2(NCC+3)
        SOUT3(NCC+2) = (70.0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT3(NCC+3) = 15.0 * 6.8947573D+3
        SOUT3(NCONV+NNCC+2) = SOUT3(NCC+2)
        SOUT3(NCONV+NNCC+3) = SOUT3(NCC+3)
        SOUT4(NCC+2) = (70.0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT4(NCC+3) = 15.0 * 6.8947573D+3
        SOUT4(NCONV+NNCC+2) = SOUT4(NCC+2)
        SOUT4(NCONV+NNCC+3) = SOUT4(NCC+3)
        SOUT5(NCC+2) = (70.0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT5(NCC+3) = 15.0 * 6.8947573D+3
        SOUT5(NCONV+NNCC+2) = SOUT5(NCC+2)
        SOUT5(NCONV+NNCC+3) = SOUT5(NCC+3)
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)
        CALL CPACK (SOUT2, NCP, IDX, XPACK, TMASS)
        SOUT2(NCC+9) = AVEMW (NCP, IDX, XPACK)
        CALL CPACK (SOUT3, NCP, IDX, XPACK, TMASS)
        SOUT3(NCC+9) = AVEMW (NCP, IDX, XPACK)
        CALL CPACK (SOUT4, NCP, IDX, XPACK, TMASS)
        SOUT4(NCC+9) = AVEMW (NCP, IDX, XPACK)
        CALL CPACK (SOUT5, NCP, IDX, XPACK, TMASS)
        SOUT5(NCC+9) = AVEMW (NCP, IDX, XPACK)
        SOUT5(NCONV+NNCC+9) = 1.0D0
C
C       If requested, write the items of interest in the outlet stream
C       vectors to the history file.
        IF ( KTEST .GE. 5 )  THEN
          WRITE (NHSTRY, 531)
  531     FORMAT ( / ' The outlet stream vectors' /
     1      14X, 'SOUT1', 10X, 'SOUT2', 10X, 'SOUT3', 10X, 'SOUT4',
     2      10X, 'SOUT5' )
          DO 240 J = 1, ITEMS
            WRITE (NHSTRY, 532) J, SOUT1(J), SOUT2(J), SOUT3(J),
     1        SOUT4(J), SOUT5(J)
  532       FORMAT ( 2X, I5, 5(1PE15.5) )
  240     CONTINUE
        ENDIF
C
      ENDIF
C
C     If this is the results pass, set up to write the second page of
```

```
C     the summary report.
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 2 )  THEN
C       Set up to write the second page of the plant summary report.
        IF ( INT(2) .EQ. 0 .AND. INT(1) .LE. 2 )   THEN
C           Calculate the number of lines in this page.
            LSTRM = 17
            LUTIL = 16
            LCOST = 11
            NDUP = REAL(58) + 0.001D0
            IF ( (NPLNT + NDUP) .EQ. 1 )  LCOST = 9
            IF ( PFLOW .LT. PMINF )  LCOST = LCOST + 3
            IF ( PFLOW .GT .PMAXF )  LCOST = LCOST + 3
            IF ( NDUP .GE. 1 )  LCOST = LCOST + 1
            LINES = LSTRM + LUTIL + LCOST
C           Now, subtract the number of lines for those portions of
C           the user block summary report which will not be written.
            IF ( INT(1) .GE. 2 )   LINES = LINES - LUTIL
            IF ( INT(1) .GE. 1 )   LINES = LINES - LCOST
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           If the summary report is going to a separate file, start a
C           new page.
            WRITE (NOUT, 800)
        ENDIF
C       Call subroutine USR09Z to start the second page of the summary
C       report.
        CALL USR09Z (INT(2), NOUT, STIN)
      ENDIF
C
C     Call subroutine USRUCO to calculate, save and report the
C     utilities, capital and operating costs for the plant.
      ID = 11
      IF (FLOWIN .GE. 2.0D0 )  THEN
          KUNITS = 5
          H2PROD = GSA(7,5)
          CALL USRUCO (NHSTRY, NOUT, IPASS, ID, PNAME, INT(1),
     1      INT(3), KTEST, REAL(21), H2PROD, KUNITS)
        ELSE
          PLNTID(ID) = '      '
          CAPCST(ID,1) = 1.
          CAPCST(ID,2) = 0.
          CAPCST(ID,3) = 0.
          CAPCST(ID,4) = 0.
          CAPCST(ID,5) = 0.
          CAPCST(ID,6) = 0.
          OPCST(ID,1) = 0.
      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 USR09' )
C
C
      RETURN
      END
C
C$ USR09A
      SUBROUTINE USR09A (KTEST, NHSTRY)
C
C     This subroutine loads the molecular weight and elemental
C     compositions of the conventional pseudocomponents entering with
C     the gasifier feed in the CPROP(J,K) array.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - July 1, 1992.
C
C     Calling arguments:
C     KTEST    = Switch for controlling the printing to the history
C                file.
C     NHSTRY   = Logical unit number of the history file.
C
C      The conventional components order follows.
C      No.  Component    Description
C       1.  T875         850 - 900 F boiling range fraction
C       2.  T925         900 - 950 F boiling range fraction
C       3.  T975         950 - 1000 F boiling range fraction
C       4.  T1000+       1000+ F boiling range material leaving the
C                        second coal liquefaction reactor.
C       5.  Future use
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
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
      COMMON /USRC09/ CWT(15), CMOLES(15), CMPCT(15), CMW(15),
     1  CWPCT(15), EWT(7), EMW(7), SLAG(2), SLAGPC(2), UANAL(7),
     2  GSA(10,10), SWT(10), SMOLES(10), SMPCT(10), SWPCT(10),
     3  SH2(11,4), SH2S(11,4), SVG(11,4), SSW(11,4), CPROP(5,7),
     4  CIN(15), KOMPS
C
C     In COMMON /USRC09/
C       CPROP(J,K) contains the conventional component properties
C         where J designates the component number and
C         K = 1 => Molecular weight
C             2 => Future use
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
C     Initialize all component properties to either 1.0 or zero.
      DO 10 J = 1, 5
        CPROP(J,1) = 1.0D0
        CPROP(J,2) = 1.0D0
   10 CONTINUE
C
C
C     Load the component molecular weights.
      CPROP(1,1) = CMW(12)
      CPROP(2,1) = CMW(13)
      CPROP(3,1) = CMW(14)
      CPROP(4,1) = CMW(15)
      CPROP(5,1) = 1.0
C
C     The following elemental compositions were taken from the
C     Aug. 20, 1990 letter to S. N. Habash from A. Basu and
C     A. B. Schachtschneider.  The 850+ F components were estimated.
C
C     Load the C6+ component sulfur contents in wt%.
      CPROP(1,5) = 0.10D0
      CPROP(2,5) = 0.15D0
      CPROP(3,5) = 0.20D0
      CPROP(4,5) = 0.50D0
      CPROP(5,5) = 0.50D0
C
C     Load the C6+ component nitrogen contents in wt%.
      CPROP(1,6) = 0.35D0
      CPROP(2,6) = 0.40D0
      CPROP(3,6) = 0.45D0
      CPROP(4,6) = 0.50D0
      CPROP(5,6) = 0.50D0
C
C     Load the C6+ component oxygen contents in wt%.
      CPROP(1,7) = 0.70D0
      CPROP(2,7) = 0.71D0
      CPROP(3,7) = 0.72D0
      CPROP(4,7) = 0.75D0
      CPROP(5,7) = 0.75D0
C
C     Load the C6+ component hydrogen contents in wt%.
      CPROP(1,4) = 9.90D0
      CPROP(2,4) = 9.80D0
      CPROP(3,4) = 9.70D0
      CPROP(4,4) = 9.00D0
      CPROP(5,4) = 5.50D0
C
C     Calculate the C6+ component carbon contents in wt% by difference.
      DO 30 J = 1, 5
        CPROP(J,3) = 100.0D0 - CPROP(J,4) - CPROP(J,5) - CPROP(J,6)
     1    - CPROP(J,7)
   30 CONTINUE
```

```
C
C     If this is the Thermal/Catalytic two-reactor yields case, reset
C     the T1000+ component properties to the appropriate values.
      IF ( MODE .EQ. 13 )  THEN
        CPROP(4,3) = 89.5D0
        CPROP(4,4) = 8.0D0
        CPROP(4,5) = 1.0D0
        CPROP(4,6) = 0.75D0
        CPROP(4,7) = 0.75D0
      ENDIF
C
C     If this is the COKER two-reactor yields case, reset the T1000+
C     component properties to the appropriate values.
      IF ( MODE .EQ. 15 )  THEN
        CPROP(4,3) = 88.0D0
        CPROP(4,4) = 5.5D0
        CPROP(4,5) = 1.5D0
        CPROP(4,6) = 1.2D0
        CPROP(4,7) = 3.8D0
      ENDIF
C
      RETURN
      END
C
C$ USR09G
      SUBROUTINE USR09G (INT1, IPASS, KTEST, NHSTRY, NOUT, COALIN,
     1  WH2OIN, WN2IN, WO2IN, RCOCO2, FCOS, FCH4, FNH3, PCSLAG)
C
C     This subroutine does the coal gasification section calculations.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - April 28, 1992.
C
C     Calling arguments:
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     IPASS  = The results pass flag.
C     KTEST  = Switch for controlling the printing to the history file.
C     NHSTRY = Logical unit number of the history file.
C     NOUT   = Logical unit number of the plant output report file.
C     COALIN = Total coal and URCOAL feed to the gasifier (dry basis),
C              lbs/hr.
C     WH2OIN = Total water flow to the gasifier, lbs/hr.
C     WN2IN  = Nitrogen flow to the gasifier, lbs/hr.
C     WO2IN  = Oxygen flow to the gasifier, lbs/hr.
C     RCOCO2 = Molar CO/CO2 ratio in the gasifier product gas.
C     FCOS   = Fraction of entering carbon which leaves the gasifier
C              as carbonyl sulfide (COS).
C     FCH4   = Fraction of entering carbon which leaves the gasifier
C              as methane (CH4).
```

```
C     FNH3   = Fraction of entering nitrogen which leaves the gasifier
C              as ammonia (NH3).
C     PCSLAG = Weight percent carbon in the net slag production leaving
C              the gasifier.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON /USRC09/ CWT(15), CMOLES(15), CMPCT(15), CMW(15),
     1  CWPCT(15), EWT(7), EMW(7), SLAG(2), SLAGPC(2), UANAL(7),
     2  GSA(10,10), SWT(10), SMOLES(10), SMPCT(10), SWPCT(10),
     3  SH2(11,4), SH2S(11,4), SVG(11,4), SSW(11,4), CPROP(5,7),
     4  CIN(15), KOMPS
C
C
C     Initialize the output compound weight vector to zero.
      DO 10 J = 1, 9
        CWT(J) = 0.0D0
   10 CONTINUE
C
C     Load the entering pounds/hour of the elements in the E vector.
      EWT(1) = COALIN * 0.01 * UANAL(2)
      EWT(2) = COALIN * 0.01 * UANAL(3)
      EWT(3) = COALIN * 0.01 * UANAL(4)
      EWT(4) = COALIN * 0.01 * UANAL(5)
      EWT(5) = COALIN * 0.01 * UANAL(6)
      EWT(6) = COALIN * 0.01 * UANAL(7)
      EWT(7) = COALIN * 0.01 * UANAL(1)
C
C     Add in the entering pounds/hr ouf the elements in the
C     pseudocomponents.
      DO 20 J = 12, KOMPS
        K = J - 11
C       Carbon and hydrogen.
        EWT(1) = EWT(1) + 0.01D0 * CIN(J) * CPROP(K,3)
        EWT(2) = EWT(2) + 0.01D0 * CIN(J) * CPROP(K,4)
C       Nitrogen, sulfur and oxygen.
        EWT(3) = EWT(3) + 0.01D0 * CIN(J) * CPROP(K,6)
        EWT(5) = EWT(5) + 0.01D0 * CIN(J) * CPROP(K,5)
        EWT(6) = EWT(6) + 0.01D0 * CIN(J) * CPROP(K,7)
   20 CONTINUE
C
C     Total the input lbs/hr of the elements in the coal.
      SUME = 0.0D0
      DO 30 J = 1, 7
        SUME = SUME + EWT(J)
   30 CONTINUE
C
      IF (KTEST .GE. 3)  THEN
C       Write the flow rates of the coal elements in lbs/hr.
        WRITE (NHSTRY, 515)
  515   FORMAT ( // ' Coal gasification section:' /
     1    ' Entering elements in lbs/hr:')
        WRITE (NHSTRY, 516)  (EWT(J), J = 1, 7)
  516   FORMAT ( 2X, 'Carbon  ', F13.2 /
```

```
     1    2X, 'Hydrogen', F13.2 /
     2    2X, 'Nitrogen', F13.2 /
     3    2X, 'Chlorine', F13.2 /
     4    2X, 'Sulfur  ', F13.2 /
     5    2X, 'Oxygen  ', F13.2 /
     6    2X, 'Ash     ', F13.2 )
        WRITE (NHSTRY, 517)  SUME
  517   FORMAT ( 2X, 'Total   ', F13.2, F14.2 )
      ENDIF
C
C     Save the total lbs/hr of carbon and hydrogen entering
C     the gasifier.
      CARBON = EWT(1)
      HIN = EWT(2)
C
C     Slag calculations.
C     ------------------
C     Remove the net slag and URCOAL production.
      SLAG(2) = EWT(7)
      SLAG(1) = SLAG(2) * PCSLAG / ( 100.0D0 - PCSLAG)
C     Calculate the remaining lbs/hr of ash and carbon.
      EWT(7) = 0.0D0
      EWT(1) = EWT(1) - SLAG(1)
      TSLAG = SLAG(1) + SLAG(2)
      SLAGPC(1) = 100.0D0 * SLAG(1) / TSLAG
      SLAGPC(2) = 100.0D0 * SLAG(2) / TSLAG
      TPCSLG = SLAGPC(1) + SLAGPC(2)
C
C     Total the pounds/hour of the elements and compounds.
      SUME = 0.0D0
      SUMC = CWT(8) + CWT(9) + CWT(10)
      DO 40 J = 1, 7
        SUME = SUME + EWT(J)
        SUMC = SUMC + CWT(J)
   40 CONTINUE
C
      IF (KTEST .GE. 4)  THEN
        WRITE (NHSTRY, 518) SLAG(1), SLAGPC(1), SLAG(2), SLAGPC(2),
     1    TSLAG, TPCSLG
  518   FORMAT ( / ' Slag flow and composition:' /
     1    14X, 'lbs/hr', 6X, 'Wt %' /
     2    2X, 'Carbon  ', F10.2, F10.3 /
     3    2X, 'Ash     ', F10.2, F10.3 /
     4    2X, 'Total   ', F10.2, F10.3 )
C
        WRITE (NHSTRY, 519)
  519   FORMAT ( / ' After the slag production, lbs/hr:')
        WRITE (NHSTRY, 520)  (EWT(J), CWT(J), J = 1, 7), CWT(8), CWT(9),
     1    CWT(10)
  520   FORMAT ( 2X, 'Carbon  ', F12.2, 5X, 'H2 ', F13.2 /
     1    2X, 'Hydrogen', F12.2, 5X, 'CO ', F13.2 /
     2    2X, 'Nitrogen', F12.2, 5X, 'CO2', F13.2 /
     3    2X, 'Chlorine', F12.2, 5X, 'CH4', F13.2 /
     4    2X, 'Sulfur  ', F12.2, 5X, 'N2 ', F13.2 /
     5    2X, 'Oxygen  ', F12.2, 5X, 'H2S', F13.2 /
```

```
     6    2X, 'Ash      ', F12.2, 5x, 'COS', F13.2 /
     7    2X, '         ', 17X,       'H2O', F13.2 /
     8    2X, '         ', 17X,       'HCl', F13.2 /
     9    2X, '         ', 17X,       'NH3', F13.2 )
        WRITE (NHSTRY, 521)  SUME, SUMC
  521   FORMAT ( 2X, 'Total   ', F12.2, F21.2 )
      ENDIF
C
C     Ammonia, nitrogen and sulfur related calculations.
C     ---------------------------------------------
C     Ammonia
      CWT(10) = FNH3 * EWT(3) * CMW(10) / EMW(3)
      WTN2 = (1.0D0 - FNH3) * EWT(3)
      EWT(2) = EWT(2) - CWT(10) * (3.0D0 * EMW(2) / CMW(10))
C     Convert all the remaining nitrogen in the coal to N2.
      CWT(5) = CWT(5) + WTN2
      EWT(3) = 0.0D0
C
C     COS calculations - Calculate the lbs/hr of carbon in COS.
      WTC = FCOS * CARBON
C     Calculate the lbs/hr of COS.
      WTCOS = WTC * CMW(7) / EMW(1)
      CWT(7) = CWT(7) + WTCOS
C     Calculate the remaining lbs/hr of carbon, sulfur and oxygen.
      EWT(1) = EWT(1) - WTC
      WTS = WTCOS * EMW(5) / CMW(7)
      EWT(5) = EWT(5) - WTS
      EWT(6) = EWT(6) - (WTCOS - WTC - WTS)
C
C     Convert all the remaing sulfur to H2S.
      WTH2S = EWT(5) * CMW(6) / EMW(5)
      CWT(6) = CWT(6) + WTH2S
C     Calculate the remaining lbs/hr of hydrogen and sulfur.
      EWT(2) = EWT(2) - (WTH2S - EWT(5))
      EWT(5) = 0.0D0
C
      IF (KTEST .GE. 4)  THEN
C       Total and write the pounds/hour of the elements and compounds.
        SUME = 0.0D0
        SUMC = CWT(8) + CWT(9) + CWT(10)
        DO 50 J = 1, 7
          SUME = SUME + EWT(J)
          SUMC = SUMC + CWT(J)
   50   CONTINUE
        WRITE (NHSTRY, 522)
  522   FORMAT ( / ' After the N and S related calculations, lbs/hr:')
        WRITE (NHSTRY, 520)  (EWT(J), CWT(J), J = 1, 7), CWT(8), CWT(9),
     1    CWT(10)
        WRITE (NHSTRY, 521)  SUME, SUMC
      ENDIF
C
C     Hydrogen related calculations.
C     ------------------------------
C     Convert all the chlorine to HCl.
      CWT(9) = EWT(4) * CMW(9) / EMW(4)
```

```
C     Calculate the remaining lbs/hr of chlorine and hydrogen.
      EWT(4) = 0.0D0
      EWT(2) = EWT(2) - CWT(9) * EMW(2) / CMW(9)
C
C     CH4 calculations - Calculate the lbs/hr of carbon going to CH4.
      XCH4 = FCH4 * CARBON
C     Calculate the CH4 production.
      WTCH4 = XCH4 * CMW(4) / EMW(1)
      CWT(4) = CWT(4) + WTCH4
C     Calculate the remaining lbs/hr of carbon and hydrogen.
      EWT(1) = EWT(1) - XCH4
      EWT(2) = EWT(2) - (WTCH4 - XCH4)
C
C     Convert all the remaining hydrogen to H2.
      CWT(1) = CWT(1) + EWT(2)
      EWT(2) = 0.0D0
C
      IF (KTEST .GE. 4)  THEN
C       Total and write the pounds/hour of the elements and compounds.
        SUME = 0.0D0
        SUMC = CWT(8) + CWT(9) + CWT(10)
        DO 60 J = 1, 7
          SUME = SUME + EWT(J)
          SUMC = SUMC + CWT(J)
   60   CONTINUE
        WRITE (NHSTRY, 523)
  523   FORMAT ( / ' After the H related calculations, lbs/hr:')
        WRITE (NHSTRY, 520)  (EWT(J), CWT(J), J = 1, 7), CWT(8), CWT(9),
     1    CWT(10)
        WRITE (NHSTRY, 521)  SUME, SUMC
      ENDIF
C
C     CO and CO2 calculations.
C     ------------------------
C     Calculate the lbs/hr of carbon going to CO and CO2.
      XCO = EWT(1) * RCOCO2 / (1.0D0 + RCOCO2)
      XCO2 = EWT(1) - XCO
C     Calculate the lbs/hr of CO and CO2 production.
      WTCO = XCO * CMW(2) / EMW(1)
      WTCO2 = XCO2 * CMW(3) / EMW(1)
      CWT(2) = CWT(2) + WTCO
      CWT(3) = CWT(3) + WTCO2
C     Calculate the remaining lbs/hr of carbon and oxygen.
      EWT(1) = 0.0D0
      EWT(6) = EWT(6) - EMW(6) * (WTCO/CMW(2) + 2.0D0*WTCO2/CMW(3))
C
C     Include the entering H2O, N2 and O2 feeds.
C     ------------------------------------------
C     Put any entering water or gaseous nitrogen in the product gas.
      CWT(8) = CWT(8) + WH2OIN
      CWT(5) = CWT(5) + WN2IN
C     Put any entering gaseous oxygen in the elemental oxygen.
      EWT(6) = EWT(6) + WO2IN
C
C     Total and write the pounds/hour of the elements and compounds.
```

```
      SUME = 0.0D0
      SUMC = CWT(8) + CWT(9) + CWT(10)
      DO 70 J = 1, 7
        SUME = SUME + EWT(J)
        SUMC = SUMC + CWT(J)
   70 CONTINUE
C
      IF (KTEST .GE. 4)  THEN
        WRITE (NHSTRY, 524)
  524   FORMAT ( / ' After the CO/CO2 calculations and including the',
     1    ' entering H2O,' / ' N2 and O2, lbs/hr:')
        WRITE (NHSTRY, 520)  (EWT(J), CWT(J), J = 1, 7), CWT(8), CWT(9),
     1    CWT(10)
        WRITE (NHSTRY, 521)  SUME, SUMC
      ENDIF
C
C     Balancing the oxygen.
C     ---------------------
C     Balance the oxygen by shifting some H2O into H2 and oxygen.
      WTH2 = - EWT(6) * CMW(1) / EMW(6)
      WTH2O = - EWT(6) + WTH2
      CWT(1) = CWT(1) + WTH2
      CWT(8) = CWT(8) - WTH2O
      EWT(6) = 0.0D0
C
C     Calculate and write the gasifier outlet streams.
      TMOLES = 0.0D0
      TWT = 0.0D0
      DO 80 J = 1, 10
        TWT = TWT + CWT(J)
        CMOLES(J) = CWT(J) / CMW(J)
        TMOLES = TMOLES + CMOLES(J)
   80 CONTINUE
      TOT1 = 0.0D0
      TOT2 = 0.0D0
      DO 82 J = 1, 10
        CWPCT(J) = 100.0D0 * CWT(J) / TWT
        CMPCT(J) = 100.0D0 * CMOLES(J) / TMOLES
        TOT1 = TOT1 + CWPCT(J)
        TOT2 = TOT2 + CMPCT(J)
   82 CONTINUE
C
      TOTIN = COALIN + WH2OIN + WN2IN + WO2IN
      DO 84 J = 12, KOMPS
        TOTIN = TOTIN + CIN(J)
   84 CONTINUE
      TOTOUT = TWT + TSLAG
C
      IF (KTEST .GE. 3)  THEN
        WRITE (NHSTRY, 527)
  527   FORMAT ( / ' Gasifier outlet gas flow and composition:' /
     1    13X, 'Lbs/hr', 8X, 'Wt %', 4X, 'Moles/hr', 7X, 'Vol %')
        WRITE (NHSTRY, 528) (CWT(J), CWPCT(J), CMOLES(J), CMPCT(J),
     1    J = 1, 10), TWT, TOT1, TMOLES, TOT2
  528   FORMAT ( 2X, 'H2   ',  F12.2, 3F12.3 /
```

```
     1    2X, 'CO   ',  F12.2, 3F12.3 /
     2    2X, 'CO2  ',  F12.2, 3F12.3 /
     3    2X, 'CH4  ',  F12.2, 3F12.3 /
     4    2X, 'N2   ',  F12.2, 3F12.3 /
     5    2X, 'H2S  ',  F12.2, 3F12.3 /
     6    2X, 'COS  ',  F12.2, 3F12.3 /
     7    2X, 'H2O  ',  F12.2, 3F12.3 /
     8    2X, 'HCl  ',  F12.2, 3F12.3 /
     9    2X, 'NH3  ',  F12.2, 3F12.3 /
     A    2X, 'Total',  F12.2, 3F12.3 )
C
        WRITE (NHSTRY, 518) SLAG(1), SLAGPC(1), SLAG(2), SLAGPC(2),
     1    TSLAG, TPCSLG
C
C       Write the overall gasifier mass balance.
        WRITE (NHSTRY, 529) TOTIN, TOTOUT
  529   FORMAT ( / ' Overall gasifier mass balance, lbs/hr:' /
     1    2x, 'Total input ', F10.1 /
     2    2x, 'Total output', F10.1 )
      ENDIF
C
C
C     Set up the output items.
C     ========================
      HCIN = CIN(12) + CIN(13) + CIN(14) + CIN(15)
      GSA(1,1) = 0.001D0 * (COALIN + HCIN)
      GSA(2,1) = 0.001D0 * WH2OIN
      GSA(3,1) = 0.001D0 * (WO2IN + WN2IN)
      GSA(1,2) = 0.0
      GSA(2,2) = 0.0
      O2MW = 2.0D0 * EMW(6)
      GSA(3,2) = (WO2IN/O2MW + WN2IN/CMW(5)) * 379.495D-6
      GSA(1,3) = 80.
      GSA(2,3) = 90.
      GSA(3,3) = 120.
      GSA(1,4) = 14.696
      GSA(2,4) = 150.
      GSA(3,4) = 180.
C
      GSA(4,1) = 0.001D0 * TWT
      GSA(5,1) = 0.001D0 * TSLAG
      GSA(4,2) = TMOLES * 379.495D-6
C
C
      IF ( IPASS .EQ. 4 .AND. INT1 .LE. 2 )  THEN
C       Write the output report.
C       ========================
        WRITE (NOUT, 801)
  801   FORMAT ( / 27X, 'PLANT 9 - SUMMARY REPORT' /
     1    17X, 'HYDROGEN PRODUCTION BY COAL/CHAR GASIFICATION')
C
        WRITE (NOUT, 851)
  851   FORMAT ( / ' GASIFICATION SECTION')
C
        WRITE (NOUT, 852)
```

```
  852   FORMAT ('  INLET STREAMS', 17X, 'COAL*', 5X, 'WATER*', 5X,
     1    'OXYGEN', 6X, 'TOTAL')
C
        TOTIN = GSA(1,1) + GSA(2,1) + GSA(3,1)
        WRITE (NOUT, 853)  (GSA(J,1), J = 1, 3), TOTIN, GSA(3,2),
     1   ((GSA(J,K), J = 1, 3), K = 3, 4)
  853   FORMAT ( 3X, 'FLOW, MLBS/HR  ', 8X, 4F11.3 /
     2   3X, 'FLOW, MM SCF/HR', 8X,  F33.3 /
     3   3X, 'TEMPERATURE, F ', 8X, 3F11.1 /
     4   3X, 'PRESSURE, PSIA ', 8X, 3F11.1 /
     5   3X, '* COAL IS ON A DRY BASIS.  THE WATER INCLUDES THAT ',
     6   'IN THE COAL.' )
C
        TOTOUT = GSA(4,1) + GSA(5,1)
        WRITE (NOUT, 854)
  854   FORMAT (/ '  OUTLET STREAMS', 18X, 'GAS', 7X, 'SLAG', 6X,
     1    'TOTAL')
        WRITE (NOUT, 855)  (GSA(J,1), J = 4, 5), TOTOUT, GSA(4,2)
  855   FORMAT ( 3X, 'FLOW, MLBS/HR  ', 8X, 3F11.3 /
     2   3X, 'FLOW, MM SCF/HR', 8X, F11.3 )
      ENDIF
C
C
      RETURN
      END
C
C$ USR09S
      SUBROUTINE USR09S (INT1, IPASS, KTEST, NHSTRY, NOUT,
     1  FCO, FCOSH, STEAM)
C
C     This subroutine does the shift section calculations.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - April 28, 1992.
C
C     Calling arguments:
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     IPASS  = The results pass flag.
C     KTEST  = Switch for controlling the printing to the history file.
C     NHSTRY = Logical unit number of the history file.
C     NOUT   = Logical unit number of the plant output report file.
C     FCO    = Fraction of CO which enters the shift reactor that
C              undergoes the water gas shift reaction
C                   CO + H2O -----> CO2 + H2
C     FCOSH  = Fraction of COS which enters the shift reactor section
C              section that is hydrolyzed to CO2 and H2S by the
C              chemical reaction
C                   COS + H2O -----> CO2 + H2S
C     STEAM  = Flow rate of steam to the shift reactor, lbs/hr.
```

```
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON /USRC09/ CWT(15), CMOLES(15), CMPCT(15), CMW(15),
     1  CWPCT(15), EWT(7), EMW(7), SLAG(2), SLAGPC(2), UANAL(7),
     2  GSA(10,10), SWT(10), SMOLES(10), SMPCT(10), SWPCT(10),
     3  SH2(11,4), SH2S(11,4), SVG(11,4), SSW(11,4), CPROP(5,7),
     4  CIN(15), KOMPS
C
C
C     Initialize the pound moles/hour of the gasifier outlet stream to
C     shift reactor outlet stream.
      DO 10 J = 1, 10
        SMOLES(J) = CMOLES(J)
   10 CONTINUE
C
C     Add in the moles/hr of steam entering the shift reactor to get
C     the total shift reactor inlet stream.
      SMOLES(8) = SMOLES(8) + STEAM / CMW(8)
C
C     Calculate the complete shift reactor inlet gas stream.
      TMOLES = 0.0D0
      TWT = 0.0D0
      DO 20 J = 1, 10
        SWT(J) = SMOLES(J) * CMW(J)
        TMOLES = TMOLES + SMOLES(J)
        TWT = TWT + SWT(J)
   20 CONTINUE
      TOT1 = 0.0D0
      TOT2 = 0.0D0
      DO 30 J = 1, 10
        SWPCT(J) = 100.0D0 * SWT(J) / TWT
        SMPCT(J) = 100.0D0 * SMOLES(J) / TMOLES
        TOT1 = TOT1 + SWPCT(J)
        TOT2 = TOT2 + SMPCT(J)
   30 CONTINUE
C
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 511)
  511   FORMAT ( // ' Shift reactor section:' /
     1    ' Shift reactor inlet gas flow and composition:' /
     2    13X, 'Lbs/hr', 8X, 'Wt %', 4X, 'Moles/hr', 7X, 'Vol %')
        WRITE (NHSTRY, 512) (SWT(J), SWPCT(J), SMOLES(J), SMPCT(J),
     1    J = 1, 10), TWT, TOT1, TMOLES, TOT2
  512   FORMAT ( 2X, 'H2   ',  F12.2, 3F12.3 /
     1    2X, 'CO   ',  F12.2, 3F12.3 /
     2    2X, 'CO2  ',  F12.2, 3F12.3 /
     3    2X, 'CH4  ',  F12.2, 3F12.3 /
     4    2X, 'N2   ',  F12.2, 3F12.3 /
     5    2X, 'H2S  ',  F12.2, 3F12.3 /
     6    2X, 'COS  ',  F12.2, 3F12.3 /
     7    2X, 'H2O  ',  F12.2, 3F12.3 /
     8    2X, 'HCl  ',  F12.2, 3F12.3 /
     9    2X, 'NH3  ',  F12.2, 3F12.3 /
     A    2X, 'Total',  F12.2, 3F12.3 )
```

```
      ENDIF
C
C     Calculate the moles of CO to be shifted.
      SHIFT = FCO * SMOLES(2)
C     Do the shift calculations.
      SMOLES(1) = SMOLES(1) + SHIFT
      SMOLES(2) = SMOLES(2) - SHIFT
      SMOLES(3) = SMOLES(3) + SHIFT
      SMOLES(8) = SMOLES(8) - SHIFT
C
C     Calculate the moles of COS to be hydrolyzed.
      HYDRO = FCOSH * SMOLES(7)
C     Do the shift calculations.
      SMOLES(3) = SMOLES(3) + HYDRO
      SMOLES(6) = SMOLES(6) + HYDRO
      SMOLES(7) = SMOLES(7) - HYDRO
      SMOLES(8) = SMOLES(8) - HYDRO
C
C     Calculate the shift reactor outlet gas stream.
      TMOLES = 0.0D0
      TWT = 0.0D0
      DO 40 J = 1, 10
        SWT(J) = SMOLES(J) * CMW(J)
        TMOLES = TMOLES + SMOLES(J)
        TWT = TWT + SWT(J)
   40 CONTINUE
      TOT1 = 0.0D0
      TOT2 = 0.0D0
      DO 50 J = 1, 10
        SWPCT(J) = 100.0D0 * SWT(J) / TWT
        SMPCT(J) = 100.0D0 * SMOLES(J) / TMOLES
        TOT1 = TOT1 + SWPCT(J)
        TOT2 = TOT2 + SMPCT(J)
   50 CONTINUE
C
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 513)
  513   FORMAT ( / ' Shift reactor outlet gas flow and composition:' /
     1    13X, 'Lbs/hr', 8X, 'Wt %', 4X, 'Moles/hr', 7X, 'Vol %')
        WRITE (NHSTRY, 512) (SWT(J), SWPCT(J), SMOLES(J), SMPCT(J),
     1    J = 1, 10), TWT, TOT1, TMOLES, TOT2
      ENDIF
C
C
C     Set up the output items.
C     ========================
C
      GSA(6,1) = 0.001D0 * TWT
      GSA(6,2) = TMOLES * 379.495D-6
C
C
      IF ( IPASS .EQ. 4 .AND. INT1 .LE. 2 )  THEN
C       Write the output report.
C       ========================
        WRITE (NOUT, 851)
```

```
  851   FORMAT (// ' SHIFT REACTOR SECTION')
C
        WRITE (NOUT, 852)
  852   FORMAT (29X, 'SHIFT REACTOR INPUT', 4X, 'REACTOR' /
     1    2X, 'STREAM', 26X, 'GAS', 6X, 'STEAM', 5X, 'OUTLET')
C
        STMMLB = 0.001D0 * STEAM
        WRITE (NOUT, 853)  GSA(4,1), STMMLB, GSA(6,1), GSA(4,2),
     1    GSA(6,2)
  853   FORMAT ( 3X, 'FLOW, MLBS/HR  ', 8X, 3F11.3 /
     1    3X, 'FLOW, MM SCF/HR', 8X,  F11.3, F22.3 )
C
        H2IMLB = 0.001D0 * CWT(1)
        H2OMLB = 0.001D0 * SWT(1)
        COIMLB = 0.001D0 * CWT(2)
        COOMLB = 0.001D0 * SWT(2)
        H2ISCF = 379.495D-6 * CWT(1) / CMW(1)
        H2OSCF = 379.495D-6 * SWT(1) / CMW(1)
        COISCF = 379.495D-6 * CWT(2) / CMW(2)
        COOSCF = 379.495D-6 * SWT(2) / CMW(2)
C
        WRITE (NOUT, 854) H2IMLB, H2OMLB, H2ISCF, H2OSCF, COIMLB,
     1    COOMLB, COISCF, COOSCF, FCO
  854     FORMAT (/ 3X, 'H2, MLBS/HR    ', 8X,  F11.3, F22.3 /
     1    3X, 'H2, MM SCF/HR  ', 8X,  F11.3, F22.3 /
     2    3X, 'CO, MLBS/HR    ', 8X,  F11.3, F22.3 /
     3    3X, 'CO, MM SCF/HR  ', 8X,  F11.3, F22.3 //
     4    3X, 'FRACTION OF CO SHIFTED', F12.4 )
      ENDIF
C
C
      RETURN
      END
C
C$ USR09R
      SUBROUTINE USR09R (CDF, INT1, IPASS, KTEST, NHSTRY, NOUT)
C
C     This subroutine simulates the Rectisol unit following the shift
C     reactor section for product recovery.  The shift reactor products
C     are separated into the following four streams
C       1.  Hydrogen-rich gas stream.
C       2.  Acid gas stream.
C       3.  Vent gas stream (the mixed tail and medium BTU gas
C           streams).
C       4.  Sour water stream.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - April 28, 1992.
C
C     Method of calculation:
C       1.  All the COS is put in the acid gas stream.
C       2.  All the H2O, HCl and NH3 are put in the sour water stream.
C           Thus, the acid gas and vent gas streams are on a dry basis.
C       3.  User supplied component distribution factors are used to
```

```
C           distribute the H2, CO, CO2, CH4, N2 and H2S among the
C           hydrogen-rich gas and acid gas stream.
C        4. All remaing material leaves in the vent gas stream.
C
C     Calling arguments:
C     CDF()  = Component distribution factors, where
C          CDF(1)  = Fraction of inlet H2 going to the hydrogen-rich
C                    gas stream.
C          CDF(2)  = Fraction of inlet H2 going to the acid gas stream.
C          CDF(3)  = Fraction of inlet CO going to the hydrogen-rich
C                    gas stream.
C          CDF(4)  = Fraction of inlet CO going to the acid gas stream.
C          CDF(5)  = Fraction of inlet CO2 going to the hydrogen-rich
C                    gas stream.
C          CDF(6)  = Fraction of inlet CO2 going to the acid gas stream.
C          CDF(7)  = Fraction of inlet CH4 going to the hydrogen-rich
C                    gas stream.
C          CDF(8)  = Fraction of inlet CH4 going to the acid gas stream.
C          CDF(9)  = Fraction of inlet N2 going to the hydrogen-rich
C                    gas stream.
C          CDF(10) = Fraction of inlet N2 going to the acid gas stream.
C          CDF(11) = Fraction of inlet H2S going to the hydrogen-rich
C                    gas stream.
C          CDF(12) = Fraction of inlet H2S going to the acid gas stream.
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     IPASS  = The results pass flag.
C     KTEST  = Switch for controlling the printing to the history file.
C     NHSTRY = Logical unit number of the history file.
C     NOUT   = Logical unit number of the plant output report file.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON /USRC09/ CWT(15), CMOLES(15), CMPCT(15), CMW(15),
     1  CWPCT(15), EWT(7), EMW(7), SLAG(2), SLAGPC(2), UANAL(7),
     2  GSA(10,10), SWT(10), SMOLES(10), SMPCT(10), SWPCT(10),
     3  SH2(11,4), SH2S(11,4), SVG(11,4), SSW(11,4), CPROP(5,7),
     4  CIN(15), KOMPS
C
C     SH2(J,K), SH2S(J,K), SVG(J,K) AND SSW(J,K) represent the
C     hydrogen-rich gas stream, acid gas stream, vent gas (mixed tail
C     and medium BTU gas) stream, and the sour water stream,
C     respectively, where
C        J = Component number (see USR09 for an ordered list of items
C            1 thru 9, and item 10 is the total of the first 9 items.
C        K = 1  =>  Weight flow rate, lbs/hr
C            2  =>  Composition, weight %
C            3  =>  Molar flow rate, lb-moles/hr
C            4  =>  Composition, mole %
C
```

```
      DIMENSION CDF(12)
C
C
C     Zero all outlet stream items.
      DO 10 J = 1, 11
        DO 10 K = 1, 4
          SH2(J,K)  = 0.0D0
          SH2S(J,K) = 0.0D0
          SVG(J,K)  = 0.0D0
          SSW(J,K)  = 0.0D0
   10 CONTINUE
C
C     Place all the COS in the acid gas stream.
      SH2S(7,1) = SWT(7)
      SH2S(7,3) = SMOLES(7)
C
C     Place all the H2O, HCl and NH3 in the sour water stream.
      DO 20 J = 8, 10
        SSW(J,1) = SWT(J)
        SSW(J,3) = SMOLES(J)
   20 CONTINUE
C
C     Distribute the H2, CO, CO2, CH4, N2 and H2S among the hydrogen-
C     rich gas, acid gas and vent gas streams.
      DO 30 J = 1, 6
        K = 2 * J - 1
        SH2(J,1)  = SWT(J) * CDF(K)
        SH2(J,3)  = SMOLES(J) * CDF(K)
        SH2S(J,1) = SWT(J) * CDF(K+1)
        SH2S(J,3) = SMOLES(J) * CDF(K+1)
        SVG(J,1)  = SWT(J) - SH2(J,1) - SH2S(J,1)
        SVG(J,3)  = SMOLES(J) - SH2(J,3) - SH2S(J,3)
   30 CONTINUE
C
C     Remove all remaining H2S from the vent gas stream and place it
C     in the sour water stream.
      SSW(6,1) = SVG(6,1)
      SSW(6,3) = SVG(6,3)
      SVG(6,1) = 0.0D0
      SVG(6,3) = 0.0D0
C
C     Calculate the totals and stream compositions.
      DO 40 K = 1, 3, 2
        DO 40 J = 1, 10
          SH2(11,K)  = SH2(11,K)  + SH2(J,K)
          SH2S(11,K) = SH2S(11,K) + SH2S(J,K)
          SVG(11,K)  = SVG(11,K)  + SVG(J,K)
          SSW(11,K)  = SSW(11,K)  + SSW(J,K)
   40 CONTINUE
C
      DO 50 K = 2, 4, 2
        DO 50 J = 1, 10
          SH2(J,K)   = 100.0D0 * SH2(J,K-1) / SH2(11,K-1)
          SH2S(J,K)  = 100.0D0 * SH2S(J,K-1) / SH2S(11,K-1)
          SVG(J,K)   = 100.0D0 * SVG(J,K-1) / SVG(11,K-1)
```

```
          SSW(J,K)   = 100.0D0 * SSW(J,K-1) / SSW(11,K-1)
          SH2(11,K)  = SH2(11,K) + SH2(J,K)
          SH2S(11,K) = SH2S(11,K) + SH2S(J,K)
          SVG(11,K)  = SVG(11,K) + SH2S(J,K)
          SSW(11,K)  = SSW(11,K) + SSW(J,K)
   50 CONTINUE
C
C     Load the results in the GSA vector.
C     Stream flow rates in Mlbs/hr.
      GSA(7,1) = 0.001D0 * SH2(11,1)
      GSA(8,1) = 0.001D0 * SH2S(11,1)
      GSA(9,1) = 0.001D0 * SVG(11,1)
      GSA(10,1) = 0.001D0 * SSW(11,1)
C     Vapor stream flow rates in MM SCF/hr.
      GSA(7,2) = SH2(11,3) * 379.495D-6
      GSA(8,2) = SH2S(11,3) * 379.495D-6
      GSA(9,2) = SVG(11,3) * 379.495D-6
C     Vapor stream hydrogen flow rates in MM SCF/hr of H2.
      GSA(7,5) = GSA(7,2) * SH2(1,4) * 0.01D0
      GSA(8,5) = GSA(8,2) * SH2S(1,4) * 0.01D0
      GSA(9,5) = GSA(9,2) * SVG(1,4) * 0.01D0
C
      IF ( KTEST .GE. 3 )  THEN
C
        WRITE (NHSTRY, 511)
  511   FORMAT ( // ' Rectisol section product streams:' /
     1    ' Hydrogen-rich gas stream:' /
     2    13X, 'Lbs/hr', 8X, 'Wt %', 4X, 'Moles/hr', 7X, 'Vol %')
        WRITE (NHSTRY, 512)  ((SH2(J,K), K = 1, 4), J = 1, 11)
  512   FORMAT ( 2X, 'H2   ',  F12.2, F12.4, F12.3, F12.4 /
     1    2X, 'CO   ',  F12.2, F12.4, F12.3, F12.4 /
     2    2X, 'CO2  ',  F12.2, F12.4, F12.3, F12.4 /
     3    2X, 'CH4  ',  F12.2, F12.4, F12.3, F12.4 /
     4    2X, 'N2   ',  F12.2, F12.4, F12.3, F12.4 /
     5    2X, 'H2S  ',  F12.2, F12.4, F12.3, F12.4 /
     6    2X, 'COS  ',  F12.2, F12.4, F12.3, F12.4 /
     7    2X, 'H2O  ',  F12.2, F12.4, F12.3, F12.4 /
     8    2X, 'HCl  ',  F12.2, F12.4, F12.3, F12.4 /
     9    2X, 'NH3  ',  F12.2, F12.4, F12.3, F12.4 /
     A    2X, 'Total',  F12.2, F12.4, F12.3, F12.4 )
C
        WRITE (NHSTRY, 513)
  513   FORMAT ( / ' Acid gas stream:' /
     1    13X, 'Lbs/hr', 8X, 'Wt %', 4X, 'Moles/hr', 7X, 'Vol %')
        WRITE (NHSTRY, 512)  ((SH2S(J,K), K = 1, 4), J = 1, 11)
C
        WRITE (NHSTRY, 514)
  514   FORMAT ( / ' Vent gas stream:' /
     1    13X, 'Lbs/hr', 8X, 'Wt %', 4X, 'Moles/hr', 7X, 'Vol %')
        WRITE (NHSTRY, 512)  ((SVG(J,K), K = 1, 4), J = 1, 11)
C
        WRITE (NHSTRY, 515)
  515   FORMAT ( / ' Sour water stream:' /
     1    13X, 'Lbs/hr', 8X, 'Wt %', 4X, 'Moles/hr', 7X, 'Mol %')
        WRITE (NHSTRY, 512)  ((SSW(J,K), K = 1, 4), J = 1, 11)
```

```
C
      ENDIF
C
      IF ( IPASS .EQ. 4 .AND. INT1 .LE. 2 )  THEN
C       Write the output report.
C       ========================
        WRITE (NOUT, 851)
  851   FORMAT (// ' RECTISOL PRODUCT RECOVERY SECTION' )
C
        WRITE (NOUT, 852)
  852   FORMAT ('  OUTLET STREAMS', 19X, 'H2', 3X, 'ACID GAS', 3X,
     1    'VENT GAS', 3X, 'SOUR H2O' )
C
        SMLB1 = 0.001D0 * SH2(11,1)
        SMLB2 = 0.001D0 * SH2S(11,1)
        SMLB3 = 0.001D0 * SVG(11,1)
        SMLB4 = 0.001D0 * SSW(11,1)
        SSCF1 = 379.495D-6 * SH2(11,3)
        SSCF2 = 379.495D-6 * SH2S(11,3)
        SSCF3 = 379.495D-6 * SVG(11,3)
        GPH = 0.001D0 * SSW(11,1) / 8.32817D0
        WT1 = 0.001D0 * SH2(1,1)
        WT2 = 0.001D0 * SH2S(1,1)
        WT3 = 0.001D0 * SVG(1,1)
        CF1 = 379.495D-6 * SH2(1,3)
        CF2 = 379.495D-6 * SH2S(1,3)
        CF3 = 379.495D-6 * SVG(1,3)
        WRITE (NOUT, 853)  SMLB1, SMLB2, SMLB3, SMLB4, SSCF1, SSCF2,
     1    SSCF3, GPH, WT1, WT2, WT3, CF1, CF2, CF3
  853   FORMAT ( 3X, 'FLOW, MLBS/HR  ', 8X, 4F11.3 /
     1    3X, 'FLOW, MM SCF/HR', 8X, 3F11.3 /
     2    3X, 'FLOW, MGAL/HR  ', 8X, 33X, F11.3 /
     3    3X, 'H2, MLBS/HR    ', 8X, 3F11.3 /
     4    3X, 'H2, MM SCF/HR  ', 8X, 3F11.3 )
C
        WRITE (NOUT, 854) (SH2(J,2), SH2S(J,2), SVG(J,2), J = 1, 6),
     1    SSW(6,2), SH2S(7,2), SSW(7,2), SSW(8,2), SSW(9,2), SSW(10,2),
     2    SH2(11,2), SH2S(11,2), SVG(11,2), SSW(11,2)
  854     FORMAT (/ 2X, 'COMPOSITION, WT%'/
     1    3X, 'H2 ', 20X, 3F11.2 /
     2    3X, 'CO ', 20X, 3F11.2 /
     3    3X, 'CO2', 20X, 3F11.2 /
     4    3X, 'CH4', 20X, 3F11.2 /
     5    3X, 'N2 ', 20X, 3F11.2 /
     6    3X, 'H2S', 20X, 4F11.2 /
     7    3X, 'COS', 20X, 2F22.2 /
     8    3X, 'H2O', 20X, F44.2 /
     9    3X, 'HCL', 20X, F44.2 /
     A    3X, 'NH3', 20X, F44.2 /
     B    3X, 'TOTAL', 18X, 4F11.2 )
C
        WRITE (NOUT, 855)
  855   FORMAT ( / 25X, '- CONTINUED ON NEXT PAGE -' )
C
      ENDIF
```

```
C
C
      RETURN
      END
C
C$ USR09Z
      SUBROUTINE USR09Z (INT2, NOUT, STIN)
C
C     Subroutine to write the overall material balance for the
C     hydrogen production by coal gasification plant.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - April 28, 1992.
C
C     Calling arguments:
C     INT2    = User block output report destination control switch.
C               0 => Write the user block output report to the normal
C                    ASPEN/SP output report file.
C               1 => Write the user block output report to a separate
C                    user block output report file on logical unit 62.
C     NOUT    = Logical unit number of the plant output report file.
C     STIN(J) = Vector of inlet stream flow rates in Mlbs/hr.
C          J => 1   Total COAL/URCOAL stream
C               2   Water/steam to gasifier
C               3   Oxygen stream to gasifier from the O2 plant
C               4   Steam to the shift reactor(s)
C               5   Future use
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON /USRC09/ CWT(15), CMOLES(15), CMPCT(15), CMW(15),
     1  CWPCT(15), EWT(7), EMW(7), SLAG(2), SLAGPC(2), UANAL(7),
     2  GSA(10,10), SWT(10), SMOLES(10), SMPCT(10), SWPCT(10),
     3  SH2(11,4), SH2S(11,4), SVG(11,4), SSW(11,4), CPROP(5,7),
     4  CIN(15), KOMPS
C
      DIMENSION STIN(5), STOUT(5)
C     STIN(5) and STOUT(5) are the total weight flow rates of the
C     major inlet and outlet streams to the entire plant in Mlbs/hr,
C     as follows.
C      J   STIN(J)                      STOUT(J)
C      1   Total COAL/URCOAL stream       Slag (from gasifier)
C      2   Water/steam (to gasifier)    Hydrogen-rich product stream
C      3   Oxygen stream                Acid gas stream
C      4   Steam (to shift reactors)    Vent gas stream
C      5   Future use                   Sour water stream
C
C
      TOTIN = STIN(1) + STIN(2) + STIN(3) + STIN(4) + STIN(5)
      TOTOUT = GSA(5,1) + GSA(7,1) + GSA(8,1) + GSA(9,1) + GSA(10,1)
C
C     Write a tile for the second page.
      WRITE (NOUT, 801)
```

```
  801 FORMAT ( / 21X, 'PLANT 9 - SUMMARY REPORT (CONTINUED)' /
     1  17X, 'HYDROGEN PRODUCTION BY COAL/CHAR GASIFICATION')
C
      WRITE (NOUT, 811)
  811 FORMAT ( // 24X, 'OVERALL PLANT MATERIAL BALANCE' //
     1  ' INLET STREAMS', 15X, 'MLBS/HR', 7X, 'PRODUCT STREAMS', 8X,
     2  'MLBS/HR' /)
C
      WRITE (NOUT, 812)  STIN(1), GSA(5,1), STIN(2), GSA(7,1), STIN(3),
     1  GSA(8,1), STIN(4), GSA(9,1), GSA(10,1)
  812 FORMAT (
     1  ' TOTAL COAL/URCOAL      ', F12.3, 7X,
     2  'SLAG FROM GASIFIER', F12.3 /
     3  ' WATER/STEAM TO GASIFIER', F12.3, 7X,
     4   'H2 PRODUCT STREAM ', F12.3 /
     5  ' OXYGEN STREAM          ', F12.3, 7X,
     6  'ACID GAS STREAM   ', F12.3 /
     7  ' STEAM TO SHIFT REACTORS', F12.3, 7X,
     8  'VENT GAS STREAM   ', F12.3 /
     9  43X, 'SOUR WATER STREAM ', F12.3 )
C
      WRITE (NOUT, 813)  TOTIN, TOTOUT
  813 FORMAT ( ' TOTAL INPUT', F24.3, 7X, 'TOTAL OUTPUT', F18.3 )
C
      WRITE (NOUT, 814)  GSA(7,5)
  814 FORMAT ( / ' HYDROGEN PRODUCTION RATE, MM SCF/HR OF H2', F10.3 )
C
C
      RETURN
      END
C
C     This file contains the following subroutine:
C       USR91     Main routine for Plant 9.1 - Hydrogen production by
C                 steam reforming of natural gas
C
C     The above subroutine requires the following non-standard ASPEN/SP
C     subroutines which are not included in this file.
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       GETSTR   Subroutine for finding the stream bead information.
C
C$ USR91
      SUBROUTINE USR91 (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:  USR91
C
C  BLOCK DESCRIPTION:  DOE Hydrogen Production by Steam Reforming of
C                      Natural Gas (Methane) Fortran Block Model
C
C                          ---------------------
C                          |                   |
```

```
C        Natural Gas ----->|     Plant 9.1      |-----> Hydrogen
C                          |                    |
C                          |  H2 Production by  |
C                          |   Steam Reforming  |
C              Steam ----->|   of Natural Gas   |-----> Flue Gas
C                          |                    |
C                          ----------------------
C
C  Prepared under DOE contract no. DE-AC22 90PC89857.
C
C  FUNCTION (MODEL, REPORT, OR BOTH):  Both
C
C  Last revision - June 5, 1992.
C
C  ASSUMPTIONS, SPECIAL FEATURES AND LIMITATIONS:
C     1.  The two inlet streams are:   Natural Gas (Methane)
C                                      Steam (Water)
C     2.  The two outlet streams are:  Hydrogen
C                                      Flue Gas
C     3.  Natural gas must be the first inlet stream.
C         Steam must be the second inlet stream.
C         The product hydrogen stream is the first outlet stream.
C         Flue gas is the second outlet stream.
C     4.  This user block model will allow for hydrogen in the natural
C         gas inlet stream.
C     5.  Only hydrogen and unreacted methane can leave the hydrogen
C         plant in the hydrogen rich product gas stream.  All other
C         conventional components leave in the flue gas stream.
C         gas stream.  All solids entering this plant do not leave it.
C         If any solids are found to enter the hydrogen plant, warning
C         messages are written both to the HISTORY file and to the
C         plant summary report.
C     6.  All input to this model and all output streams from this user
C         model must be of the same ASPEN/SP stream class.  Only the
C         following three stream classes can be used; CONVENTIONAL,
C         MIXNC or MIXNCPSD.
C     7.  Important Variables:
C         S1(J,K) = Flow rates and composition of the Natural gas inlet
C                   stream, the first inlet stream.
C         S2(J,K) = Flow rates and composition of the process water
C                   inlet stream, the second inlet stream.
C         S3(J,K) = Flow rates and composition of the product hydrogen
C                   gas outlet stream, the first outlet stream.
C         S4(J,K) = Flow rates and composition of the product flue gas,
C                   the second outlet stream.
C           For the above 4 arrays, subscripts J and K designate
C             J = 1  =>  Flow rate in moles/hour.
C               = 2  =>  Composition in mole or volume percent.
C               = 3  =>  Flow rate in pounds/hour.
C               = 4  =>  Composition in weight percent.
C             K = 1  =>  Hydrogen
C               = 2  =>  Methane (natural gas)
C               = 3  =>  Ethane
C               = 4  =>  Propane
C               = 5  =>  Water
```

```
C               = 6  =>  Carbon dioxide
C               = 7  =>  Carbon monoxide
C               = 8  =>  Other components
C               = 9  =>  Total
C     8.  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 DCL91.REP.
C         INT(3)  = Number of operating duplicate trains, excluding
C                   spares.
C                   If INT(3) = 0, the minimun number of duplicate
C                     trains will be determined so that the capacity
C                     each train does not exceed the maximum train
C                     capacity specified by variable REAL(52).
C                   If INT(3) > 0, this number of duplicate trains will
C                     be used.
C         INT(4)  = History file additional output control switch.
C                   0 => Write no additional output to the history 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     9.  The 70 real parameters are:
C         REAL(1)   = Fraction of CH4 reacting to produce H2 and CO2.
C         REAL(2)   = Fraction of CH4 reacting to produce H2 and CO.
C         REAL(3)   = Fraction of hydrogen produced that leaves in the
C                     hydrogen-rich product gas stream.
C         REAL(4)   = Purity of the hydrogen-rich product gas, mole %.
C         REAL(5) -
C          REAL(20) = Future use.
C         REAL(21)  = Constant factor for the power consumption, kw.
C         REAL(22)  = Power consumption per MM SCF/hr of hydrogen
C                     produced, kw/(MM SCF/hr of H2).
C         REAL(23)  = Constant factor for the 900 psig / 750 F steam
C                     consumption, Mlbs/hr.
C         REAL(24)  = 900 psig / 750 F  steam consumption per MM SCF/hr
C                     of hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
C         REAL(25)  = Constant factor for the 900 psig saturated steam
C                     consumption, Mlbs/hr.
C         REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr
```

```
C                    of hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
C         REAL(27)  = Constant factor for the 600 psig / 720 F steam
C                    consumption, Mlbs/hr.
C         REAL(28)  = 600 psig / 720 F  steam consumption per MM SCF/hr
C                    of hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
C         REAL(29)  = Constant factor for the 600 psig / 750 F steam
C                    consumption, Mlbs/hr.
C         REAL(30)  = 600 psig saturated steam consumption per MM SCF/hr
C                    of hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
C         REAL(31)  = Constant factor for the 150 psig saturated steam
C                    consumption, Mlbs/hr.
C         REAL(32)  = 150 psig saturated steam consumption per MM SCF/hr
C                    of hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
C         REAL(33)  = Constant factor for the 50 psig saturated steam
C                    consumption, Mlbs/hr.
C         REAL(34)  = 50 psig saturated steam consumption per MM SCF/hr
C                    of hydrogen produced, (Mlbs/hr)/(MM SCF/hr of H2).
C         REAL(35)  = Constant factor for the plant fuel consumption,
C                    MM BTU/hr.
C         REAL(36)  = Plant fuel consumption per MM SCF/hr of hydrogen
C                    produced, (MM BTU/hr)/(MM SCF/hr of H2).
C         REAL(37)  = Constant factor for the cooling water consumption,
C                    Mgal/hr.
C         REAL(38)  = Cooling water consumption per of MM SCF/hr of
C                    hydrogen produced, (Mgal/hr)/(MM SCF/hr of H2).
C         REAL(39)  = Constant factor for the process water consumption,
C                    Mgal/hr.
C         REAL(40)  = Process water consumption per MM SCF/hr of
C                    hydrogen produced, (Mgal/hr)/(MM SCF/hr of H2).
C         REAL(41)  = Constant factor for the nitrogen consumption,
C                    MM SCF/hr of N2.
C         REAL(42)  = Nitrogen consumption per MM SCF/hr of hydrogen
C                    produced, (MM SCF/hr of N2)/(MM SCF/hr of H2).
C         REAL(43) -
C          REAL(48) = Future use.
C         REAL(49)  = Constant factor for the number of operators per
C                    day, operators/day.
C         REAL(50)  = Number of operators per day per train,
C                    (operators/day)/train.
C         REAL(51)  = Reference hydrogen production rate for a single
c                    train in MM SCF/hr of H2 for the calculation of
C                    the ISBL field cost of a single train as a
C                    function of train capacity.
C         REAL(52)  = Maximum size of a single train as defined by the
C                    hydrogen production rate in MM SCF/hr of H2.
C         REAL(53)  = Minimum size of a single train as defined by the
C                    hydrogen production rate in MM SCF/hr of H2.
C         REAL(54)  = Constant A in the plant ISBL field cost equation.
C         REAL(55)  = Constant B in the plant ISBL field cost equation.
C         REAL(56)  = Constant E in the plant ISBL field cost equation.
C         REAL(57)  = Constant F in the plant ISBL field cost equation.
C         REAL(58)  = Number of spare trains.
C         REAL(59) -
C          REAL(70) = Future use.
C
```

```
C  NOTE:  MM SCF/hr of hydrogen produced means MM SCF/hr of hydrogen
C         in the hydrogen-rich product gas stream and NOT the total
C         flow rate of the hydrogen-rich product gas stream.
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
      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
C
C     Local variable declaration statements.
      DIMENSION RX(9), PD(9), S1(4,9), S2(4,9), S3(4,9), S4(4,9)
C     RX(J) is the total reactor inlet flow in moles/hr.
C     PD(J) is the total reactor outlet flow in moles/hr.
C     S1(J,K) is the short stream array for the first inlet stream.
C     S2(J,K) is the short stream array for the second inlet stream.
C     S3(J,K) is the short stream array for the first outlet stream.
C     S4(J,K) is the short stream array for the second outlet stream.
C
      DIMENSION PSA(4,10)
C     PSA(J,K) is the Plant Stream Array, where
C       J = Stream number identifier
C           1 => The inlet methane stream
C           2 => The inlet process water stream
C           3 => The outlet hydrogen stream
C           4 => The outlet flue gas stream
C       K = Stream property identifier
C           1 => Total flow rate, Mlbs/hr
C           2 => Total flow rate, MMSCF/hr
C           3 => Stream temperature, degrees Fahrenheit
C           4 => Stream pressure, PSIA
C           5 => Total flow rate, Mgal/hr
C           6 - 10 => Future use
C
      DIMENSION ICN(2), ICNAME(14), ICNUMB(7)
C
      CHARACTER * 4  ICN, ICNAME
```

```
      CHARACTER * 6  PNAME
C
C     Initialize the component identifications.
      DATA ICNAME / 'H2  ', '    ', 'CH4 ', '    ', 'C2H6', '    ',
     1  'C3H8', '    ', 'H2O ', '    ', 'CO2 ', '    ',
     2  'CO  ', '    ' /
C
      DATA PNAME / '9.1   ' /
C
C
C     PARAMETER INITIALIZATION SECTION
C     --------------------------------
C     Set the KTEST switch which controls the optional printing to the
C     history file (0 => No printing  and  1 => Print debugging data).
      KTEST = INT(4)
C
      IF ( KTEST .GE. 1 )   WRITE (NHSTRY, 701)  IPASS
  701 FORMAT ( // 1X, 'Plant 9.1 - Supplementary data from subroutine',
     1  ' USR91' /
     2  2X, 'Hydrogen Production by Steam Reforming of Natural Gas',
     3  10X, 'IPASS =', I3 )
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 = 1
      IF ( NSUBS .GE. 2 .AND. ITYPE(2) .EQ. 3 )  KLASS = 2
C
C     Check for a substream PSD attribute on the second substream of the
C     first inlet stream.
      NUMPSD = 0
      IF ( KLASS .EQ. 2 )  THEN
        CALL GETSTR (IDS(1,4), NB, LB, NBD, LBD)
        NUMATT = NPAT (LBD, 2)
        IF ( NUMATT .GT. 0 )   THEN
          NUMPSD = NAVAR (LBD, 2, 1)
          KLASS = 3
        ENDIF
      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
      IF ( KLASS .GE. 2 )  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
      FLOWIN = CF * ( SIN1(J)*SIN1(K) + SIN2(J)*SIN2(K) )
C
      IF ( FLOWIN .LE. 1.0D0 )   THEN
C       Skip all remaing calculations if this plant has no flow.
        IF ( KTEST .GE. 1 )  WRITE (NHSTRY, 702)
  702   FORMAT ( / ' There is no material entering plant 9.1, the ',
     1    'hydrogen production by' /
     2    ' steam reforming of natural gas plant.' )
        GO TO 999
C       ---------
      ENDIF
C
C     Check to insure that there are exactly 2 inlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSIN .NE. 2 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 701)  IPASS
        WRITE (NHSTRY, 703)  NSIN
  703   FORMAT ( / 1X, '* ERROR * - The hydrogen production plant ',
     1    'requires exactly 2 inlet streams.' /
     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 are exactly 2 outlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSOUT .NE. 2 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 701)  IPASS
        WRITE (NHSTRY, 704)  NSOUT
  704   FORMAT ( / 1X, '* ERROR * - The hydrogen production plant ',
     1    'requires exactly 2 outlet streams.' /
     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     Find the relative component numbers of H2, CH4, C2H6, C3H8, H2O,
C     CO2, and CO.  Load them in the ICNUMB() vector.
      DO 5 J = 1, 7
        K = 2 * J - 1
        ICN(1) = ICNAME(K)
        ICN(2) = ICNAME(K+1)
        CALL USRCCN (ICN, ICNUMB(J))
        IF ( ICNUMB(J) .EQ. 0 ) THEN
          IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 701)  IPASS
          WRITE (NHSTRY, 705)  ICN(1), ICN(2)
  705     FORMAT ( / 1X, '* ERROR * - The following component is ',
```

```
     1      'missing from your component list' / 5X, 2A4 /
     2      3X, 'The H2 plant requires this component.  Please ',
     3      'add it to your' /
     4      3X, 'component list and try again.' //
     5      3X, 'EXECUTION IS BEING TERMINATED.' / )
          STOP
        ENDIF
    5 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     Set up the fraction of CH4 reacting to produce H2 and CO2.
      FTOCO2 = REAL(1)
C     Set up the fraction of CH4 reacting to produce H2 and CO.
      FTOCO = REAL(2)
C     Set up the fractional hydrogen recovery in the hydrogen-rich
C     product gas stream.
      RECVY = REAL(3)
C     Set up the purity of the hydrogen-rich product gas in mole %.
      PURITY = REAL(4)
C
      IF ( KTEST .GE. 2 )  WRITE (NHSTRY, 706)  FTOCO2, FTOCO, RECVY,
     1   PURITY
  706 FORMAT ( / 2X, 'Fraction of CH4 reacting to H2 and CO2', F12.6 /
     1  2X, 'Fraction of CH4 reacting to H2 and CO ', F12.6 /
     2  2X, 'Fraction H2 to hydrogen-rich product  ', F12.6 /
     3  2X, 'Purity of H2 rich gas, mole %       ', F12.4 )
C
C     Set up the maximum and minimum train flow rates in MMSCF/hr of
C     hydrogen produced.
      PMAXF = REAL(52)
      PMINF = REAL(53)
C
      IF ( KTEST .GE. 5 )  THEN
        WRITE (NHSTRY, 707)
  707   FORMAT ( / '  Inlet stream vectors' /
     1    14X, 'SIN1', 11X, 'SIN2' )
        DO 8 J = 1, ITEMS
          WRITE (NHSTRY, 708) J, SIN1(J), SIN2(J)
  708     FORMAT ( 2X, I5, 2(1PE15.5) )
    8   CONTINUE
      ENDIF
C
C     Load the inlet stream compositions in the S1 and S2 arrays.
C
C     Zero the entire short flow rate and composition arrays for both
C     the inlet and outlet streams.
      DO 12 J = 1, 4
```

```
          DO 10 K = 1, 9
            S1(J,K) = 0.0D0
            S2(J,K) = 0.0D0
            S3(J,K) = 0.0D0
            S4(J,K) = 0.0D0
   10     CONTINUE
   12 CONTINUE
C
C     CF is the conversion factor from Kg/sec to lbs/hr.
      DO 20 J = 1, NCC
        IGOTIT = 0
C       Test for and load the known components.
        DO 15 K = 1, 7
          IF ( J .EQ. ICNUMB(K) )  THEN
            IGOTIT = 1
            S1(1,K) = CF * SIN1(J)
            S1(3,K) = XMW(J) * CF * SIN1(J)
            S2(1,K) = CF * SIN2(J)
            S2(3,K) = XMW(J) * CF * SIN2(J)
          ENDIF
   15   CONTINUE
C       Other components.
        IF ( IGOTIT .LE. 0 )  THEN
          S1(1,8) = S1(1,8) + CF * SIN1(J)
          S1(3,8) = S1(3,8) + XMW(J) * CF * SIN1(J)
          S2(1,8) = S2(1,8) + CF * SIN2(J)
          S2(3,8) = S2(3,8) + XMW(J) * CF * SIN2(J)
        ENDIF
   20 CONTINUE
C
C     Check for any solids in the feed streams, and if found, write a
C     warning message to the History file.  NOTE: Only stream classes
C     CONVENTIONAL, MIXNC OR MIXNCPSD are allowed for the input and
C     and output streams.  All must be of the same stream class.
      IER = 0
      IF ( NSUBS .GE. 2 .AND. ITYPE(2) .EQ. 3 )  THEN
        IF ( NNCC .GE. 1 )  THEN
          K = NCONV + NNCC + 1
          SOLIDS = CF * (SIN1(K) + SIN2(K))
          IF ( SOLIDS .GE. 1.0D0)  THEN
            IER = 1
            IF ( KTEST .LE. 0 )  WRITE (NHSTRY, 701)  IPASS
            WRITE (NHSTRY, 709) SOLIDS
  709       FORMAT (/ 1X, '* WARNING * - One of the inlet streams to ',
     1        'the hydrogen plant' /
     2        2X, 'contains solids, ', F10.1, ' lbs/hr.' /
     3        2X, 'These solids are being ignored.  Please remove ',
     4        ' these solids from the' /
     5        2X, 'feed stream to the hydrogen plant.' )
          ENDIF
        ENDIF
      ENDIF
C
C     Calculate the total moles and weights of the inlet streams.
      S1(1,9) = 0.0D0
```

```
      S1(3,9) = 0.0D0
      S2(1,9) = 0.0D0
      S2(3,9) = 0.0D0
      DO 22 J = 1, 8
        S1(1,9) = S1(1,9) + S1(1,J)
        S1(3,9) = S1(3,9) + S1(3,J)
        S2(1,9) = S2(1,9) + S2(1,J)
        S2(3,9) = S2(3,9) + S2(3,J)
   22 CONTINUE
C     Calculate the compositions of the inlet streams.
      DO 24 J = 1, 8
        S1(2,J) = 100.0D0 *  S1(1,J) / S1(1,9)
        S1(4,J) = 100.0D0 *  S1(3,J) / S1(3,9)
        S2(2,J) = 100.0D0 *  S2(1,J) / S2(1,9)
        S2(4,J) = 100.0D0 *  S2(3,J) / S2(3,9)
   24 CONTINUE
C
C     If requested, write the inlet stream arrays to the history file.
      IF ( KTEST .GE. 2 )  THEN
          S1(2,9) = 0.0D0
          S1(4,9) = 0.0D0
          S2(2,9) = 0.0D0
          S2(4,9) = 0.0D0
        DO 26 J = 1, 8
          S1(2,9) = S1(2,9) + S1(2,J)
          S1(4,9) = S1(4,9) + S1(4,J)
          S2(2,9) = S2(2,9) + S2(2,J)
          S2(4,9) = S2(4,9) + S2(4,J)
   26   CONTINUE
        WRITE (NHSTRY, 710)
  710   FORMAT ( / ' Inlet stream compositions:' //
     1    2X, 'Natural Gas Inlet Stream - The first inlet stream.')
          WRITE (NHSTRY, 711) (S1(1,K), S1(2,K), S1(3,K), S1(4,K),
     1      K = 1, 9)
  711     FORMAT ( 3X, 'Component ', 14X, 'Moles/hr', 6X, 'Mole %',
     1      6X, 'Lbs/hr', 4X, 'Weight %' /
     2      3X, 'Hydrogen         ', F15.2, F12.2, F12.1, F12.2 /
     3      3X, 'Methane          ', F15.2, F12.2, F12.1, F12.2 /
     4      3X, 'Ethane           ', F15.2, F12.2, F12.1, F12.2 /
     5      3X, 'Propane          ', F15.2, F12.2, F12.1, F12.2 /
     6      3X, 'Water            ', F15.2, F12.2, F12.1, F12.2 /
     7      3X, 'Carbon dioxide   ', F15.2, F12.2, F12.1, F12.2 /
     8      3X, 'Carbon monoxide  ', F15.2, F12.2, F12.1, F12.2 /
     9      3X, 'Other components ', F15.2, F12.2, F12.1, F12.2 /
     A      3X, 'Total            ', F15.2, F12.2, F12.1, F12.2 )
        WRITE (NHSTRY, 712)
  712   FORMAT ( / '  Water Inlet Stream - The second inlet stream.')
          WRITE (NHSTRY, 711) (S2(1,K), S2(2,K), S2(3,K), S2(4,K),
     1      K = 1, 9)
      ENDIF
C
C
C     CALCULATIONS PASS SECTION
C     -------------------------
C     Calculation Method:
```

```
C
C     Natural gas, consisting of methane with traces of ethane and
C     and propane, is steam reformed to produce hydrogen and CO2 by
C     the following reactions.
C          CH4  + 2 H2O  ----->  CO2 + 4 H2
C          CH4  +   H2O  ----->  CO  + 3 H2
C          C2H6 + 4 H2O  ----->  2 CO2 + 7 H2
C          C3H8 + 6 H2O  ----->  3 CO2 + 10 H2
C     All ethane and propane are completely reacted with water
C     (hydrolyzed) to produce CO2 and H2.  Methane can react in one
C     of the above two possible ways.   The fraction going in each
C     reaction is specified by the REAL(1) and REAL(2) parameters.
C     The unreacted methane can leave in either the hydrogen-rich
C     gas stream as the only impurity, or in the flue gas stream.
C     The amount of unreacted methane is determined by the difference
C     between the sum of REAL(1) and REAL(2) and 1.0.  The hydrogen
C     recovery specifies the fraction of hydrogen that is produced
C     which leaves in the hydrogen-rich gas stream.  The hydrogen
C     purity, specified in parameter REAL(4), determines the amount
C     of methane which leaves in the hydrogen-rich gas.
C
C     REACTOR CALCULATIONS:
C     Copy the total inlet flow rate into the reactor inlet and
C     outlet streams.
      DO 100 J = 1, 9
        RX(J) = S1(1,J) + S2(1,J)
        PD(J) = RX(J)
  100 CONTINUE
C
C     React all the ethane to CO2 and H2.
      PD(1) = PD(1) + 7.0D0*RX(3)
      PD(5) = PD(5) - 4.0D0*RX(3)
      PD(6) = PD(6) + 2.0D0*RX(3)
      PD(3) = 0.0D0
C     React all the propane to CO2 and H2.
      PD(1) = PD(1) + 10.0D0*RX(4)
      PD(5) = PD(5) - 6.0D0*RX(4)
      PD(6) = PD(6) + 3.0D0*RX(4)
      PD(4) = 0.0D0
C     React some methane to CO2 and H2.
      X = RX(2)*FTOCO2
      PD(1) = PD(1) + 4.0D0*X
      PD(5) = PD(5) - 2.0D0*X
      PD(6) = PD(6) + 1.0D0*X
      PD(2) = PD(2) - X
C     React some methane to CO and H2.
      X = RX(2)*FTOCO
      PD(1) = PD(1) + 3.0D0*X
      PD(5) = PD(5) - 1.0D0*X
      PD(7) = PD(7) + 1.0D0*X
      PD(2) = PD(2) - X
C     Calculate the total moles of product.
      PD(9) = 0.0D0
      DO 110 J = 1, 8
        PD(9) = PD(9) + PD(J)
```

```
  110 CONTINUE
C
C     If requested, write out the reactor component flow rates.
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 721)  (RX(J), PD(J), J = 1, 9)
  721   FORMAT ( / ' Reactor flows in moles/hour:' /
     1      3X, 'Component ', 17X, 'Inlet', 6X, 'Outlet' /
     2      3X, 'Hydrogen          ', F15.2, F12.2 /
     3      3X, 'Methane           ', F15.2, F12.2 /
     4      3X, 'Ethane            ', F15.2, F12.2 /
     5      3X, 'Propane           ', F15.2, F12.2 /
     6      3X, 'Water             ', F15.2, F12.2 /
     7      3X, 'Carbon dioxide    ', F15.2, F12.2 /
     8      3X, 'Carbon monoxide   ', F15.2, F12.2 /
     9      3X, 'Other components ', F15.2, F12.2 /
     A      3X, 'Total             ', F15.2, F12.2 )
      ENDIF
C
C     Set up the outlet stream copositions.
C     Hydrogen.
      S3(1,1) = RECVY * PD(1)
      S4(1,1) = PD(1) - S3(1,1)
C     Methane.
      S3(1,2) = ((100.0 - PURITY)/PURITY) * S3(1,1)
      S4(1,2) = PD(2) - S3(1,2)
C     Other known components.
      DO 40 J = 3, 7
        S3(1,J) = 0.0D0
        S4(1,J) = PD(J)
   40 CONTINUE
C     Unknown components - get from input vectors.
      S3(1,8) = 0.0D0
      S3(3,8) = 0.0D0
      S4(1,8) = S1(1,8) + S2(1,8)
      S4(3,8) = S1(3,8) + S2(3,8)
C     Load the weights of the all the above known components.
      DO 42 J = 1, 7
        K = ICNUMB(J)
        S3(3,J) = XMW(K) * S3(1,J)
        S4(3,J) = XMW(K) * S4(1,J)
   42 CONTINUE
C
C     Check for insufficient water.
      IER1 = 0
      IF ( S4(1,6) .LT. 0.0D0 )  THEN
        IER1 = 1
        H2OM = - S4(1,6)
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 701)  IPASS
        WRITE (NHSTRY, 725)  H2OM
  725   FORMAT ( / ' * WARNING * - Insufficient water has been ',
     1    'supplied to Plant 9.1.' /
     2    1X, F10.1, ' moles/hr more water is needed.  The ',
     3    'calculations will continue assuming' /
     4    3X, 'sufficient water has been supplied, but the plant ',
     5    'will NOT be in mass balance.' )
```

```
          S4(1,6) = 0.0D0
          S4(2,6) = 0.0D0
          S4(3,6) = 0.0D0
          S4(4,6) = 0.0D0
        ENDIF
C
C       Calculate the total moles and weights of the outlet streams.
        S3(1,9) = 0.0D0
        S3(3,9) = 0.0D0
        S4(1,9) = 0.0D0
        S4(3,9) = 0.0D0
        DO 44 J = 1, 8
          S3(1,9) = S3(1,9) + S3(1,J)
          S3(3,9) = S3(3,9) + S3(3,J)
          S4(1,9) = S4(1,9) + S4(1,J)
          S4(3,9) = S4(3,9) + S4(3,J)
   44   CONTINUE
C       Calculate the compositions of the outlet streams.
        DO 46 J = 1, 8
          S3(2,J) = 100.0D0 *  S3(1,J) / S3(1,9)
          S3(4,J) = 100.0D0 *  S3(3,J) / S3(3,9)
          S4(2,J) = 100.0D0 *  S4(1,J) / S4(1,9)
          S4(4,J) = 100.0D0 *  S4(3,J) / S4(3,9)
   46   CONTINUE
C
C       If requested, write the outlet stream arrays to the history file.
        IF ( KTEST .GE. 3 )  THEN
          S3(2,9) = 0.0D0
          S3(4,9) = 0.0D0
          S4(2,9) = 0.0D0
          S4(4,9) = 0.0D0
          DO 48 J = 1, 8
            S3(2,9) = S3(2,9) + S3(2,J)
            S3(4,9) = S3(4,9) + S3(4,J)
            S4(2,9) = S4(2,9) + S4(2,J)
            S4(4,9) = S4(4,9) + S4(4,J)
   48     CONTINUE
          WRITE (NHSTRY, 731)
  731     FORMAT ( // ' Outlet stream compositions:' //
     1      2X, 'Hydrogen Gas Outlet Stream - The first outlet stream.')
          WRITE (NHSTRY, 711) (S3(1,K), S3(2,K), S3(3,K), S3(4,K),
     1      K = 1, 9)
          WRITE (NHSTRY, 732)
  732     FORMAT ( / '  Flue Gas Outlet Stream - The second outlet ',
     1      'stream.')
          WRITE (NHSTRY, 711) (S4(1,K), S4(2,K), S4(3,K), S4(4,K),
     1      K = 1, 9)
        ENDIF
C
C
C       Set up the properties of the product streams.
C       ---------------------------------------------
        IF ( IPASS .NE. 4 )  THEN
C         First, zero all the items in the product stream vectors.
          DO 50 J = 1, ITEMS
```

```
          SOUT1(J) = 0.0D0
          SOUT2(J) = 0.0D0
   50   CONTINUE
C
        DO 340 J = 1, NCC
          IGOTIT = 0
C         Test for and load the known components.
          DO 325 K = 1, 7
            IF ( J .EQ. ICNUMB(K) )  THEN
              IGOTIT = 1
              SOUT1(J) = S3(1,K) / CF
              SOUT2(J) = S4(1,K) / CF
              GO TO 330
            ENDIF
  325     CONTINUE
C         Unknown components.
          IF ( IGOTIT .LE. 0 )  THEN
            SOUT1(J) = 0.0D0
            SOUT2(J) = SIN1(J) + SIN2(J)
          ENDIF
  330     SOUT1(NCC + 1) = SOUT1(NCC + 1) + SOUT1(J)
          SOUT2(NCC + 1) = SOUT2(NCC + 1) + SOUT2(J)
  340   CONTINUE
C
C       Set the default temperature and pressure of the outlet streams
C       to 70 F and 15 PSIA.  Return these values to ASPEN/SP in degrees
C       Kelvin and Pascals.  These default values can be overriden by
C       the FLASH-SPECS sentence in the ASPEN/SP input file.
        SOUT1(NCC+2) = (70.0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT1(NCC+3) = 15.0 * 6.8947573D+3
        SOUT2(NCC+2) = (70.0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT2(NCC+3) = 15.0 * 6.8947573D+3
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)
        CALL CPACK (SOUT2, NCP, IDX, XPACK, TMASS)
        SOUT2(NCC+9) = AVEMW (NCP, IDX, XPACK)
C
C       If requested, write the items of interest in the inlet and
C       outlet stream vectors to the history file.
        IF ( KTEST .GE. 5 )  THEN
          WRITE (NHSTRY, 741)
  741     FORMAT ( // ' The inlet and outlet stream vectors' /
     1      14X, 'SIN1', 11X, 'SIN2', 10X, 'SOUT1', 10X, 'SOUT2' )
          DO 350 J = 1, ITEMS
            WRITE (NHSTRY, 742) J, SIN1(J), SIN2(J), SOUT1(J), SOUT2(J)
  742       FORMAT ( 2X, I5, 4(1PE15.5) )
  350     CONTINUE
        ENDIF
C
      ENDIF
C
```

```
C     Calculate the useable H2 production rate in MM SCF/hr of H2.
      H2PROD = S3(1,1) * 379.495D-6
C
C     If it has not been specified by the user in variable INT(3),
C     calculate the number of operating duplicate trains, excluding
C     spares (NPLNT), based on the total flow rate of the reference
C     stream.  However, if the maximum capacity of a single train
C     has not been specified, set the number of operating trains to 1.
      NPLNT = INT(3)
      IF ( (NPLNT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
         NPLNT = H2PROD  / PMAXF
         IF ( (MOD(H2PROD, PMAXF)) .GT. 0.0D0 )  NPLNT = NPLNT + 1
        ELSE
         IF ( NPLNT .EQ. 0 )   NPLNT = 1
      ENDIF
C
C     Calculate the flow rate of the hydrogen production rate in
C     MM SCF/hr (PFLOW) for each of the individual duplicate trains.
      XPLANT = NPLNT
      PFLOW = H2PROD / XPLANT
C
C
C     If requested, skip writing the stream section of the user model
C     report if this is not the report pass or if the output report
C     control switch, INT(1), has a value of 3 or more.
      IF ( IPASS.EQ.4 .AND. INT(1).LE.2 )   THEN
C
C       STREAM INPUT/OUTPUT REPORT SECTION.
C       Calculate the required stream values for the plant summary
C       report from the inlet and outlet stream vectors, and save them
C       in the Plant Stream Array, PSA(J,K).
C
C       Total flow rate, Mlbs/hr.
        PSA(1,1) = 0.001D0 * S1(3,9)
        PSA(2,1) = 0.001D0 * S2(3,9)
        PSA(3,1) = 0.001D0 * S3(3,9)
        PSA(4,1) = 0.001D0 * S4(3,9)
C       TOTAL INPUT and OUTPUT stream flow rates in Mlbs/hour.
        TFIN =  PSA(1,1) + PSA(2,1)
        TFOUT = PSA(3,1) + PSA(4,1)
C       Total flow rate, MMSCF/hr.
C       Conversion factor, lbs mole/hr -> SCF/hr = 379.495
        PSA(1,2) = S1(1,9) * 379.495D-6
        PSA(3,2) = S3(1,9) * 379.495D-6
        PSA(4,2) = S4(1,9) * 379.495D-6
C       Stream temperature, degrees Fahrenheit.
        PSA(1,3) = SIN1(NCC+2) * 1.8D0 - 459.67D0
        PSA(2,3) = SIN2(NCC+2) * 1.8D0 - 459.67D0
        PSA(3,3) = SOUT1(NCC+2) * 1.8D0 - 459.67D0
        PSA(4,3) = SOUT2(NCC+2) * 1.8D0 - 459.67D0
C       Stream pressure, PSIA.
        PSA(1,4) = SIN1(NCC+3) / 6.8947573D+3
        PSA(2,4) = SIN2(NCC+3) / 6.8947573D+3
        PSA(3,4) = SOUT1(NCC+3) / 6.8947573D+3
        PSA(4,4) = SOUT2(NCC+3) / 6.8947573D+3
```

```
C       Water flow rate, Mlbs/hr.
C       Conversion factor, 1 gal = 8.32817 lbs. of water.
        PSA(2,5) = (S2(3,9) / 8.32817D0) * .001D0
C
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 this user block report.
            LSTRM = 26
            LUTIL = 16
            LCOST = 11
            IF ( IER .GE. 1 )  LSTRM = LSTRM + 4
            IF ( IER1 .GE. 1 )  LSTRM = LSTRM + 4
            NDUP = REAL(58) + 0.001D0
            IF ( (NPLNT + NDUP) .EQ. 1 )  LCOST = 9
            IF ( PFLOW .LT. PMINF )  LCOST = LCOST + 3
            IF ( PFLOW .GT .PMAXF )  LCOST = LCOST + 3
            IF ( NDUP .GE. 1 )  LCOST = LCOST + 1
            LINES = LSTRM + LUTIL + LCOST
C           Now, subtract the number of lines for those portions of
C           the user block summary report which will not be written.
            IF ( INT(1) .GE. 2 )   LINES = LINES - LUTIL
            IF ( INT(1) .GE. 1 )   LINES = LINES - LCOST
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 DCL91.REP to contain
C           this user block summary report.
            OPEN (UNIT=62, FILE='DCL91.REP', STATUS='UNKNOWN',
     1        ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2        BUFFERED='BUFFERED')
            WRITE (NOUT, 800)
C           FORMAT statement 800 will print across a page because it
C           contains the PC top-of-form character (ASCII character 012)
C           between two quote marks ( i.e., 'TOF').
  800       FORMAT ( 'TOF' )
        ENDIF
C
C       Write the component mass balance.
        WRITE (NOUT, 801)
  801   FORMAT (/ 27X, 'PLANT 9.1 - SUMMARY REPORT' /
     1    13X, 'HYDROGEN PRODUCTION BY STEAM REFORMING OF NATURAL GAS')
        WRITE (NOUT, 802) H2PROD
  802   FORMAT (// ' HYDROGEN PRODUCTION RATE, MM SCF/HR OF H2', F10.3)
C
C       Write the Inlet and Outlet stream flow rates.
        WRITE (NOUT, 803)
  803   FORMAT (// 'INLET AND OUTLET STREAMS:' / 34X, 'INLET',
     1    21X, 'OUTLET' / 25X, 'NATURAL GAS', 5X, 'WATER', 8X,
     2    'HYDROGEN', 2X, 'FLUE GAS' / 'FLOW RATES')
        WRITE (NOUT, 804) PSA(1,1), PSA(2,1), PSA(3,1), PSA(4,1)
```

```
  804   FORMAT ( 2X, 'MLBS/HR  ', 14X, F11.3, F10.3, 6X, 2F10.3)
        WRITE (NOUT, 805) PSA(1,2), PSA(3,2), PSA(4,2)
  805   FORMAT ( 2X, 'MM SCF/HR', 14X, F11.3, 16X, 2F10.3)
        WRITE (NOUT, 806) PSA(2,5)
  806   FORMAT ( 2X, 'MGAL/HR   ', 23X, F11.3)
C
C       Write the Inlet and Outlet stream compositions in mole%.
        WRITE (NOUT, 807)
  807   FORMAT (/ 'COMPOSITION, MOLE%' )
        WRITE (NOUT, 808) (S1(2,K), S2(2,K), S3(2,K), S4(2,K),
     1    K = 1, 9)
  808     FORMAT ( 2X, 'HYDROGEN      ', 10X, 2F10.2, 6X, 2F10.2 /
     1      2X, 'METHANE       ', 10X, 2F10.2, 6X, 2F10.2 /
     2      2X, 'ETHANE        ', 10X, 2F10.2, 6X, 2F10.2 /
     3      2X, 'PROPANE       ', 10X, 2F10.2, 6X, 2F10.2 /
     4      2X, 'WATER         ', 10X, 2F10.2, 6X, 2F10.2 /
     5      2X, 'CARBON DIOXIDE', 10X, 2F10.2, 6X, 2F10.2 /
     5      2X, 'CARBON MONOXIDE', 9X, 2F10.2, 6X, 2F10.2 /
     6      2X, 'OTHER COMPONENTS', 8X, 2F10.2, 6X, 2F10.2 /
     7      2X, 'TOTAL         ', 10X, 2F10.2, 6X, 2F10.2 )
C
        IF ( IER .GE. 1 )  WRITE (NOUT, 810)
  810     FORMAT (/ 1X, '*WARNING* ONE OF THE FEED STREAMS TO THE ',
     1      'HYDROGEN PLANT' /
     2      2X, 'CONTAINS SOLIDS.  THESE SOLIDS ARE BEING IGNORED.  ',
     3      'PLEASE REMOVE' /
     4      2X, 'THESE SOLIDS FROM THE FEED STREAM TO THE HYDROGEN ',
     5      'PLANT.' )
C
        IF ( IER1 .GE. 1 )  WRITE (NOUT, 811)
  811     FORMAT (/ 1X, '*WARNING* INSUFFICIENT WATER HAS BEEN ',
     1      'SUPPLIED TO THIS PLANT.' /
     2      2X, 'A SUFFICIENT AMOUNT OF WATER HAS BEEN ASSUMED.  ',
     3      'THE PLANT IS' /
     4      2X, 'NOT IN MASS BALANCE.  SEE THE HISTORY FILE FOR ',
     5      'MORE INFORMATION.' )
      ENDIF
C
C     Call subroutine USRUCO to calculate, save and report the
C     utilities, capital and operation costs for the plant.
      ID = 12
      KUNITS = 5
      CALL USRUCO (NHSTRY, NOUT, IPASS, ID, PNAME, INT(1), INT(3),
     1  KTEST, REAL(21), H2PROD, KUNITS )
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, 730)
  730 FORMAT ( / ' Leaving subroutine USR91' )
C
      RETURN
      END
```

```
C
C$  Subroutine USR10
C
C     This file contains the following subroutine:
C       USR10    Main routine for Plant 10 - Air Separation Plant
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 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       GETSTR   Subroutine for finding the stream bead information.
C
C$ USR10
      SUBROUTINE USR10 (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:  USR10
C
C  BLOCK DESCRIPTION:   DOE Air Separation Plant Fortran Block Model
C
C                     ---------------------
C                     |                   |
C                     |      Plant 10     |------> Oxygen
C                     |                   |
C            Air ---->|   Air Separation  |
C                     |       Plant       |------> Nitrogen
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 - May 29, 1992.
C
C  ASSUMPTIONS, SPECIAL FEATURES AND LIMITATIONS:
C     1.  The single inlet air stream to this air separation plant
C         must contain the following two components, O2 and N2.
C     2.  Variable KO2 is the relative component number of O2.
C     3.  Variable KN2 is the relative component number of N2.
C     4.  Outlet stream 1 is the oxygen stream of purity REAL(1).
C     5.  Outlet stream 2 is the nitrogen stream of purity REAL(2).
C     6.  Important variables:
C         FOO =  Molar flow rate of oxygen in the oxygen stream.
C         FON =  Molar flow rate of nitrogen in the oxygen stream.
C         FNO =  Molar flow rate of oxygen in the nitrogen stream.
C         FNN =  Molar flow rate of nitrogen in the nitrogen stream.
C         KO2 =  Internal component number of oxygen.
C         KN2 =  Internal component number of nitrogen.
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 DCL10.REP.
C          INT(3)  = Number of operating duplicate trains, excluding
C                    spares.
C                    If INT(3) = 0, the minimun number of duplicate
C                      trains will be determined so that the capacity
C                      each train does not exceed the maximum train
C                      capacity specified by variable REAL(52).
C                    If INT(3) > 0, this number of duplicate trains will
C                      be used.
C          INT(4)  = History file additional output control switch.
C                    0 => Write no additional output to the history 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     8.  The 70 real parameters are:
C         REAL(1)   = Purity of the product oxygen stream, mole %.
C         REAL(2)   = Purity of the product nitrogen stream, mole %.
C         REAL(3) -
C          REAL(20) = Future use.
C         REAL(21)  = Constant factor for the power consumption, kw.
C         REAL(22)  = Power consumption per MM SCF/hr of the oxygen
C                     stream flow rate, kw/(MM SCF/hr of O2).
C         REAL(23)  = Constant factor for the 900 psig / 750 F steam
C                     consumption, Mlbs/hr.
C         REAL(24)  = 900 psig / 750 F  steam consumption per MM SCF/hr
C                     of the oxygen stream flow rate,
C                     (Mlbs/hr)/(MM SCF/hr of O2).
C         REAL(25)  = Constant factor for the 900 psig saturated steam
C                     consumption, Mlbs/hr.
C         REAL(26)  = 900 psig saturated steam consumption per MM SCF/hr
C                     of the oxygen stream flow rate,
C                     (Mlbs/hr)/(MM SCF/hr of O2).
C         REAL(27)  = Constant factor for the 600 psig / 720 F steam
C                     consumption, Mlbs/hr.
C         REAL(28)  = 600 psig / 720 F  steam consumption per MM SCF/hr
C                     of the oxygen stream flow rate,
C                     (Mlbs/hr)/(MM SCF/hr of O2).
C         REAL(29)  = Constant factor for the 600 psig saturated steam
```

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

```
C   NOTE: MM SCF/hr of O2 means the oxygen production rate in
C         MM SCF/hr of oxygen in the product oxygen stream and NOT
C         NOT the total flow rate of the product oxygen stream.
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
      COMMON /USRC01/ PLNTID(32), UTIL(32,15), CAPCST(32,7), OPCST(32,5)
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
C
C     Local variable declaration statements.
      DIMENSION PSA(3,10)
C     PSA(J,K) is the Plant Stream Array, where
C       J = Stream number identifier
C           1 => The inlet air stream
C           2 => The product oxygen stream
C           3 => The product nitrogen stream
C       K = Stream property identifier
C           1 => Flow rate, lb-moles/hr
C           2 => Flow rate, MM SCF/hr
C           3 => Flow rate, Mlbs/hr
C           4 => Stream temperature, degrees Fahrenheit
C           5 => Stream pressure, PSIA
C           6 => Stream oxygen concentration, wt%
C           7 => Stream nitrogen concentration, wt%
C           8 => Stream oxygen concentration, mol% or vol%
C           9 => Stream nitrogen concentration, mol% or vol%
C           10 => Future use
C
      DIMENSION ICN(2), ICNAME(4), ICNUMB(4)
C
      CHARACTER * 4  ICN, ICNAME
      CHARACTER * 6  PLNTID, PNAME
C
C     Initialize the component identification of N2 and O2.
```

```
      DATA ICNAME / 'N2  ', '    ', 'O2  ', '    ' /
C
      DATA PNAME / '10    ' /
C
C
C     PARAMETER INITIALIZATION SECTION
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)
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 10 - Supplementary data from subroutine',
     1    ' USR10' /
     2    2X, 'The Air Separation Plant', 10X, 'IPASS =', I3 )
      ENDIF
C
C     Check to insure that there is exactly 1 inlet stream, and if not,
C     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 air separation plant ',
     1    'requires only 1 single 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 are exactly 2 outlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSOUT .NE. 2 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 503)  NSOUT
  503   FORMAT ( / 1X, '* ERROR * - The air separation plant ',
     1    'requires exactly 2 outlet streams.' /
     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     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 = 1
C
      IER = 0
      IF ( NSUBS .GE. 2 .AND. ITYPE(2) .EQ. 3 )  THEN
```

```
        KLASS = 2
        IF ( NNCC .GE. 1 )  THEN
          K = NCC + 9 + NNCC + 1
C         CF is the conversion factor from Kg/sec to lbs/hr.
          CF = 3600.0D0 / 0.45359237D0
          SOLIDS = CF * SIN1(K)
          IF ( SOLIDS .GE. 1.0D0)  THEN
            IER = 1
            IF ( KTEST .LE. 0 )  WRITE (NHSTRY, 501)  IPASS
            WRITE (NHSTRY, 504) SOLIDS
  504       FORMAT (/ 1X, '* WARNING * The feed stream to the ',
     1        'air separation plant' /
     2        3X, 'contains solids, ', F10.1, ' lbs/hr.' /
     3        3X, 'These solids are being ignored.  Please remove ',
     4        'these solids from the' /
     5        3X, 'feed stream to the air separation plant.' )
            ENDIF
          ENDIF
      ENDIF
C
C     Check for a substream PSD attribute on the second substream of the
C     first inlet stream.
      NUMPSD = 0
      IF ( KLASS .EQ. 2 )  THEN
        CALL GETSTR (IDS(1,4), NB, LB, NBD, LBD)
        NUMATT = NPAT (LBD, 2)
        IF ( NUMATT .GT. 0 )   THEN
          NUMPSD = NAVAR (LBD, 2, 1)
          KLASS = 3
        ENDIF
      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
      IF ( KLASS .GE. 2 )  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
      FLOWIN = CF * SIN1(NCC+1)*SIN1(NCC+9)
C
      IF ( FLOWIN .LE. 0.09D0 )   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 plant 10, the ',
```

```
     1    'air separation plant.' )
        GO TO 999
C       ---------
      ENDIF
C
C     Find the relative component numbers of N2 and O2, and load them
C     in variables KN2 and KO2.
      DO 20 J = 1, 2
        K = 2 * J - 1
        ICN(1) = ICNAME(K)
        ICN(2) = ICNAME(K+1)
        CALL USRCCN (ICN, ICNUMB(J))
        IF ( ICNUMB(J) .EQ. 0 ) THEN
          IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501) IPASS
          WRITE (NHSTRY, 506)  ICN(1), ICN(2)
  506     FORMAT ( / 1X, '* ERROR * - The following component is ',
     1      'missing from your component list' / 5X, 2A4 /
     2      3X, 'The air separation plant requires this component.  ',
     3      'Please add it to your' /
     4      3X, 'component list and try again.' //
     5      3X, 'EXECUTION IS BEING TERMINATED.' / )
          STOP
        ENDIF
   20 CONTINUE
      KN2   = ICNUMB(1)
      KO2   = ICNUMB(2)
C
C
C     INPUT SECTION
C     -------------
C     Set purity of the product oxygen stream in mole% or vol%.
      PURTYO = REAL(1)
C     Set purity of the product nitrogen stream in mole% or vol%.
      PURTYN = REAL(2)
C     Set up the maximum and minimum train flow rates in MM SCF/hour
C     of oxygen.
      PMAXF = REAL(52)
      PMINF = REAL(53)
C
C     Check the validity of the supplied purity of the product oxygen
C     stream, and if it is invalid, set it to 97.0% and write a
C     warning message.
      IER2 = 0
      IF ( PURTYO .LE. 20.9D0 .OR. PURTYO .GE. 100.0D0 )  THEN
        IER2 = 1
        IF ( KTEST .LE. 0 )  WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 507)  PURTYO
  507   FORMAT (/ 1X, '* WARNING * The specified purity of the ',
     1    'product oxygen stream of', F7.2, ' vol%' /
     2    3X, 'is invalid.  It is being set to 99.5 vol%.  Execution ',
     3    'is continuing.' / )
        PURTYO = 99.5D0
      ENDIF
C
C     Check the validity of the supplied purity of the product nitrogen
```

```
C     stream, and if it is invalid, set it to 99.9% and write a
C     warning message.
      IER3 = 0
      IF ( PURTYN .LE. 79.1D0 .OR. PURTYN .GT. 100.0D0 )  THEN
        IER3 = 1
        IF ( KTEST .LE. 0 )  WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 508)  PURTYN
  508   FORMAT (/ 1X, '* WARNING * The specified purity of the ',
     1    'product nitrogen stream of', F7.2, ' vol%'  /
     2    3X, 'is invalid.  It is being set to 99.9 vol%.  Execution ',
     3    'is continuing.' / )
        PURTYN = 99.9D0
      ENDIF
C
C     If requested, write the items of interest in the inlet coal
C     stream vector to the history file.
      IF ( KTEST .GE. 5 )  THEN
        WRITE (NHSTRY, 511)
  511   FORMAT ( / '  The inlet stream vector:'/
     1    3X, 'Item', 10X, 'SIN1' )
        DO 40 J = 1, ITEMS
          WRITE (NHSTRY, 512) J, SIN1(J)
  512     FORMAT ( 1X, I6, 3X, 1PE15.5 )
   40   CONTINUE
      ENDIF
C
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 components in the inlet air stream.
      OTHERS = 0.0D0
      DO 50 J = 1, NCC
        IF ( J .EQ. KO2 )  THEN
C         Set FAIRO to the molar flow rate of oxygen in the inlet air
C         stream.
          FAIRO = SIN1(KO2)
          GO TO 50
        ENDIF
        IF ( J .EQ. KN2 )  THEN
C         Set FAIRN to the molar flow rate of nitrogen in the inlet air
C         stream.
          FAIRN = SIN1(KN2)
          GO TO 50
        ENDIF
        OTHERS = OTHERS + SIN1(J) * CF * XMW(J)
   50 CONTINUE
C
C     Check to see if any other conventional components are in the
C     inlet air stream, and if so, write a warning message.
      IER1 = 0
      IF ( OTHERS .GE. 1.0D0)  THEN
        IER1 = 1
        IF ( KTEST .LE. 0 )  WRITE (NHSTRY, 501)  IPASS
```

```
      WRITE (NHSTRY, 509)  OTHERS
509   FORMAT (/ 1X, '* WARNING * The feed stream to the ',
     1   'air separation plant' /
     2   3X, 'contains components other than oxygen and nitrogen,',
     4   F10.1, ' lbs/hr.' /
     5   3X, 'These components are being ignored.  Please remove ',
     6   'them from the' /
     7   3X, 'feed stream to the air separation plant.' / )
      ENDIF
C
C
C     CALCULATIONS PASS SECTION
C     -------------------------
C     From a basic material balance around the oxygen plant;
C     Calculate the molar oxygen flow rate in the product oxygen
C     stream.
      X1 = (100.0D0 - PURTYO) / PURTYO
      FOO = (100.0D0*FAIRN - PURTYN*(FAIRO+FAIRN)) /
     1      (100.0D0*X1 - PURTYN*(1.0D0+X1))
C
C     Calculate the molar nitrogen flow rate in the product
C     oxygen stream.
      FON = ((100.0D0 * FOO) - (PURTYO * FOO)) / PURTYO
C
C     Calculate the molar oxygen flow rate in the product nitrogen
C     stream.
      FNO = FAIRO - FOO
C
C     Calculate the molar nitrogen flow rate in the product nitrogen
C     stream.
      FNN = FAIRN - FON
C
C     Calculate the useable oxygen production rate in MM SCF/hr.
      O2PROD = CF * FOO * 379.495D-6
C
C     If it has not been specified by the user in variable INT(3),
C     calculate the number of operating duplicate trains, excluding
C     spares (NPLNT), based on the total inlet gas flow rate in
C     Mlbs/hour.  However, if the maximum capacity of a single train
C     has not been specified, set the number of operating trains to 1.
      NPLNT = INT(3)
      IF ( (NPLNT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
         NPLNT = O2PROD  / PMAXF
         IF ( (MOD(O2PROD, PMAXF)) .GT. 0.0D0 )  NPLNT = NPLNT + 1
        ELSE
         IF ( NPLNT .EQ. 0 )   NPLNT = 1
      ENDIF
C
C     Calculate the useable oxygen flow rate in the oxygen rich
C     product gas stream in MM SCF/hr (PFLOW) for each of the
C     individual duplicate trains.
      XPLANT = NPLNT
      PFLOW = O2PROD / XPLANT
C
C     Set up the properties of the product streams.
```

```
C     ---------------------------------------------
      IF ( IPASS .NE. 4 )   THEN
C       First, zero all the items in the product streams.
        DO 100 J = 1, ITEMS
          SOUT1(J) = 0.0D0
          SOUT2(J) = 0.0D0
  100   CONTINUE
C
C       Set the non-zero component flow rates in the product streams to
C       their calculated values.
        SOUT1(KO2) = FOO
        SOUT1(KN2) = FON
        SOUT2(KO2) = FNO
        SOUT2(KN2) = FNN
C
C       Calculate the total molar flow rates of the product streams.
        SOUT1(NCC+1) = 0.0D0
        SOUT2(NCC+1) = 0.0D0
        DO 410 J = 1, NCC
          SOUT1(NCC+1) = SOUT1(NCC+1) + SOUT1(J)
          SOUT2(NCC+1) = SOUT2(NCC+1) + SOUT2(J)
  410   CONTINUE
C
C       Set the default temperature and pressure of the outlet streams
C       to 70 F and 15 PSIA.  Return these values to ASPEN/SP in degrees
C       Kelvin and Pascals.  These default values can be overiden by the
C       FLASH-SPECS sentence in the ASPEN/SP input file.
        SOUT1(NCC+2) = (70.0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT1(NCC+3) = 15.0 * 6.8947573D+3
        SOUT2(NCC+2) = (70.0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT2(NCC+3) = 15.0 * 6.8947573D+3
C
C       Call subroutine CPACK and funcion AVEMW to calculate the
C       average molecular weight of the two product streams.
        CALL CPACK (SOUT1, NCP, IDX, XPACK, TMASS)
        SOUT1(NCC+9) = AVEMW (NCP, IDX, XPACK)
        CALL CPACK (SOUT2, NCP, IDX, XPACK, TMASS)
        SOUT2(NCC+9) = AVEMW (NCP, IDX, XPACK)
C
C       If requested, write the items of interest in the outlet stream
C       vectors to the history file.
        IF ( KTEST .GE. 5 )  THEN
          WRITE (NHSTRY, 531)
  531     FORMAT ( / ' The outlet stream vectors' /
     1      14X, 'SOUT1', 10X, 'SOUT2' )
          DO 240 J = 1, ITEMS
            WRITE (NHSTRY, 532) J, SOUT1(J), SOUT2(J)
  532       FORMAT ( 2X, I5, 2(1PE15.5) )
  240     CONTINUE
        ENDIF
C
      ENDIF
C
C
C     Skip writing the entire user model report if the ouput report
```

```
C     control switch, INT(1), has a value of 3 or more.
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 2 )   THEN
C
C       STREAM INPUT/OUTPUT REPORT SECTION.
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 this user block report.
            LSTRM = 28
            LUTIL = 16
            LCOST = 11
            IF ( IER .GE. 1 )  LSTRM = LSTRM + 4
            IF ( IER1 .GE. 1 )  LSTRM = LSTRM + 4
            IF ( IER2 .GE. 1 )  LSTRM = LSTRM + 3
            IF ( IER3 .GE. 1 )  LSTRM = LSTRM + 3
            NDUP = REAL(58) + 0.001D0
            IF ( (NPLNT + NDUP) .EQ. 1 )  LCOST = 9
            IF ( PFLOW .LT. PMINF )  LCOST = LCOST + 3
            IF ( PFLOW .GT .PMAXF )  LCOST = LCOST + 3
            IF ( NDUP .GE. 1 )  LCOST = LCOST + 1
            LINES = LSTRM + LUTIL + LCOST
C           Now, subtract the number of lines for those portions of
C           the user block summary report which will not be written.
            IF ( INT(1) .GE. 2 )   LINES = LINES - LUTIL
            IF ( INT(1) .GE. 1 )   LINES = LINES - LCOST
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 DCL10.REP to contain
C           this user block summary report.
            OPEN (UNIT=62, FILE='DCL10.REP', STATUS='UNKNOWN',
     1        ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2        BUFFERED='BUFFERED')
            WRITE (NOUT, 800)
C           FORMAT statement 800 will print across a page because it
C           contains the PC top-of-form character (ASCII character 012)
C           between two quote marks ( i.e., 'TOF').
  800       FORMAT ( 'TOF' )
        ENDIF
C
C       Calculate the required stream values for the plant summary
C       report from the inlet and outlet stream vectors, and save them
C       in the Plant Stream Array, PSA(J,K).
C       Flow rate in lb-moles/hour.
        PSA(1,1) = SIN1(NCC+1) * CF
        PSA(2,1) = SOUT1(NCC+1) * CF
        PSA(3,1) = SOUT2(NCC+1) * CF
C       Flow rate in MM SCF/hour.
        PSA(1,2) = PSA(1,1) * 379.495D-6
        PSA(2,2) = PSA(2,1) * 379.495D-6
        PSA(3,2) = PSA(3,1) * 379.495D-6
```

```
C       Flow rate in Mlbs/hour.
        PSA(1,3) = 0.001D0 * PSA(1,1) * SIN1(NCC+9)
        PSA(2,3) = 0.001D0 * PSA(2,1) * SOUT1(NCC+9)
        PSA(3,3) = 0.001D0 * PSA(3,1) * SOUT2(NCC+9)
C       TOTAL INPUT and OUTPUT stream flow rates in Mlbs/hour.
        TFIN =  PSA(1,3)
        TFOUT = PSA(2,3) + PSA(3,3)
C       Stream temperature, degrees Fahrenheit.
        PSA(1,4) = SIN1(NCC+2) * 1.8D0 - 459.67D0
        PSA(2,4) = SOUT1(NCC+2) * 1.8D0 - 459.67D0
        PSA(3,4) = SOUT2(NCC+2) * 1.8D0 - 459.67D0
C       Stream pressure, PSIA.
        PSA(1,5) = SIN1(NCC+3) / 6.8947573D+3
        PSA(2,5) = SOUT1(NCC+3) / 6.8947573D+3
        PSA(3,5) = SOUT2(NCC+3) / 6.8947573D+3
C       Oxygen concentration, wt%.
        PSA(1,6) = SIN1(KO2) * XMW(KO2) * 100.0D0 /
     1    (SIN1(NCC+1) * SIN1(NCC+9))
        PSA(2,6) = SOUT1(KO2) * XMW(KO2) * 100.0D0 /
     1    (SOUT1(NCC+1) * SOUT1(NCC+9))
        PSA(3,6) = SOUT2(KO2) * XMW(KO2) * 100.0D0 /
     1    (SOUT2(NCC+1) * SOUT2(NCC+9))
C       Nitrogen concentration, wt%.
        PSA(1,7) = SIN1(KN2) * XMW(KN2) * 100.0D0 /
     1    (SIN1(NCC+1) * SIN1(NCC+9))
        PSA(2,7) = SOUT1(KN2) * XMW(KN2) * 100.0D0 /
     1    (SOUT1(NCC+1) * SOUT1(NCC+9))
        PSA(3,7) = SOUT2(KN2) * XMW(KN2) * 100.0D0 /
     1    (SOUT2(NCC+1) * SOUT2(NCC+9))
C       Oxygen concentration, mol%.
        PSA(1,8) = SIN1(KO2) * 100.0D0 / SIN1(NCC+1)
        PSA(2,8) = SOUT1(KO2) * 100.0D0 / SOUT1(NCC+1)
        PSA(3,8) = SOUT2(KO2) * 100.0D0 / SOUT2(NCC+1)
C       Nitrogen concentration, mol%.
        PSA(1,9) = SIN1(KN2) * 100.0D0 / SIN1(NCC+1)
        PSA(2,9) = SOUT1(KN2) * 100.0D0 / SOUT1(NCC+1)
        PSA(3,9) = SOUT2(KN2) * 100.0D0 / SOUT2(NCC+1)
C
C       Write the stream input/output section of the Plant Summary
C       Report for the Air Separation Plant.
        WRITE (NOUT, 801)
  801   FORMAT ( / 27X, 'PLANT 10 - SUMMARY REPORT' /
     1    29X, 'AIR SEPARATION PLANT' //
     2    28X, 'SIMPLIFIED BLOCK MODEL' )
C
        WRITE (NOUT, 802) O2PROD, TFIN, TFOUT
  802   FORMAT ( / 1X, 'OXYGEN PRODUCTION RATE, MM SCF/HR OF O2',
     1    F9.3 //
     2    1X, 'TOTAL INPUT, MLBS/HR        ', F19.3 /
     3    1X, 'TOTAL OUTPUT, MLBS/HR       ', F19.3 )
C
        WRITE (NOUT, 803)
  803   FORMAT ( / 1X, 'STREAM SUMMARY', 13X, 'INLET', 16X, 'OUTLET' /
     1    28X, '-----', 7X, '----------------------' /
     2    30X, 'AIR', 9X, 'OXYGEN', 7X, 'NITROGEN' )
```

```
C
      WRITE (NOUT, 804) ((PSA(J,K), J = 1, 3), K = 1, 5)
 804  FORMAT ( / 1X, 'FLOW, LB MOLES/HR', 3F15.1 /
    1   1X, 'FLOW, MM SCF/HR  ', 3F15.3 /
    2   1X, 'FLOW, MLBS/HR    ', 3F15.3 /
    3   1X, 'TEMPERATURE, F   ', 3F15.1 /
    4   1X, 'PRESSURE, PSIA   ', 3F15.1 )
C
      WRITE (NOUT, 805) ((PSA(J,K), J = 1, 3), K = 6, 7)
 805  FORMAT ( / 1X, 'COMPOSITION, WT%' /
    1   2X, 'OXYGEN          ', 3F15.2 /
    2   2X, 'NITROGEN        ', 3F15.2 )
C
      WRITE (NOUT, 806) ((PSA(J,K), J = 1, 3), K = 8, 9)
 806  FORMAT ( / 1X, 'COMPOSITION, MOL% OR VOL%' /
    1   2X, 'OXYGEN          ', 3F15.2 /
    2   2X, 'NITROGEN        ', 3F15.2 )
C
      IF ( IER .GE. 1 )  WRITE (NOUT, 810)
 810    FORMAT (/ 1X, '*WARNING* THE FEED STREAM TO THE AIR ',
    1     'SEPARATION PLANT' /
    2     2X, 'CONTAINS SOLIDS.  THESE SOLIDS ARE BEING IGNORED.  ',
    3     'PLEASE REMOVE' /
    4     2X, 'THESE SOLIDS FROM THE FEED STREAM TO THE AIR ',
    5     'SEPARATION PLANT.' )
C
      IF ( IER1 .GE. 1 )  WRITE (NOUT, 811)
 811    FORMAT (/ 1X, '*WARNING* THE FEED STREAM TO THE AIR ',
    1     'SEPARATION PLANT CONTAINS' /
    2     2X, 'COMPONENTS OTHER THAN O2 AND N2. ',
    3     'THEY ARE BEING IGNORED.' /
    4     2X, 'PLEASE REMOVE THESE COMPONENTS FROM THE ',
    5     'FEED STREAM.' )
C
      IF ( IER2 .GE. 1 )  WRITE (NOUT, 812)
 812    FORMAT (/ 1X, '*WARNING* THE SPECIFIED PURITY OF THE ',
    1     'PRODUCT OXYGEN STREAM' /
    2     2X, 'WAS INVALID.  IT HAS BEEN RESET TO 97.0 VOL%.' )
C
      IF ( IER3 .GE. 1 )  WRITE (NOUT, 813)
 813    FORMAT (/ 1X, '*WARNING* THE SPECIFIED PURITY OF THE ',
    1     'PRODUCT NITROGEN STREAM' /
    2     2X, 'WAS INVALID.  IT HAS BEEN RESET TO 99.5 VOL%.' )
C
    ENDIF
C
C   Call subroutine USRUCO to calculate, save and report the
C   utilities, capital and operating costs for the plant.
    ID = 13
    IF ( FLOWIN .GE. 2.0D0 )   THEN
       KUNITS = 6
       CALL USRUCO (NHSTRY, NOUT, IPASS, ID, PNAME, INT(1),
    1    INT(3), KTEST, REAL(21), O2PROD, KUNITS)
      ELSE
       PLNTID(ID) = '      '
```

```
          CAPCST(ID,1) = 1.
          CAPCST(ID,2) = 0.
          CAPCST(ID,3) = 0.
          CAPCST(ID,4) = 0.
          CAPCST(ID,5) = 0.
          CAPCST(ID,6) = 0.
          OPCST(ID,1) = 0.
      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 USR10' )
C
      RETURN
      END
C
C$  Subroutine USR11
C
C     This file contains the following subroutine:
C       USR11    Main routine for Plant 11 - The Recovery Sulfur Plant.
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 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       GETSTR   Subroutine for finding the stream bead information.
C
C
C$ USR11
      SUBROUTINE USR11 (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:  USR11
C
C  BLOCK DESCRIPTION:  DOE Sulfur Plant Fortran Block Model
C
C                      ---------------------
C                      |                   |
C                      |      Plant 11     |-----> Flue Gas
C       Feed Gas ---->|                   |
C                      |      Sulfur       |-----> Liquid Sulfur
C                      |   Recovery Plant  |
C                      |                   |
C                      ---------------------
C
C     This is a Claus type suflur plant followed by a Scott tail gas
C     unit and an incinerator.  With respect to sulfur, the net
C     chemical reaction is
```

```
C             2 H2S + O2 ---> 2 S + 2 H2O
C
C  Prepared under DOE contract no. DE-AC22 90PC89857.
C
C  FUNCTION (MODEL, REPORT, OR BOTH):  Both
C
C  Last revision - May 29, 1992.
C
C  ASSUMPTIONS, SPECIAL FEATURES AND LIMITATIONS:
C     1.  Required non-ASPEN/SP subroutines: NSQCC.
C     2.  The single inlet stream is:      Feed gas
C     3.  The two outlet streams are:  1.  Flue Gas
C                                      2.  Liquid Sulfur
C     4.  This user block model will work with any number of
C         conventional and non-conventional components.  It will
C         automatically find the relative component numbers of H2, H2S,
C         COS, L-SULFUR (liquid sulfur), and CO.  These component
C         names must be in the component list of the problem.
C     5.  All other components in the feed stream other than the sulfur
C         that is recovered from the H2S and COS sulfur leave in the
C         flue gas stream.  All entering L-SULFUR (liquid sulfur)
C         is assumed to be recovered and any sulfur recovered from the
C         H2S and COS leaves in the liquid product stream.  Since the
C         oxidation reactions are not considered, for mass balance
C         purposes, the hydrogen in the entering H2S leaves in the flue
C         gas stream as H2, and the carbon and oxygen in the COS leaves
C         in the flue gas stream as CO.
C     6.  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 DCL11.REP.
C         INT(3)  = Number of operating duplicate trains, excluding
C                   spares.
C                   If INT(3) = 0, the minimun number of duplicate
C                     trains will be determined so that the capacity
C                     each train does not exceed the maximum train
C                     capacity specified by variable REAL(52).
C                   If INT(3) > 0, this number of duplicate trains will
C                     be used.
C         INT(4)  = History file additional output control switch.
C                   0 => Write no additional output to the history 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     7.  The 70 real parameters are:
C         REAL(1)    = Fractional sulfur recovery; fraction of sulfur in
C                      the entering H2S and COS that is recovered in the
C                      product liquid sulfur stream.  All entering liquid
C                      sulfur entering in the feed stream is assumed to
C                      be recovered in the liquid sulfur product stream.
C         REAL(2) -
C          REAL(20) = Future use.
C         REAL(21)   = Constant factor for the power consumption, kw.
C         REAL(22)   = Power consumption per Mlbs/hour of product sulfur,
C                      kw/(Mlbs/hr).
C         REAL(23)   = Constant factor for the 900 psig / 750 F steam
C                      consumption, Mlbs/hr.
C         REAL(24)   = 900 psig / 750 F  steam consumption per Mlbs/hr
C                      of product sulfur, Mlbs/(Mlbs/hr).
C         REAL(25)   = Constant factor for the 900 psig saturated steam
C                      consumption, Mlbs/hr.
C         REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr
C                      of product sulfur, Mlbs/(Mlbs/hr).
C         REAL(27)   = Constant factor for the 600 psig / 720 F steam
C                      consumption, Mlbs/hr.
C         REAL(28)   = 600 psig / 720 F  steam consumption per Mlbs/hr
C                      of product sulfur, Mlbs/(Mlbs/hr).
C         REAL(29)   = Constant factor for the 600 psig saturated steam
C                      consumption, Mlbs/hr.
C         REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr
C                      of product sulfur, Mlbs/(Mlbs/hr).
C         REAL(31)   = Constant factor for the 150 psig saturated steam
C                      consumption, Mlbs/hr.
C         REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr
C                      of product sulfur, Mlbs/(Mlbs/hr).
C         REAL(33)   = Constant factor for the 50 psig saturated steam
C                      consumption, Mlbs/hr.
C         REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr
C                      of product sulfur, Mlbs/(Mlbs/hr).
C         REAL(35)   = Constant factor for the plant fuel consumption,
C                      MM BTU/hr.
C         REAL(36)   = Plant fuel consumption per Mlbs/hr of product
C                      sulfur, (MM BTU/hr)/(Mlbs/hr).
C         REAL(37)   = Constant factor for the cooling water consumption,
C                      Mgal/hr.
C         REAL(38)   = Cooling water consumption per Mlbs/hr of product
C                      sulfur, (Mgal/hr)/(Mlbs/hr).
C         REAL(39)   = Constant factor for the process water consumption,
C                      Mgal/hr.
C         REAL(40)   = Process water consumption per Mlbs/hr of product
C                      sulfur, (Mgal/hr)/(Mlbs/hr).
C         REAL(41)   = Constant factor for the nitrogen consumption,
C                      MM SCF/hr of N2.
C         REAL(42)   = Nitrogen consumption per Mlbs/hr of product
```

```
C                    sulfur, (MM SCF/hr of N2)/(Mlbs/hr).
C         REAL(43) -
C          REAL(48) = Future use.
C         REAL(49)  = Constant factor for the number of operators per
C                     day, operators/day.
C         REAL(50)  = Number of operators per day per train,
C                     (operators/day)/train.
C         REAL(51)  = Reference product sulfur flow rate of a single
C                     train in Mlbs/hr of S for the calculation of the
C                     ISBL field cost of a single train as a function
C                     of train capacity.
C         REAL(52)  = Maximum size of a single train as defined by the
C                     the product sulfur flow rate in Mlbs/hr of S.
C         REAL(53)  = Minimum size of a single train as defined by the
C                     the product sulfur flow rate in Mlbs/hr of S.
C         REAL(54)  = Constant A in the plant ISBL field cost equation.
C         REAL(55)  = Constant B in the plant ISBL field cost equation.
C         REAL(56)  = Constant E in the plant ISBL field cost equation.
C         REAL(57)  = Constant F in the plant ISBL field cost equation.
C         REAL(58)  = Number of spare trains.
C         REAL(59) -
C          REAL(70) = Future use.
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
      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
C
C     Local variable declaration statements.
      DIMENSION PSA(5,10)
C     PSA(J,K) is the Plant Stream Array, where
C       J = Stream number identifier
C           1 => The inlet gas stream
C           2 => The flue gas stream
C           3 => The product sulfur stream
C           4 => Future use
```

```
C           5 => Future use
C       K = Stream property identifier
C           1 => Total stream flow rate, Mlbs/hr
C           2 => Total stream flow rate, MM SCF/hr
C           3 => Stream temperature, degrees Fahrenheit
C           4 => Stream pressure, PSIA
C           5 - 10 => Future use
C
      DIMENSION ICN(2), ICNAME(10), ICNUMB(5)
C
      CHARACTER * 4  ICN, ICNAME
      CHARACTER * 6  PNAME
C
C     Initialize the component identification of H2, H2S, COS (carbonyl
C     sulfide), L-SULFUR (liquid sulfur), CO (carbon monoxide).
      DATA ICNAME / 'H2  ', '    ', 'H2S ', '    ', 'COS ', '    ',
     1  'L-SU', 'LFUR', 'CO  ', '    '/
C
      DATA PNAME / '11    ' /
C
C
C     PARAMETER INITIALIZATION SECTION
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)
C
C     If requested, write the subroutine heading to the history file.
      IF ( KTEST .GE. 1 )  THEN
        WRITE (NHSTRY, 701) IPASS
  701   FORMAT ( // 1X, 'Plant 11 - Supplementary data from subroutine',
     1    ' USR11' /
     2    2X, 'The Sulfur Recovery Plant', 10X, 'IPASS =', I3 )
      ENDIF
C
C     Check to insure that there is exactly 1 inlet stream, and if not,
C     print an error message and terminate execution.
      IF ( NSIN .NE. 1 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 701)  IPASS
        WRITE (NHSTRY, 702)  NSIN
  702   FORMAT ( / 1X, '* ERROR * - The sulfur recovery plant ',
     1    'requires only 1 single 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 are exactly 2 outlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSOUT .NE. 2 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 701)  IPASS
        WRITE (NHSTRY, 703)  NSOUT
  703   FORMAT ( / 1X, '* ERROR * - The sulfur recovery plant ',
```

```
     1    'requires exactly 2 outlet streams.' /
     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     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 = 1
C
      IER = 0
      IF ( NSUBS .GE. 2 .AND. ITYPE(2) .EQ. 3 )  THEN
        KLASS = 2
        IF ( NNCC .GE. 1 )  THEN
          K = NCC + 9 + NNCC + 1
C         CF is the conversion factor from Kg/sec to lbs/hr.
          CF = 3600.0D0 / 0.45359237D0
          TOTNC = CF * SIN1(K)
          IF ( TOTNC .GE. 1.0D0)  THEN
            IER = 1
            IF ( KTEST .LE. 0 )  WRITE (NHSTRY, 701)  IPASS
            WRITE (NHSTRY, 704)  TOTNC
  704       FORMAT (/ 1X, '* WARNING * The feed stream to the ',
     1        'sulfur recovery plant' /
     2        3X, 'contains solids, ', F10.1, ' lbs/hr.' /
     3        3X, 'These solids are being ignored.  Please remove ',
     4        'these solids from the' /
     5        3X, 'feed stream to the sulfur recovery plant.' )
            ENDIF
          ENDIF
      ENDIF
C
C     Check for a substream PSD attribute on the second substream of the
C     first inlet stream.
      NUMPSD = 0
      IF ( KLASS .EQ. 2 )  THEN
        CALL GETSTR (IDS(1,4), NB, LB, NBD, LBD)
        NUMATT = NPAT (LBD, 2)
        IF ( NUMATT .GT. 0 )   THEN
          NUMPSD = NAVAR (LBD, 2, 1)
          KLASS = 3
        ENDIF
      ENDIF
C
C     Set the offset variable for the conventional substream.
      NCONV = (NCC + 9)
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
```

```
C     Find the number of items in the whole inlet stream vector.
      ITEMS = NCONV
      IF ( KLASS .GE. 2 )  ITEMS = ITEMS + ( NNCC + 9 )
     1                             + NITEMS * NNCC + NUMPSD
C
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
      TOTIN = CF * SIN1(NCC+1)*SIN1(NCC+9)
C
      IF ( TOTIN .LE. 1.0D0 )   THEN
C       Skip all remaing calculations if this plant has no flow.
        IF ( KTEST .GE. 1 )  WRITE (NHSTRY, 705)
  705   FORMAT ( / '  There is no material entering plant 11, the ',
     1    'sulfur recovery plant.' )
        GO TO 999
C       ---------
      ENDIF
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     Set up the maximum and minimum train flow rates in Mlbs/hr of
C     product sulfur.
      PMAXF = REAL(52)
      PMINF = REAL(53)
C
C     If requested, write the items of interest in the inlet gas stream
C     vector to the history file.
      IF ( KTEST .GE. 5 )  THEN
        WRITE (NHSTRY, 706)
  706   FORMAT ( / '   Inlet gas stream vector' )
        DO 20 J = 1, ITEMS
          WRITE (NHSTRY, 707) J, SIN1(J)
  707     FORMAT ( 2X, I6, 3X,  1PE15.5 )
   20   CONTINUE
      ENDIF
C
C     Find the relative component numbers of hydrogen, hydrogen sulfide,
C     COS, liquid sulfur and CO, and load them in variables KH2, KH2S,
C     KCOS and KCO, respectively.
      DO 30 J = 1, 5
        K = 2 * J - 1
        ICN(1) = ICNAME(K)
        ICN(2) = ICNAME(K+1)
        CALL USRCCN (ICN, ICNUMB(J))
        IF ( ICNUMB(J) .EQ. 0 ) THEN
          IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 701)
```

```
          WRITE (NHSTRY, 708)  ICN(1), ICN(2)
  708     FORMAT ( / 1X, '* ERROR * - The following component is ',
     1      'missing from your component list' / 5X, 2A4 /
     2      3X, 'the sulfur plant requires this component.  Please ',
     3      'add it to your' /
     4      3X, 'component list and try again.' //
     5      3X, 'EXECUTION IS BEING TERMINATED.' / )
          STOP
        ENDIF
   30 CONTINUE
      KH2   = ICNUMB(1)
      KH2S  = ICNUMB(2)
      KCOS  = ICNUMB(3)
      KS    = ICNUMB(4)
      KCO   = ICNUMB(5)
C
C
C     Set up the main components in the inlet gas stream in lbs/hr.
C     CF is the conversion factor from Kg/sec to lbs/hr.
      CF = 3600.0D0 / 0.45359237D0
C     Set the entering mass flow rates of H2, H2S, COS, liquid sulfur
C     and CO in lbs/hr.
      H2IN  = SIN1(KH2) * XMW(KH2) * CF
      H2SIN = SIN1(KH2S) * XMW(KH2S) * CF
      COSIN = SIN1(KCOS) * XMW(KCOS) * CF
      SIN   = SIN1(KS) * XMW(KS) * CF
      COIN  = SIN1(KCO) * XMW(KCO) * CF

C     Total flow rate of all conventional and non-conventional
C     components.
      TOTC = 0.0D0
      TOTNC = 0.0D0
      DO 40 J = 1, NCC
        TOTC = TOTC + SIN1(J) * XMW(J) * CF
   40 CONTINUE
      IF ( NNCC .GE. 1 )   THEN
        DO 42 J = 1, NNCC
          TOTNC = TOTNC + SIN1(NCONV+J) * CF
   42   CONTINUE
      ENDIF
      TOTIN = TOTC + TOTNC
C
C     If requested, write the total amount of other components in the
C     gas feed stream.
      OTHERC = TOTC - H2IN - H2SIN - COSIN - SIN - COIN
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 709)  REAL(1)
  709   FORMAT ( / '  Fraction of sulfur in the entering H2S and COS',
     1    ' recovered =', F11.7 )
        WRITE (NHSTRY, 710)  H2IN, H2SIN, COSIN, SIN, COIN, OTHERC,
     1    TOTNC, TOTIN
  710   FORMAT ( / '  Key components in the sulfur plant feed stream',
     1    ' in lbs/hr:' /
     2    4X, 'Hydrogen           ', F10.0 /
     3    4X, 'Hydrogen sulfide   ', F10.0 /
```

```
     4    4X, 'COS                  ', F10.0 /
     5    4X, 'Sulfur               ', F10.0 /
     6    4X, 'CO                   ', F10.0 /
     7    4X, 'Other conventional ', F10.0 /
     8    4X, 'Non-conventional     ', F10.0 /
     9    4X, 'Total                ', F10.0 )
      ENDIF
C
C
C     CALCULATIONS PASS SECTION
C     -------------------------
C     Calculation Method:
C        This is a simplistic sulfur plant model which does not consider
C     the oxidation step and the air requirement, since that would add
C     more complexity to the overall model that is necessary.  The
C     minimum air requirement for oxidation is estimated based on the
C     amount of sulfur entering the plant.
C        This model assumes a specified fraction of the entering sulfur
C     is recovered in the liquid product stream.
C        In order to maintain a mass balance on the inlet gas stream,
C     this model functions as follows.
C        Any sulfur in the entering stream (SIN1) that is in H2S that
C     is recovered is converted to S and H2.  The H2 leaves unoxidized
C     in the flue gas stream (SOUT1) along with any non-recovered H2S.
C     All recovered sulfur leaves in the liquid sulfur product stream
C     (SOUT2).
C        Any sulfur in the entering stream (SIN1) that is in COS that
C     is recovered is converted to S and CO.  The CO leaves unoxidized
C     in the flue gas stream (SOUT1) along with any non-recovered COS.
C     All recovered sulfur leaves in the liquid sulfur product stream
C     (SOUT2).
C        All sulfur entering the plant is assumed to be recovered and
C     leaves in the liquid sulfur product stream (SOUT2).
C        In reality, all other material in the inlet gas stream is
C     oxidized to CO2 and H2O and leaves the unit in the flue gas
C     stream (SOUT1).  In this simplified model, the oxidization
C     step is not considered, and all material other than H2 COS and
C     sulfur in the inlet gas stream is put in the flue gas stream.
C        Because this model does not consider the oxidation step and
C     maintains a mass balance around the entire sulfur plant only
C     with respect to the inlet gas stream.  It does not consider any
C     air associated with the oxidization of the H2S, COS and other
C     components.  Consequently, the flow rate of the flue gas stream
C     is significantly underpredicted by this model.
C        Since the inlet gas stream should not contain any material in
C     the solid substream, the following procedure is used to handle
C     this situation.  First, warning messagres are written to both
C     the history and report files.  Secondly, for simplicity, all
C     material in the solid substream of the inlet gas stream is
C     transfered directly to the flue gas stream.
C
C     Calculate the total stream flow rates in lbs/hr.
      SOUT = SIN + REAL(1) * ( H2SIN * XMW(KS) / XMW(KH2S)  +
     1  COSIN * XMW(KS) / XMW(KCOS) )
      FLUGAS = TOTIN - SOUT
```

```
C
      IF ( KTEST .GE. 3 )  THEN
C       If requested, write the component mass balance to the history
C       file
        WRITE (NHSTRY, 711) TOTIN, FLUGAS, SOUT
  711   FORMAT (/ 2X, 'Mass balance in lbs/hour' /
     1    4X, 'Inlet gas =     ', F12.0 /
     2    4X, 'Flue gas =      ', F12.0 /
     3    4X, 'Product sulfur =', F12.0 )
      ENDIF
C
C     Calculate the total product sulfur stream flow rate in Mlbs/kr.
      SFLOW = 0.001D0 * SOUT
C
C     If it has not been specified by the user in variable INT(3),
C     calculate the number of operating duplicate trains, excluding
C     spares (NPLNT), based on the total flow rate of the reference
C     stream.  However, if the maximum capacity of a single train
C     has not been specified, set the number of operating plants to 1.
      NPLNT = INT(3)
      IF ( (NPLNT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
          NPLNT = SFLOW  / PMAXF
          IF ( (MOD(SFLOW, PMAXF)) .GT. 0.0D0 )  NPLNT = NPLNT + 1
        ELSE
          IF ( NPLNT .EQ. 0 )   NPLNT = 1
      ENDIF
C
C     Calculate the flow rate of the reference product sulfur stream
C     in Mlbs/hr (PFLOW) for each of the individual duplicate plants.
      XPLANT = NPLNT
      PFLOW = SFLOW / XPLANT
C
C
C     Set up the properties of the product streams.
C     ---------------------------------------------
      IF ( IPASS .NE. 4 )   THEN
C       First, zero all the items in the product stream vectors.
        DO 200 J = 1, ITEMS
          SOUT1(J) = 0.0D0
          SOUT2(J) = 0.0D0
  200   CONTINUE
C
C       Load the flow rates of the conventional components in the
C       outlet streams in Kg-moles/sec.
        DO 210 J = 1, NCC
          IF ( J .EQ. KH2S )  THEN
C             Hydrogen sulfide.
              SOUT1(KH2S) = (1.0D0 - REAL(1)) * SIN1(KH2S)
              SOUT2(KH2S) = 0.0D0
            ELSE IF ( J .EQ. KCOS )  THEN
C             COS (Carbonyl sulfide).
              SOUT1(KCOS) = (1.0D0 - REAL(1)) * SIN1(KCOS)
              SOUT2(KH2S) = 0.0D0
            ELSE IF ( J .EQ. KS )  THEN
C             Liquid sulfur.
```

```
              SOUT1(KS) = 0.0D0
              SOUT2(KS) = SIN1(KS) + REAL(1)*(SIN1(KH2S) + SIN1(KCOS))
            ELSE IF ( J .EQ. KH2 )  THEN
C             Hydrogen.
              SOUT1(KH2) = SIN1(J) + REAL(1) * SIN1(KH2S)
              SOUT2(KH2) = 0.0D0
            ELSE IF ( J .EQ. KCO )  THEN
C             CO (Carbon monoxide).
              SOUT1(KCO) = SIN1(KCO) + REAL(1) * SIN1(KCOS)
              SOUT2(KCO) = 0.0D0
            ELSE
C             All other conventional components.
              SOUT1(J) = SIN1(J)
              SOUT2(J) = 0.0D0
          ENDIF
  210   CONTINUE
C       Calculate the total molar flow rate of all conventional
C       components in the outlet streams.
        SOUT1(NCC+1) = 0.0D0
        DO 220 J = 1, NCC
          SOUT1(NCC+1) = SOUT1(NCC+1) + SOUT1(J)
  220   CONTINUE
        SOUT2(NCC+1) = SOUT2(KS)
C
C       Set the flow rates any non-conventional components in the
C       product streams.
        IF ( NNCC .EQ. 1)  THEN
         SOUT1(NCONV+1) = SIN1(NCONV+1)
         SOUT2(NCONV+1) = 0.0D0
        ENDIF
        IF ( NNCC .GE. 2)  THEN
          DO 230 J = 1, NNCC
            SOUT1(NCONV+J) = SIN1(NCONV+J)
            SOUT2(NCONV+J) = 0.0D0
  230     CONTINUE
        ENDIF
C
C       Set the total mass flow rates in the NONCONV substream.
        IF ( NNCC .GE. 1 )  THEN
          SOUT1(NCONV+NNCC+1) = 0.0D0
          SOUT2(NCONV+NNCC+1) = 0.0D0
          DO 240 J = 1, NNCC
            SOUT1(NCONV+NNCC+1) = SOUT1(NCONV+NNCC+1) + SOUT1(NCONV+J)
  240     CONTINUE
        ENDIF
C
C       Set the default temperature and pressure of the outlet streams
C       to 70 F and 15 PSIA.  Return these values to ASPEN/SP in degrees
C       Kelvin and Pascals.  These default values can be overriden by
C       the FLASH-SPECS sentence in the ASPEN/SP input file.
        SOUT1(NCC+2) = (70.0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT1(NCC+3) = 15.0 * 6.8947573D+3
        SOUT2(NCC+2) = (70.0 - 32.0D0)/1.8D0 + 273.15D0
        SOUT2(NCC+3) = 15.0 * 6.8947573D+3
        IF ( NNCC .GE. 1 )  THEN
```

```
          SOUT1(NCONV+NNCC+2) = SOUT1(NCC+2)
          SOUT1(NCONV+NNCC+3) = SOUT1(NCC+3)
          SOUT2(NCONV+NNCC+2) = SOUT2(NCC+2)
          SOUT2(NCONV+NNCC+3) = SOUT2(NCC+3)
        ENDIF
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)
        CALL CPACK (SOUT2, NCP, IDX, XPACK, TMASS)
        SOUT2(NCC+9) = AVEMW (NCP, IDX, XPACK)
C
C
C       If requested, write the items of interest in the inlet and
C       outlet stream vectors to the history file.
        IF ( KTEST .GE. 5 )  THEN
          WRITE (NHSTRY, 721)
  721     FORMAT ( / ' The inlet and outlet stream vectors' /
     1      14X, ' SIN1', 10X, 'SOUT1', 10X, 'SOUT2' )
          DO 250 J = 1, ITEMS
            WRITE (NHSTRY, 722) J, SIN1(J), SOUT1(J), SOUT2(J)
  722       FORMAT ( 2X, I5, 3(1PE15.5) )
  250     CONTINUE
        ENDIF
C
      ENDIF
C
C
C     STREAM INPUT/OUTPUT REPORT SECTION.
C     -----------------------------------
C     If requested, skip writing the stream section of the user model
C     report if this is not the report pass or if the output report
C     control switch, INT(1), has a value of 3 or more.
      IF ( IPASS.EQ.4 .AND. INT(1).LE.2 )   THEN
C
C       Calculate the required stream values for the plant summary
C       report from the inlet and outlet stream vectors, and save them
C       in the Plant Stream Array, PSA(J,K).
C       Total stream flow rates, Mlbs/hr.
        PSA(1,1) = 0.001D0 * TOTIN
        PSA(2,1) = 0.001D0 * FLUGAS
        PSA(3,1) = 0.001D0 * SOUT
C       Total stream flow rates (ignoring any solids), MM SCF/hr.
        PSA(1,2) = SIN1(NCC+1) * CF * 379.495D-6
        PSA(2,2) = SOUT1(NCC+1) * CF * 379.495D-6
        PSA(3,2) = 0.0D0
C       Stream temperature, degrees Fahrenheit.
        PSA(1,3) = SIN1(NCC+2) * 1.8D0 - 459.67D0
        PSA(2,3) = SOUT1(NCC+2) * 1.8D0 - 459.67D0
        PSA(3,3) = SOUT2(NCC+2) * 1.8D0 - 459.67D0
C       Stream pressure, PSIA.
        PSA(1,4) = SIN1(NCC+3) / 6.8947573D+3
        PSA(2,4) = SOUT1(NCC+3) / 6.8947573D+3
```

```
      PSA(3,4) = SOUT2(NCC+3) / 6.8947573D+3
C
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 this user block report.
          LSTRM = 19
          LUTIL = 16
          LCOST = 11
          IF ( IER .GE. 1 )  LSTRM = LSTRM + 4
          NDUP = REAL(58) + 0.001D0
          IF ( (NPLNT + NDUP) .EQ. 1 )  LCOST = 9
          IF ( PFLOW .LT. PMINF )  LCOST = LCOST + 3
          IF ( PFLOW .GT .PMAXF )  LCOST = LCOST + 3
          IF ( NDUP .GE. 1 )  LCOST = LCOST + 1
          LINES = LSTRM + LUTIL + LCOST
C         Now, subtract the number of lines for those portions of
C         the user block summary report which will not be written.
          IF ( INT(1) .GE. 2 )   LINES = LINES - LUTIL
          IF ( INT(1) .GE. 1 )   LINES = LINES - LCOST
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 DCL11.REP to contain
C         this user block summary report.
          OPEN (UNIT=62, FILE='DCL11.REP', STATUS='UNKNOWN',
     1      ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2      BUFFERED='BUFFERED')
          WRITE (NOUT, 800)
C         FORMAT statement 800 will print across a page because it
C         contains the PC top-of-form character (ASCII character 012)
C         between two quote marks ( i.e., 'TOF').
  800     FORMAT ( 'TOF' )
      ENDIF
C
C     Write the component mass balance.
      WRITE (NOUT, 801)
  801 FORMAT (/ 27X, 'PLANT 11 - SUMMARY REPORT' /
     1  33X, 'SULFUR PLANT')
C
      WRITE (NOUT, 802)
  802 FORMAT (// 1X, '                    ', 4X, 'FEED GAS', 3X,
     1  ' FLUE GAS ', 4X, ' SULFUR ' )
C
      WRITE (NOUT, 803)  (PSA(J,1), J = 1, 3), PSA(1,2), PSA(2,2),
     1  ((PSA(J,K), J = 1, 3), K = 3, 4)
  803 FORMAT (1X, 'FLOW, MLBS/HR', 7X, F11.3, F12.3, F12.3 /
     2  1X, 'FLOW, MM SCF/HR', 5X, F11.3, F12.3, /
     1  1X, 'TEMPERATURE, F', 6X, F11.1, F12.1, F12.1 /
     2  1X, 'PRESSURE, PSIA', 6X, F11.1, F12.1, F12.1 )
C
```

```
      WRITE (NOUT, 804)
  804 FORMAT (/ 1X, 'NOTE:  THE FLOW RATE OF THE FLUE GAS STREAM IS',
     1  ' SIGNIFICANTLY UNDER' /
     2  8X, 'PREDICTED BECAUSE THE INLET AIR STREAM IS NOT',
     3  ' CONSIDERED.')
C
      WRITE (NOUT, 805) REAL(1)
  805 FORMAT (/ 1X, 'FRACTIONAL LIQUID SULFUR RECOVERY =', F11.7 )
C
C     Calculate a minimum air requirement in MM SCF/hr based on the
C     amount of H2S in the inlet gas stream (0.5 moles of O2 per mole
C     of H2S and COS).
      O2 = 0.5D0 * (SIN1(KH2S) + SIN1(KCOS)) * CF
      AIR = O2 * 379.495D-3 / 0.209
      WRITE (NOUT, 806)  AIR
  806 FORMAT ( / 1X, 'DEPENDING UPON THE IMPURITIES IN THE FEED, ',
     1  'THIS SULFUR PLANT WILL' /
     2  1X, 'REQUIRE AT LEAST', F10.3, ' M SCF/HR OF AIR.' )
C
      IF ( IER .GE. 1 )  WRITE (NOUT, 808)
  808 FORMAT (/ 1X, '*WARNING* THE INLET GAS STREAM TO THE SULFUR ',
     1  'PLANT CONTAINS SOLIDS.' /
     2  1X, 'THESE SOLIDS HAVE BEEN PUT IN THE FLUE GAS STREAM.  ',
     3  'PLEASE REMOVE' /
     4  1X, 'THESE SOLIDS FROM THE GAS FEED STREAM TO THE SULFUR ',
     5  'PLANT.' )
C
     ENDIF
C
C    Call subroutine USRUCO to calculate, save and report the
C    utilities, capital, and operating costs for the plant.
     ID = 14
     KUNITS = 2
     CALL USRUCO (NHSTRY, NOUT, IPASS, ID, PNAME, INT(1), INT(3),
    1 KTEST, REAL(21), SFLOW, KUNITS )
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, 731)
  731 FORMAT ( / '  Leaving subroutine USR11' )
C
     RETURN
     END
C
C$  Subroutine USR31
C
C    This file contains the following subroutines:
C      USR31    Main routine for Plant 31, the utilities plant.
C      USR31A   Master subroutine for the utilities plant calculations.
C      USR31B   Subroutine to do the steam demand calculations.
C      USR31C   Subroutine to do the electric power calculations.
C      USR31D   Subroutine to do the capital cost calculations.
```

```
C       USR31S   Subroutine to write the utilities plant summary report.
C
C     The above subroutines require the following non-standard ASPEN/SP
C     subroutines and named commons which are not included in this file.
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       /USRCO1/ AND /USRCO3/
C
C$ USR31
      SUBROUTINE USR31 (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:  USR31
C
C  BLOCK DESCRIPTION:  Plant 31, DOE Coal Liquefction Utilities Plant
C
C                 Simplified Fortran Block Model
C
C                  -----------------------
C                  |       Plant 31      |
C     Fuel gas ---->|                     |----> Flue gas
C                  |       Utilities     |
C                  |        Plant        |
C                  -----------------------
C
C
C  Prepared under DOE contract no. DE-AC22 90PC89857.
C
C  FUNCTION (MODEL, REPORT, OR BOTH):  Both
C
C  Last revision - June 16, 1992
C
C  ASSUMPTIONS, SPECIAL FEATURES AND LIMITATIONS:
C     1.  The one inlet stream is:   1. Fuel gas
C     2.  This model requires one outlet stream.  In order to
C         maintain a mass balance, the inlet stream is copied to the
C         the outlet stream.  This outlet stream will not have the
C         correct composition or flow rate since this model does not
C         do the combustion calculations.
C     3.  This user block model will work with any number of
C         conventional and non-components in the inlet stream.
C     4.  The 20 integer parameters are:
C         INT(1)  = User block summary report control switch.
C                   0 => Write the complete user block summary report.
C                   1 => Not used.
C                   2 => Not used.
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 DCL31.REP.
C          INT(3)  = Future use.
C          INT(4)  = History file additional output control switch.
C                    0 => Write no additional output to the history 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)  = Future use.
C          INT(6) -  Switches to select which fuels are burned in the
C           INT(10)  steam boiler to produce steam and/or electric
C                    power to satisfy the steam demand.  The fuel
C                    specified in INT(6) is used until it is all
C                    consumed, the steam demand is satisfied, or the
C                    capacity to use this fuel is reached.  Then the
C                    INT(7) fuel is used, etc.  The fuel codes are
C                      1 = Coal
C                      2 = ROSE-SR unit bottoms
C                      3 = Coke
C                      4 = Natural gas
C                      5 = Plant fuel
C          INT(11) - Switches to select which fuels are burned in to
C           INT(16)  satisfy the electric power demand.  The fuel
C                    specified in INT(11) is used until it is all
C                    consumed, the power demand is satisfied, or the
C                    capacity to use this fuel is reached.  Then the
C                    INT(12) fuel is used, etc.  The fuel codes are
C                      1 = Coal
C                      2 = ROSE-SR unit bottoms
C                      3 = Coke
C                      4 = Natural gas
C                      5 = Plant fuel
C                      6 = Purchased electric power
C     5.  The 20 real parameters are:
C      NOTE:  In this version the capital cost and operator calculations
C             have been bypassed since this is considered an OSBL plant.
C         REAL(1)  = Reference electric power generation rate of a
C                    single train in MW.
C         REAL(2)  = Maximum size of a single train as defined by the
C                    electric power generation rate in MW.
C         REAL(3)  = Minimum size of a single train as defined by the
C                    electric power generation rate in MW.
C         REAL(4)  = Constant A in the plant ISBL field cost equation.
C         REAL(5)  = Constant B in the plant ISBL field cost equation.
C         REAL(6)  = Constant E in the plant ISBL field cost equation.
C         REAL(7)  = Constant F in the plant ISBL field cost equation.
C         REAL(8)  = Number of spare trains.
C         REAL(9)  = Future use
C         REAL(10) = Future use
```

```
C         REAL(11) = Constant factor for the number of operators per
C                    day, operators/day.
C         REAL(12) = Number of operators per day per operating train,
C                    (operators/day)/train.
C         REAL(13) -
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     Local varialble declarations.
      COMMON /USRC01/ PLNTID(32), UTIL(32,15), CAPCST(32,7), OPCST(32,5)
      DIMENSION KS(5), KP(6), PSA(13,5), TOT(15)
C     NOTE: The items in the PSA (utilities Plant Summarry Array) array
C           are defined in subroutine USR31S.
C
      COMMON /USRC03/ FIN(5,4), FOUT(20,4), PGAS, PPWR
C
C     FIN(J,K), and FOUT(J,K) are inlet and outlet stream flow rates.
C     PGAS is the purchased natural gas rate after power production in
C       MSCF/hr.
C     PPWR is the purchased electricity in Megawatts/hr.
C
      CHARACTER * 6  PLNTID, PNAME
C
C     Initialize the utilities plant identification name and internal
C     internal identification number in the PLNTID, UTIL, CAPCST and
C     OPCST arrays.
      DATA PNAME / '31    ' /
      DATA ID / 18 /
C
C
C     PARAMETER INITIALIZATION SECTION
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)
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 31 - Supplementary data from ',
     1    'subroutine USR31' /
     2    2X, 'The Utilities Plant', 20X, 'IPASS =', I3 )
      ENDIF
C
C     Check to insure that there is exactly 1 inlet streams, 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 * - Plant 31 requires exactly ',
     1    '1 inlet streams.' /
     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 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 * - Plant 31 requires exactly one ',
     1    '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     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 = 1
C
C     Does the inlet stream contain non-conventional components?
      NUMPSD = 0
      IF ( NSUBS .EQ. 2 .AND. ITYPE(2) .EQ. 3 )   THEN
        KLASS = 2
C       Check for a substream PSD attribute on the second substream of
C       the first inlet stream.
        CALL GETSTR (IDS(1,4), NB, LB, NBD, LBD)
        NUMATT = NPAT (LBD, 2)
        IF ( NUMATT .GT. 0 )   THEN
          NUMPSD = NAVAR (LBD, 2, 1)
          KLASS = 3
        ENDIF
      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     non-conventional substream.
      NCCONV = NCONV
      IF ( KLASS .GE. 2 )   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
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 integer parameters in the KS and KP vectors, as
C     appropriate.
      KS(1) = INT(6)
      KS(2) = INT(7)
      KS(3) = INT(8)
      KS(4) = INT(9)
      KS(5) = INT(10)
      KP(1) = INT(11)
      KP(2) = INT(12)
      KP(3) = INT(13)
      KP(4) = INT(14)
      KP(5) = INT(15)
      KP(6) = INT(16)
C
      IF ( KTEST .GE. 2 )  THEN
        WRITE (NHSTRY, 504)  (INT(J), J = 1, 20)
  504   FORMAT ( / ' The input INTEGER parameters:' /
     1    2X, 10I5 / 2X, 10I5 )
      ENDIF
C
C
C     CALCULATION SECTION
C     -------------------
C
C     Zero the Utility plant productions and consumptions.
      DO 40 J = 1, 15
        UTIL(ID,J) = 0.0D0
   40 CONTINUE
C
      CALL USR31A (ID, INT(4), KS, KP, NHSTRY, PSA, TOT )
C
C     Calculate the total electric power production in MW.
      CAP = - 0.001D0 * UTIL(ID,1)
```

```
C
C     Skip the call subroutine USR31D to calculate the capital cost
C     and operator requirements of the utilities plant and save the
C     results without writing anything to the plant summary report
C     since this is considered an OSBL plant.
C     KPRNT = 0
C     CALL USR31D (ID, INT(3), KPRNT, NOUT, CAP, REAL, PNAME)
C
C
C     Set up and write the first page of the plant summary report.
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 3 )  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           Set the number of lines in the first page of the report to
C           54 to force ASPEN to write a single page.
            LINES = 54
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 DCL31.REP to contain
C           this user block summary report.
            OPEN (UNIT=62, FILE='DCL31.REP', STATUS='UNKNOWN',
     1        ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2        BUFFERED='BUFFERED')
            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' )
        ENDIF
C
C       Call subroutine USR31S to write a summary of the utilities
C       plant operations.
        CALL USR31S (NOUT, PSA, TOT)
C
C       Skip the call to subroutine USR31D to calculate the capital
C       cost and operator requirements of the utilities plant and
C       write the results to the plant summary report since this plant
C       is considered to be an OSBL plant
C       KPRNT = 1
C       CALL USR31D (ID, INT(3), KPRNT, NOUT, CAP, REAL, PNAME)
      ENDIF
C
C
C     Set up and write the second page of the plant summary report.
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 3 )  THEN
        IF ( INT(2) .EQ. 0 )   THEN
C           Set the number of lines in the second page of the report to
C           52 to force ASPEN to write a single page.
            LINES = 52
```

```
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           If this is the report pass and the plant sumamry report is
C           being written to a separate file, start a new page.
            WRITE (NOUT, 800)
        ENDIF
C
        WRITE (NOUT, 801)
  801   FORMAT ( / 24X, 'PLANT 31 - SUMMARY REPORT' /
     1    29X, 'UTILITIES PLANT')
C       Call subroutine USR31T to write the main body of the overall
C       complex utility summary table the utilities plant.
        CALL USR31T (NHSTRY, NOUT, IPASS, INT(1), INT(2), KTEST)
      ENDIF
C
C     Load the purchased electric power in Mwatts in /USRC03/.
      PPWR = 0.001D0 * TOT(1)
C     Load the amount of natural gas that has to be purchased.
      PGAS = PSA(5,1) + PSA(11,1) + PSA(13,1)
C
      IF ( KTEST .GE. 3 )  WRITE (NHSTRY, 530)  PPWR, PGAS
  530 FORMAT ( / ' PPWR AND PGAS', 2X, 2F12.4 )
C
C     If this is not the report pass, copy the inlet stream to the
C     outlet stream to maintain a mass balance.
      IF ( IPASS .NE. 4 )   THEN
        DO 160 J = 1, ITEMS
          SOUT1(J) = SIN1(J)
  160   CONTINUE
C
C       If requested, write the inlet and outlet stream vectors to the
C       history file.
        IF ( KTEST .GE. 5 )  THEN
          WRITE (NHSTRY, 550)
  550     FORMAT ( // ' The inlet and outlet stream vectors:' /
     1      12X, ' SIN1', 10X, 'SOUT1' )
          DO 170 J = 1, ITEMS
            WRITE (NHSTRY, 551) J, SIN1(J), SOUT1(J)
  551       FORMAT ( 1X, I4, 2(1PE15.5) )
  170     CONTINUE
        ENDIF
      ENDIF
C
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
      IF ( KTEST .GE. 1 )  WRITE (NHSTRY, 590)
  590 FORMAT ( / ' Leaving subroutine USR31' )
C
      RETURN
```

```
      END
C
C$ USR31A
      SUBROUTINE USR31A (ID, KTEST, KS, KP, NHSTRY, PSA, TOT)
C
C     This subroutine is the master routine for the calculations for
C     Plant 31, the utilities Plant.
C
C     This subroutine calls subroutines USR31B, USR31C, USR31S and
C     USR31T.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - June 16, 1992
C
C     Calling arguments:
C     ID     = Utilities plant internal identification number in the
C              PLNTID, UTIL, CAPCST and OPCST arrays.
C     KS(5)  = Switch to select which fuel is being burned in the
C              steam boiler to produce steam and/or electric power to
C              satisfy the steam demand.  The fuel specified in KS(1) is
C              used until it is all consumed, the steam demand is
C              satisfied, or the capacity to use the fuel is reached,
C              then the KS(2) fuel, etc.  The KS(J) values designate the
C              following fuels.
C              1 => Coal
C              2 => Char (ROSE-SR unit bottoms)
C              3 => Coke
C              4 => Natural gas
C              5 => Gaseous plant fuel
C     KP(6)  = Switch to select how to satisfy the electic power demand.
C              If coal, char, coke or plant fuel is used, then a
C              conventional solids fuel fired steam power plant is
C              asssumed, and if natural gas is used, then combustion
C              turbines are assumed because they are more efficient.
C              The fuel specified in KP(1) is used until it is all
C              consumed, the power demand is satisfied, or the capacity
C              to use this fuel is reached, then the KP(2) fuel, etc.
C              The KP(J) values designate the following fuels.
C              1 => Coal
C              2 => Char (ROSE-SR unit bottoms)
C              3 => Coke
C              4 => Natural gas
C              5 => Gaseous plant fuel
C              6 => Purchased electric power
C     NHSTRY = Logical unit number of the history file.
C     PSA()  = Utilities Plant Summary Array - see subroutine USR31S
C              for a description of the items in the PSA array.
C     TOT()  = Vector containing running utilities totals.
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 => Common 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
      COMMON /USRC03/ FIN(5,4), FOUT(20,4), PGAS, PPWR, OPTN6
C     See subrouotine USRSR1 for the complete definition of all the
```

```
C     items in named common block /USRC03/.  Only OPTN6 is used here,
C     and when it is 1.0, Option 6 is in use.
C
C     Local variable declarations.
      DIMENSION KP(6), KS(5), PSA(13,5), TOT(15)
      DIMENSION H(7), HHV(5), QMAX(5), QMAXP(5), QMAXS(6), SOLID(5)
C
      CHARACTER * 6  PLNTID, PNAME, BLANK6
      CHARACTER * 4  SOLID
C
      DATA BLANK6 / '      ' /
      DATA PNAME  / '31    ' /
      DATA SOLID  / 'COAL', 'CHAR', 'COKE', 'NGAS', 'PF  ' /
C
C     H(1) is the enthalpy of 900 psig steam at 750 F.
C     H(2) is the enthalpy of 900 psig saturated steam.
C     H(3) is the enthalpy of 600 psig steam at 720 F.
C     H(4) is the enthalpy of 600 psig saturated steam.
C     H(5) is the enthalpy of 150 psig saturated steam.
C     H(6) is the enthalpy of 50 psig saturated steam.
C     H(7) is the enthalpy of the very high temperature and high
C       pressure steam (1250 F at 1525 psia) used in the co-gen unit.
C       This steam goes to steam turbines to make electric power and
C       exactly the correct amount of lower pressure steam to satisfy
C       the steam demand.
      DATA H / 1360.D0, 1195.0D0, 1362.0D0, 1203.0D0, 1196.0D0,
     1  1179.0D0, 1607.0D0 /
C
C     BTUPKW is the conversion factor from MBTUs/hr to killowatts.
      DATA BTUPKW / 3.412141635D0 /
C
C     BTUSCF is the energy content of the purchased natural gas in
C     BTU/SCF.
      DATA BTUSCF / 1000.0D0 /
C
C     HHV(1) is the high heating value of the coal in BTU/lb.
C     HHV(2) is the high heating value of the char in BTU/lb.
C     HHV(3) is the high heating value of the coke in BTU/lb.
C     HHV(4) is a fake high heating value of natural gas.
C     HHV(5) is a fake high heating value of gaseous plant fuel.
      DATA HHV / 12000.0D0, 7500.0D0, 14000.0D0, 1.0D0, 1.0D0 /
C
C     EFFCT = Fractional combustion turbine efficiency to electric
C             power.
C     EFFST = Fractional steam turbine efficiency to electric power.
C             NOTE: If EFFST is set to 0, the steam generation section
C                   will only have a steam boiler; i.e., it will not
C                   be a co-gen unit.
C     EFFGB = Fractional gas fired boiler efficiency to steam.
C     EFFSB = Fractional solids fired boiler efficiency to steam.
C     EFFSP = Fractional efficiency of a solids fuel fired power plant
C             that produces only electric power.
C     NOTE: EFFCT was calculated to match the baseline design case
C           total natural gas consumption.
      DATA EFFCT, EFFST, EFFGB, EFFSB, EFFSP / 0.32513593D0, 0.40D0,
```

```
     1  0.80D0, 0.82D0, 0.30D0 /
C
C     QMAX() contains the maximum available energy in MM BTU/hr in
C     coal, char (ROSE-SR unit bottoms), coke, natural gas, and
C     gaseous plant fuel.
      DATA QMAX / 1.0D+40, 0.0D0, 0.0D0, 1.0D+40, 0.0D0 /
C
C     QMAXGT is the maximum combustion turbine unit input heat duty
C     capacity in MM BTU/hr for generating electrical power from
C     gaseous plant fuel in section 1.
      DATA QMAXGT / 1000.0D0  /
C
C     QMAXP contains the maximum capacities of the power generation
C     section.  QMAXP(1-5) are the maximum unit input heat duties in
C     in MM BTU/hr for using coal, char, coke, natural gas, and gaseous
C     plant fuel in the power generation section.
      DATA QMAXP / 1.0D+40, 0.0D0, 0.0D0, 1.0D+40, 1.0D+20 /
C
C     QMAXS contains the maximum capacities of the steam generation
C     section.  QMAXS(1-5) are the maximum unit input heat duties in
C     MM BTU/hr for using coal, char, coke, natural gas, and gaseous
C     plant fuel in the steam generation section.  QMAXS(6) is the
C     maximum electric power generating capacity from excess steam
C     in Mwatts.
      DATA QMAXS / 1.0D+40, 0.0D0, 0.0D0, 1.0D+40, 0.0D0,
     1  1000.0D0  /
C
C
C     If Option 6 is in use, reset the efficience of the gas boiler
C     to better represent this situation.
      IF ( OPTN6 .GE. 0.99D0 )   EFFGB = 0.585D0
C
C     Load the plant identification in the PLNTID vector.
      PLNTID(ID) = PNAME
C
C     Initialize the PSA array and TOT vector to zero.
      DO 8 J = 1, 13
        DO 6 K = 1, 5
          PSA(J,K) = 0.0D0
   6    CONTINUE
   8  CONTINUE
      DO 10 J = 1, 15
        TOT(J) = 0.0D0
  10  CONTINUE
C
C     Zero the utilities plant items in the UTIL array.
      DO 12 J = 1, 10
        UTIL(ID,J) = 0.0D0
  12  CONTINUE
C
C     Total the utilities for all the other plants.
      DO 20 J = 1, 32
        IF ( PLNTID(J).EQ.BLANK6 .OR. PLNTID(J).EQ.PNAME )  GO TO 20
          IF ( J .EQ. ID )   GO TO 20
             DO 18 K = 1, 15
```

```
              TOT(K) = TOT(K) + UTIL(J,K)
   18       CONTINUE
   20 CONTINUE
C
C
      IF ( KTEST .GE. 2 )  THEN
        WRITE (NHSTRY, 711)
  711   FORMAT ( / ' Total utilities useage for all other plants ',
     1    'except this utilities plant.' )
        WRITE (NHSTRY, 712)
  712   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'  )
        WRITE (NHSTRY, 713) TOT(1), TOT(8), TOT(9), TOT(10), TOT(11)
  713   FORMAT ( 1X, 'Total', 2X, F10.0, F15.3, 2F13.2, F13.3 )
C
        WRITE (NHSTRY, 715)
  715   FORMAT (/ 9X, 23('-'), ' Steams, Mlbs/hr ', 23('-') /
     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' )
        WRITE (NHSTRY, 716)  (TOT(K), K = 2, 7)
  716   FORMAT ( 1X, 'Total', F11.1, 5F11.1 )
      ENDIF
C
C     If there is a net 600 psig steam demand, shift the 600 psig
C     saturated steam demand to 600 psig steam at 720 F which is
C     generated and used to satisfy this demand.
      SUM600 = TOT(4) + TOT(5)
      IF ( SUM600 .GT. 0.0D0 )  THEN
        TOT(4) = TOT(4) + TOT(5)
        TOT(5) = 0.0
      ENDIF
C
      IF ( KTEST .GE. 2 )  THEN
        IF ( SUM600 .GT. 0.0D0 )  WRITE (NHSTRY, 717)  TOT(4)
  717   FORMAT ( / 1X, 'Note: The 600 psig saturated steam demand is ',
     1    'satisfied by' /
     2    3X, '600 psig steam at 720 F.', F11.3,
     3    ' Mlbs/hr of 600 psig steam' /
     4    3X, 'at 720 F will be produced.' )
      ENDIF
C
C
C     Start the calculations for the Utilities plant, Plant 31.
C     ---------------------------------------------------------
C
C     PLANT FUEL
C     ==========
C     Is any plant fuel available for power and steam generation.  If
C     not, write a message stating how much natural gas is required to
C     satisfy the plant fuel demand for the other plants.
```

```
      IF ( TOT(8) .GT. 0.0D0 )  THEN
        GAS = 1.0D3 * TOT(8) / BTUSCF
        WRITE (NHSTRY, 718)  TOT(8), GAS
  718   FORMAT ( / 1X, 'Insufficient Plant Fuel' /
     1    1X, F10.3, ' MM BTU/hr of natural gas are required ',
     2    'to satisfy the plant fuel' /
     3    1X, 'balance.  This corresponds to ', F10.3,
     4    ' MSCF/hr of natural gas.' )
        PSA(13,1) = GAS
        PSA(13,2) = TOT(8)
      ENDIF
C
C
C     Load the amount of available plant fuel in QMAX(5).
      QMAX(5) = - TOT(8)
C
C     SECTION 1 - Electrical Power from plant fuel in a gas turbine.
C     ==============================================================
C     Burn all possible plant fuel (low BTU gas) in combustion turbines
C     to make electric power.  The hot off gas from the combustion
C     turbines goes to supplemental boilers to make both steam and
C     electric power in a co-gen unit.  The use of this off gas in these
c     boilers is reflected in the high efficiencies of these units.
C     Is plant fuel available to make electric power.
      IF ( TOT(8) .LT. 0.0D0 )  THEN
C       Do the combustion turbines capacity limit the amount of plant
C       fuel that can be used to produce electric power?
        IF ( QMAXGT .GT. -TOT(8) )  THEN
C           Sufficient combustion turbine capacity is available.
            FRAC = 1.0D0
          ELSE
C           Inufficient combustion turbine capacity is available.
            FRAC = - QMAXGT / TOT(8)
        ENDIF
C
C       Burn all possible plant fuel, FRAC * TOT(8), in a combustion
C       turbine to produce electric power.
        FUEL = - FRAC * TOT(8)
        E1 = 1000.0D0 * FUEL * EFFCT / BTUPKW
C       Load the power produced and plant fuel consumed in the UTIL
C       array for this plant and adjust the total.
        UTIL(ID,1) = UTIL(ID,1) - E1
        UTIL(ID,8) = UTIL(ID,8) + FUEL
        TOT(1) = TOT(1) - E1
        TOT(8) = TOT(8) + FUEL
        PWR = 0.001D0 * E1
        IF ( KTEST .GE. 2 )  WRITE (NHSTRY, 721)  FUEL, PWR
  721   FORMAT ( / 1X, F10.3, ' MM BTU/hr of plant fuel have been',
     1    ' burned in a combustion' /
     2    ' turbine to produce ', F10.3, ' Mwatts of electric',
     3    ' power.' )
C       Load the results in row 1 of the PSA array for printing.
        PSA(1,2) = FUEL
        PSA(1,3) = PWR
C       Calculate the remaining amount of this fuel.
```

```
        QMAX(5) = QMAX(5) - FUEL
C       Has all the available plant fuel been consumed?
        IF ( QMAX(5) .GT. 0.0005D0 )  THEN
          IF ( KTEST .GE. 2 )  WRITE (NHSTRY, 722)  QMAX(5)
  722   FORMAT ( / ' All the available plant fuel could not be',
     1    ' consumed in the combustion turbines.' /
     2    1X, F9.3, ' MM BTU/hr are still available.' )
        ENDIF
      ENDIF
C
C
C     SECTION 2 - Steam generation section.
C     ====================================
C     If excess power is available, do not make any more in the steam
C     steam generation section.  Accomplish this by setting the steam
C     turbine efficiency to power to zero.
      IF ( TOT(1) .LT. 0.0D0 )  THEN
          STEFF = 0.0D0
        ELSE
          STEFF = EFFST
      ENDIF
C
C     Loop on the available fuels until the steam demand is satisfied.
      DO 30 J = 1, 5
        ST1 = TOT(2) + TOT(3) + TOT(4) + TOT(5) + TOT(6) + TOT(7)
C       Skip the steam calculations if the steam demand is satisfied.
        IF ( J .GE. 2 .AND. ST1 .LE. 1.0D-3 )  GO TO 30
        KS1 = KS(J)
C       Check to insure that the KS1 switch has a valid value, and if
C       not, set it to 1 which will make coal the solid fuel.
        IF ( KS1 .LE. 0 .OR. KS1 .GE. 6 )  KS1 = 1
        IF ( QMAX(KS1).GT.0.0005D0 .AND. QMAXS(KS1).GT.0.0005D0 )  THEN
C         Call subroutine USR31B to do the steam demand calculations.
          CALL USR31B (BTUSCF, EFFGB, EFFSB, STEFF, E2, FUEL, H, HHV,
     1      ID, KS1, KTEST, NHSTRY, SCFS, SOLID, SOLIDS, TOT, FRACS,
     2      QMAX, QMAXS)
          ST2 = TOT(2) + TOT(3) + TOT(4) + TOT(5) + TOT(6) + TOT(7)
          IF ( ST1 .LE. 1.0D-3 )  THEN
C             Extra steam was available and was used to generate power.
C             Load the results in row 7 of the PSA array for printing.
              PSA(7,1) = - ST1 + ST2
              PSA(7,2) = FUEL
              PSA(7,3) = 0.001D0 * E2
              PSA(7,4) = ST1 - ST2
              CONTINUE
            ELSE
C             Steam had to be generated to satisfy the steam demand.
C             Load the results in the PSA array for printing.
              K = KS1 + 1
              IF ( KS1 .LE. 3 ) THEN
                  PSA(K,1) = 1000.0D0 * FUEL / HHV(KS1)
                ELSE
                  PSA(K,1) = SCFS
              ENDIF
              PSA(K,2) = FUEL
```

```
                PSA(K,3) = 0.001D0 * E2
                PSA(K,4) = ST1 - ST2
C               Calculate the remaining amount of this fuel.
                QMAX(KS1) = QMAX(KS1) - FUEL
            ENDIF
          ENDIF
   30 CONTINUE
C
C
C     SECTION 3 - Power plant section.
C     ================================
C     Loop on the available fuels until the electric power demand is
C     satisfied.
      DO 40 J = 1, 6
C       Skip the power calculations if the power demand is satisfied.
        IF ( TOT(1) .LE. 1.0D-3 )  GO TO 40
        KPOLD = KP1
        KP1 = KP(J)
C       Skip the power calculations if the power demand is to be
C       satisfied by purchasing electric power..
        IF ( J .GE. 2 .AND. KPOLD .EQ. 6 )  GO TO 42
C       Check to insure that the KP1 switch has a valid value, and if
C       not, set it to 1 which will make coal the solid fuel.
        IF ( KP1 .LE. 0 .OR. KP1 .GE. 7 )  KP1 = 1
        IF ( (QMAX(KP1).GT.0.0005D0 .AND. QMAXP(KP1).GT.0.0005D0 ) .OR.
     1    KP1 .EQ. 6 )  THEN
C         Call subroutine USR31C to do the electric power calculations.
          CALL USR31C (BTUSCF, EFFCT, EFFSP, FUEL, HHV, ID, KP1, KTEST,
     1      NHSTRY, PWR, SCFE, SOLID, SOLIDS, TOT, QMAX, QMAXP)
C         Load the results in the PSA array for printing.
          IF ( KP1 .LE. 5 )  THEN
C           Electric power is produced.
            K = KP1 + 7
            IF ( KP1 .LE. 3 ) THEN
                PSA(K,1) = 1000.0D0 * FUEL / HHV(KP1)
              ELSE
                PSA(K,1) = SCFE
            ENDIF
            PSA(K,2) = FUEL
            PSA(K,3) = PWR
C           Calculate the remaining amount of this fuel.
            QMAX(KP1) = QMAX(KP1) - FUEL
          ENDIF
        ENDIF
   40 CONTINUE
   42 CONTINUE
C
C
      IF ( TOT(8) .GE. 0.001D0 )  THEN
C       Natural gas has to be purchased, calculate the amount required
C       in MSCF/hr.
        SCF = 1.0D+3 * TOT(8) / BTUSCF
        IF ( KTEST .GE. 2 )  WRITE (NHSTRY, 736)  SCF, TOT(8)
  736   FORMAT ( / 1X, F10.3, ' MSCF/hr of natural gas has to be',
     1    ' purchased to supply' /
```

```
     2    1X, F10.3, ' MM BTU/hr of energy to the utilities plant.' )
       ENDIF
C
C
      IF ( KTEST .GE. 2 )  THEN
        WRITE (NHSTRY, 741)
  741   FORMAT ( // ' Total utilities after the utilities plant ',
     1    'calculations.' )
        WRITE (NHSTRY, 712)
        WRITE (NHSTRY, 713)  TOT(1), TOT(8), TOT(9), TOT(10), TOT(11)
        WRITE (NHSTRY, 715)
        WRITE (NHSTRY, 716)  (TOT(K), K = 2, 7)
      ENDIF
C
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 751)
  751   FORMAT ( / ' Before USR31S  - the PSA Array:' )
        DO 910 J = 1, 13
          WRITE (NHSTRY, 752)  J, (PSA(J,K), K = 1, 5)
  752     FORMAT ( 1X, I5, 5(1PE14.4) )
  910   CONTINUE
        WRITE (NHSTRY, 753)  (QMAX(K), K = 1, 5)
  753   FORMAT ( '  QMAX', 5(1PE14.4) )
      ENDIF
C
      RETURN
      END
C
C$ USR31B
      SUBROUTINE USR31B (BTUSCF, EFFGB, EFFSB, EFFST, E2, FUEL, H, HHV,
     1  ID, KS1, KTEST, NHSTRY, SCF, SOLID, SOLIDS, TOT, FRACS, QMAX,
     2  QMAXS)
C
C     This subroutine does the steam demand related calculations for
C     the utilities plant.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - May 27, 1992.
C
C     Calling arguments:
C     BTUSCF = Energy content of the purchased natural gas in BTU/SCF.
C     EFFGB  = Fractional gas fired boiler efficiency to steam.
C     EFFSB  = Fractional solid fired boiler efficiency to steam.
C     EFFST  = Fractional steam turbine efficiency to electric power.
C     E2     = Electric power produced during co-gen in kwatts.
C     FUEL   = Required energy input in MM BTU/hr.
C     H(7)   = Vector of steam enthalpies in BTU/lb for
C            H(1) = 900 psig, 750 F          H(5) = 150 psig saturated
C            H(2) = 600 psig saturated       H(6) = 50 psig saturated
C            H(3) = 600 psig, 720 F          H(7) = 1525 psia, 1250 F
C            H(4) = 600 psig saturated
C     HHV(5) = Vector of high heating values of coal, char and coke in
C              BTU/lb.  Items 4 and 5 are fake values for natural gas
C              and gaseous plant fuel.
```

```
C     ID     = Utilities plant internal identification number in the
C              PLNTID, UTIL, CAPCST and OPCST arrays.
C     KS1    = Switch to select which fuel is being burned in the
C              steam boiler to produce steam and/or electric power to
C              satisfy the steam demand.
C              1 => Coal
C              2 => Char (ROSE-SR unit bottoms)
C              3 => Coke
C              4 => Natural gas
C              5 => Gaseous plant fuel
C     KTEST  = Switch for controlling the printing to the history file.
C     NHSTRY = Logical unit number of the history file.
C     SCF    = Natural gas useage in MSCF/hr.
C     SOLID(3) = Vector of solid identification names.
C     SOLIDS   = Solid fuel useage in Mlbs/hr.
C     TOT(15)  = Vector of total utility consumptions.
C     QMAX(5)  = Vector of the energy available in each of the above
C                energy sources in MM BTU/hr.
C     QMAXS(6) = Vector of the maximum capacities of the steam
C                generation section.  QMAXS(1-5) are the maximum unit
C                input heat duties for using each of the above energy
C                sources in MM BTU/hr.  QMAXS(6) is the maximum electric
C                power generating capacity from excess steam in Mwatts.
C     FRACS    = Fraction of excess steam consumed in power generation.
C
C     Important variables in COMMON /USRC01/.
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 H(7), HHV(5), SOLID(5), TOT(15), QMAX(5), QMAXS(6)
C
      CHARACTER * 6  PLNTID
```

```
      CHARACTER * 4  SOLID
C
C     BTUPKW is the conversion factor from MBTUs/hr to killowatts.
      DATA BTUPKW / 3.412141635D0 /
C
C
C     Initialization.
      E2 = 0.0D0
      SCF = 0.0D0
      FUEL = 0.0D0
C
C     Calculate the total amount of steam that has to be generated in
C     Mlbs/hr.
      STEAM = TOT(2) + TOT(3) + TOT(4) + TOT(5) + TOT(6) + TOT(7)
C
      IF ( STEAM .LT. 0.0D0 )  THEN
C       This facility produces excess steam.  It will be used to
C       generate electric power.
        XSTEAM = - STEAM
C       Calculate the electric power production from this steam in a
C       condensing steam turbine assuming exit conditions of 162 F and
C       5 psia corresponding to a water enthalpy of 130 BTU/lb.
        FUEL = 0.0D0
        DO 20 J = 2, 7
          FUEL = FUEL - TOT(J) * (H(J-1) -130.0D0) * 1.0D-3
   20   CONTINUE
C       If the steam turbine efficiency is zero, then the excess steam
C       is vented without producing any electric power.
        PWR = FUEL * EFFST / BTUPKW
        IF ( PWR .GT. QMAXS(6) )  THEN
            FRACS = QMAXS(6) / PWR
          ELSE
            FRACS = 1.0D0
        ENDIF
        PWR = FRACS * PWR
        FUEL = FRACS * FUEL
        XSTEAM = FRACS * XSTEAM
        E2 = 1000.0D0 * PWR
        IF ( KTEST .GE. 2 )  WRITE (NHSTRY, 711)  XSTEAM, FUEL, PWR
  711   FORMAT ( / ' This facility produces ', F10.3, ' Mlbs/hr of',
     1    ' excess steam.  This steam contains' /
     2    1X, F10.3, ' MM BTU/hr of available energy which is being',
     3    ' used to generate'/
     4    1X, F10.3, ' Mwatts of electric power.')
        UTIL(ID,1) = UTIL(ID,1) - E2
        TOT(1) = TOT(1) - E2
        DO 22 J = 2, 7
          UTIL(ID,J) = UTIL(ID,J) - FRACS * TOT(J)
          TOT(J) = TOT(J) - FRACS * TOT(J)
   22   CONTINUE
      ENDIF
C
      IF ( STEAM .GT. 0.0D0 )  THEN
C       Satisfy the steam demand in a co-gen unit by producing a very
C       high temperature and high pressure steam and letting it down
```

```
C       in steam turbines to make electricity and exactly satisfy the
C       steam demand.  E2 is the amount of electric power produced in
C       Kwatts.
        E2 = 0.0D0
        DO 50 J = 2, 7
          E2 = E2 + TOT(J) * ( H(7) - H(J-1) )
   50   CONTINUE
        E2 = E2 * EFFST / BTUPKW
C       Calculate the total energy duty required to satisfy the steam
C       demand in MM BTU/hr for the co-gen plant.
        IF ( EFFST .GT. 0.001D0 )  THEN
C           Co-gen unit - Steam turbines have a realistic efficiency.
            DUTY = STEAM * H(7) * 0.001D0
          ELSE
C           Steam generation only - No steam turbines are present since
C           the steam turbine efficiency is very small or zero.
            DUTY = 0.0D0
            DO 54 J = 2, 7
              DUTY = DUTY + TOT(J) * H(J-1) * 0.001D0
   54       CONTINUE
        ENDIF
C
        IF ( KS1 .GE. 1 .AND. KS1 .LE. 3 )  THEN
C         Burn a solid fuel (coal, char or coke) in a co-gen unit to
C         make very high temperature and pressure steam which is let
C         down in steam turbines to satisfy the steam demand and, at
C         the same time, make some electric power. Switch KS1 designates
C         which solid fuel is used.
C         Calculate the required hest input in MM BTU/hr.
          FUEL = DUTY / EFFSB
C         Adjust, if neccessary, for the amount of available fuel.
          IF ( QMAX(KS1) .GT. FUEL )   THEN
              FRACA = 1.0
            ELSE
              FRACA = QMAX(KS1) / FUEL
          ENDIF
          FUEL = FRACA * FUEL
          STEAM = FRACA * STEAM
          E2 = FRACA * E2
C         Adjust, if neccessary, for the capacity to use this fuel.
          IF ( FUEL .GT. QMAXS(KS1) )   THEN
              FRACC = QMAXS(KS1) / FUEL
            ELSE
              FRACC = 1.0
          ENDIF
          FUEL = FRACC * FUEL
          STEAM = FRACC * STEAM
          E2 = FRACC * E2
C         Calculate the solids fuel use in Mlbs/hr.
          SOLIDS = 1000.0D0 * FUEL / HHV(KS1)
          PWR = 0.001D0 * E2
          IF ( KTEST .GE. 2 .AND. EFFST .GT. 0.001D0 )
     1      WRITE (NHSTRY, 722)  KS1, SOLID(KS1), STEAM, PWR, FUEL,
     2      SOLIDS, SOLID(KS1)
  722     FORMAT ( / ' Steam generation section - Fuel option =', I3 /
```

```
     1      ' Burn ', A4, ' in a co-gen unit to make', F10.3,
     2      ' Mlbs/hr of steam and', F10.3 /
     3      ' MWatts of electric power.  This requires ', F10.3, ' MM',
     4      ' BTU/hr of energy input' /
     5      ' that is supplied by', F11.3, ' Mlbs/hr of ', A4, '.' )
          IF ( KTEST .GE. 2 .AND. EFFST .LE. 0.001D0 )
     1      WRITE (NHSTRY, 723)  KS1, SOLID(KS1), STEAM, FUEL,
     2      SOLIDS, SOLID(KS1)
  723     FORMAT ( / ' Steam generation section - Fuel option =', I3 /
     1      ' Burn ', A4, ' in a steam boiler to make', F10.3,
     2      ' Mlbs/hr of steam.' /
     3      ' This requires ', F10.3, ' MM', ' BTU/hr of energy input'/
     4      ' that is supplied by', F11.3, ' Mlbs/hr of ', A4, '.' )
C         Load the above electric power and steam productions for this
C         option in the UTIL array, and adjust the totals.
          UTIL(ID,1) = UTIL(ID,1) - E2
          TOT(1) = TOT(1) - E2
C         NOTE the plant fuel consumption is not changed for this
C         option.
          DO 62 J = 2, 7
            UTIL(ID,J) = UTIL(ID,J) - FRACA * FRACC * TOT(J)
            TOT(J) = TOT(J) - FRACA * FRACC * TOT(J)
   62     CONTINUE
        ENDIF
C
        IF ( KS1 .EQ. 4 .OR. KS1 .EQ. 5 )  THEN
C         Burn purchased natural gas or gaseous plant fuel in a co-gen
C         unit to make very high temperature and pressure steam which is
C         let dowm in steam turbines to satisfy the steam demand and, at
C         the same time, generate some electric power.
C         Calculate the amount of fuel that has to be burned in the
C         gas boiler to generate the required amount of steam.
          FUEL = DUTY / EFFGB
C         Adjust, if neccessary, for the amount of available fuel.
          IF ( QMAX(KS1) .GT. FUEL )   THEN
              FRACA = 1.0
            ELSE
              FRACA = QMAX(KS1) / FUEL
          ENDIF
          FUEL = FRACA * FUEL
          STEAM = FRACA * STEAM
          E2 = FRACA * E2
C         Adjust, if neccessary, for the capacity to use this fuel.
          IF ( FUEL .GT. QMAXS(KS1) )   THEN
              FRACC = QMAXS(KS1) / FUEL
            ELSE
              FRACC = 1.0
          ENDIF
          FUEL = FRACC * FUEL
          SCF = 1000.0D0 * FUEL / BTUSCF
C         Since the volume of plant fuel cannot be calculated, set it
C         to zero.
          IF ( KS1 .EQ. 5 )   SCF = 0.0D0
          STEAM = FRACC * STEAM
          E2 = FRACC * E2
```

```
          PWR = 0.001D0 * E2
          IF ( KTEST .GE. 2 )  THEN
            IF ( KS1 .EQ. 4 .AND. EFFST .GT. 0.001D0 )
     1         WRITE (NHSTRY, 731)  KS1, STEAM, PWR, SCF, FUEL
  731       FORMAT ( / ' Steam generation section - Fuel option =', I3/
     1        ' Purchase natural gas and burn it in a co-gen unit to',
     2        ' make ', F10.3, ' Mlbs/hr of' /
     3        ' steam and ', F10.3, ' MWatts of electric power.  This',
     4        ' requires', F10.3, ' MSCF/hr' /
     5        ' of natural gas to supply ', F10.3, ' MM BTU/hr of',
     6        ' energy imput.' )
            IF ( KS1 .EQ. 4 .AND. EFFST .LE. 0.001D0 )
     1         WRITE (NHSTRY, 732)  KS1, STEAM, SCF, FUEL
  732       FORMAT ( / ' Steam generation section - Fuel option =', I3/
     1        ' Purchase natural gas and burn it in a steam boiler to',
     2        ' make ', F10.3, ' Mlbs/hr' /
     3        ' of steam.  This requires ', F10.3, ' MSCF/hr of',
     4        ' natural gas to supply ' /
     5        1X, F10.3, ' MM BTU/hr of energy imput.' )
            IF ( KS1 .EQ. 5 .AND. EFFST .GT. 0.001D0 )
     1         WRITE (NHSTRY, 733)  KS1, STEAM, PWR, FUEL
  733       FORMAT ( / ' Steam generation section - Fuel option =', I3/
     1        ' Burn gaseous plant fuel in a co-gen unit to make',
     2        F10.3, ' Mlbs/hr of steam and' /
     3        1X, F10.3, ' MWatts of electric power.  This plant fuel',
     4        ' supplies ', F10.3 /
     5        ' MM BTU/hr of energy input.' )
            IF ( KS1 .EQ. 5 .AND. EFFST .LE. 0.001D0 )
     1         WRITE (NHSTRY, 734)  KS1, STEAM, FUEL
  734       FORMAT ( / ' Steam generation section - Fuel option =', I3/
     1        ' Burn gaseous plant fuel in a steam boiler to make',
     2        F10.3, ' Mlbs/hr of steam.' /
     3        ' This plant fuel supplies ', F10.3 /
     4        ' MM BTU/hr of energy input.' )
          ENDIF
C         Load the above electric power and steam productions, and the
C         plant fuel consumption for this option in the UTIL array, and
C         adjust the totals.
          UTIL(ID,1) = UTIL(ID,1) - E2
          TOT(1) = TOT(1) - E2
          DO 72 J = 2, 7
            UTIL(ID,J) = UTIL(ID,J) - FRACA * FRACC * TOT(J)
            TOT(J) = TOT(J) - FRACA * FRACC * TOT(J)
   72     CONTINUE
          UTIL(ID,8) = UTIL(ID,8) + FUEL
          TOT(8) = TOT(8) + FUEL
        ENDIF
C
      ENDIF
C
      RETURN
      END
C
C$ USR31C
      SUBROUTINE USR31C (BTUSCF, EFFCT, EFFSP, HEAT, HHV, ID, KP1,
```

```
     1  KTEST, NHSTRY, PWR, SCF, SOLID, SOLIDS, TOT, QMAX, QMAXP)
C
C     This subroutine does the electric power calculations for the
C     utilities plant.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - May 27, 1992.
C
C     Calling arguments:
C     BTUSCF = Energy content of the purchased natural gas in BTU/SCF.
C     EFFCF  = Fractional combustion turbine effeiciency to electric
C              power.
C     EFFSP  = Fractional solid fired boiler efficiency to electric
C              power.
C     HEAT   = Required energy input in MM BTU/hr.
C     HHV(5) = Vector of high heating values of coal, char and coke in
C              BTU/lb.  Items 4 and 5 are fake values for natural gas
C              and gaseous plant fuel.
C     ID     = Utilities plant internal identification number in the
C              PLNTID, UTIL, CAPCST and OPCST arrays.
C     KP1    = Switch to select how to satisfy the electic power demand.
C              If coal, char, coke or plant fuel is used, then a
C              conventional solids fuel fired steam power plant is
C              asssumed, and if natural gas is used, then combustion
C              turbines are assumed because they are more efficient.
C              The fuel specified in KP1 is used until it is all
C              consumed, the power demand is satisfied, or the capacity
C              to use this fuel is reached.  The KP1 value designates
C              the following fuels.
C              1 => Coal
C              2 => Char (ROSE-SR unit bottoms)
C              3 => Coke
C              4 => Natural gas
C              5 => Gaseous plant fuel
C              6 => Purchased electric power
C     KTEST  = Switch for controlling the printing to the history file.
C     NHSTRY = Logical unit number of the history file.
C     PWR    = Electric power production in Mwatts.
C     SCF    = Natural gas useage in MSCF/hr.
C     SOLID(3) = Vector of solid identification names.
C     SOLIDS   = Solid fuel useage in Mlbs/hr.
C     TOT(15)  = Vector of total utility consumptions.
C     QMAX(5)  = Vector of the energy available in each of the above
C                energy sources in MM BTU/hr.
C     QMAXP(5) = Vector of the maximum capacities of the power
C                generation section.  QMAXP(1-5) are the maximum unit
C                input heat duties for using each of the above energy
C                sources in MM BTU/hr.
C
C     Important variables in COMMON /USRC01/.
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 HHV(3), QMAX(5), QMAXP(5), SOLID(3), TOT(15)
C
      CHARACTER * 6  PLNTID
      CHARACTER * 4  SOLID
C
C     BTUPKW is the conversion factor from MBTUs/hr to killowatts.
      DATA BTUPKW / 3.412141635D0 /
C
C
C     Initialization.
      SCF = 0.0D0
      PWR = 0.0D0
      HEAT = 0.0D0
C
C     Is the electric power demand satisfied?
      IF ( TOT(1) .GT. 1.0D-3 )  THEN
C         The electic power demand has not been satisfied.
          PWR = 0.001D0 * TOT(1)
C
          IF ( KP1 .EQ. 6 ) THEN
C           Purchase electric power to satisfy the power demand.
            IF ( KTEST .GE. 2 )  WRITE (NHSTRY, 731)  KP1, PWR
  731       FORMAT ( / ' Electric power make-up option =', I3 /
     1        ' The electric power demand will be satisfied',
     2        ' by purchasing ', F10.3, ' Mwatts' /
     3        ' of electric power.' )
C           NOTE the electric power demand is not changed for this
C           option.
          ENDIF
C
          IF ( KP1 .LE. 3 .OR. KP1 .EQ. 5 )  THEN
C           Burn the fuel (coal, char, coke or plant fuel) in a solids
C           fuel fires steam boiler only to make electric power; i.e.,
```

```
C           a conventional steam power plant.  Note that gaseous plant
C           fuel is included here because it is assumed that it only a
C           small amount that will  supplement the main solid fuel.
C           Switch KP1 designates which fuel is used.
C           Calculate the required heat duty in MM BTU/hr.
            HEAT = 1.0E-3 * TOT(1) * BTUPKW / EFFSP
C           Calculate the solids fuel use in Mlbs/hr.
            SOLIDS = 1000.0D0 * HEAT / HHV(KP1)
            PWR = 0.001D0 * TOT(1)
C           Adjust, if neccessary, for the amount of available fuel.
            IF ( QMAX(KP1) .GT. HEAT )   THEN
                FRACA = 1.0
              ELSE
                FRACA = QMAX(KP1) / HEAT
            ENDIF
            HEAT = FRACA * HEAT
            SCF = FRACA * SCF
            PWR = FRACA * PWR
C           Adjust, if neccessary, for the capacity to use this fuel.
            IF ( HEAT .GT. QMAXP(KP1) )   THEN
                FRACC = QMAXP(KP1) / HEAT
              ELSE
                FRACC = 1.0
            ENDIF
            HEAT = FRACC * HEAT
            SCF = FRACC * SCF
            PWR = FRACC * PWR
            IF ( KTEST .GE. 2 )  THEN
              IF ( KP1 .LE. 3 )  WRITE (NHSTRY, 732)  KP1, PWR,
     1          SOLIDS, SOLID(KP1), SOLID(KP1), HEAT
  732         FORMAT ( / ' Electric power make-up option =', I3 /
     1          1X, F10.3, ' Mwatts of electric power are produced by',
     2          ' burning ', F10.3, ' Mlbs/hr' /
     3          ' of ', A4, '.  This ', A4, ' supplies ', F10.3,
     4          ' MM BTU/hr of energy.' )
              IF ( KP1 .EQ. 5 )  WRITE (NHSTRY, 733)  KP1, PWR, HEAT
  733         FORMAT ( / ' Electric power make-up option =', I3 /
     1          1X, F10.3, ' Mwatts of electric power are produced by',
     2          ' burning plant fuel.'/
     3          ' This plant fuel supplies ', F10.3, ' MM BTU/hr of',
     4          ' energy.' )
            ENDIF
C           Load the above electric power production for this option
C           in the UTIL array, and adjust the total.
            UTIL(ID,1) = UTIL(ID,1) - 1000.0D0 * PWR
            TOT(1) = TOT(1) - 1000.0 * PWR
C           NOTE the plant fuel consumption is not changed for this
C           option when a solid fuel is the energy source.
            IF ( KP1 .EQ. 5 )  THEN
              UTIL(ID,8) = UTIL(ID,8) + HEAT
              TOT(8) = TOT(8) + HEAT
            ENDIF
          ENDIF
C
          IF ( KP1 .EQ. 4 ) THEN
```

```
C           Purchase natural gas and burn it in a combustion turbine
C           to generate electric power.
C           Calculate the required heat duty in MM BTU/hr and the
C           amount of natural gas in MSCF/hr.
            PWR = 0.001D0 * TOT(1)
            HEAT = 1.0E-3 * TOT(1) * BTUPKW / EFFCT
            SCF = 1.0E+3 * HEAT / BTUSCF
C           Adjust, if neccessary, for the amount of available fuel.
            IF ( QMAX(4) .GT. HEAT )   THEN
                FRACA = 1.0
              ELSE
                FRACA = QMAX(4) / HEAT
            ENDIF
            HEAT = FRACA * HEAT
            SCF = FRACA * SCF
            PWR = FRACA * PWR
C           Adjust, if neccessary, for the capacity to use this fuel.
            IF ( HEAT .GT. QMAXP(4) )   THEN
                FRACC = QMAXP(4) / HEAT
              ELSE
                FRACC = 1.0
            ENDIF
            HEAT = FRACC * HEAT
            SCF = FRACC * SCF
            PWR = FRACC * PWR
            IF ( KTEST .GE. 2 )  WRITE (NHSTRY, 735)  KP1, PWR,
     1        SCF, HEAT
  735       FORMAT ( / ' Electric power make-up option =', I3 /
     1        1X, F10.3, ' MWatts of electric power are produced by',
     2        ' burning ', F10.3, ' MSCF/hr' /
     3        ' of natural gas in a combustion turbine.  This gas',
     4        ' supplies ', F10.3 /
     5        ' MM BTU/hr of energy.' )
C           Load the above electric power production and fuel
C           consumption for this option in the UTIL array and adjust
C           the totals.
            UTIL(ID,1) = UTIL(ID,1) - 1000.0D0 * PWR
            UTIL(ID,8) = UTIL(ID,8) + HEAT
            TOT(1) = TOT(1) - 1000.0D0 * PWR
            TOT(8) = TOT(8) + HEAT
          ENDIF
C
C
        ELSE
C
C         Extra electric power will be sold.
          IF ( TOT(1) .GT. 1.0D-3 )  THEN
            PWR = - 0.001D0 * TOT(1)
            IF ( KTEST .GE. 2 )  WRITE (NHSTRY, 736)  PWR
  736       FORMAT ( / 1X, F10.3, ' Mwatts of electric power will',
     1        ' be sold.' )
          ENDIF
C
      ENDIF
C
```

```
      RETURN
      END
C
C$ USR31D
      SUBROUTINE USR31D (ID, INT3, KPRNT, NOUT, CAP, CON, PNAME)
C
C     This subroutine was adapted from subroutine USRUCO and
C         1.  Calculates the Utilities, Capital costs for the
C             utilities plant.
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 - May 29, 1992.
C
C     Calling arguments:
C     ID     = Plant internal identification number.
C     INT3   = Number of operating duplicate trains, excluding spares.
C              If INT3 = 0, the minimum 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(2).
C              If INT3 > 0, this number of duplicate trains will be
C                used.
C     KPRNT  = Switch to control writing the results to the Plant
C              Summary Reoprt.
C                0 => Do not write the results to the summary report.
C                1 or more => Write the results to the summary report.
C     NOUT   = Logical unit number of the plant output report file.
C     CAP    = Total capacity of all duplicate plants in MW of
C              electric power generated.
C     CON()  = Vector of plant parameters for calculating the utilities,
C              capital costs and operating costs as a function of train
C              capacity as defined by the CAP variable.
C       CON(1)   = Reference capacity of a single train as defined by
C                  power generation rate in MW for the calculation
C                  of the capital cost of a single train as a function
C                  of the power generation rate.
C       CON(2)   = Maximum size of a single train as defined by the
C                  power generation rate in MW.
C       CON(3)   = Minimum size of a single train as defined by the
C                  power generation rate in MW.
C       CON(4)   = Constant A in the plant ISBL field cost equation.
C       CON(5)   = Constant B in the plant ISBL field cost equation.
C       CON(6)   = Constant E in the plant ISBL field cost equation.
C       CON(7)   = Constant F in the plant ISBL field cost equation.
C       CON(8)   = Number of spare trains.
C       CON(9)   = Future use.
C       CON(10)  = Future use.
C       CON(11)  = Constant factor for the number of operators per
C                  day, operators/day.
C       CON(12)  = Number of operators per day per train,
C                  (operators/day)/train.
```

```
C        CON(13) -
C         CON(20) = Future use.
C      PNAME  = Plant name (CHARACTER * 6)
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                    (See subroutine USRUCO for a detailed description.)
C                     18 => Plant 31, Steam and power generation plant.
C      UTIL(J,K)   = Plant utilities consumptions, where
C                    (See subroutine USRUCO for a detailed description.)
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 => 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(*)
C
       DIMENSION PCA(2,3)
C      PCA(J,K) is the Plant Cost Array, where
C        J = Property for each plant
C            1 => Plant capacity
C            2 => Plant cost
C        K = Total or duplicate plant 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 / 'MWatts                ' /
C
C
C     Input variable error checking.
      IF ( ID .LE. 0 .OR. ID .GE. 21 )  THEN
        WRITE (NHSTRY, 801) ID
  801   FORMAT ( // ' SEVERE ERROR - Subroutine USR31D 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 USR31D 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 USR31D has been called ',
     1    'with a negative key power ' /
     2    '  generation rate for plant ', A6 /
     3    '  The utilities capital costs and operating ',
     4    'cost calculations' /
     5    '  for this plant are being skipped.' //)
        GO TO 999
      ENDIF
C
C
C     Load the reference, maximum and minimum capacities of a single
C     plant expressed as the key flow rate in CAP units into the
C     appropriate variables.
      PREFF = CON(1)
      PMAXF = CON(2)
      PMINF = CON(3)
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 Cost Calculations.
C       Set up the constants in the plant ISBL field cost equation.
        A = CON(4)
        B = CON(5)
        E = CON(6)
        F = CON(7)
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.
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 = Flow key flow rate of a single train that is being
C                   used to scale the capital cost of a single train
C                   as a 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
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
C           train 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 train
C           capacity.
C       5.  Constant F is the 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(8) - 1.0) * PCA(2,3)
C
C     Calculate the total number of operators/day.  Do not include a
C     set of operators for any spare trains.
      XPLTS = XPLANT + CON(8)
      OPERS = CON(11) + XPLTS * CON(12)
C
C
C     If this pass is made only to report the results with KPRNT >=1,
C     do not save the results in named COMMON /USRC01/.
      IF ( KPRNT .LE. 0 )  THEN
        PLNTID(ID) = PNAME
        CAPCST(ID,1) = XPLANT
        CAPCST(ID,2) = PFLOW
        CAPCST(ID,3) = PCA(2,2)
        CAPCST(ID,4) = PCA(2,1)
        CAPCST(ID,5) = CON(8)
        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 the print switch (KPRNT) is 1 or larger, write the results
C       to the plant summary report.
          IF ( KPRNT .GE. 1 )   THEN
          WRITE (NOUT, 822)  OPCST(ID,1)
  822     FORMAT ( / 2X, 'TOTAL PLANT OPERATORS/DAY    ', F18.1 )
          WRITE (NOUT, 831)
  831     FORMAT (// 28X, 'PLANT COSTING INFORMATION' )
C         Get the number of duplicate trains in an integer variable.
          NDUP = CON(8) + 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, PMAXF, PUNITS, 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, (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 COST, MM$', 22X, 2F11.3, F13.3 )
C
C         If the calculated plant size is below the specified minimum
C         train size, write a warning message.
          IF ( (PCA(1,1).LT.PMINF) .OR. (PCA(1,2).LT.PMINF) )
     1      WRITE (NOUT, 840)
  840     FORMAT (/ ' WARNING - THE ABOVE PLANT COSTS MAY BE IN',
     1      ' ERROR SINCE THE CALCULATED' /
     2      11X, 'TRAIN SIZE IS BELOW THE SPECIFIED MINIMUM TRAIN ',
     3      'SIZE.')
C
C         If the calculated plant size is above the specified maximum
C         train size, write a warning message.
          IF ( ( (NPLT.EQ.1) .AND. (PCA(1,1).GT.PMAXF)) .OR.
     1       (PCA(1,2).GT.PMAXF) )   WRITE (NOUT, 841)
  841     FORMAT (/ ' WARNING - THE ABOVE PLANT COSTS MAY BE IN',
     1      ' ERROR SINCE THE CALCULATED' /
     2      11X, 'TRAIN SIZE IS ABOVE THE SPECIFIED MAXIMUM TRAIN ',
     3      'SIZE.')
        ENDIF
C
  999 RETURN
      END
C
C$ USR31S
      SUBROUTINE USR31S (NOUT, PSA, TOT)
C
C     This subroutine writes the utilities plant summary report.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - February 12, 1992.
C
C     Calling arguments:
C     NOUT   = Logical unit number of the plant output report file.
C     PSA(J,K) = Utilities Plant Summary Array, where
C                J designates the following utilities plant items.
C                  1 => Combustion turbines using plant fuel to make
C                       electric power.
C                  2 => Coal feed to the co-gen unit.
C                  3 => CSD bottoms (char) feed to the co-gen unit.
C                  4 => Coke feed to the co-gen unit.
C                  5 => Natural gas feed to the co-gen unit.
```

```
C                    6 => Gaseous plant fuel feed to the co-gen unit.
C                    7 => Excess steam is available and is being used to
C                         to generate electric power.
C                    8 => Coal feed to the power plant.
C                    9 => CSD bottoms (char) feed to the power plant.
C                   10 => Coke feed to the power plant.
C                   11 => Natural gas feed to the combustion turbines
C                         in the power plant.
C                   12 => Gaseous plant fuel feed to the power plant.
C                   13 => Natural gas to supplement plant fuel.
C                  K designates the following utilities plant items.
C                    1 => Weight of the solid fuel in Mlbs/hr or volume
C                         of natural gas in MM SCF/hr.
C                    2 => Energy consumed in MM BTU/hr.
C                    3 => Net electric power production in Mwatts.
C                    4 => Net steam production in Mlbs/hr.
C                    5 = Future use.
C     TOT(15)  = Total of the following utilities leaving the utilities
C                plant where J designates the 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
C     Local variable declarations.
      DIMENSION PSA(13,5), TOT(15)
C
      CHARACTER * 6  PLNTID, PNAME
C
C
C       Write the output report.
C       ========================
        WRITE (NOUT, 801)
  801   FORMAT ( / 26X, 'PLANT 31 - SUMMARY REPORT' /
     1    31X, 'UTILITIES PLANT')
C
        WRITE (NOUT, 802)
  802   FORMAT ( / 50X, 'NET PRODUCTION' /
     1    47X, 'ELECTRIC', 5X, 'STEAM,' /
     2    5X, 'ENERGY SOURCE', 4X, 'AMOUNT*', 5X, 'MMBTU/HR', 5X,
     3    'POWER, MW', 4X, 'MLBS/HR' )
```

```
C
      WRITE (NOUT, 803)
  803 FORMAT ( / 1X, 'COMBUSTION TURBINES SECTION' )
C
      IF ( PSA(1,2) .GT. 1.0D-5)  THEN
         WRITE (NOUT, 804) PSA(1,2), PSA(1,3)
  804    FORMAT ( 5X, 'PLANT FUEL', F26.3, F14.3 )
       ELSE
         WRITE (NOUT, 805)
  805    FORMAT ( 5X, 'NO PLANT FUEL IS AVAILABLE.' )
      ENDIF
C
      WRITE (NOUT, 811)
  811 FORMAT ( / 1X, 'STEAM GENERATION SECTION' )
C
      IF ( PSA(2,2) .GT. 1.0D-4)  WRITE (NOUT, 812) (PSA(2,J),J=1,4)
  812 FORMAT ( 5X, 'COAL', F20.3, F12.3, F14.3, F12.3 )
C
      IF ( PSA(3,2) .GT. 1.0D-4)  WRITE (NOUT, 813) (PSA(3,J),J=1,4)
  813 FORMAT ( 5X, 'CSD BOTTOMS', F13.3, F12.3, F14.3, F12.3 )
C
      IF ( PSA(4,2) .GT. 1.0D-4)  WRITE (NOUT, 814) (PSA(4,J),J=1,4)
  814 FORMAT ( 5X, 'COKE', F20.3, F12.3, F14.3, F12.3 )
C
      IF ( PSA(5,2) .GT. 1.0D-4)  WRITE (NOUT, 815) (PSA(5,J),J=1,4)
  815 FORMAT ( 5X, 'NATURAL GAS', F13.3, F12.3, F14.3, F12.3 )
C
      IF ( PSA(6,2) .GT. 1.0D-4)  WRITE (NOUT, 816) (PSA(6,J),J=2,4)
  816 FORMAT ( 5X, 'PLANT FUEL ', F25.3, F14.3, F12.3 )
C
      IF ( PSA(7,2) .GT. 1.0D-4)  WRITE (NOUT, 817) (PSA(7,J),J=1,4)
  817 FORMAT ( 5X, 'EXCESS STEAM', F12.3, F12.3, F14.3, F12.3 )
C
C     If all excess steam has not been used to generate power, vent
C     any residual excess steam.
      XSTEAM = TOT(2) + TOT(3) + TOT(4) + TOT(5) + TOT(6)
      IF ( XSTEAM .LE. -0.001D0 )  THEN
        STEAM = - XSTEAM
        WRITE (NOUT, 818)  STEAM, XSTEAM
  818   FORMAT ( 5X, 'VENTED STEAM', F12.3, F38.3 )
      ENDIF
C
      WRITE (NOUT, 821)
  821 FORMAT ( / 1X, 'POWER PLANT SECTION' )
C
      IF ( PSA(8,2) .GT. 1.0D-4)  WRITE (NOUT, 822) (PSA(8,J),J=1,3)
  822 FORMAT ( 5X, 'COAL', F20.3, F12.3, F14.3 )
C
      IF ( PSA(9,2) .GT. 1.0D-4)  WRITE (NOUT, 823) (PSA(9,J),J=1,3)
  823 FORMAT ( 5X, 'CSD BOTTOMS', F13.3, F12.3, F14.3 )
C
      IF ( PSA(10,2) .GT. 1.0D-4)  WRITE (NOUT, 824) (PSA(10,J),J=1,3)
  824 FORMAT ( 5X, 'COKE', F20.3, F12.3, F14.3 )
C
      IF ( PSA(11,2) .GT. 1.0D-4)  WRITE (NOUT, 825) (PSA(11,J),J=1,3)
```

```
  825   FORMAT ( 5X, 'NATURAL GAS', F13.3, F12.3, F14.3 )
C
        IF ( PSA(12,2) .GT. 1.0D-4)  WRITE (NOUT, 826) (PSA(12,J),J=2,3)
  826   FORMAT ( 5X, 'PLANT FUEL ', F25.3, F14.3 )
C
        IF ( PSA(13,2) .GT. 1.0D-4)  WRITE (NOUT, 827) (PSA(13,J),J=1,2)
  827   FORMAT ( / 1X, 'SUPPLEMENTAL PLANT FUEL' /
     1    5X, 'NATURAL GAS', F13.3, F12.3 )
C
C       Purchased electric power in Mwatts.
        PPWR = 0.001D0 * TOT(1)
        IF ( PPWR .GT. 1.0D-3)  WRITE (NOUT, 830) PPWR
  830   FORMAT ( 5X, 'PURCHASED  ', F39.3 )
C
        SUM2 = 0.0D0
        SUM3 = PPWR
        SUM4 = XSTEAM
        DO 20 J = 1, 13
          SUM2 = SUM2 + PSA(J,2)
          SUM3 = SUM3 + PSA(J,3)
          SUM4 = SUM4 + PSA(J,4)
   20   CONTINUE
C
        WRITE (NOUT, 831)  SUM2, SUM3, SUM4
  831   FORMAT ( 33X, '--------', 6X, '--------', 4X, '--------' /
     1    1X, 'UTILITIES PLANT TOTAL', F19.3, F14.3, F12.3 )
C
C       Calculate the amount of natural gas that has to be purchased.
        PGAS = PSA(5,1) + PSA(11,1) + PSA(13,1)
        PBTU = PSA(5,2) + PSA(11,2) + PSA(13,2)
C
        IF ( PGAS.GT.1.0D-4 .OR. PPWR.GT.1.0D-4 )  WRITE (NOUT, 832)
  832   FORMAT ( / 1X, 'PURCHASED MATERIALS' )
        IF ( PGAS.GT.1.0D-4 )  WRITE (NOUT, 833) PGAS, PBTU
  833   FORMAT ( 5X, 'NATURAL GAS', F13.3, F12.3 )
        IF ( PPWR.GT.1.0D-4 )  WRITE (NOUT, 834) PPWR
  834   FORMAT ( 5X, 'ELECTRIC POWER', F36.3 )
C
        WRITE (NOUT, 838)
  838   FORMAT ( / ' *SOLID FUEL AMOUNTS ARE IN MLBS/HR, AND NATURAL',
     1    ' GAS IS IN MSCF/HR.' /
     2    '  NEGATIVE NET PRODUCTION VALUES INDICATE CONSUMPTION.' )
C
      RETURN
      END
C
C$  Subroutine USR38
C
C     This file contains the following subroutines:
C       USR38    Main routine for ammonia recovery plant model.
C       USR38R   Subroutine to write the summary report for the
C                ammonia recovery plant.
C       USR38S   Subroutine to load the outlet streams into the
C                product stream vectors.
C
```

```
C     NOTE:  This model uses common block COMMON /USR02M/.
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 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       GETSTR   Subroutine for finding the stream bead information.
C       USRBD1   User BLOCK DATA routine to initialize the items in
C                the USRCXX named COMMON blocks.
C
C$ USR38
      SUBROUTINE USR38 (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:  USR38
C
C  BLOCK DESCRIPTION:  Ammonia Recovery Plant Model
C
C                      -----------------------
C                      |       Plant 38      |
C                      |                     | ---> Ammonia Product
C       Total Feed---->|   Ammonia Recovery  |
C                      |        Plant        | ---> Total Sour Water and
C                      |                     |        Acid Gas Stream
C                      -----------------------
C
C  Prepared under DOE contract no. DE-AC22-90PC 89857.
C
C  FUNCTION (MODEL, REPORT, OR BOTH):  Both
C
C  Last revision - May 29, 1992.
C
C  DESCRIPTION
C  -----------
C    This is a very simple model of the PHOSAM-W Ammonia Recovery Plant.
C    It is designed only to satisfy the mass balance requirements and
C    produce the correct amount of ammonia from the entering sour
C    water.  It produces only two product streams; the recovered
C    ammonia product stream and a stream containing all other material
C    present in the entering feed.  A splitter block may be added
C    following this Fortran block model to approximate splitting
C    this other material into an acid gas stream and a sour water
C    stream, if desired.
C
C    Two input parameters define the how this plant performs.  The
C    first specifies the fraction of the entering ammonia that is
C    recovered in the ammonia product stream.  The second specifies
C    the purity of the product ammonia stream in wt%.  Water is the
C    only impurity which may be in the ammonia product stream.
C
C  ASSUMPTIONS, SPECIAL FEATURES AND LIMITATIONS:
C     1.  The single inlet stream is the total sour water feed stream.
```

```
C     2.  There are 2 product streams.
C           1.  The ammonia product stream.
C           2.  The total sour water and acid gas stream.
C     3.  This user block model will work with any number of
C         conventional components, but requires that NH3 and H2O
C         must be available in the component list.
C     4.  This user block Fortran model requires that all inupt and
C         output streams are of the ASPEN/SP stream class
C         conventional, MIXNC, or MIXNCPSD.
C     5.  If the inlet stream is of class MIXNC or MIXNCPSD, then
C         the order of the items in the ATTR-COMPS statement must be
C         PROXANAL, ULTANAL, SULFANAL AND AOXANAL because it is in
C         this order that ASPEN/SP stores these items, and this
C         subroutine assumes this order.  Therefore, the three
C         ATTR-COMPS 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 non-conventional (solid) components in the input stream
C         will be ignored, and the plant will not be in mass balance.
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 DCL38.REP.
C         INT(3)  = Number of operating duplicate trains, excluding
C                   spares.
C                   If INT(3) = 0, the minimum number of duplicate
C                     trains will be determined so that the capacity
C                     each train does not exceed the maximum train
C                     capacity specified by variable REAL(52).
C                   If INT(3) > 0, this number of duplicate trains will
C                     be used.
C         INT(4)  = History file additional output control switch.
C                   0 => Write no additional output to the history 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     8.  The 70 real parameters are:
C         REAL(1)   = Ammonia recovery, percent.
```

```
C          REAL(2)   = Purity of ammonia product, wt %.
C          REAL(3) -
C           REAL(20) = Future use.
C          REAL(21)  = Constant factor for the power consumption, kw.
C          REAL(22)  = Power consumption per Mlbs/hr of NH3 recovered,
C                      kw/(Mlbs/hr of NH3 recovered)
C          REAL(23)  = Constant factor for the 900 psig / 750 F steam
C                      consumption, Mlbs/hr.
C          REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr
C                      of NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3
C                      recovered).
C          REAL(25)  = Constant factor for the 900 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr
C                      of NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3
C                      recovered).
C          REAL(27)  = Constant factor for the 600 psig / 720 F steam
C                      consumption, Mlbs/hr.
C          REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr
C                      of NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3
C                      recovered).
C          REAL(29)  = Constant factor for the 600 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr
C                      of NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3
C                      recovered).
C          REAL(31)  = Constant factor for the 150 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr
C                      of NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3
C                      recovered).
C          REAL(33)  = Constant factor for the 50 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr
C                      of NH3 recovered, (Mlbs/hr)/(Mlbs/hr of NH3
C                      recovered).
C          REAL(35)  = Constant factor for the plant fuel consumption,
C                      MM BTU/hr.
C          REAL(36)  = Plant fuel consumption per Mlbs/hr of NH3
C                      recovered, MM BTU/hr)/(Mlbs/hr of NH3 recovered).
C          REAL(37)  = Constant factor for the cooling water consumption,
C                      Mgal/hr.
C          REAL(38)  = Cooling water consumption per Mlbs/hr of NH3
C                      recovered, MM BTU/hr)/(Mlbs/hr of NH3 recovered).
C          REAL(39)  = Constant factor for the process water consumption,
C                      Mgal/hr.
C          REAL(40)  = Process water consumption per Mlbs/hr of NH3
C                      recovered, MM BTU/hr)/(Mlbs/hr of NH3 recovered).
C          REAL(41)  = Constant factor for the nitrogen consumption,
C                      MM SCF/hr of N2.
C          REAL(42)  = Nitrogen consumption per Mlbs/hr of NH3 recovered,
C                      (MM SCF/hr of N2)/(Mlbs/hr of NH3 recovered).
C          REAL(43) -
C           REAL(48) = Future use.
C          REAL(49)  = Constant factor for the number of operators per
```

```
C                       day, operators/day.
C         REAL(50)  = Number of operators per day per operating train,
C                     (operators/day)/train.
C         REAL(51)  = Reference NH3 recovery rate of a single train in
C                     Mlbs/hr of NH3 recovered for the calculation of
C                     the ISBL field cost of a single train as a
C                     function of train capacity.
C         REAL(52)  = Maximum size of a single train as defined by the
C                     NH3 recovery rate in Mlbs/hr of NH3 recovered.
C         REAL(53)  = Minimum size of a single train as defined by the
C                     NH3 recovery rate in Mlbs/hr of NH3 recovered.
C         REAL(54)  = Constant A in the plant ISBL field cost equation.
C         REAL(55)  = Constant B in the plant ISBL field cost equation.
C         REAL(56)  = Constant E in the plant ISBL field cost equation.
C         REAL(57)  = Constant F in the plant ISBL field cost equation.
C         REAL(58)  = Number of spare trains.
C         REAL(59) -
C          REAL(70) = 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.   NH3          Ammonia
C       2.   H2O          Water
C       3.-
C        9.  blank        Future use
C       10.  OTHERS       Other components (i.e., not NH3 or H2O.
C
      COMMON /USRO2M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(2,5), ST2(3,5)
C
C     In COMMON /USRO2M/
C       CIN(J) contains the component flow rates entering the
C         ammonia recovery plant in lbs/hr.
C       COUT(J) contains the component flow rates leaving the
C         ammonia recovery plant in the Ammonia product stream in
C         lbs/hr.
C       CPROP(J,K) is not used.
```

```
C       ICNUMB(J) contains the relative component numbers.
C       ST1(J,K) and ST2(J,K) contain the properties of up to 2 inlet
C         and 3 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
C     Local variable declaration statements.
      DIMENSION ICN(2), ICNAME(20)
C
      CHARACTER * 4  BLANK4, ICN, ICNAME
      CHARACTER * 6  PNAME
C
C     Initialize the component identifications.
      DATA KOMPS / 2 /
      DATA KMAX  / 10 /
      DATA BLANK4 / '    ' /
      DATA ICNAME / 'NH3 ', '    ', 'H2O ', '    ', '    ', '    ',
     1  '    ', '    ', '    ', '    ', '    ', '    ', '    ', '    ',
     2  '    ', '    ', '    ', 'OTHE', 'RS  ' /
C
      DATA PNAME / '38    ' /
C
C
C     PARAMETER INITIALIZATION SECTION
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)
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 38 - Supplementary data from ',
     1    'subroutine USR38' /
     2    2X, 'Ammonia Recovery Plant', 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 ammonia recovery plant ',
     1    'requires 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 are exactly 2 outlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSOUT .NE. 2 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501) IPASS
        WRITE (NHSTRY, 503)  NSOUT
  503   FORMAT ( / 1X, '* ERROR * - The ammonia recovery plant ',
     1    'requires exactly 2 outlet streams.' /
     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     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 = 1
C
C     Can the inlet stream contain non-conventional components?
      NUMPSD = 0
      IF ( NSUBS .EQ. 2 .AND. ITYPE(2) .EQ. 3 )   THEN
        KLASS = 2
C       Check for a substream PSD attribute on the second substream of
C       the first inlet stream.
        CALL GETSTR (IDS(1,4), NB, LB, NBD, LBD)
        NUMATT = NPAT (LBD, 2)
        IF ( NUMATT .GT. 0 )   THEN
          NUMPSD = NAVAR (LBD, 2, 1)
          KLASS = 3
        ENDIF
      ENDIF
C
C     Set the offset variable for the conventional substream.
      NCONV = (NCC + 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 = NCONV
      IF ( KLASS .EQ. 2 )  ITEMS = ITEMS + ( NNCC + 9 )
     1                             + NITEMS * NNCC
      IF ( KLASS .EQ. 3 )  ITEMS = ITEMS + NUMPSD
C
C     Calculate the total inlet flow rate of all conventional
C     components in lbs/hr, and save it in ST1(1,1).
C     CF is the conversion factor from Kg/sec to lbs/hr.
      CF = 3600.0D0 / 0.45359237D0
      J = NCC + 1
      K = NCC + 9
      ST1(1,1) = CF * SIN1(J)*SIN1(K)
C
```

```
      IF ( ST1(1,1) .LE. 1.0D0 )   THEN
C       Skip all remaing calculations if this plant has no flow.
        IF ( KTEST .GE. 1 )  WRITE (NHSTRY, 504)
  504   FORMAT ( / ' There is no material entering plant 38, the ',
     1    'ammonia recovery plant.' )
        GO TO 999
C       ---------
      ENDIF
C
      SOLIDS = 0.0D0
      IF ( KLASS .GE. 2 )   THEN
        J = NCC + 9 + NNCC + 1
        SOLIDS = CF * SIN1(J)
        IF ( SOLIDS .GE. 1.0D0 )  THEN
          IF ( KTEST .LE. 0 )  WRITE (NHSTRY, 501)  IPASS
          WRITE (NHSTRY, 505) SOLIDS
  505     FORMAT (/ 1X, '* WARNING * The feed stream to the ',
     1      'ammonia recovery plant' /
     2      3X, 'contains solids, ', F10.1, ' lbs/hr.' /
     3      3X, 'These solids are being ignored.  The plant will ',
     4      'NOT be in mass balance.' /
     5      3X, 'Please remove these solids from the feed stream to ',
     6      'this plant.' )
        ENDIF
      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 ammonia recovery plant model 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     Set up the ammonia recovery rate and purity.
      RECVY = REAL(1)
      PURITY = REAL(2)
C
C     If requested, write the sepecified input parameters.
      IF ( KTEST .GE. 3 )  WRITE (NHSTRY, 508) RECVY, PURITY
  508 FORMAT ( / ' Specified Ammonia Recovery = ', F10.4, ' %' /
     1  ' Specified Ammonia Purity   = ', F10.4, ' wt%' )
C
C     Check the validity of the supplied NH3 recovery, and if it is
C     invalid, set it to 99.0% and write a warning message.
      IER1 = 0
      IF ( RECVY .LE. 90.0D0 .OR. RECVY .GE. 100.0D0 )  THEN
        IER1 = 1
        IF ( KTEST .LE. 0 )  WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 509)  RECVY
  509   FORMAT (/ 1X, '* WARNING * The specified ammonia recovery ',
     1    'of', F7.2, ' percent is invalid.' /
     2    3X, 'It is being set to 99.0 %.  Execution ',
     3    'is continuing.' / )
        RECVY = 99.0D0
      ENDIF
C
C     Check the validity of the supplied NH3 purity, and if it is
C     invalid, set it to 99.0% and write a warning message.
      IER2 = 0
      IF ( PURITY .LE. 90.0D0 .OR. PURITY .GE. 100.0D0 )  THEN
        IER2 = 1
        IF ( KTEST .LE. 0 )  WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 510)  PURITY
  510   FORMAT (/ 1X, '* WARNING * The specified purity of the ',
     1    'product ammonia stream of', F7.2, ' wt%' /
     2    3X, 'is invalid.  It is being set to 99.0 wt%.  Execution ',
     3    'is continuing.' / )
        PURITY = 99.0D0
      ENDIF
C
C     Set up the maximum and minimum train flow rates in Mlbs/hour
C     of NH3 recovered.
      PMAXF = REAL(52)
      PMINF = REAL(53)
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, 520)
  520   FORMAT ( / '  The inlet stream vector:'/
     1    3X, 'Item', 8X, 'SIN1' )
        DO 30 J = 1, ITEMS
          WRITE (NHSTRY, 521) J, SIN1(J)
  521     FORMAT ( 1X, I6, 1X, 1PE15.5 )
   30   CONTINUE
      ENDIF
C
```

```
C     Load the NH3 and H2O inlet flow rates in Mlbs/hr.
      CFM = 0.001D0 * CF
      OTHERS = 0.0
      DO 44 J = 1, NCC
        DO 42 K = 1, KOMPS
        IF ( J .EQ. ICNUMB(K) )  THEN
          CIN(K) = CFM * XMW(J) * SIN1(J)
          GO TO 44
        ENDIF
   42   CONTINUE
        OTHERS = OTHERS + CFM * XMW(J) * SIN1(J)
   44 CONTINUE
      CIN(10) = OTHERS
C
C     If requested, write the component inlet flow rates.
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 531)
  531   FORMAT ( / ' Component inlet flow rates in Mlbs/hr:' )
        SUM = 0.0D0
        DO 52 J = 1, KMAX
          K = 2 * J - 1
          IF ( ICNAME(K) .EQ. BLANK4 )   GO TO 52
            SUM = SUM + CIN(J)
            WRITE (NHSTRY, 532) ICNAME(K), ICNAME(K+1), CIN(J)
  532       FORMAT ( 2X, 2A4, 3X, F10.3 )
   52   CONTINUE
        WRITE (NHSTRY, 533) SUM
  533   FORMAT ( '  Total    ', F13.3 )
      ENDIF
C
C
C     Calculate the component recoveries in Mlbs/hr in the ammonia
C     product stream.  Any remaining material goes to the reject stream.
C     Ammonia - RECVY is the percent ammonia recovery.
      COUT(1) = 0.01D0 * RECVY * CIN(1)
C     WATER - PURITY is the ammonia purity in wt %.
      COUT(2) = COUT(1) * (100.0D0 - PURITY) / PURITY
C     If necessary, limit the water leaving in the NH3 product to
C     that entering in the feed.
      IF  ( COUT(2) .GT. CIN(2) )   COUT(2) = CIN(2)
C
C     If requested, write the component outlet flow rates.
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 541)
  541   FORMAT ( / ' Component inlet and outlet flow rates in ',
     1    'Mlbs/hr:' /
     2    18X, 'Inlet', 8X, 'NH3', 7X, 'Reject' )
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        DO 62 J = 1, KMAX
          K = 2 * J - 1
          IF ( ICNAME(K) .EQ. BLANK4 )   GO TO 62
            X = CIN(J) - COUT(J)
            SUM1 = SUM1 + CIN(J)
```

```
            SUM2 = SUM2 + COUT(J)
            SUM3 = SUM3 + X
            WRITE (NHSTRY, 542) ICNAME(K), ICNAME(K+1), CIN(J),
     1        COUT(J), X
  542       FORMAT ( 2X, 2A4, F13.3, F12.3, F12.3 )
   62   CONTINUE
        WRITE (NHSTRY, 543) SUM1, SUM2, SUM3
  543   FORMAT ( '  Total   ', F13.3, F12.3, F12.3 )
      ENDIF
C
C     If it has not been specified by the user in variable INT(3),
C     calculate the number of operating duplicate trains, excluding
C     spares (NPLNT), based on the total flow rate of the reference
C     stream.  However, if the maximum capacity of a single train
C     has not been specified, set the number of operating trains to 1.
      NPLNT = INT(3)
      IF ( (NPLNT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
          NPLNT = COUT(1) / PMAXF
          IF ( (MOD(COUT(1), PMAXF)) .GT. 0.0D0 )  NPLNT = NPLNT + 1
        ELSE
          IF ( NPLNT .EQ. 0 )   NPLNT = 1
      ENDIF
C
C     Calculate the feed rate for each of the duplicate trains (PFLOW)
C     in Mlbs/hr.
      XPLNT = NPLNT
      PFLOW = COUT(1) / XPLNT
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 plant summary report.
            LSTRM = 13
            LUTIL = 16
            LCOST = 11
            IF (SOLIDS .GE. 1.0D0 )  LSTRM = LSTRM + 4
            IF (IER1 .GE. 1 )  LSTRM = LSTRM + 3
            IF (IER2 .GE. 1 )  LSTRM = LSTRM + 3
            NDUP = REAL(58) + 0.001D0
            IF ( (NPLNT + NDUP) .EQ. 1 )  LCOST = 9
            IF ( PFLOW .LT. PMINF )  LCOST = LCOST + 3
            IF ( PFLOW .GT .PMAXF )  LCOST = LCOST + 3
            IF ( NDUP .GE. 1 )  LCOST = LCOST + 1
            LINES = LSTRM + LUTIL + LCOST
C           Now, subtract the number of lines for those portions of
C           the user block summary report which will not be written.
            IF ( INT(1) .GE. 2 )   LINES = LINES - LUTIL
            IF ( INT(1) .GE. 1 )   LINES = LINES - LCOST
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 DCL38.REP to contain
C           this user block summary report.
            OPEN (UNIT=62, FILE='DCL38.REP', STATUS='UNKNOWN',
     1        ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2        BUFFERED='BUFFERED')
            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' )
        ENDIF
      ENDIF
C
C     Load the entering inlet and outlet stream temperatures (in
C     degrees Fahrenheit) and stream pressures (in PSIA) in the ST1
C     and ST2 arrays.  The outlet stream conditions will be reset
C     later in the calculations.
      X = 1.8D0
      X1 = 459.67D0
      ST1(1,2) = X * SIN1(NCC+2) - X1
      ST2(1,2) = X * SOUT1(NCC+2) - X1
      ST2(2,2) = X * SOUT2(NCC+2) - X1
      X = 1.0D0 / 6.8947573D+3
      ST1(1,3) = X * SIN1(NCC+3)
      ST2(1,3) = X * SOUT1(NCC+3)
      ST2(2,3) = X * SOUT2(NCC+3)
C
C
C     If required, write the plant summary report.
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 2 )  THEN
C       Call Subroutine USR38R to write the ammonia recovery plant
C       summary report.
        CALL USR38R (ICNAME, KOMPS, KTEST, NHSTRY, NOUT)
C
C       If appropriate, write the following warning message to the plant
C       summary report.
        IF ( SOLIDS .GE. 1.0D0 )  WRITE (NOUT, 811)
  811   FORMAT (/ 1X, '*WARNING* THE FEED STREAM TO THIS ',
     1    'PLANT CONTAINS SOLIDS.' /
     2    2X, 'THEY ARE BEING IGNORED.  ',
     3    'THIS PLANT IS NOT IN MASS BALANCE.' /
     4    2X, 'PLEASE REMOVE THESE SOLIDS FROM THE ',
     5    'FEED STREAM.' )
C
        IF ( IER1 .GE. 1 )  WRITE (NOUT, 812)
  812     FORMAT (/ 1X, '*WARNING* THE SPECIFIED AMMONIA ',
     1      'RECOVERY WAS INVALID.' /
     2      2X, 'IT HAS BEEN RESET TO 99.0 %.' )
C
        IF ( IER2 .GE. 1 )  WRITE (NOUT, 813)
  813     FORMAT (/ 1X, '*WARNING* THE SPECIFIED PURITY OF THE ',
     1      'PRODUCT AMMONIA STREAM' /
     2      2X, 'WAS INVALID.  IT HAS BEEN RESET TO 99.0 WT%.' )
      ENDIF
```

```
C
      IF ( IPASS .NE. 4 )   THEN
C       Call Subroutine USR38S to load the product streams into the
C       SOUT1 and SOUT2 vectors for transfer to ASPEN/SP.
        CALL USR38S (ICNAME, ITEMS, KLASS, KOMPS, KTEST,
     1    NCC, NHSTRY, NNCC, SIN1, SOUT1, SOUT2 )
      ENDIF
C
C     Call subroutine USRUCO to calculate, save and report the
C     utilities, capital and operating costs for the plant.
      ID = 15
      KUNITS = 7
      CALL USRUCO (NHSTRY, NOUT, IPASS, ID, PNAME, INT(1), INT(3),
     1  KTEST, REAL(21), COUT(1), KUNITS)
C
C     If the summary report for this user block 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, 590)
  590 FORMAT ( / ' Leaving subroutine USR38' )
C
      RETURN
      END
C
C$ USR38R
      SUBROUTINE USR38R (ICNAME, KOMPS, KTEST, NHSTRY, NOUT)
C
C     This subroutine writes the ammonia recovery plant summary
C     report.
C     This subroutine is only called when IPASS .EQ. 4 and
C     INT1 .LE. 2.
C
C     Prepared under DOE contract no. DE-AC22 91PC90027.
C
C     Last revision - February 18, 1992.
C
C     Calling arguments:
C     ICNAME() = Vector of component identifications (CHARACTER * 4)
C     KOMPS    = Number of conventional components used in this model.
C     KTEST    = Switch for controlling the printing to the history
C                file.
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
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(2,5), ST2(3,5)
C
      DIMENSION ICNAME(*)
C
```

```
      CHARACTER * 4  ICNAME
C
C
C
C       Write the stream section of the plant summary report.
C       ====================================================
        WRITE (NOUT, 801)
  801   FORMAT ( / 27X, 'PLANT 38 - SUMMARY REPORT' /
     1    28X, 'AMMONIA RECOVERY PLANT')
C
        WRITE (NOUT, 821)
  821   FORMAT ( / '  STREAM FLOW RATES, MLBS/HR' /
     1    4X, 'COMPONENT', 8X, '   FEED', 5X, 'NH3 PRODUCT', 6X,
     2    'SOUR H2O' )
C
C       Write the individual stream component flow rates in Mlbs/hr.
        X = CIN(1) - COUT(1)
        X3 = X
        WRITE (NOUT, 831) ICNAME(1), ICNAME(2), CIN(1), COUT(1),
     1    X
  831   FORMAT ( 4X, 2A4, F16.3, 2F14.3 )
        X = CIN(2) - COUT(2)
        X3 = X3 + X
        WRITE (NOUT, 831) ICNAME(3), ICNAME(4), CIN(2), COUT(2),
     1    X
        X = CIN(10) - COUT(10)
        X3 = X3 + X
        WRITE (NOUT, 831) ICNAME(19), ICNAME(20), CIN(10), COUT(10),
     1    X
        X1 = CIN(1) + CIN(2) + CIN(10)
        X2 = COUT(1) + COUT(2) + COUT(10)
        WRITE (NOUT, 832)  X1, X2, X3
  832   FORMAT ( 4X, 'TOTAL', 3X, F16.3, 2F14.3 )
C
        WRITE (NOUT, 841) ST1(1,2), ST2(1,2), ST2(2,2), ST1(1,3),
     1    ST2(1,3), ST2(1,3)
  841   FORMAT ( / 4X, 'TEMPERATURE, F', F10.1, 2F14.1 /
     1    4X, 'PRESSURE, PSIA', F10.1, 2F14.1 )
C
      RETURN
      END
C
C$ USR38S
      SUBROUTINE USR38S (ICNAME, ITEMS, KLASS, KOMPS, KTEST,
     1  NCC, NHSTRY, NNCC, SIN1, SOUT1, SOUT2 )
C
C     This subroutine loads the two product stream properties into
C     the SOUT1 and SOUT2 vectors for transfer to ASPEN/SP.
C     This subroutine is not called when IPASS = 4.
C
C     Prepared under DOE contract no. DE-AC22 91PC90027.
C
C     Last revision - February 18, 1992.
C
C     Calling arguments:
```

```
C     ICNAME() = Vector of component identifications (CHARACTER * 4)
C     ITEMS    = Total number of items in the SOUT1 vector.
C     KLASS    = Stream class identification switch
C                1 => Conventional (MIXED)
C                2 => MIXNC
C                3 => MIXNCPSD
C     KOMPS    = Number of conventional components used in this model.
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     NNCC     = Number of non-conventional components.
C     SIN1()   = ASPEN/SP stream vector for reactor inlet stream.
C     SOUT1()  = ASPEN/SP stream vector for the ammonia product
C                stream.
C     SOUT2()  = ASPEN/SP stream vector for the combined sour water and
C                acid gas product stream.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON/MW/XMW(1)
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(2,5), ST2(3,5)
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(*), SIN1(*), SOUT1(*), SOUT2(*)
C
C     Local variable declarations.
C
      CHARACTER * 4  ICNAME
C
C
C     First, zero all the items in the product stream vectors.
      DO 200 J = 1, ITEMS
        SOUT1(J) = 0.0D0
        SOUT2(J) = 0.0D0
  200 CONTINUE
C
C     CF is the conversion factor from Kg/sec to Mlbs/hr.
      CF = 0.001D0 * 3600.0D0 / 0.45359237D0
C
C     Load the conventional component molar flow rates.
      SUM1 = 0.0D0
      SUM2 = 0.0D0
      DO 210 J = 1, NCC
        DO 208 K = 1, KOMPS
          IF ( J .EQ. ICNUMB(K) )  THEN
            SOUT1(J) = COUT(K) / (CF * XMW(J))
            SOUT2(J) = (CIN(K) - COUT(K)) / (CF * XMW(J))
```

```
            SUM1 = SUM1 + SOUT1(J)
            SUM2 = SUM2 + SOUT2(J)
            GO TO 210
          ENDIF
  208   CONTINUE
        SOUT1(J) = 0.0D0
        SOUT2(J) = SIN1(J)
        SUM1 = SUM1 + SOUT1(J)
        SUM2 = SUM2 + SOUT2(J)
  210 CONTINUE
C     Load the total molar flow rate of the conventional components.
      SOUT1(NCC+1) = SUM1
      SOUT2(NCC+1) = SUM2
C
C     NOTE: Any non-conventional components are ignored.
C
C     Set the outlet stream temperatures and pressures to the
C     default values of 70 F and 1 atmosphere.  These default values
C     may be overridden by a FLASH-SPECS sentence in the input file.
      SOUT1(NCC+2) = ( 70.0D0 + 459.67D0 ) / 1.8D0
      SOUT1(NCC+3) = 6.8947573D+3 * 14.696D0
      SOUT2(NCC+2) = SOUT1(NCC+2)
      SOUT2(NCC+3) = SOUT1(NCC+3)
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)
      CALL CPACK (SOUT2, NCP, IDX, XPACK, TMASS)
      SOUT2(NCC+9) = AVEMW (NCP, IDX, XPACK)
C
C     If requested, write the items of interest in the inlet and
C     outlet stream vectors to the history file.
      IF ( KTEST .GE. 5 )  THEN
        WRITE (NHSTRY, 531)
  531   FORMAT ( // ' The inlet and outlet stream vectors:' /
     1    14X, ' SIN1', 10X, 'SOUT1', 10X, 'SOUT2')
        DO 290 J = 1, ITEMS
          WRITE (NHSTRY, 532) J, SIN1(J), SOUT1(J), SOUT2(J)
  532     FORMAT ( 2X, I5, 6(1PE15.5) )
  290   CONTINUE
      ENDIF
C
      RETURN
      END
C
C$  Subroutine USR39
C
C     This file contains the following subroutines:
C       USR39    Main routine for phenol recovery plant model.
C       USR39R   Subroutine to write the summary report for the
C                phenol recovery plant.
C       USR39S   Subroutine to load the outlet streams into the
C                product stream vectors.
```

```
C
C     NOTE:  This model uses common block COMMON /USR02M/.
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 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       GETSTR   Subroutine for finding the stream bead information.
C       USRBD1   User BLOCK DATA routine to initialize the items in
C                the USRCXX named COMMON blocks.
C
C$ USR39
      SUBROUTINE USR39 (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:  USR39
C
C  BLOCK DESCRIPTION:  Phenol Recovery Plant Model
C
C                      ----------------------
C                      |       Plant 39     |
C                      |                    | ---> Phenol Product
C       Total Feed---->|   Phenol Recovery  |
C                      |       Plant        | ---> Total Waste Water
C                      |                    |        Stream
C                      ----------------------
C
C  Prepared under DOE contract no. DE-AC22-90PC 89857.
C
C  FUNCTION (MODEL, REPORT, OR BOTH):  Both
C
C  Last revision - February 18, 1992.
C
C  DESCRIPTION
C  -----------
C    This is a very simple model of the Glitsch Phenol Recovery Plant.
C    It is designed only to satisfy the mass balance requirements and
C    produce the correct amount of phenol from the entering sour
C    water.  It produces only two product streams; the recovered
C    phenol product stream and a waste water stream containing all
C    other material present in the entering feed.  Part of this stream
C    recycled to plant 2, and part goes to the waste water treatment
C    plant.
C
C    Two input parameters define the how this plant performs.  The
C    first specifies the fraction of the entering phenol that is
C    recovered in the phenol product stream.  The second specifies
C    the purity of the product phenol stream in wt%.  Water is the
C    only impurity which may be in the phenol product stream.
C
C  ASSUMPTIONS, SPECIAL FEATURES AND LIMITATIONS:
C     1.  The single inlet stream is the total sour water feed stream.
```

```
C     2.  There are 2 product streams.
C           1.  The phenol product stream.
C           2.  The total waste water stream.
C     3.  This user block model will work with any number of
C         conventional components, but requires that T375, T425 and
C         H2O must be available in the component list.  Phenol is
C         assumed to be contained in the T475, T525, T575, and T625
C         components.
C     4.  This user block Fortran model requires that all inupt and
C         output streams are of the ASPEN/SP stream class
C         conventional, MIXNC, or MIXNCPSD.
C     5.  If the inlet stream is of class MIXNC or MIXNCPSD, then
C         the order of the items in the ATTR-COMPS statement must be
C         PROXANAL, ULTANAL, SULFANAL AND AOXANAL because it is in
C         this order that ASPEN/SP stores these items, and this
C         subroutine assumes this order.  Therefore, the three
C         ATTR-COMPS 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 non-conventional (solid) components in the input stream
C         will be ignored, and the plant will not be in mass balance.
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 DCL39.REP.
C         INT(3)  = Number of operating duplicate trains, excluding
C                   spares.
C                   If INT(3) = 0, the minimum number of duplicate
C                     trains will be determined so that the capacity
C                     each train does not exceed the maximum train
C                     capacity specified by variable REAL(52).
C                   If INT(3) > 0, this number of duplicate trains will
C                     be used.
C         INT(4)  = History file additional output control switch.
C                   0 => Write no additional output to the history 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     8.  The 70 real parameters are:
C         REAL(1)    = Phenol recovery, percent.
C         REAL(2)    = Purity of phenol product, wt %.
C         REAL(3) -
C          REAL(20)  = Future use.
C         REAL(21)   = Constant factor for the power consumption, kw.
C         REAL(22)   = Power consumption per Mlbs/hr of Phenol recovered,
C                      kw/(Mlbs/hr of Phenol recovered)
C         REAL(23)   = Constant factor for the 900 psig / 750 F steam
C                      consumption, Mlbs/hr.
C         REAL(24)   = 900 psig / 750 F steam consumption per Mlbs/hr
C                      of Phenol recovered, (Mlbs/hr)/(Mlbs/hr of Phenol
C                      recovered).
C         REAL(25)   = Constant factor for the 900 psig saturated steam
C                      consumption, Mlbs/hr.
C         REAL(26)   = 900 psig saturated steam consumption per Mlbs/hr
C                      of Phenol recovered, (Mlbs/hr)/(Mlbs/hr of Phenol
C                      recovered).
C         REAL(27)   = Constant factor for the 600 psig / 720 F steam
C                      consumption, Mlbs/hr.
C         REAL(28)   = 600 psig / 720 F steam consumption per Mlbs/hr
C                      of Phenol recovered, (Mlbs/hr)/(Mlbs/hr of Phenol
C                      recovered).
C         REAL(29)   = Constant factor for the 600 psig saturated steam
C                      consumption, Mlbs/hr.
C         REAL(30)   = 600 psig saturated steam consumption per Mlbs/hr
C                      of Phenol recovered, (Mlbs/hr)/(Mlbs/hr of Phenol
C                      recovered).
C         REAL(31)   = Constant factor for the 150 psig saturated steam
C                      consumption, Mlbs/hr.
C         REAL(32)   = 150 psig saturated steam consumption per Mlbs/hr
C                      of Phenol recovered, (Mlbs/hr)/(Mlbs/hr of Phenol
C                      recovered).
C         REAL(33)   = Constant factor for the 50 psig saturated steam
C                      consumption, Mlbs/hr.
C         REAL(34)   = 50 psig saturated steam consumption per Mlbs/hr
C                      of Phenol recovered, (Mlbs/hr)/(Mlbs/hr of Phenol
C                      recovered).
C         REAL(35)   = Constant factor for the plant fuel consumption,
C                      MM BTU/hr.
C         REAL(36)   = Plant fuel consumption per Mlbs/hr of Phenol
C                      recovered, MM BTU/hr)/(Mlbs/hr of Phenol
C                      recovered).
C         REAL(37)   = Constant factor for the cooling water consumption,
C                      Mgal/hr.
C         REAL(38)   = Cooling water consumption per Mlbs/hr of Phenol
C                      recovered, MM BTU/hr)/(Mlbs/hr of Phenol
C                      recovered).
C         REAL(39)   = Constant factor for the process water consumption,
C                      Mgal/hr.
C         REAL(40)   = Process water consumption per Mlbs/hr of Phenol
C                      recovered, MM BTU/hr)/(Mlbs/hr of Phenol
C                      recovered).
C         REAL(41)   = Constant factor for the nitrogen consumption,
C                      MM SCF/hr of N2.
```

```
C         REAL(42)  = Nitrogen consumption per Mlbs/hr of Phenol
C                     recovered, (MM SCF/hr of N2)/(Mlbs/hr of Phenol
C                     recovered).
C         REAL(43) -
C          REAL(48) = Future use.
C         REAL(49)  = Constant factor for the number of operators per
C                     day, operators/day.
C         REAL(50)  = Number of operators per day per operating train,
C                     (operators/day)/train.
C         REAL(51)  = Reference Phenol recovery rate of a single train
C                     in Mlbs/hr of Phenol recovered for the calculation
C                     of the ISBL field cost of a single train as a
C                     function of train capacity.
C         REAL(52)  = Maximum size of a single train as defined by the
C                     Phenol recovery rate in Mlbs/hr of Phenol
C                     recovered.
C         REAL(53)  = Minimum size of a single train as defined by the
C                     Phenol recovery rate in Mlbs/hr of Phenol
C                     recovered.
C         REAL(54)  = Constant A in the plant ISBL field cost equation.
C         REAL(55)  = Constant B in the plant ISBL field cost equation.
C         REAL(56)  = Constant E in the plant ISBL field cost equation.
C         REAL(57)  = Constant F in the plant ISBL field cost equation.
C         REAL(58)  = Number of spare trains.
C         REAL(59) -
C          REAL(70) = Future use.
C
C     NOTE:  In the above, phenol recovered means pure phenol recovered.
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.   T475         Phenol and organics
C       2.   T525         Phenol and organics
C       3.   T575         Phenol and organics
C       4.   T625         Phenol and organics
C       5.   H2O          Water
C       6.-
C        9.  blank        Future use
```

```
C       10.  OTHERS       Other components (i.e., not Phenol or H2O.
C
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(2,5), ST2(3,5)
C
C     In COMMON /USR02M/
C       CIN(J) contains the component flow rates entering the
C         phenol recovery plant in lbs/hr.
C       COUT(J) contains the component flow rates leaving the
C         phenol recovery plant in the Phenol product stream in
C         lbs/hr.
C       CPROP(J,K) is not used.
C       ICNUMB(J) contains the relative component numbers.
C       ST1(J,K) and ST2(J,K) contain the properties of up to 2 inlet
C         and 3 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
C     Local variable declaration statements.
      DIMENSION ICN(2), ICNAME(20)
C
      CHARACTER * 4  BLANK4, ICN, ICNAME
      CHARACTER * 6  PNAME
C
C     Initialize the component identifications.
      DATA KOMPS / 5 /
      DATA KMAX  / 10 /
      DATA BLANK4 / '    ' /
      DATA ICNAME / 'T475', '    ', 'T525', '    ', 'T575', '    ',
     1  'T625', '    ', 'H2O ', '    ', '    ', '    ', '    ', '    ',
     2  '    ', '    ', '    ', '    ', 'OTHE', 'RS  '/
C
      DATA PNAME / '39    ' /
C
C
C     PARAMETER INITIALIZATION SECTION
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)
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 39 - Supplementary data from ',
     1    'subroutine USR39' /
     2    2X, 'Phenol Recovery Plant', 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 phenol recovery plant ',
     1    'requires 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 are exactly 2 outlet streams, and if
C     not, print an error message and terminate execution.
      IF ( NSOUT .NE. 2 ) THEN
        IF ( KTEST .LE. 0 )   WRITE (NHSTRY, 501) IPASS
        WRITE (NHSTRY, 503)  NSOUT
  503   FORMAT ( / 1X, '* ERROR * - The phenol recovery plant ',
     1    'requires exactly 2 outlet streams.' /
     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     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 = 1
C
C     Can the inlet stream contain non-conventional components?
      NUMPSD = 0
      IF ( NSUBS .EQ. 2 .AND. ITYPE(2) .EQ. 3 )   THEN
        KLASS = 2
C       Check for a substream PSD attribute on the second substream of
C       the first inlet stream.
        CALL GETSTR (IDS(1,4), NB, LB, NBD, LBD)
        NUMATT = NPAT (LBD, 2)
        IF ( NUMATT .GT. 0 )   THEN
          NUMPSD = NAVAR (LBD, 2, 1)
          KLASS = 3
        ENDIF
      ENDIF
C
C     Set the offset variable for the conventional substream.
      NCONV = (NCC + 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 = NCONV
```

```
      IF ( KLASS .EQ. 2 )  ITEMS = ITEMS + ( NNCC + 9 )
     1                             + NITEMS * NNCC
      IF ( KLASS .EQ. 3 )  ITEMS = ITEMS + NUMPSD
C
C     Calculate the total inlet flow rate of all conventional
C     components in lbs/hr, and save it in ST1(1,1).
C     CF is the conversion factor from Kg/sec to lbs/hr.
      CF = 3600.0D0 / 0.45359237D0
      J = NCC + 1
      K = NCC + 9
      ST1(1,1) = CF * SIN1(J)*SIN1(K)
C
      IF ( ST1(1,1) .LE. 1.0D0 )   THEN
C       Skip all remaing calculations if this plant has no flow.
        IF ( KTEST .GE. 1 )  WRITE (NHSTRY, 504)
  504   FORMAT ( / ' There is no material entering Plant 39, the ',
     1    'phenol recovery plant.' )
        GO TO 999
C       ---------
      ENDIF
C
      SOLIDS = 0.0D0
      IF ( KLASS .GE. 2 )   THEN
        J = NCC + 9 + NNCC + 1
        SOLIDS = CF * SIN1(J)
        IF ( SOLIDS .GE. 1.0D0 )  THEN
          IF ( KTEST .LE. 0 )  WRITE (NHSTRY, 501)  IPASS
          WRITE (NHSTRY, 505) SOLIDS
  505     FORMAT (/ 1X, '* WARNING * The feed stream to the ',
     1      'phenol recovery plant' /
     2      3X, 'contains solids, ', F10.1, ' lbs/hr.' /
     3      3X, 'These solids are being ignored.  The plant will ',
     4      'NOT be in mass balance.' /
     5      3X, 'Please remove these solids from the feed stream to ',
     6      'this plant.' )
        ENDIF
      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 phenol recovery plant model 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     Set up the phenol recovery rate and purity.
      RECVY = REAL(1)
      PURITY = REAL(2)
C
C     If requested, write the sepecified input parameters.
      IF ( KTEST .GE. 3 )  WRITE (NHSTRY, 508) RECVY, PURITY
  508 FORMAT ( / ' Specified Phenol Recovery = ', F10.4, ' %' /
     1  ' Specified Phenol Purity   = ', F10.4, ' wt%' )
C
C     Check the validity of the supplied Phenol recovery, and if it is
C     invalid, set it to 97.0% and write a warning message.
      IER1 = 0
      IF ( RECVY .LE. 90.0D0 .OR. RECVY .GE. 100.0D0 )  THEN
        IER1 = 1
        IF ( KTEST .LE. 0 )  WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 509)  RECVY
  509   FORMAT (/ 1X, '* WARNING * The specified phenol recovery ',
     1    'of', F7.2, ' percent is invalid.' /
     2    3X, 'It is being set to 97.0 %.  Execution ',
     3    'is continuing.' / )
        RECVY = 97.0D0
      ENDIF
C
C     Check the validity of the supplied Phenol purity, and if it is
C     invalid, set it to 90.0% and write a warning message.
      IER2 = 0
      IF ( PURITY .LE. 80.0D0 .OR. PURITY .GE. 100.0D0 )  THEN
        IER2 = 1
        IF ( KTEST .LE. 0 )  WRITE (NHSTRY, 501)  IPASS
        WRITE (NHSTRY, 510)  PURITY
  510   FORMAT (/ 1X, '* WARNING * The specified purity of the ',
     1    'product phenol stream of', F7.2, ' wt%' /
     2    3X, 'is invalid.  It is being set to 90.0 wt%.  Execution ',
     3    'is continuing.' / )
        PURITY = 90.0D0
      ENDIF
C
C     Set up the maximum and minimum train flow rates in Mlbs/hour
C     of Phenol recovered.
      PMAXF = REAL(52)
      PMINF = REAL(53)
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, 520)
  520   FORMAT ( / '  The inlet stream vector:'/
     1    3X, 'Item', 8X, 'SIN1' )
        DO 30 J = 1, ITEMS
          WRITE (NHSTRY, 521) J, SIN1(J)
  521     FORMAT ( 1X, I6, 1X, 1PE15.5 )
   30   CONTINUE
      ENDIF
C
C     Load the T475 T525, T575 and T625 components (Phenol) and H2O
C     inlet flow rates in Mlbs/hr.
      CFM = 0.001D0 * CF
      OTHERS = 0.0
      DO 44 J = 1, NCC
        DO 42 K = 1, KOMPS
        IF ( J .EQ. ICNUMB(K) )  THEN
          CIN(K) = CFM * XMW(J) * SIN1(J)
          GO TO 44
        ENDIF
   42   CONTINUE
        OTHERS = OTHERS + CFM * XMW(J) * SIN1(J)
   44 CONTINUE
      CIN(10) = OTHERS
C
C     If requested, write the component inlet flow rates.
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 531)
  531   FORMAT ( / ' Component inlet flow rates in Mlbs/hr:' )
        SUM = 0.0D0
        DO 52 J = 1, KMAX
          K = 2 * J - 1
          IF ( ICNAME(K) .EQ. BLANK4 )   GO TO 52
            SUM = SUM + CIN(J)
            WRITE (NHSTRY, 532) ICNAME(K), ICNAME(K+1), CIN(J)
  532       FORMAT ( 2X, 2A4, 3X, F10.3 )
   52   CONTINUE
        WRITE (NHSTRY, 533) SUM
  533   FORMAT ( '  Total    ', F13.3 )
      ENDIF
C
C
C     Calculate the component recoveries in Mlbs/hr in the phenol
C     product stream.  Any remaining material goes to the reject stream.
C     Phenol - RECVY is the percent phenol recovery.
      KM1 = KOMPS - 1
      PHENOL = 0.0D0
      DO 54 J = 1, KM1
        COUT(J) = 0.01D0 * RECVY * CIN(J)
        PHENOL = PHENOL + COUT(J)
   54 CONTINUE
C     WATER - PURITY is the phenol purity in wt %.
      COUT(5) = (PHENOL) * (100.0D0 - PURITY) / PURITY
```

```
C     If necessary, limit the water leaving in the Phenol product to
C     that entering in the feed.
      IF  ( COUT(5) .GT. CIN(5) )   COUT(5) = CIN(5)
C
C     If requested, write the component outlet flow rates.
      IF ( KTEST .GE. 3 )  THEN
        WRITE (NHSTRY, 541)
  541   FORMAT ( / ' Component inlet and outlet flow rates in ',
     1    'Mlbs/hr:' /
     2    18X, 'Inlet', 8X, 'Phenol', 8X, 'Reject' )
        SUM1 = 0.0D0
        SUM2 = 0.0D0
        SUM3 = 0.0D0
        DO 62 J = 1, KMAX
          K = 2 * J - 1
          IF ( ICNAME(K) .EQ. BLANK4 )   GO TO 62
            X = CIN(J) - COUT(J)
            SUM1 = SUM1 + CIN(J)
            SUM2 = SUM2 + COUT(J)
            SUM3 = SUM3 + X
            WRITE (NHSTRY, 542) ICNAME(K), ICNAME(K+1), CIN(J),
     1        COUT(J), X
  542       FORMAT ( 2X, 2A4, F13.3, F14.3, F14.3 )
   62   CONTINUE
        WRITE (NHSTRY, 543) SUM1, SUM2, SUM3
  543   FORMAT ( '  Total   ', F13.3, F14.3, F14.3 )
      ENDIF
C
C     If it has not been specified by the user in variable INT(3),
C     calculate the number of operating duplicate trains, excluding
C     spares (NPLNT), based on the total flow rate of the reference
C     stream.  However, if the maximum capacity of a single train
C     has not been specified, set the number of operating trains to 1.
      NPLNT = INT(3)
      FLOW = PHENOL
      IF ( (NPLNT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
          NPLNT = FLOW / PMAXF
          IF ( (MOD(FLOW, PMAXF)) .GT. 0.0D0 )  NPLNT = NPLNT + 1
        ELSE
          IF ( NPLNT .EQ. 0 )   NPLNT = 1
      ENDIF
C
C     Calculate the feed rate for each of the duplicate trains (PFLOW)
C     in Mlbs/hr.
      XPLNT = NPLNT
      PFLOW = FLOW / XPLNT
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 plant summary report.
```

```
            LSTRM = 13
            LUTIL = 16
            LCOST = 11
            IF (SOLIDS .GE. 1.0D0 )  LSTRM = LSTRM + 4
            IF (IER1 .GE. 1 )  LSTRM = LSTRM + 3
            IF (IER2 .GE. 1 )  LSTRM = LSTRM + 3
            NDUP = REAL(58) + 0.001D0
            IF ( (NPLNT + NDUP) .EQ. 1 )  LCOST = 9
            IF ( PFLOW .LT. PMINF )  LCOST = LCOST + 3
            IF ( PFLOW .GT .PMAXF )  LCOST = LCOST + 3
            IF ( NDUP .GE. 1 )  LCOST = LCOST + 1
            LINES = LSTRM + LUTIL + LCOST
C           Now, subtract the number of lines for those portions of
C           the user block summary report which will not be written.
            IF ( INT(1) .GE. 2 )   LINES = LINES - LUTIL
            IF ( INT(1) .GE. 1 )   LINES = LINES - LCOST
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 DCL39.REP to contain
C           this user block summary report.
            OPEN (UNIT=62, FILE='DCL39.REP', STATUS='UNKNOWN',
     1        ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2        BUFFERED='BUFFERED')
            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' )
        ENDIF
      ENDIF
C
C     Load the entering inlet and outlet stream temperatures (in
C     degrees Fahrenheit) and stream pressures (in PSIA) in the ST1
C     and ST2 arrays.  The outlet stream conditions will be reset
C     later in the calculations.
      X = 1.8D0
      X1 = 459.67D0
      ST1(1,2) = X * SIN1(NCC+2) - X1
      ST2(1,2) = X * SOUT1(NCC+2) - X1
      ST2(2,2) = X * SOUT2(NCC+2) - X1
      X = 1.0D0 / 6.8947573D+3
      ST1(1,3) = X * SIN1(NCC+3)
      ST2(1,3) = X * SOUT1(NCC+3)
      ST2(2,3) = X * SOUT2(NCC+3)
C
C
C     If required, write the plant summary report.
      IF ( IPASS .EQ. 4 .AND. INT(1) .LE. 2 )  THEN
C       Call Subroutine USR39R to write the phenol recovery plant
C       summary report.
        CALL USR39R (ICNAME, KOMPS, KTEST, NHSTRY, NOUT)
C
C       If appropriate, write the following warning message to the plant
```

```
C       summary report.
        IF ( SOLIDS .GE. 1.0D0 )  WRITE (NOUT, 811)
  811   FORMAT (/ 1X, '*WARNING* THE FEED STREAM TO THIS ',
     1    'PLANT CONTAINS SOLIDS.' /
     2    2X, 'THEY ARE BEING IGNORED.  ',
     3    'THIS PLANT IS NOT IN MASS BALANCE.' /
     4    2X, 'PLEASE REMOVE THESE SOLIDS FROM THE ',
     5    'FEED STREAM.' )
C
        IF ( IER1 .GE. 1 )  WRITE (NOUT, 812)
  812     FORMAT (/ 1X, '*WARNING* THE SPECIFIED PHENOL ',
     1      'RECOVERY WAS INVALID.' /
     2      2X, 'IT HAS BEEN RESET TO 97.0 %.' )
C
        IF ( IER2 .GE. 1 )  WRITE (NOUT, 813)
  813     FORMAT (/ 1X, '*WARNING* THE SPECIFIED PURITY OF THE ',
     1      'PRODUCT PHENOL STREAM' /
     2      2X, 'WAS INVALID.  IT HAS BEEN RESET TO 90.0 WT%.' )
      ENDIF
C
      IF ( IPASS .NE. 4 )   THEN
C       Call Subroutine USR39S to load the product streams into the
C       SOUT1 and SOUT2 vectors for transfer to ASPEN/SP.
        CALL USR39S (ICNAME, ITEMS, KLASS, KOMPS, KTEST,
     1    NCC, NHSTRY, NNCC, SIN1, SOUT1, SOUT2 )
      ENDIF
C
C     Call subroutine USRUCO to calculate, save and report the
C     utilities, capital and operating costs for the plant.
      ID = 16
      KUNITS = 8
      CALL USRUCO (NHSTRY, NOUT, IPASS, ID, PNAME, INT(1), INT(3),
     1  KTEST, REAL(21), FLOW, KUNITS)
C
C     If the summary report for this user block 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, 590)
  590 FORMAT ( / ' Leaving subroutine USR39' )
C
      RETURN
      END
C
C$ USR39R
      SUBROUTINE USR39R (ICNAME, KOMPS, KTEST, NHSTRY, NOUT)
C
C     This subroutine writes the phenol recovery plant summary
C     report.
C     This subroutine is only called when IPASS .EQ. 4 and
C     INT1 .LE. 2.
C
C     Prepared under DOE contract no. DE-AC22 91PC90027.
C
```

```
C     Last revision - April 20, 1992.
C
C     Calling arguments:
C     ICNAME() = Vector of component identifications (CHARACTER * 4)
C     KOMPS    = Number of conventional components used in this model.
C     KTEST    = Switch for controlling the printing to the history
C                file.
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
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(2,5), ST2(3,5)
C
      DIMENSION ICNAME(*)
C
      CHARACTER * 4  ICNAME
C
C
C
C       Write the stream section of the plant summary report.
C       ====================================================
        WRITE (NOUT, 801)
  801   FORMAT ( / 27X, 'PLANT 39 - SUMMARY REPORT' /
     1    29X, 'PHENOL RECOVERY PLANT')
C
        WRITE (NOUT, 821)
  821   FORMAT ( / '  STREAM FLOW RATES, MLBS/HR' /
     1    4X, 'COMPONENT', 8X, '   FEED', 4X, 'PHENOL PRODUCT', 3X,
     2    'WASTE H2O' )
C
C       Write the individual stream component flow rates in Mlbs/hr.
C       The penols are components 1 thru 4, T475 and T625.
        PIN = 0.0D0
        POUT = 0.0D0
        DO 10 J = 1, 4
          PIN = PIN + CIN(J)
          POUT = POUT + COUT(J)
   10   CONTINUE
        X = PIN - POUT
        X3 = X
        WRITE (NOUT, 830) PIN, POUT, X
  830   FORMAT ( 4X, 'PHENOLS ', F16.3, 2F14.3 )
C
        X = CIN(5) - COUT(5)
        X3 = X3 + X
        WRITE (NOUT, 831) ICNAME(9), ICNAME(10), CIN(5), COUT(5),
     1    X
  831   FORMAT ( 4X, 2A4, F16.3, 2F14.3 )
        X = CIN(10) - COUT(10)
        X3 = X3 + X
        WRITE (NOUT, 831) ICNAME(19), ICNAME(20), CIN(10), COUT(10),
```

```
     1    X
          X1 = PIN + CIN(5) + CIN(10)
          X2 = POUT + COUT(5) + COUT(10)
          WRITE (NOUT, 832)  X1, X2, X3
  832     FORMAT ( 4X, 'TOTAL', 3X, F16.3, 2F14.3 )
C
          WRITE (NOUT, 841) ST1(1,2), ST2(1,2), ST2(2,2), ST1(1,3),
     1    ST2(1,3), ST2(1,3)
  841     FORMAT ( / 4X, 'TEMPERATURE, F', F10.1, 2F14.1 /
     1    4X, 'PRESSURE, PSIA', F10.1, 2F14.1 )
C
      RETURN
      END
C
C$ USR39S
      SUBROUTINE USR39S (ICNAME, ITEMS, KLASS, KOMPS, KTEST,
     1  NCC, NHSTRY, NNCC, SIN1, SOUT1, SOUT2 )
C
C     This subroutine loads the two product stream properties into
C     the SOUT1 and SOUT2 vectors for transfer to ASPEN/SP.
C     This subroutine is not called when IPASS = 4.
C
C     Prepared under DOE contract no. DE-AC22 91PC90027.
C
C     Last revision - April 3, 1992.
C
C     Calling arguments:
C     ICNAME() = Vector of component identifications (CHARACTER * 4)
C     ITEMS    = Total number of items in the SOUT1 vector.
C     KLASS    = Stream class identification switch
C                1 => Conventional (MIXED)
C                2 => MIXNC
C                3 => MIXNCPSD
C     KOMPS    = Number of conventional components used in this model.
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     NNCC     = Number of non-conventional components.
C     SIN1()   = ASPEN/SP stream vector for reactor inlet stream.
C     SOUT1()  = ASPEN/SP stream vector for the phenol product
C                stream.
C     SOUT2()  = ASPEN/SP stream vector for the combined sour water and
C                acid gas product stream.
C
C
      IMPLICIT DOUBLE PRECISION (A-H, O-Z)
C
      COMMON/MW/XMW(1)
      COMMON /USR02M/ CIN(50), COUT(50), CPROP(40,7), ICNUMB(50),
     1  ST1(2,5), ST2(3,5)
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 /USRCO2/
C     only to save space since all block models use these variables.
C
      DIMENSION ICNAME(*), SIN1(*), SOUT1(*), SOUT2(*)
C
C     Local variable declarations.
C
      CHARACTER * 4  ICNAME
C
C
C     First, zero all the items in the product stream vectors.
      DO 200 J = 1, ITEMS
        SOUT1(J) = 0.0D0
        SOUT2(J) = 0.0D0
  200 CONTINUE
C
C     CF is the conversion factor from Kg/sec to Mlbs/hr.
      CF = 0.001D0 * 3600.0D0 / 0.45359237D0
C
C     Load the conventional component molar flow rates.
      SUM1 = 0.0D0
      SUM2 = 0.0D0
      DO 210 J = 1, NCC
        DO 208 K = 1, KOMPS
          IF ( J .EQ. ICNUMB(K) )  THEN
            SOUT1(J) = COUT(K) / (CF * XMW(J))
            SOUT2(J) = (CIN(K) - COUT(K)) / (CF * XMW(J))
            SUM1 = SUM1 + SOUT1(J)
            SUM2 = SUM2 + SOUT2(J)
            GO TO 210
          ENDIF
  208   CONTINUE
        SOUT1(J) = 0.0D0
        SOUT2(J) = SIN1(J)
        SUM1 = SUM1 + SOUT1(J)
        SUM2 = SUM2 + SOUT2(J)
  210 CONTINUE
C     Load the total molar flow rate of the conventional components.
      SOUT1(NCC+1) = SUM1
      SOUT2(NCC+1) = SUM2
C
C     NOTE: Any non-conventional components are ignored.
C
C     Set the outlet stream temperatures and pressures to the
C     default values of 70 F and 1 atmosphere.  These default values
C     may be overridden by a FLASH-SPECS sentence in the input file.
      SOUT1(NCC+2) = ( 70.0D0 + 459.67D0 ) / 1.8D0
      SOUT1(NCC+3) = 6.8947573D+3 * 14.696D0
      SOUT2(NCC+2) = SOUT1(NCC+2)
      SOUT2(NCC+3) = SOUT1(NCC+3)
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)
      CALL CPACK (SOUT2, NCP, IDX, XPACK, TMASS)
      SOUT2(NCC+9) = AVEMW (NCP, IDX, XPACK)
C
C     If requested, write the items of interest in the inlet and
C     outlet stream vectors to the history file.
      IF ( KTEST .GE. 5 )  THEN
        WRITE (NHSTRY, 531)
  531   FORMAT ( // ' The inlet and outlet stream vectors:' /
     1    14X, ' SIN1', 10X, 'SOUT1', 10X, 'SOUT2')
        DO 290 J = 1, ITEMS
          WRITE (NHSTRY, 532) J, SIN1(J), SOUT1(J), SOUT2(J)
  532     FORMAT ( 2X, I5, 6(1PE15.5) )
  290   CONTINUE
      ENDIF
C
      RETURN
      END
C
C$  Subroutine USRA6
C
C     This file contains the following subroutines:
C       USRA6    Main routine for the Fluidized Bed Combustor and
C                Steam Turbine Generator Unit.
C       USRA6S   Subroutine to write the first part of the plant
C                summary report for the Fluidized Bed Combustor and
C                Steam Turbine Generator Unit.
C
C     The above subroutine requires the following non-standard ASPEN/SP
C     subroutines which are not included in this file.
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       GETSTR   Subroutine for finding the stream bead information.
C
C$ USRA6
      SUBROUTINE USRA6 (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:  USRA6
C
C  BLOCK DESCRIPTION:  Plants 31.1 and 31.4 the Fluidized Bed Combustor
C                      and Steam Turbine Generator Unit
C
C  Fluidized Bed Combustor and Steam Turbine Generator Unit Block Model
C
C                      ----------------------
C                      |                    |
C                      | Plants 31.1 & 31.4 |
C                      |                    |
C  Ash Concentrate---->|    FBC & Steam     |-----> Combined Product
C                      |  Turbine Generator |
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 - May 29, 1992.
C
C  ASSUMPTIONS, SPECIAL FEATURES AND LIMITATIONS:
C     1.  This is a very simplified model of Plants 31.1 and 31.4, the
C         fluidized bed combustor and steam turbine generator.  It is
C         designed only to calculate the solids waste stream flow rate,
C         CaCO3 requirement, utilities consumptions (or productions) and
C         economic parameters and maintain a mass balance.  It is not
C         designed to be a detailed simulation of the two plants.
C
C         This model is designed to work with a SEP block that splits
C         the outlet into a pseudo vapor stream and a solids stream that
C         has to be disposed.  Based on the inlet flow rate and amount
C         of ash in the entering feed, this model approximates the
C         inlet air requirement, CaCO3 requirement and flue gas rate
C         based on simple correlations.
C     2.  This model has a single inlet stream.
C     3.  This model has a single outlet stream.
C     4.  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     5.  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     6.  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     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 DCLA6.REP.
C          INT(3)  = Number of operating duplicate trains, excluding
C                    spares.
C                    If INT(3) = 0, the minimum number of duplicate
C                      trains will be determined so that the capacity
C                      each train does not exceed the maximum train
C                      capacity specified by variable REAL(52).
C                    If INT(3) > 0, this number of duplicate trains will
C                      be used.
C          INT(4)  = History file additional output control switch.
C                    0 => Write no additional output to the history 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     8.  The 70 real parameters are:
C          REAL(1)   = Solids production expressed as fraction of URCOAL
C                      in feed ending up in solids.
C          REAL(2) -
C           REAL(20) = Future use.
C          REAL(21)  = Constant factor for the power consumption, kw.
C          REAL(22)  = Power consumption per Mlbs/hr of unit feed,
C                      kw/(Mlbs/hr of unit feed)
C          REAL(23)  = Constant factor for the 900 psig / 750 F steam
C                      consumption, Mlbs/hr.
C          REAL(24)  = 900 psig / 750 F steam consumption per Mlbs/hr of
C                      unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
C          REAL(25)  = Constant factor for the 900 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(26)  = 900 psig saturated steam consumption per Mlbs/hr
C                      of unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
C          REAL(27)  = Constant factor for the 600 psig / 720 F steam
C                      consumption, Mlbs/hr.
C          REAL(28)  = 600 psig / 720 F steam consumption per Mlbs/hr of
C                      unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
C          REAL(29)  = Constant factor for the 600 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(30)  = 600 psig saturated steam consumption per Mlbs/hr
C                      of unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
C          REAL(31)  = Constant factor for the 150 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(32)  = 150 psig saturated steam consumption per Mlbs/hr
C                      of unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
C          REAL(33)  = Constant factor for the 50 psig saturated steam
C                      consumption, Mlbs/hr.
C          REAL(34)  = 50 psig saturated steam consumption per Mlbs/hr
C                      of unit feed, (Mlbs/hr)/(Mlbs/hr of unit feed).
C          REAL(35)  = Constant factor for the plant fuel consumption,
C                      MM BTU/hr.
C          REAL(36)  = Plant fuel consumption per Mlbs/hr of unit feed,
C                      (MM BTU/hr)/(Mlbs/hr of unit feed).
C          REAL(37)  = Constant factor for the cooling water consumption,
```

```
C                       Mgal/hr.
C         REAL(38)  = Cooling water consumption per Mlbs/hr of unit
C                     feed, (Mgal/hr)/(Mlbs/hr of unit feed).
C         REAL(39)  = Constant factor for the process water consumption,
C                     Mgal/hr.
C         REAL(40)  = Process water consumption per Mlbs/hr of unit
C                     feed, (Mgal/hr)/(Mlbs/hr of unit feed).
C         REAL(41)  = Constant factor for the nitrogen consumption,
C                     MM SCF/hr of N2.
C         REAL(42)  = Nitrogen consumption per Mlbs/hr of unit feed,
C                     (MM SCF/hr of N2)/(Mlbs/hr of unit feed).
C         REAL(43) -
C          REAL(48) = Future use.
C         REAL(49)  = Constant factor for the number of operators per
C                     day, operators/day.
C         REAL(50)  = Number of operators per day per train,
C                     (operators/day)/train.
C         REAL(51)  = Reference feed rate to a single train in Mlbs/hr
C                     of unit feed for the calculation of the ISBL field
c                     cost of a single train as a function of train
C                     capacity.
C         REAL(52)  = Maximum size of a single train as defined by the
C                     feed rate in Mlbs/hr of unit feed.
C         REAL(53)  = Minimum size of a single train as defined by the
C                     feed rate in Mlbs/hr of unit feed.
C         REAL(54)  = Constant A in the plant ISBL field cost equation.
C         REAL(55)  = Constant B in the plant ISBL field cost equation.
C         REAL(56)  = Constant E in the plant ISBL field cost equation.
C         REAL(57)  = Constant F in the plant ISBL field cost equation.
C         REAL(58)  = Number of spare trains.
C         REAL(59) -
C          REAL(70) = Future use.
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
      DIMENSION OXIN1(10), OXIN1N(10), UANAME(8), UIN1(7), UIN2(7),
     1  UIN3(7), UIN1N(7), UIN2N(7), UIN3N(7), ULTAC(7)
C
      CHARACTER * 6  PNAME
      CHARACTER * 8  UANAME
```

```
C
      DATA PNAME / '31.1-4' /
      DATA UANAME / 'Ash     ', 'Carbon  ', 'Hydrogen', 'Nitrogen',
     1              'Chlorine', 'Sulfur  ', 'Oxygen  ', 'Total   ' /
C
C
C     PARAMETER INITIALIZATION SECTION
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)
C
C     If requested, write the subroutine heading to the history file.
      IF ( KTEST .GE. 1 )  THEN
        WRITE (NHSTRY, 501) IPASS
  501   FORMAT ( // 1X, 'Plants 31.1 & 31.4 - Supplementary data ',
     1    'from subroutine USRA6' /
     2    2X, 'The FBC and Steam Turbine Generator Unit', 12X,
     3   '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 FBC unit requires ',
     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 FBC unit requires ',
     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 FBC ',
```

```
     1    'unit is not of stream' /
     2    3X, 'class MIXNC or MIXNCPSD.  This model will not work.  ',
     3    'Please set all' /
     4    3X, 'input streams to one of these stream classes and try ',
     5    '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 Mlbs/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 = 0.001 * CF * (X + SIN1(J))
C
      IF ( FLOWIN .LE. 0.001D0 )   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 FBC unit.' )
        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 FBC ',
     1    'unit must allow for' /
     2    3X, 'three non-conventional components, COAL, URCOAL and ',
     3    'SLAG.  Please' /
     4    3X, 'adjust your component list to contain them in the ',
     5    'above order and try again.' //
     6    3X, 'EXECUTION IS BEING TERMINATED.' / )
        STOP
      ENDIF
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     Set up the maximum and minimum train flow rates in Mlbs/hour
C     of unit feed.
      PMAXF = REAL(52)
      PMINF = REAL(53)
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     Calculate the inlet URCOAL flow in Mlbs/hr.
      URCFLO = 0.001 * CF * SIN1(NCONV+2)
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)  (UANAME(J), UIN1(J), UIN2(J), UIN3(J),
     1      J = 1, 7), UANAME(8), SUMIN1, SUMIN2, SUMIN3
  518     FORMAT ( ' Component', 9X, 'Coal', 7X, 'URCOAL', 9X, 'SLAG',
     1      8( / 2X, A8, 3F13.2 ) )
C
          WRITE (NHSTRY, 519)
  519     FORMAT ( / ' Normalized non-conventional component Ultimate ',
     1      'analyses:')
          WRITE (NHSTRY, 518)  (UANAME(J), UIN1N(J), UIN2N(J), UIN3N(J),
     1      J = 1, 7), UANAME(8), SUM1, SUM2, SUM3
      ENDIF
C
C     Load the ash oxide (AOXANAL) analyses of the fresh inlet coal and
C     normalize to 100%.
      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, 520)
  520     FORMAT ( / ' Supplied and normalized ash oxide (AOXANAL) ',
     1      'analyses of the fresh coal:')
```

```
         WRITE (NHSTRY, 521)  (OXIN1(J), OXIN1N(J), J = 1, 10)
  521    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, 522)  SUM, SUM1
  522    FORMAT ( 2X, 'Total    ', 2F13.2 )
       ENDIF
C
C      Calculate the total ash in the URCOAL in Mlbs/hr.
       ASH = URCFLO * .01 * UIN2N(1)
C
C      Calculate the total combustibles in Mlbs/hr.
       COMB = FLOWIN - ASH
C
C      Calculate the total solids in Mlbs/hr.
       SOLIDS = REAL(1) * URCFLO
C
C      Calculate the total flue gas in MMSCF/hr.
       FGAS = COMB * 0.2473078
C
C      Calculate the total air requirement in MMSCF/hr.
       AIR = COMB * 0.2422837
C
C      Calculate the total CaCO3 requirement in Mlbs/hr.
       CACO3 = ASH * 0.2446334
C
C      Write the calculated values to the history file.
       IF ( KTEST .GE. 3 )  THEN
         WRITE (NHSTRY, 533) ASH, COMB, SOLIDS, FGAS, AIR, CACO3
  533    FORMAT ( / 2X, 'Ash                ', F10.3 , ' Mlbs/hr'
     1           / 2X, 'Combustibles        ', F10.3 , ' Mlbs/hr'
     2           / 2X, 'Solids Produced     ', F10.3 , ' Mlbs/hr'
     3           / 2X, 'Flue Gas Produced   ', F10.3 , ' MMSCF/hr'
     4           / 2X, 'Inlet Air Required  ', F10.3 , ' MMSCF/hr'
     5           / 2X, 'CaCO3 Required      ', F10.3 , ' Mlbs/hr' )
       ENDIF
C
C      If it has not been specified by the user in variable INT(3),
C      calculate the number of operating duplicate trains, excluding
C      spares (NPLNT), based on the total flow rate of the reference
C      stream.  However, if the maximum capacity of a single train
C      has not been specified, set the number of operating trains to 1.
       NPLNT = INT(3)
       IF ( (NPLNT .EQ. 0) .AND. (PMAXF .GT. 0.0D0) )   THEN
           NPLNT = FLOWIN  / PMAXF
           IF ( (MOD(FLOWIN, PMAXF)) .GT. 0.0D0 )  NPLNT = NPLNT + 1
         ELSE
```

```
          IF ( NPLNT .EQ. 0 )   NPLNT = 1
        ENDIF
C
C       Calculate the feed rate for each of the duplicate trains (PFLOW)
C       in Mlbs/hr.
        XPLNT = NPLNT
        PFLOW = FLOWIN / XPLNT
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.
              LSTRM = 15
              LUTIL = 16
              LCOST = 11
              NDUP = REAL(58) + 0.001D0
              IF ( (NPLNT + NDUP) .EQ. 1 )  LCOST = 9
              IF ( PFLOW .LT. PMINF )  LCOST = LCOST + 3
              IF ( PFLOW .GT .PMAXF )  LCOST = LCOST + 3
              IF ( NDUP .GE. 1 )  LCOST = LCOST + 1
              LINES = LSTRM + LUTIL + LCOST
C             Now, subtract the number of lines for those portions of
C             the user block summary report which will not be written.
              IF ( INT(1) .GE. 2 )   LINES = LINES - LUTIL
              IF ( INT(1) .GE. 1 )   LINES = LINES - LCOST
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 DCL81.REP to contain
C             this user block summary report.
              OPEN (UNIT=62, FILE='DCLA6.REP', STATUS='UNKNOWN',
     1          ACCESS='SEQUENTIAL', FORM='FORMATTED',
     2          BUFFERED='BUFFERED')
              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' )
          ENDIF
        ENDIF
C
        IF ( IPASS .EQ. 4 )   THEN
C         Call Subroutine USRA6S to write the first part of the plant
C         summary report.
        CALL USRA6S (INT(1), NOUT, FLOWIN, SOLIDS, FGAS, AIR, CACO3)
        ENDIF
C
C       Call subroutine USRUCO to calculate, save and report the
C       utilities, capital and operating costs for the plant.
        ID = 21
```

```
      KUNITS = 2
      CALL USRUCO (NHSTRY, NOUT, IPASS, ID, PNAME, INT(1), INT(3),
     1  KTEST, REAL(21), FLOWIN, KUNITS)
C
C
C     If this is not the report pass, copy the inlet stream to the
C     outlet stream to maintain a mass balance.
      IF ( IPASS .NE. 4 )   THEN
        DO 160 J = 1, ITEMS
          SOUT1(J) = SIN1(J)
  160   CONTINUE
C
C       If requested, write the items of interest in the inlet and
C       outlet stream vectors to the history file.
        IF ( KTEST .GE. 5 )  THEN
          WRITE (NHSTRY, 531)
  531     FORMAT ( / '  The inlet and outlet stream vectors:'/
     1      3X, 'Item', 8X, 'SIN1', 8X, 'SOUT1' )
          DO 170 J = 1, ITEMS
            WRITE (NHSTRY, 532) J, SIN1(J), SOUT1(J)
  532       FORMAT ( 1X, I6, 1X, 1PE15.5, 1PE15.5 )
  170     CONTINUE
        ENDIF
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 USRA6' )
C
C
      RETURN
      END
C
C$ USRA6S
      SUBROUTINE USRA6S (INT1, NOUT, FLOWIN, SOLIDS, FGAS, AIR, CACO3)
C
C     This subroutine writes the first part of the plant summary report
C     for the Fluidized Bed Combustor and Steam Turbine Generator unit.
C     This subroutine is only called when IPASS equals 4.
C
C     Prepared under DOE contract no. DE-AC22 90PC89857.
C
C     Last revision - April 14, 1992.
C
C     Calling arguments:
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     NOUT    = Logical unit number of the plant output report file.
C     FLOWIN  = Flow rate of the inlet stream in Mlbs/hr.
C     SOLIDS  = Flow rate of the solids stream for disposal in Mlbs/hr.
C     FGAS    = Flow rate of the outlet flue gas stream in MMSCF/hr.
C     AIR     = Flow rate of the required inlet air stream in MMSCF/hr.
C     CACO3   = Flow rate of the required inlet CaCO3 stream in Mlbs/hr.
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)
C
C
      IF ( INT1 .LE. 2 )  THEN
C
C       Write the first part of the plant summary report.
C       ================================================
        WRITE (NOUT, 801)
  801   FORMAT ( / '                PLANTS 31.1 & 31.4 SUMMARY REPORT'
     1           / '      FLUIDIZED BED COMBUSTOR AND STEAM TURBINE ',
     2             'GENERATOR'
     3           / '                          SIMPLIFIED MODEL' )
C
C       Write the plant feed rate in Mlbs/hr.
        WRITE (NOUT, 802) FLOWIN
  802   FORMAT ( // 4X, 'PLANT FEED          ', F26.3 , ' MLBS/HR' )
C
        WRITE (NOUT, 803)
  803   FORMAT ( / 2X, 'BASED ON THE ABOVE FEED RATE, THIS ',
     1    'PLANT WILL GENERATE' )
C
C       Write the solids for disposal in Mlbs/hr.
        WRITE (NOUT, 804) SOLIDS
  804   FORMAT ( 4X, 'SOLIDS FOR DISPOSAL', F26.3 , ' MLBS/HR' )
C
C       Write the flue gas out in MMSCF/hr.
        WRITE (NOUT, 805) FGAS
  805   FORMAT ( 4X, 'FLUE GAS            ', F26.3 , ' MMSCF/HR' )
C
        WRITE (NOUT, 806)
  806   FORMAT ( / 2X, 'IT WILL REQUIRE' )
C
C       Write the required air in MMSCF/hr.
        WRITE (NOUT, 807) AIR
  807   FORMAT ( 4X, 'AIR                 ', F26.3 , ' MMSCF/HR' )
C
C       Write the required CaCO3 in Mlbs/hr.
        WRITE (NOUT, 808) CACO3
  808   FORMAT ( 4X, 'CACO3               ', F26.3 , ' MLBS/HR' )
C
      ENDIF
C
C
```

```
999 RETURN
    END
```