TRW

TRW Space & Technology Division
One Space Park
Redondo Beach, CA 90278

DOE DESIGN REVIEW MEETING

Englewood, Colorado
February 8, 1994

Briefing By TRW on
HCCP Progress

AIDEA Contract No: HCP-008 and 02765-P201X
DOE Cooperative Agreement No: DE-FC22-91 PC90544

AGENDA

TRW Combustion System for HCCP

- Introduction
- Summary of March 1993 PETC Presentation
  - Design requirements
  - Design verification tests
  - Healy hardware design
- Design Progress Since March 1993
- Phase 2 Status and Plan
- Concluding Remarks

INTRODUCTION

Purpose:

Update Progress Made Since March 1993

Major Milestones:

- Design of TRW hardware completed in July 16, 1993
  - Two 350 MMBtu/hr combustors (precombustor, slagging combustor and slag recovery section)
  - Two forced circulation water cooling systems to and from the steam drum
  - Two direct coal feed systems from the exhauster outlet
  - One limestone feed system servicing both combustors
- Cold flow modeling data and design verification test data were used to improve/correct the design , resulting in the final design
- On December 10, 1993, Phase 2 funding for engineering only was authorized through March 31, 1994
- Release for fabrication is on hold until all environmental issues have been resolved

SUMMARY OF MARCH 1993

PETC PRESENTATION

HEALY COMBUSTOR DESIGN REQUIREMENTS

Nominal Firing Rate	315 MMBtu/hr
Maximum Firing Rate	350 MMBtu/hr
Maximum Turndown* (System)	3:1
Maximum Turndown* (Per combustor)	2:1
Design Life	30 Years/2000 cycles
Availability	Goal of 100% with one 10 day outage/year
CO Emissions	≤ 200 ppmV @ economizer outlet
NO_x Emissions	≤ 0.35 LB/MMBtu @ economizer outlet
Fuels	o Design based on performance coal o Must operate satisfactorily on run of mine, 55/45 blend and waste coals
Combustion Air Temperature	630 - 730°F
Air Side Pressure Loss	≤ 40" H_2O
Coolant Conditions	590°F, 1400 psig
Minimum Coolant Mass Velocity	600,000 LB/FT^2 HR
Slag Removal	> 70%
Other	Must comply with ASME and other applicable codes. Tube/membrane wall construction. All circuits must be drainable.

*Stable combustion without clean fuel assist

HEALY COAL FEED SYSTEM PRIMARY REQUIREMENTS

1. COAL FEED SYSTEM TYPE:	NONSTORAGE SYSTEM
2. MAXIMUM COAL AND AIR FLOW RATE:	50,000 lb/hr COAL 125,000 lb/hr AIR
3. MINIMUM CFS INLET PRESSURE:	60 inch W.G. at 100 % load
4. INLET AIR TEMPERATURE & HUMIDITY	135 ^{o}F nominal (150 ^{o}F max), 20 to 70% Relative humidity
5. COAL TYPE:	Performance, ROM, Blend, Waste coal (25% ash, mostly SiO_2)
6. COAL GRIND:	50 to 70% through 200 mesh
7. Coal Moisture:	9 to 13 % Moisture (4% surface moisture)
8. COMBUSTOR INTERFACE PRESSURE AT 100 % LOAD:	22 +/- 3 inch W.G. at precombustor 13 +/- 3 inch W.G. at slagging combustor
9. COAL FLOW SPLIT RANGE:	32 to 45 % split to precombustor
10. COAL FLOW ACCURACY OUTPUT:	Output +/-2.5 %, based on +/- 1.0 % inlet
14. INLET AIR FLOW CONTROL ACCURACY:	+/-2 % at nominal flow rates
21. COAL LINE ACCUMULATION:	CFS designed for > 20 % margin above saltation
31. CFS INERTING:	Must have isolation and inerting capability
32. CFS FIRE EXTINGUISHING:	Must have isolation & extinguishing capability
33. HARDWARE DESIGN STRESS:	Withstand explosion pressure of 50 psig
36. OPERATING ENVIRONMENT:	Indoor, 80^{o}F, 14 psia, 60 % relative humidity
37. OPERATING LIFE:	100 % availability 355 days/year, 30 design life

HEALY LIMESTONE FEED SYSTEM PRIMARY REQUIREMENTS

1. NUMBER OF COMBUSTORS per LFS	2
2. LIMESTONE SILO CAPACITY:	5000 Ft^3
3. MAXIMUM LIMESTONE FLOW RATE:	7,000 lb/hr
4. LIMESTONE FLOW CONTROL ACCURACY:	+/- 5% for 700 to 7000 lb/hr
5. INLET AIR TEMPERATURE & HUMIDITY	80 ^oF plant nominal , 20 to 70% Relative humidity
6. SORBENT TYPE:	Cantwell limestone, less than 4% surface moisture
7. SORBENT GRIND:	70% through 200 mesh
8. COMBUSTOR INTERFACE PRESSURE	0 +/- 3 inch W.G. at slagging combustor at 100% load
9. LIMESTONE FLOW SPLIT:	50:50 to each combustor or to one combustor, 0:100 or 100:0
10. TRANSPORT LINE ACCUMULATION:	CFS designed for > 20 % margin above saltation
11. OPERATING ENVIRONMENT:	Indoor, 80^oF, 14 psia, 60 % relative humidity
12. OPERATING LIFE:	100 % availability 355 days/year, 30 design life

DESIGN VERIFICATION TESTS

- The full scale precombustor and one-third scale direct coal feed system fully satisfied the objectives of the test program
- Sufficient data were obtained to validate performance predictions, to verify proposed operating conditions and to finalize the design of the precombustor and coal feed system
- Operational problems encountered with equipment were resolved by design changes and/or modification of procedures
  - Verified precombustor pressure drops
  - Modified splitter outlets to prevent coal accumulation
- The confidence level on the design and performance of the total system increased significantly

Precombustor DVT

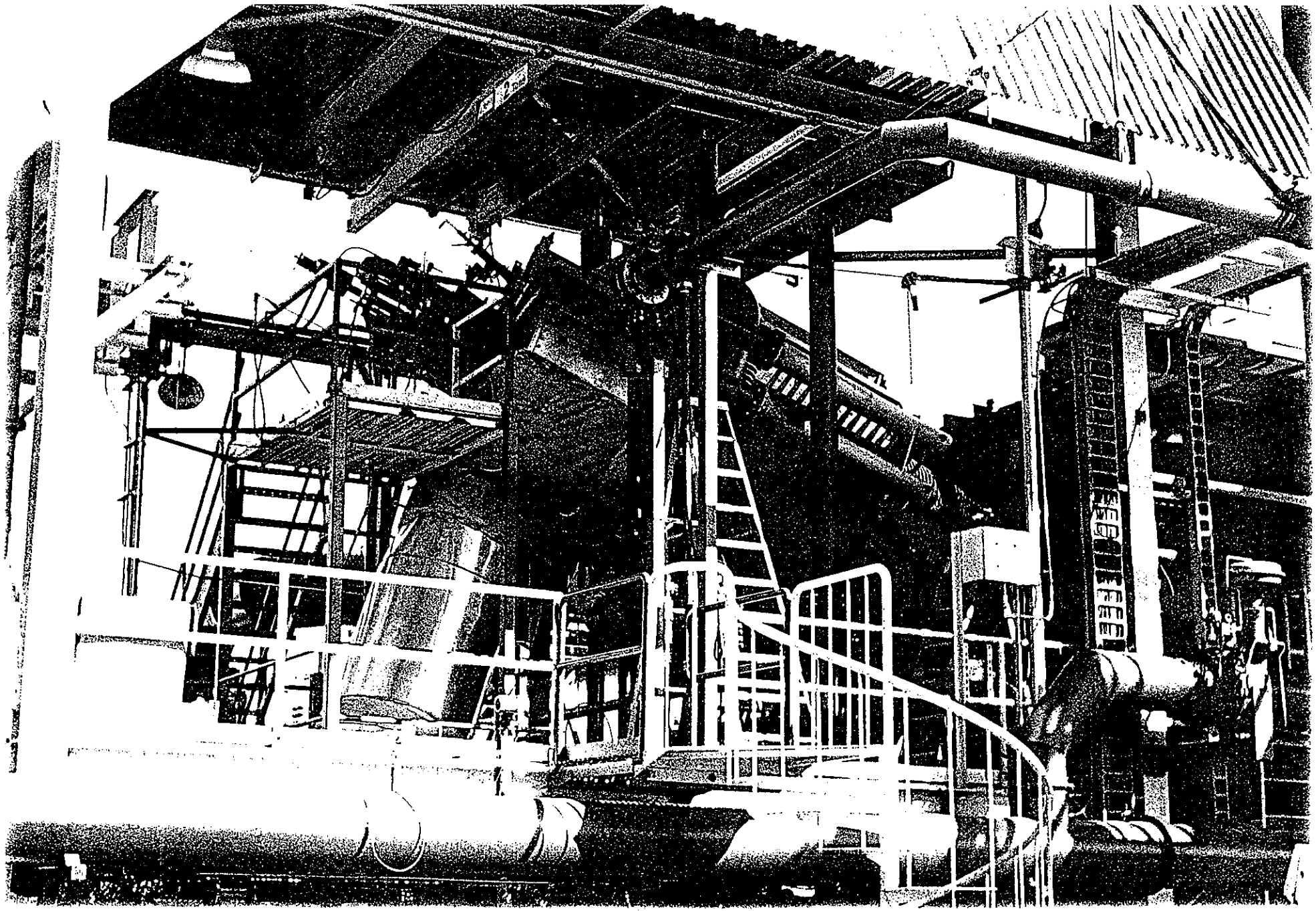
Summary of Tests Performed

(Totals Include Tests with DCFS)

- 28 Tests
- 43 hours on coal
- 50 hours on oil
- 160 tons of coal burned

Test Parameters

- 35-134 MBTU/hr coal load
- 19-70 MBTU/hr oil load
- 400-750 ^{0}F secondary air preheat



PRECOMBUSTOR DVT RESULTS

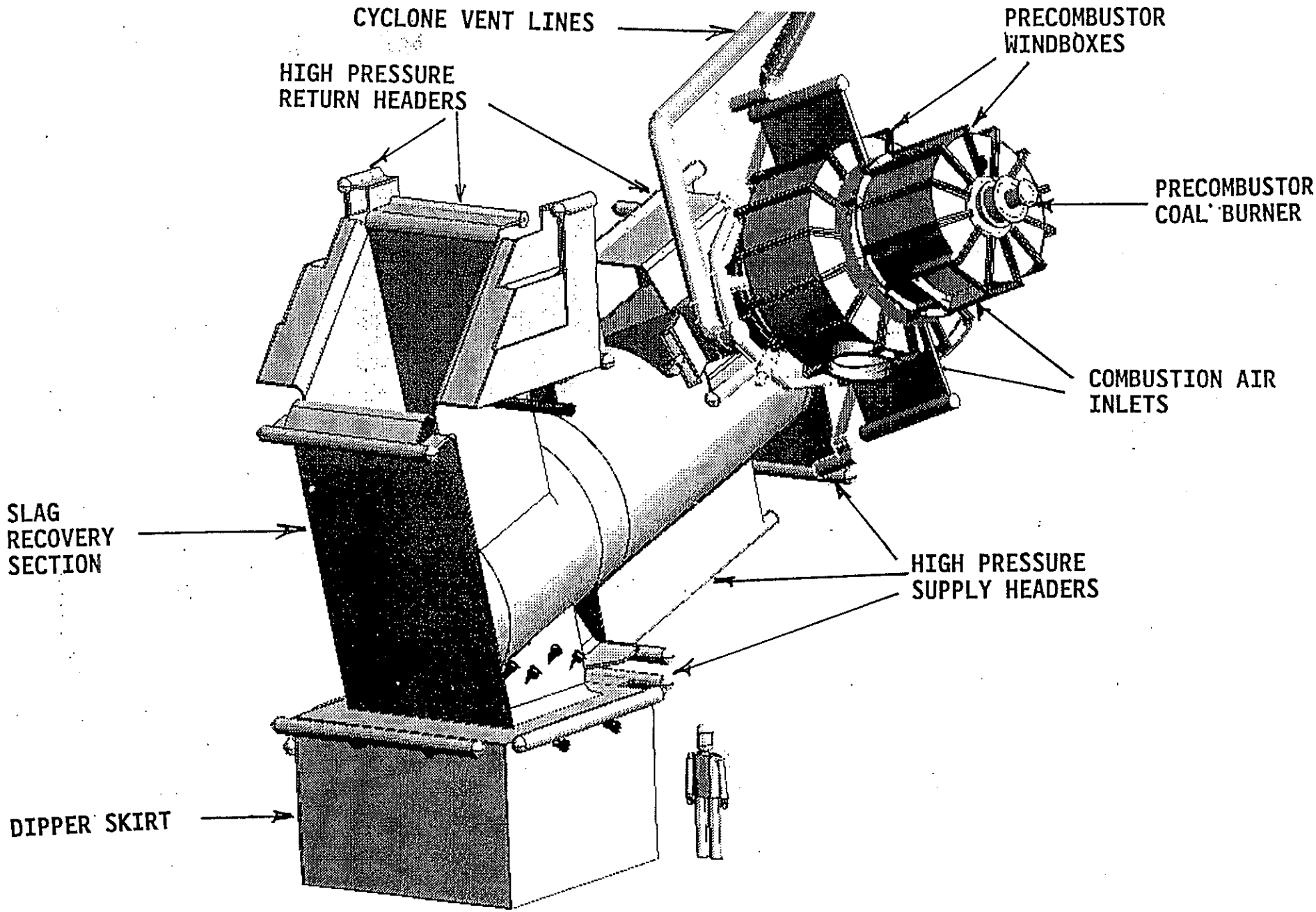
The tests addressed and verified the following:

- Coal burner performance including ignition, stability and load variations
- Prevention of slagging and fouling
- Combustion of cyclone vent air including coal fires
- Demonstration of Healy start-up and shut-down procedures
- Validation of design heat fluxes and cooling loads
- Operation of oil ignitor/burner
- Verification of pressure budget for Healy design
- Reliable operation of flame scanner system
- Thermal effects and mismatches

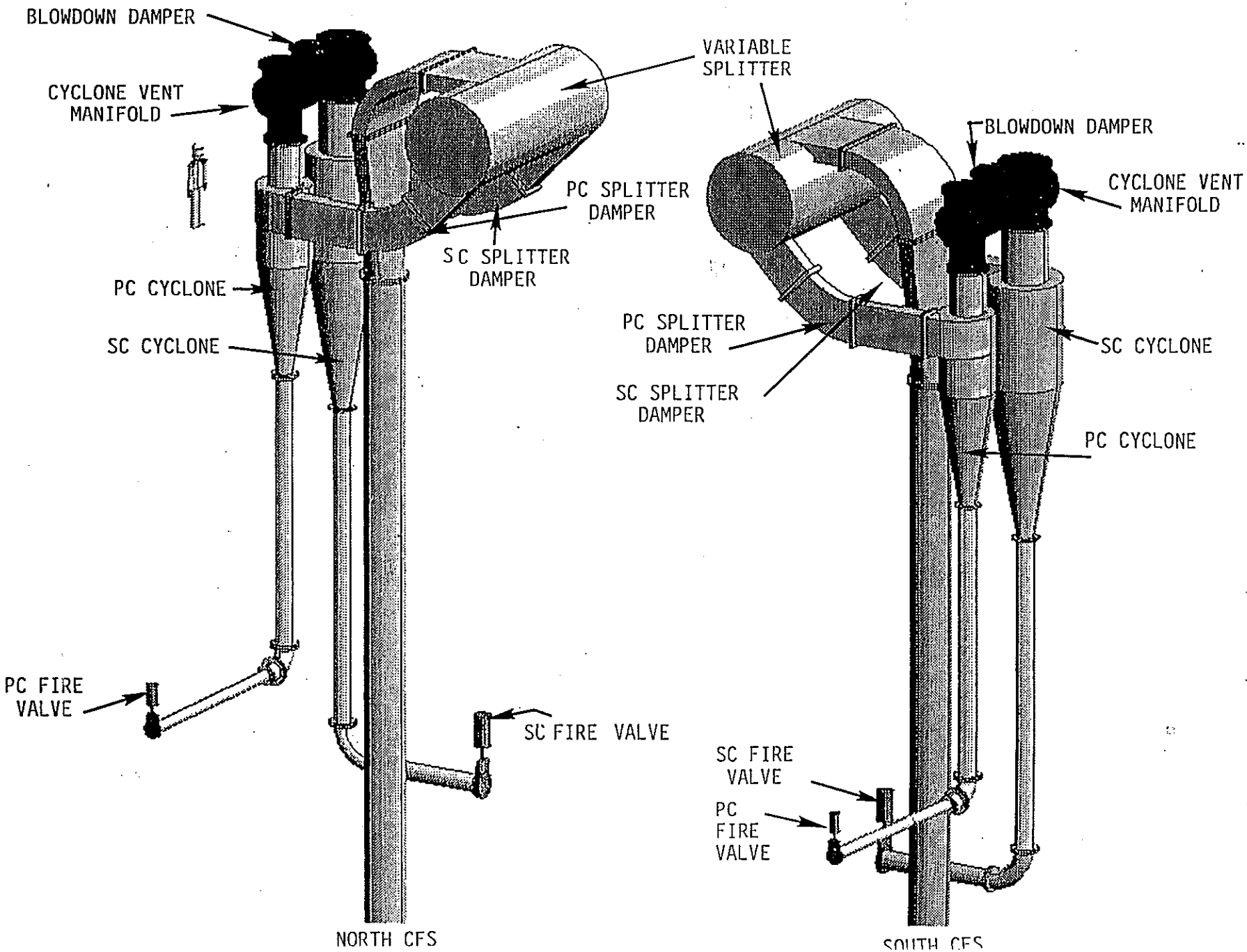
DVT CONCLUSION SUMMARY

ISSUE	RESULT
DESIGN SCALABILITY	DESIGN DEMONSTRATED SCALABLE FROM COLD FLOW TO DVT
SYSTEM PRESSURE REQUIREMENT	COAL FEED SYSTEM CAN OPERATE WITHIN 60 INCH HEALY PRESSURE REQUIREMENT. EDUCTOR/BLOWERS NOT REQUIRED
COAL FLOW SPLIT	REPEATABLE COAL FLOW SPLITS DEMONSTRATED
FLOW STABILITY	STABLE FLOW DEMONSTRATED OVER SUSTAINED PERIOD OF OPERATION AT FULL LOAD
COAL STORAGE/ ACCUMULATION	NO ACCUMULATION OR STORAGE OF COAL IN DESIGN
LINE PURGE AFTER TRIP	DEMONSTRATED STARTUP AFTER COMBUSTOR TRIP WITHOUT PURGING
SALTATION VELOCITY	CAN USE PC COAL BURNER AND SC SPLITTER PRESSURE DROPS TO MONITOR MARGIN ABOVE SALTATION
COAL STATIC CHARGE	DO NOT NEED HUMIDITY CONTROL

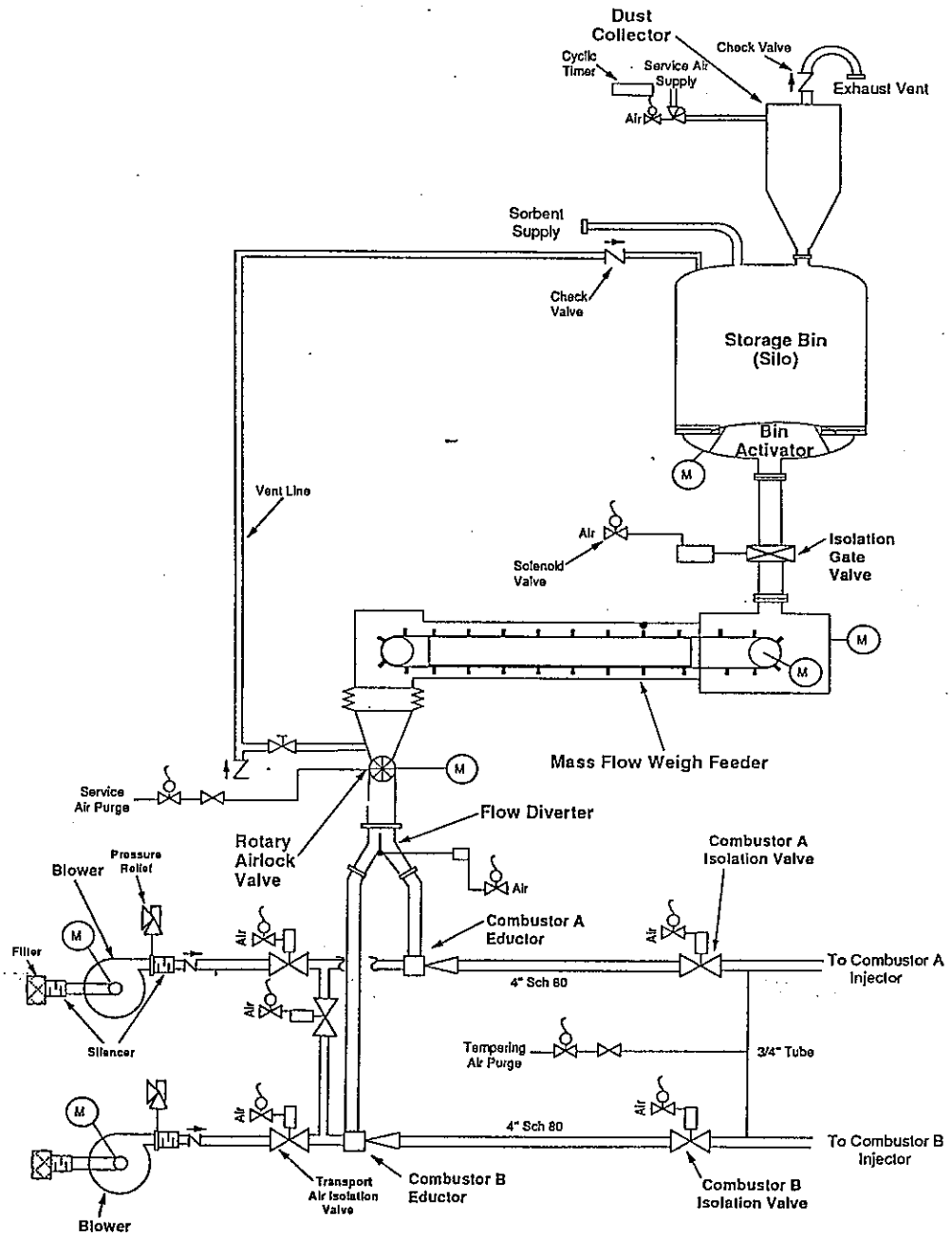
HEALY COMBUSTOR



HEALY COAL FEED SYSTEM



HEALY LIMESTONE FEED SYSTEM



DESIGN PROGRESS SINCE MARCH 1993

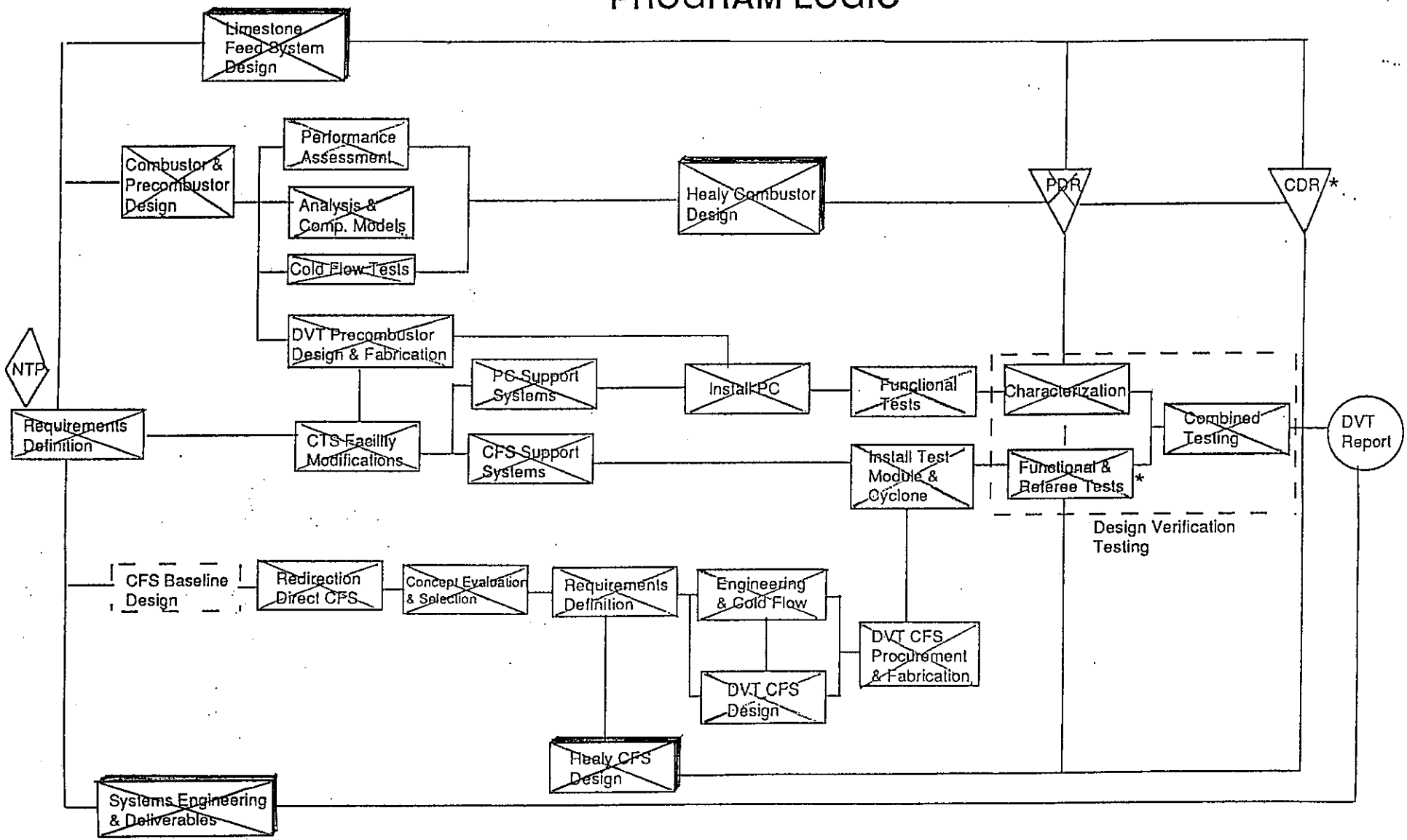
General:

- Resolved Plant Steel Interferences
- Revised All Drawings and Documents For Final Submittal
  - Corrected interferences
  - Made minor design changes
  - Improved logic sequences

Status:

- As Part of Phase 2 Engineering, we are
  - Finalizing all documents and drawings, incorporating minor changes in terms of tag numbers, certifications
  - Continuing our negotiations with our subcontractors, Foster Wheeler, Delta-Ducon and Vibra Screw
  - Preparing revised schedule and plan based on April 1, 1994 date for release-for-fabrication

PROGRAM LOGIC



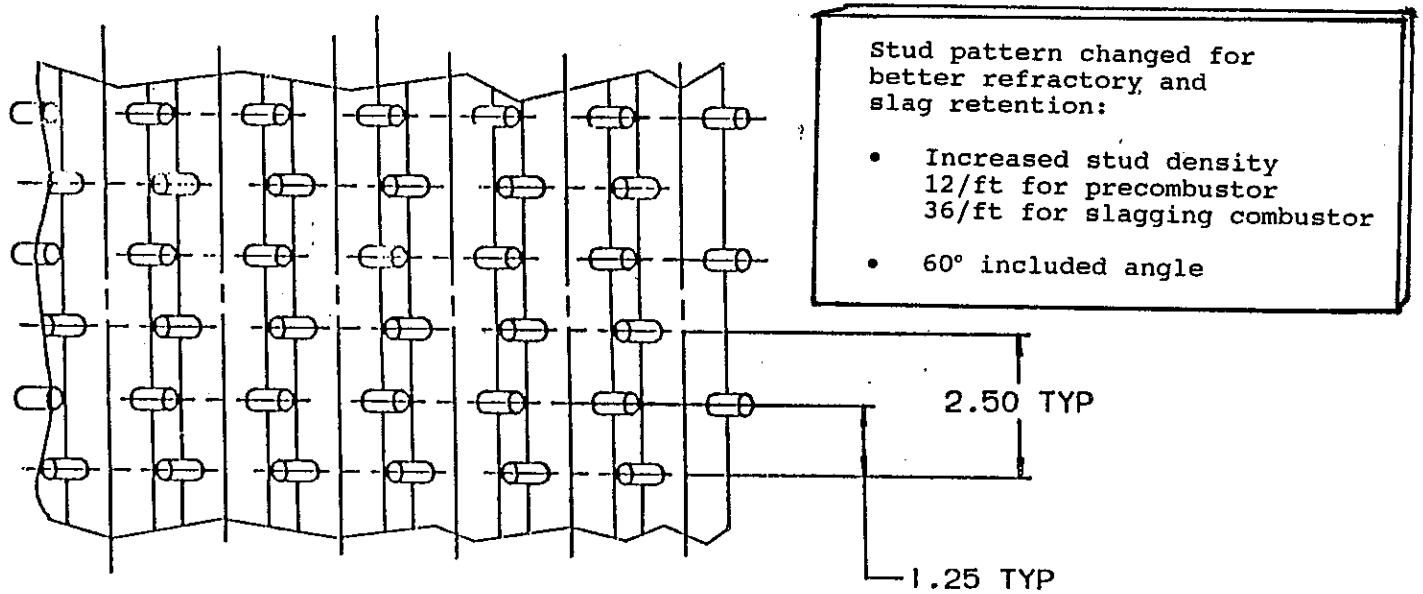
* Not required (Deleted)

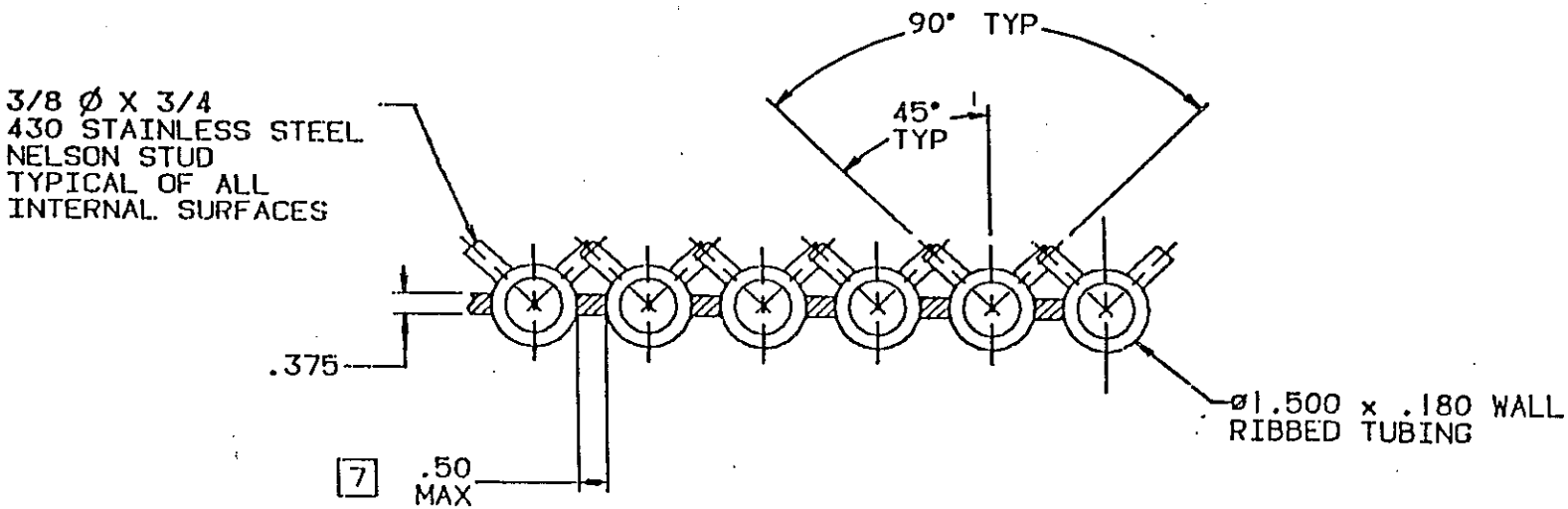
Shaded boxes completed Since March 1993

COMBUSTOR AND COOLING WATER SYSTEMS

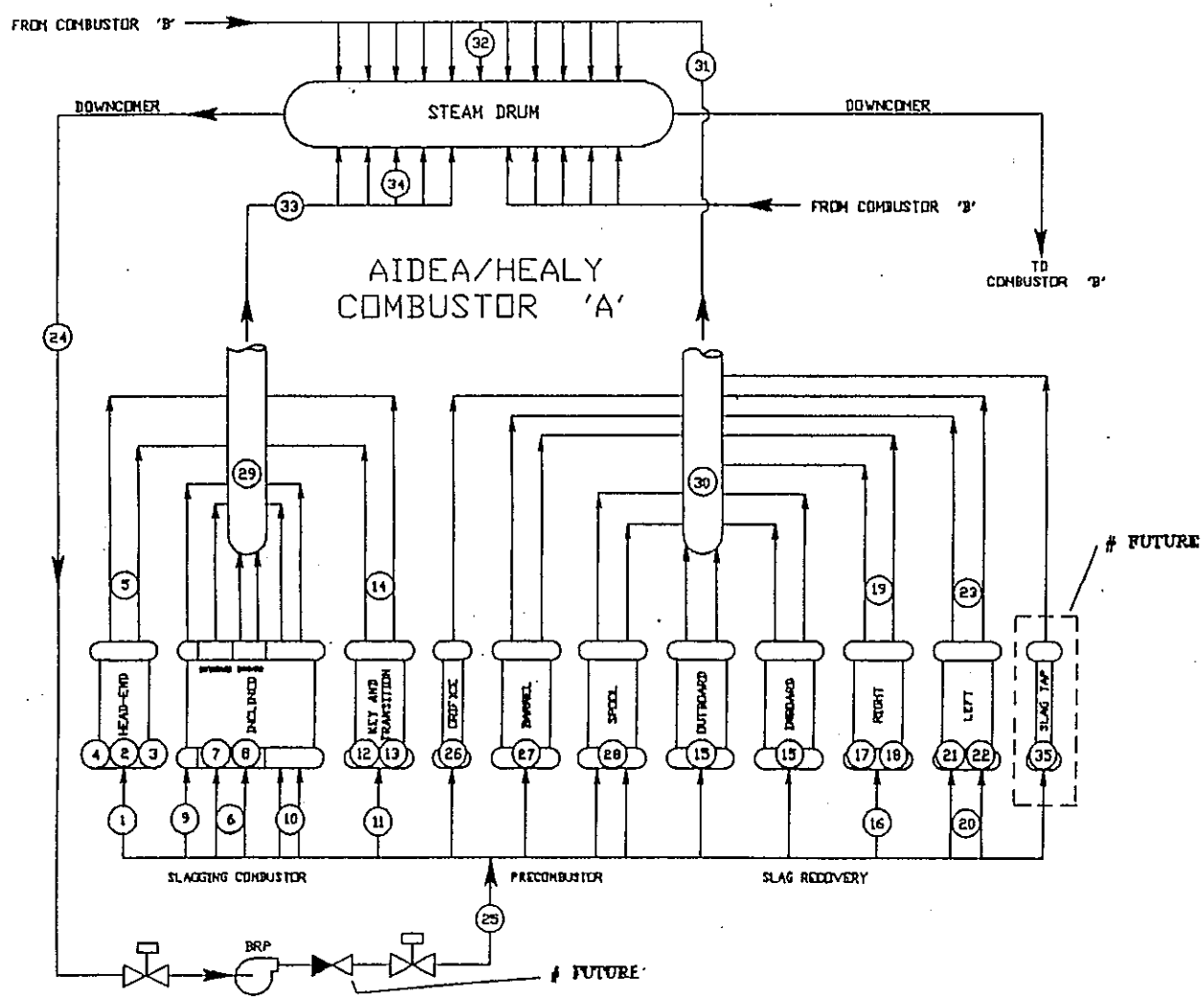
- Worked out routing of LP piping for dipper skirt shield and swirl dampers
- Worked out details for reinforcement of seals in slagging stage/slag recovery section transition zone to carry dead weight loads. Slag tap plugging was worst case concern
- Revised and finalized specs for refractory and stud arrangement working with FWEC refractory specialist
- Finalized details of headend injector penetrations and reinforcements for potential over pressure loads
- Finalized exact locations of all instrumentation including water wall thermocouples
- Selected final locations for oil burner fuel trains
- FWEC completed final layouts of combustor downcomers, risers and hearers
- FWEC finalized loads for the above
- Worked details of precombustor windbox design to accommodate temperature differentials of up to 300°F between combustion air and water walls. FWEC used model to predict 300°F; TRW and FWEC combined on stress analysis to finalize design

COMBUSTION CHAMBER WALL CONSTRUCTION





High Pressure Cooling System



HEALY COMBUSTOR DESIGN DATA

WALL CONSTRUCTION:	TUBE - MEMBRANE (SEE ATTACHED DATA)
NOMINAL COOLING LOAD:	46 MBTU/HR
MAXIMUM DESIGN COOLING LOAD:	76 MBTU/HR
COOLANT FLOW RATE:	3.1 X 10^6 LB/HR
NOMINAL EXIT QUALITY:	1.5%
COOLANT DESIGN TEMPERATURE:	600°F
COOLANT DESIGN PRESSURE:	1600 PSIG
NUMBER OF COOLING CIRCUITS:	12
MINIMUM MASS FLUX:	750,000 LB/FT^{2}HR (600,000 FOR P.C.)
MAXIMUM INTERNAL PRESSURE:	18 PSIG (FUEL OIL DEFLAGRATION)
DESIGN HEAT FLUXES	
- SLAGGED WALL MAXIMUM:	16 BTU/FT^2 SEC
- BARE WALL MAXIMUM:	78 BTU/FT^2 SEC
CORROSION ALLOWANCES	
- TUBE:	0.095 INCH
- MEMBRANE:	0.125 INCH

Coolant Flow rate changed to
3.6 X 10^6 lb/hr to
- match Hayward-Tyler pump curves
- provide margin

DIRECT COAL FEED SYSTEM

Recommended Extinguishing Method:

- TRW has recommended the application of CO_2 for fire extinguishing with water deluge backup in CFS
- TRW will provide three 1" dia. ports per CFS for CO_2 fire extinguishing
- TRW will provide two ports on variable splitter and two ports on cyclone manifold for water deluge via fire hose insertion

Fire Detection:

- CO monitor used for detecting abnormally high levels of CO will initiate alarm
- Thermocouples mounted in limited locations of pipe will be used

DIRECT COAL FEED SYSTEM (CONTINUED)

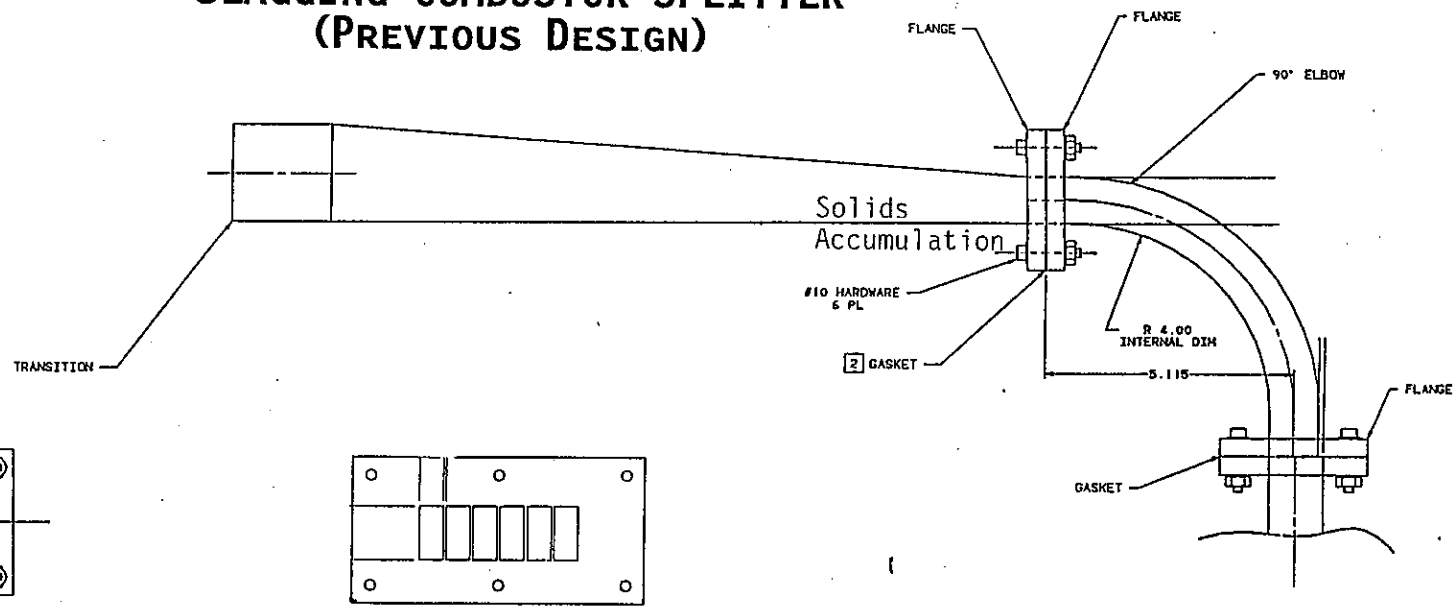
Approach to Eliminating Fire in CFS:

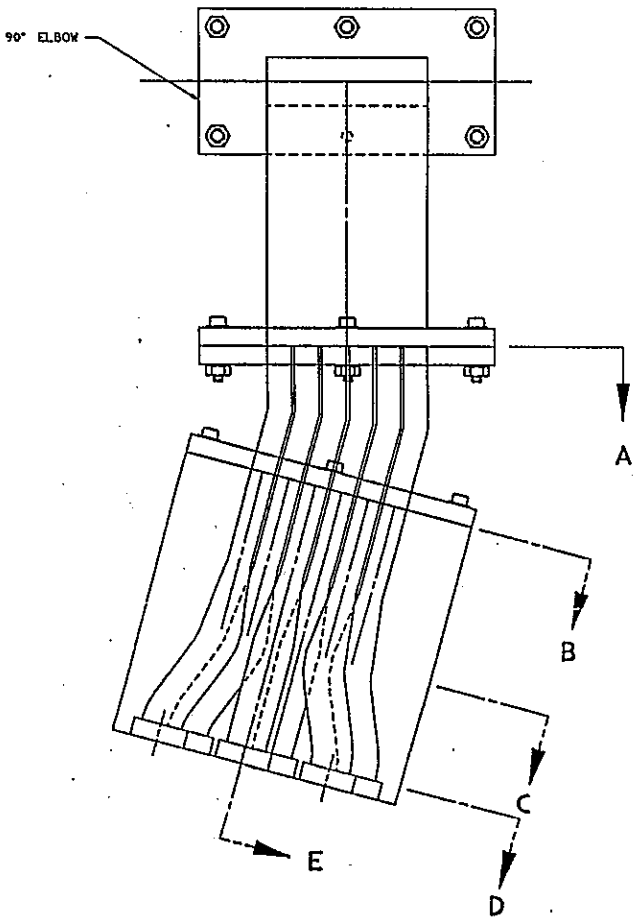
- CFS CO monitor fire detection will initiate alarm
- 1st approach - allow continued operation to transport smoldering coal to combustor
- Second approach - After fuel trip, operator initiates CFS CO_2 fire extinguishing
- Last approach - CO_2 fire extinguishing fails, water deluge fire extinguishing will be initiated using 2.5" ports on variable splitter and above both cyclones

CO2 Requirements:

- 30 psia CO_2, minimum 4000 ft^3 (both CFS)
- One CO_2 isolation valve per CFS supplies three injection ports on CFS - CFS inlet, SC blowdown, PC blowdown)
- Water drains provided at CFS low points

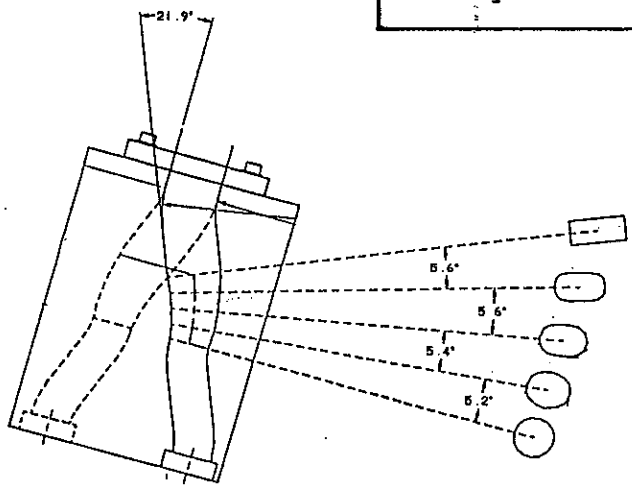
SLAGGING COMBUSTOR SPLITTER
(PREVIOUS DESIGN)





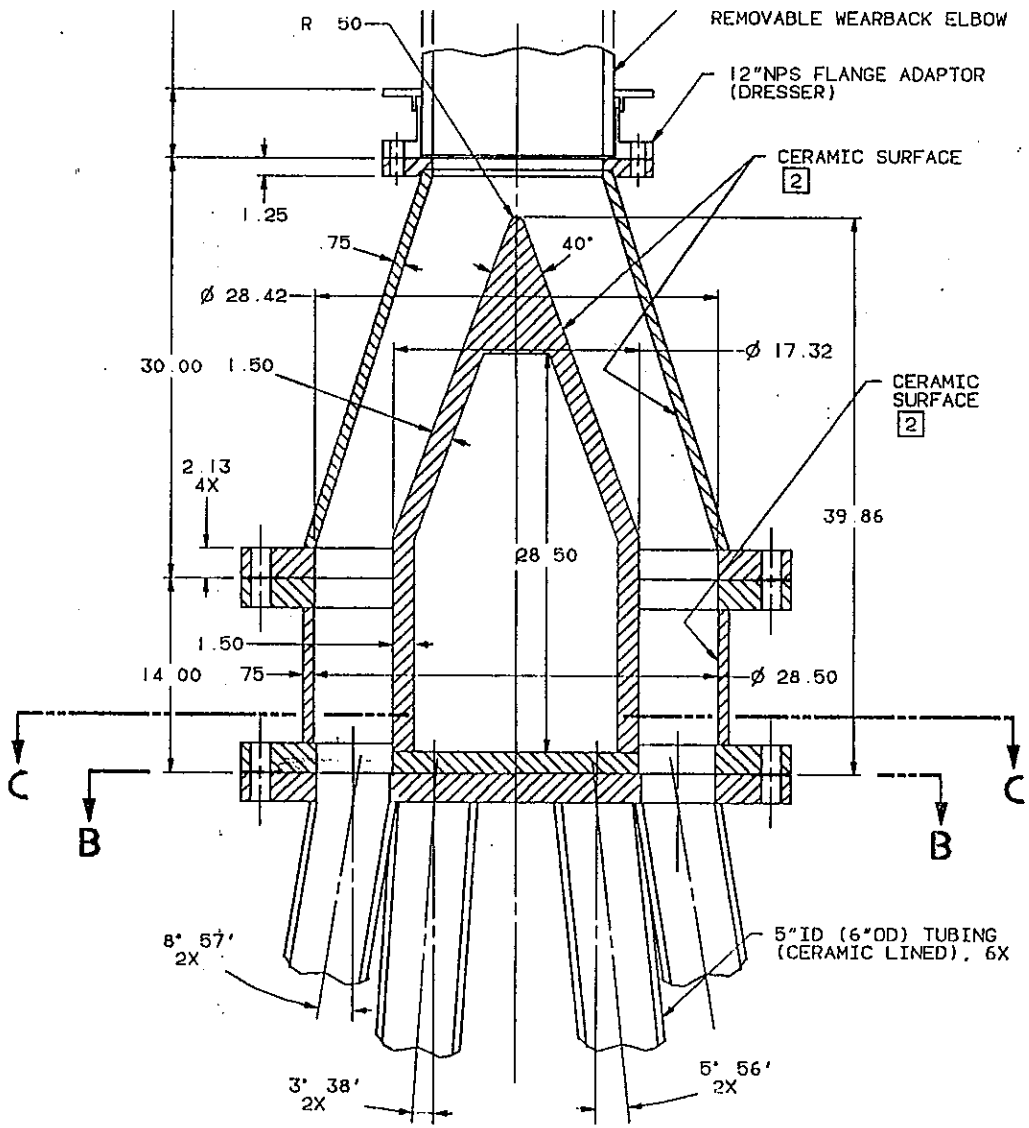
VIEW A–A

- Cold flow test demonstrated that this splitter design did not meet all requirements
  - Solids accumulation
  - Higher pressured drop
- TRW cone splitter has met all requirements (see next chart)



VIEW E–E

Final Slagging Combustor Splitter Design



CFS ABRASION CONTROL

COMPONENT	APPROACH
INLET CFS PIPE	- Low velocity - Vertical orientation
INLET RECTANGULAR ELBOW	- Low velocity - Refractory lined
TRANSITION	- Constant area transition - Low velocity - Vertical orientation
VARIABLE SPLITTER	- Surfaces exposed to coal flow troweled refractory lined - Low velocity - Profiled surfaces, no obstructions
SLITTER DAMPER & DISCHARGE DUCT	- Duct bottom refractory lined - Inclined duct to minimize velocities
CYCLONES	- Barrel section refractory lined - Cone section removable and refractory lined
TRANSPORT PIPING	- Schedule 80 wall thickness minimum for horizontal runs - High Brinell pipe where appropriate - Replaceable wearback elbows
SC SPLITTER	- Wearback elbow - Refractory lined cone and discharge manifold - Replaceable wear components

IGNITOR CONTROL LOGIC CONTROL LOGIC

- Spark Ignitor (HESI)
  - Incorporated HESI extended interlock. HESI must be fully extended before ignitor light-off or purge
- Oil Ignitor
  - Updated logic for constant air pressure atomization

COOLING WATER SYSTEM CONTROL LOGIC

- Circulation Pump Monitoring
  - Added critical temperature monitoring of pump impeller casing, motor coolant, and downcomer temperature. (per typical pump instruction manual)
- Deleted references to Motor Operated Pump Suction Valves
- Added Logic for Natural Circulation Valves. Valves Will Open on HP Cooling Water System Trip

COAL FEED AND AIR FLOW CONTROL LOGIC

- Fuel/Air Cross-Limiting
  - Improved interfacing with FWEC logic
- CFS Cyclone Damper Positioners
  - Changed logic from analog (pneumatic positioner) to digital (motor operated positioner)
- CFS Instrument Purge
  - Incorporated logic for timed instrument purge and instrument signal lock
- Added Control Logic and Monitoring of CFS Fire Extinguishing System
- Coal Transport Line Purge
  - When combustor is out-of-service, transport lines downstream of fire valves are purged with tempering air

LIMESTONE FEED SYSTEM CONTROL LOGIC

- Blower Monitoring
  - Removed low flow switches. Logic now monitors blower outlet pressure
- Limestone Mass Weigh Feeder
  - Improve plugged chute logic
- Limestone Silo Level Alarm
  - Deleted silo low level switch. Will monitor level by analog level sensor
- Local Controls
  - Added power on/off at PCS for local control cabinet

PHASE 2 STATUS AND PLAN

- Engineering tasks associated with completion of documents and drawings marked "Approved as Revised" or "Revise and Resubmit" are continuing
  - All are minor and do not affect the project schedule
- We are evaluating two schedule options based on a Release-for-Fabrication date of April 1, 1994 (Previously October 1, 1993 - a slip of six months)
  - (1) Same completion date as before (Schedule compression)
  - (2) Relaxed completion date with minimum extension of end date
- TRW's schedule heavily dependent on FWEC's schedule since FWEC is responsible for
  - Combustor/cooling system fabrication
  - Fabrication of boiler
  - Erection of the above

CONCLUDING REMARKS

- The design has been successfully completed and we are awaiting AIDEA's release-for-fabrication authorization
- Phase 2 planning is being revised, subject to April 1, 1994 release-for-fabrication date
- The design verification tests in Phase 1 were extremely valuable in validating our design and preventing costly rework during Phase 3
- Negotiations on Phase 2 subcontracts have been initiated with
  - Foster Wheeler Energy Corporation
  - Delta Ducon
  - Vibra Screw
- There was no TRW activity during a five month hiatus between July and December 1993.