INNOVATIVE CLEAN COAL TECHNOLOGY

Plant Crist SCR Project
SCR Pilot-Plant

Design Bases

Volume 2

Project No.
DE-FC22-90PC89652

DEMONSTRATION OF SELECTIVE CATALYTIC REDUCTION (SCR) TECHNOLOGY FOR THE CONTROL OF NITROGEN OXIDE (Nox) EMISSIONS FROM HIGH-SULFUR, COAL-FIRED BOILERS

PREPARED FOR
U.S. DEPARTMENT OF ENERGY
PITTSBURGH, PENNSYLVANIA

JUNE 1991

SCR

INNOVATIVE CLEAN COAL TECHNOLOGY
PLANT CRIST SCR PROJECT
SCR PILOT PLANT

DESIGN BASES

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SECTION

6.0 AREA 400: SCR REACTORS

Area 400 consists of the three large, 5000-scfm and six small, 400-scfm SCR reactors. The layout and flow control of both the large and small reactors are discussed further in the following sections. A list of Area 400 major equipment is provided in Table 6.2-1.

6.1 DESCRIPTION

The original concept included a common bypass for all three large reactors. This concept was changed in favor of individual reactor bypasses to simplify the flow control and operation of the pilot plant. Each large reactor bypass, shown in Figure 6.1-1, will be able to send flue gas to the APH or a bypass heat exchanger.

There will be five small reactors for high dust service (i.e., ahead of the hot-side ESP) and one small reactor for low dust service (i.e., after the hot-side ESP). The small reactors will be grouped in banks of three for fan service. There is no bypass of small reactors. (See Figure 6.1-1.)

The transition piece at the reactor inlet must be designed to reduce the gas flow from 60 fps down to 15 fps and assure that the velocity components of flow are uniformly distributed across the reactor cross-section. DynaGen will respond to SCS with recommendations on reactor transition pieces that allow uniform expansion and contraction of gas into the reactors. (See Section 4.0, Area 200.) Each reactor will be equipped with a dummy layer of inert ceramic at the reactor inlet to provide some gas pressure drop and help to redistribute the gas flow.

Each reactor will be custom designed to allow each participant sufficent flexibility for testing catalyst. The linear velocity will vary between 2.0 and 2.5 Nm^3/sec to minimize plugging of catalyst. The large reactors will have three layers of catalyst beds, with space for an additional fourth layer. The large reactors are expected to have internal dimensions of about 1.37m x 1.06m, about 4.5 ft x 3.5 ft, in cross-sectional dimensions, allowing for both the module dimensions and clearance. The small reactor will also have three catalyst layers, including space for an additional fourth layer, with the small reactor expected to have internal dimensions of about 330mm x 330mm,

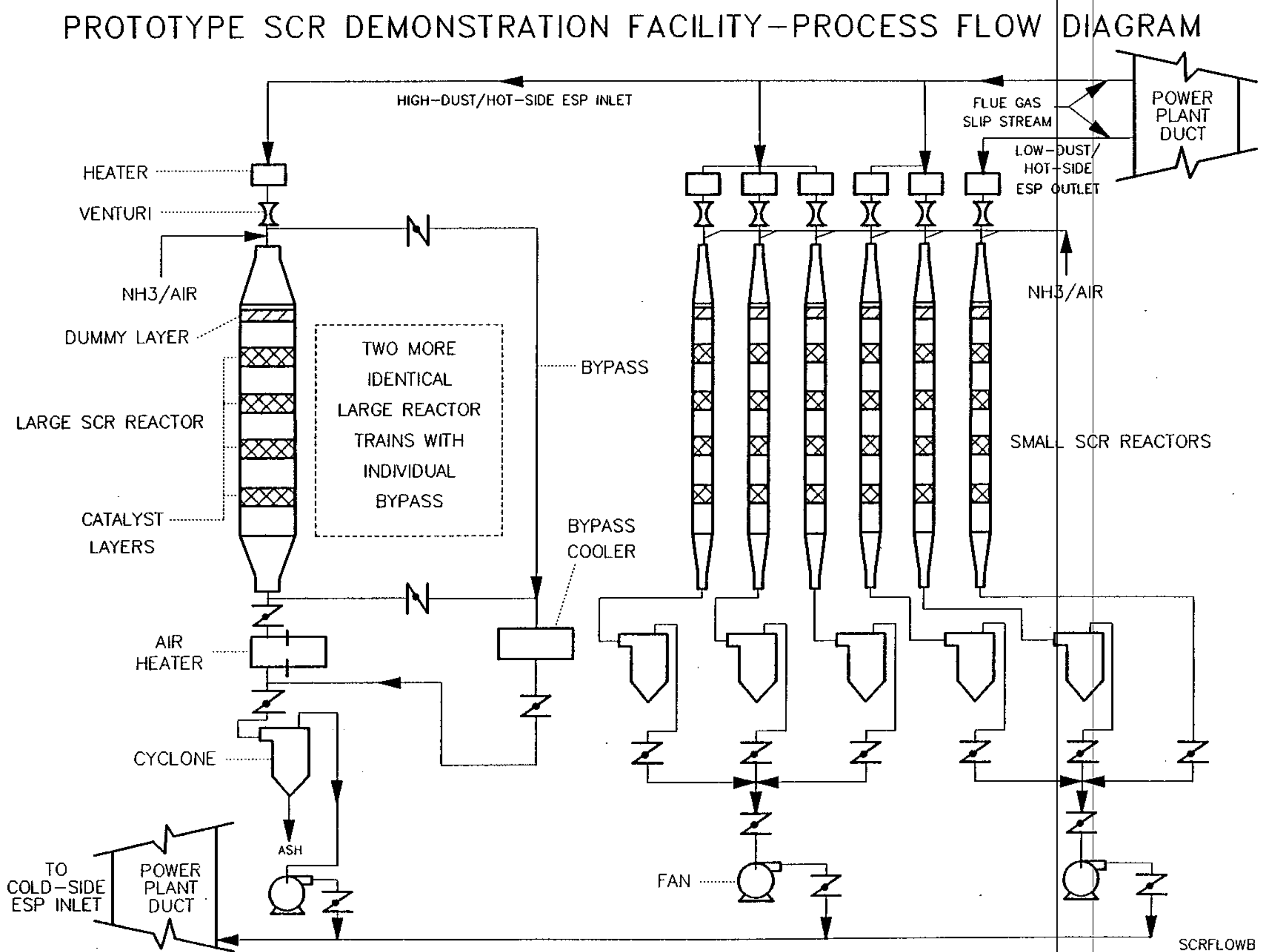


Figure 6.1-1. Small SCR reactor.

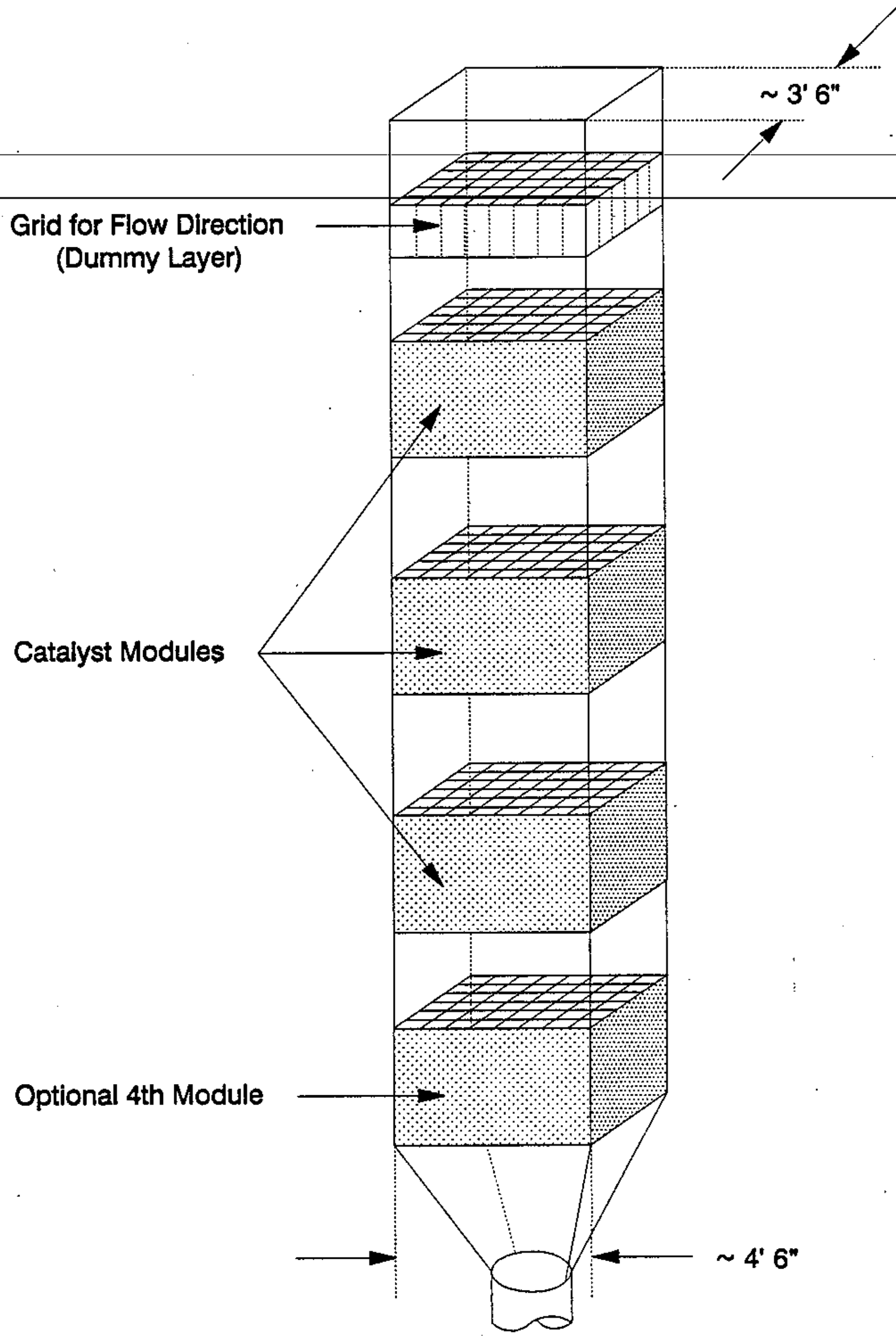


Figure 6.1-2. Sketch of large reactor.

about 1 ft x 1 ft. The catalysts will be housed in movable structures called baskets. The dimensions of the catalyst modules for each catalyst supplier are given in EXHIBIT 6.1-A . The baskets will be made of carbon steel. Each catalyst vendor will supply the basket for its catalyst.

Preliminary heat transfer calculations show that 6-inch thick mineral fiber insulation (normal ductwork insulation at these temperatures) provides an acceptable heat loss (less than 55 Btu/sq ft) and provides a safe surface temperature (less than 140°F) for personnel protection. (See EXHIBIT 6.1-B.) The calculations show that the gas temperature drops 0.5°F for the large reactors and 2°F for the small reactors, assuming negligible heat of reaction. However, based on field experience, actual heat loss is typically four to five times greater than that calculated. Therefore, insulation thickness of 1 ft will be used on the reactors and inlet ductwork.

Thermocouples will be directly attached to the catalyst surface for permissives on startup and temperature measurement. (See Figure 6.1-3.) According to previous pilot plant experience, there can be as much as 60° to 70°C difference between the bulk gas and catalyst surface temperatures. This measurement will also provide some indication of the thermal inertia of the catalyst during startup and shutdown. In addition, bulk gas temperature measuring will be included in the final design of the reactor.
The use of catalyst bed heaters are not included in the reactor design at this time. During cold shutdowns, the heated ammonia dilution air will provide a warm air purge to prevent water condensation and sulfuric acid formation, which would accelerate catalyst poison migration from the flyash.

The large reactors will have a bolted door design very similar to the Electric Power Research Institute (EPRI) pilot plant at the Tennessee Valley Authority (TVA) Shawnee Station. Minimum door and flange thickness of 1/2 in. should provide adequate protection against deformation, thereby minimizing air inleakage through the doors. Similar type pilot plants use conventional synthetic gaskets or ceramic-type rope to provide an adequate seal. One

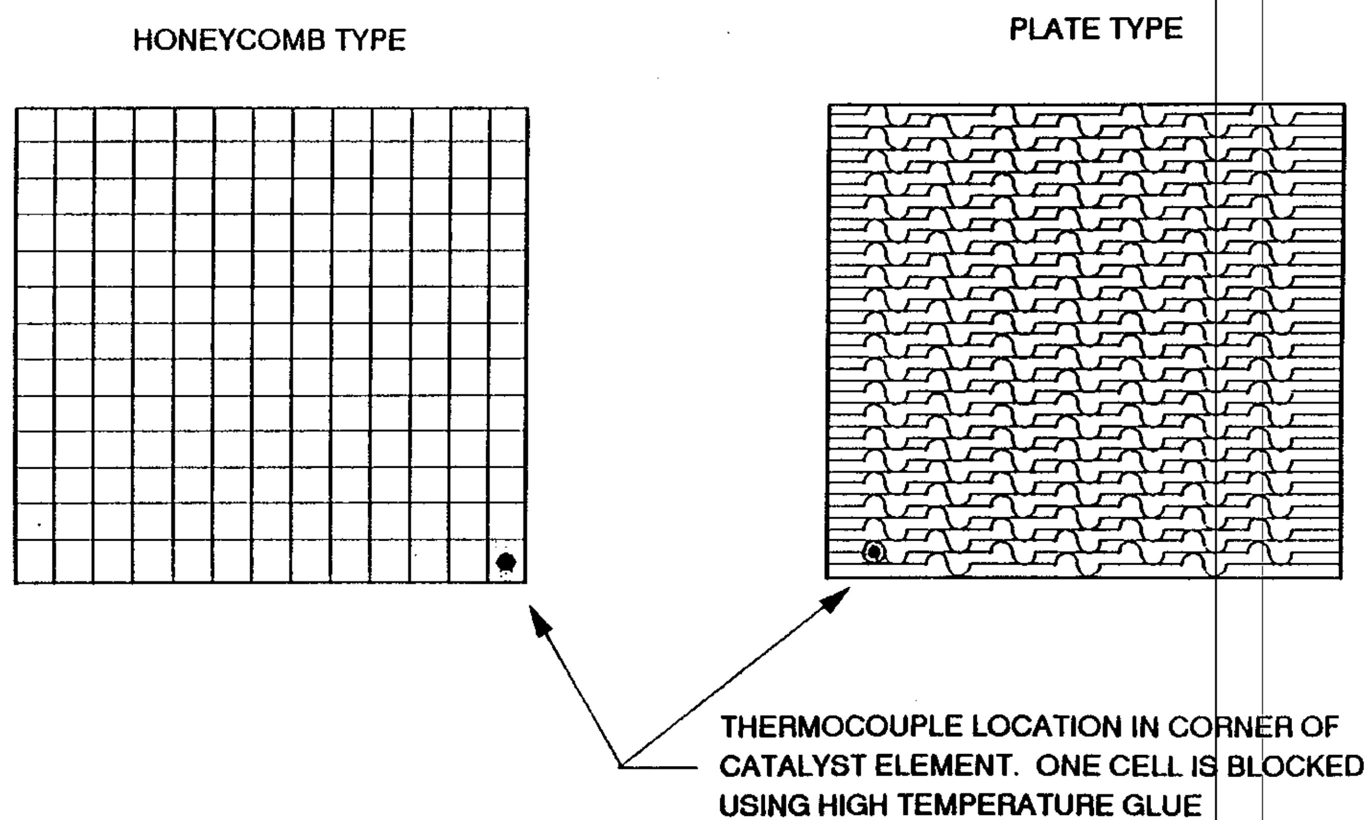


Figure 6.1-3. Catalyst surface temperature measurement.

project participant has recommended 100 mm as minimum bolt spacing for the door.

Sampling ports for the large and small reactors will be located between the flow straightening grid and the first catalyst layer, at the outlet of the reactor, and in between each catalyst layer.

This will include three sampling ports on the 3-ft, reactor door side of the large reactors at each sampling location. The small reactors will have only one sample port at each location. If possible, the ports will be combined for more than one purpose, such as sootblowing.

Materials of construction for reactors will be ASTM A516 or ASTM A204 carbon steel structural plate. Utility stations for steam, air, and electrical will be installed on each reactor level to allow easy hookup for servicing the reactors.

6.1.1 Flyash Buildup on Catalyst and Sootblowing

Flyash buildup on the reactor walls and the catalyst surface is a concern for the pilot scale reactors. Previous pilot plant experience suggests that flyash deposition is due to small recirculation zones at the entrance and exit of the catalyst modules. SCS intends to minimize the recirculation zones, and hence the flyash buildup on the catalyst modules, by mimimizing the distance which the catalyst support structure protrudes into the gas path of the reactor. Obviously, the optimum situation is to have the reactor inner walls as smooth as possible without flow disturbances.

The reactor design also allows approximately 5 to 6 ft between catalyst modules to allow flow patterns to become more streamlined before entering the next catalyst module. The flue gas incident angle to the surface of the catalyst should never be more than 30 degrees, as measured from the vertical to prevent the formation of stalagmites of flyash from growing upon the surface of the catalyst. (See Figure 6.1-4.) The effect of flue gas incient angle on flyash deposition is clearly shown in Figures 6.1-5 and 6.1-6.

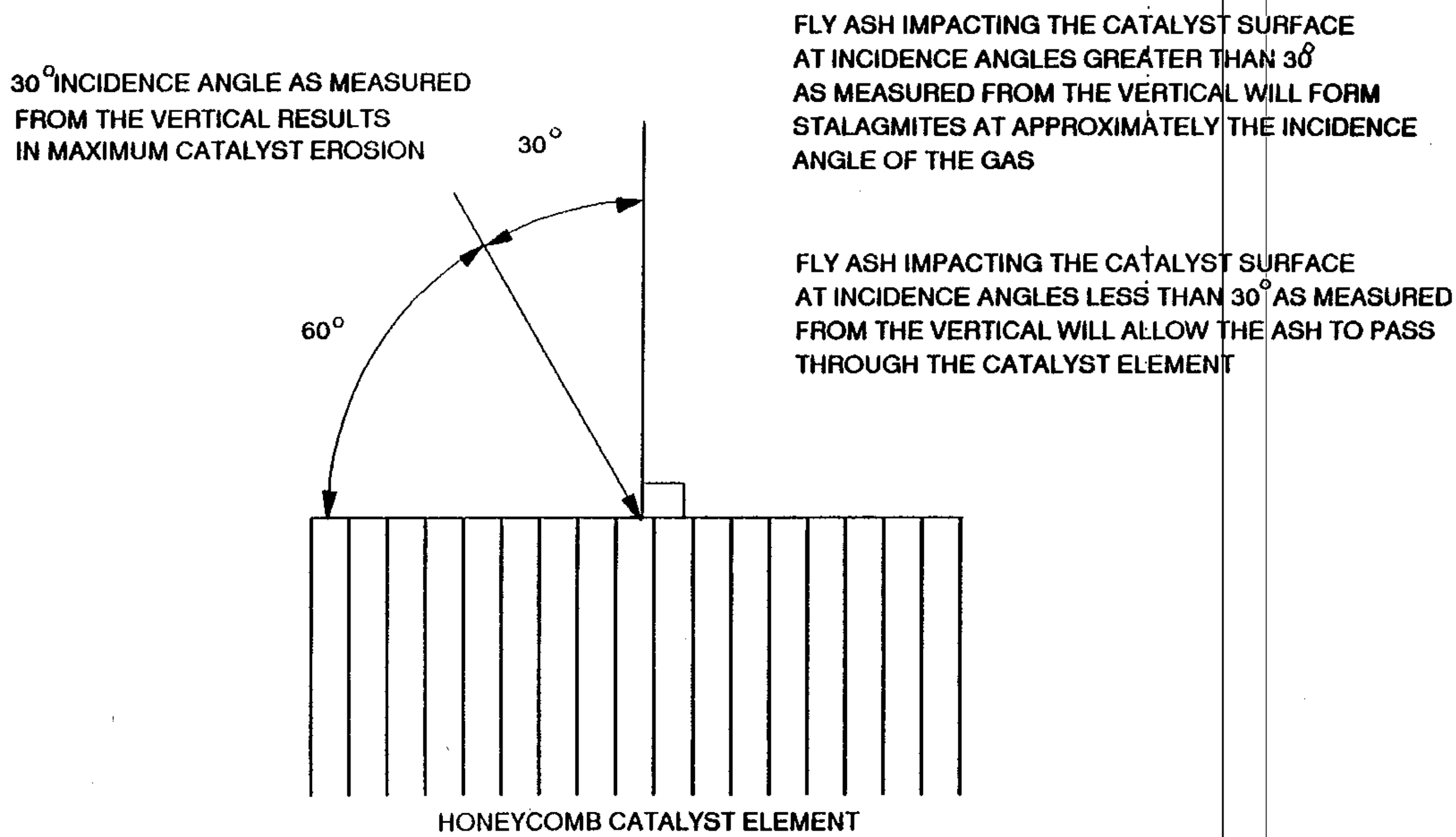


Figure 6.1-4. Flue gas incident angle to the surface of the catalyst.

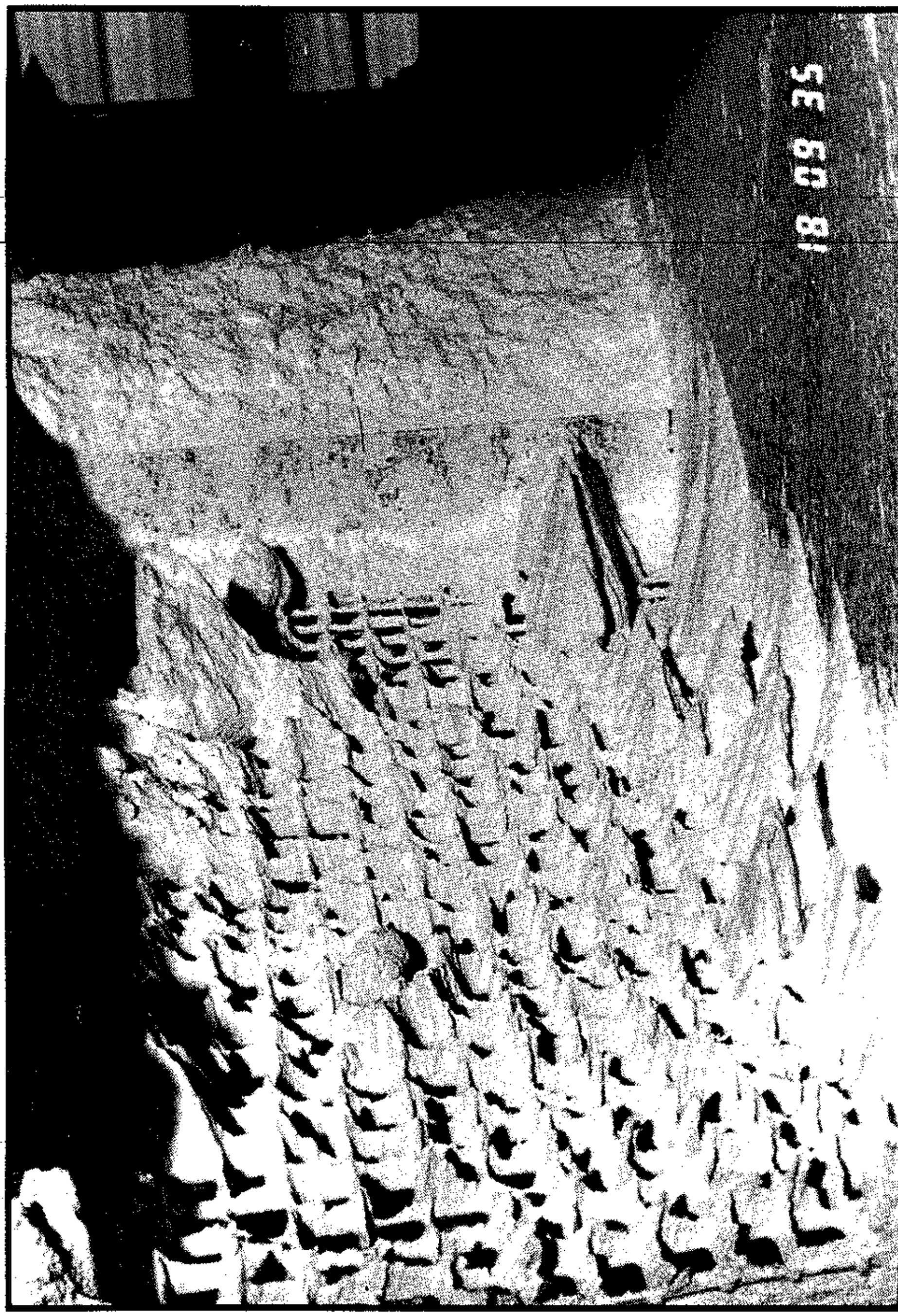


Figure 6.1-5. Effect of flue gas incident angle on flyash deposition. This cold flow models clearly shows the stalagmites which are formed due the high flyash loadings. Note the increased accumulation along the walls of the reactor due mainly to large surfact-to-volume ratio of the pilot reactor.

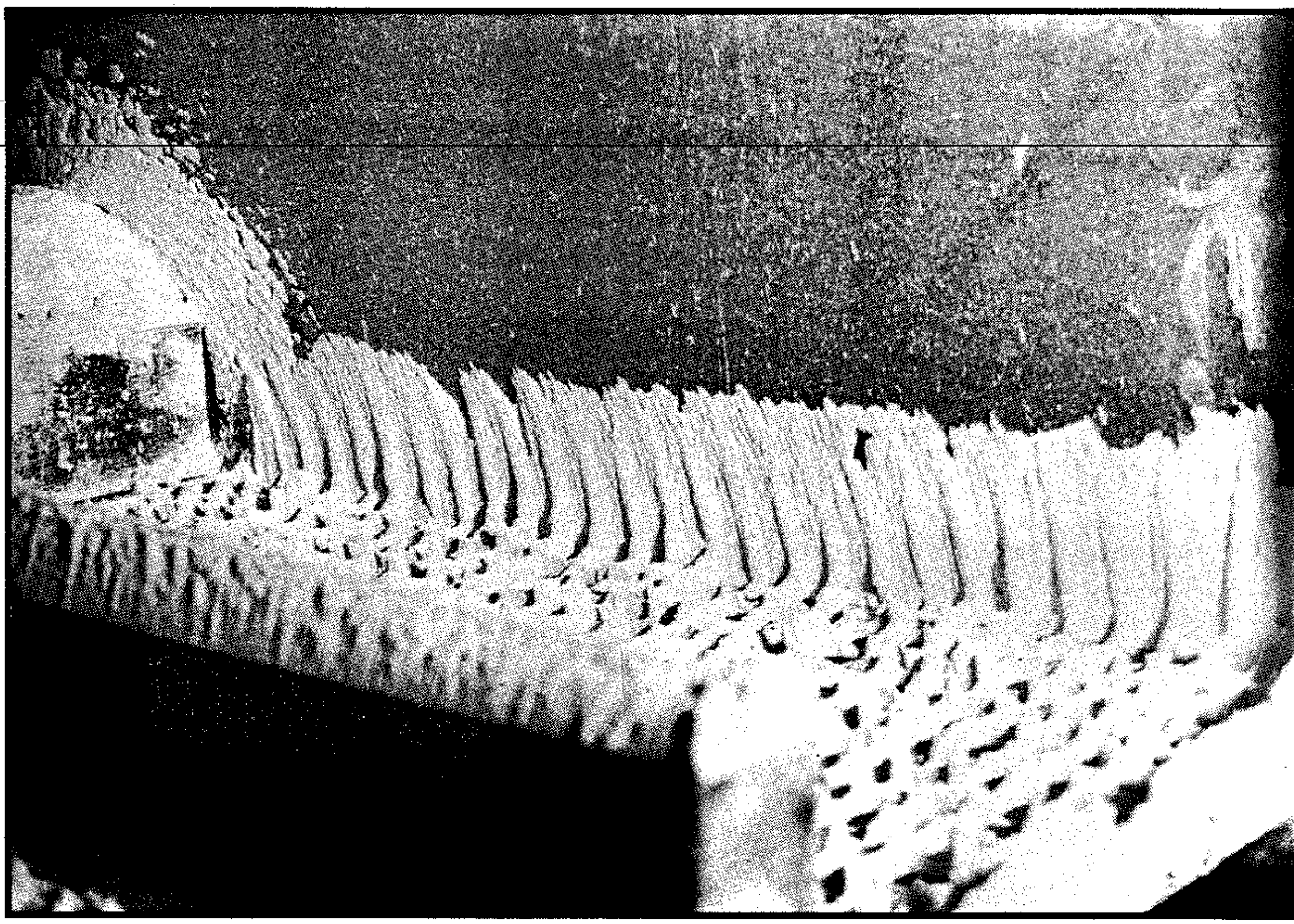
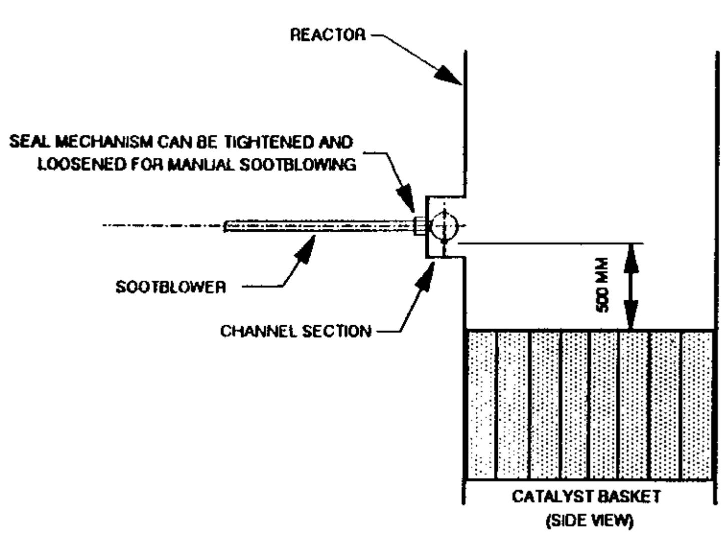


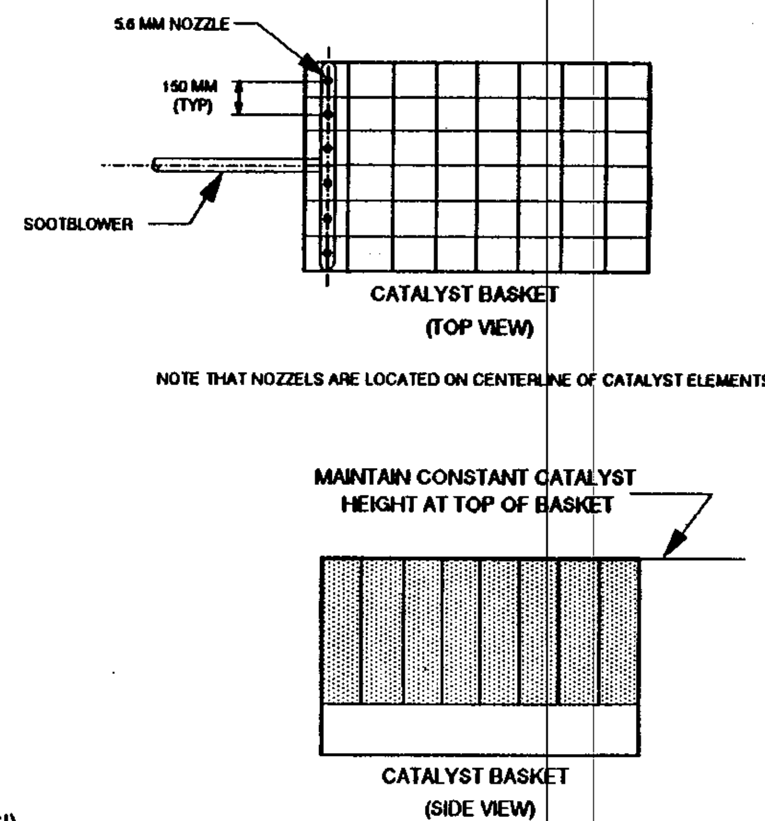
Figure 6.1-6. Effect of flue gas incident angle on flyash deposition. The formation of stalagmites is sensitive to the incidence angle of the flue gas to the catalyst surface. This simulation was accomplished by blocking one side of the reactor flow path (the left side of the photograph) and forcing all gas through one-half the cross-sectional area of the reactor. The stalagmites are formed at approximately the incidence angle of the gas as it impacts the catalyst surface. Although leaning at an angle, these stalagmites are structurally stable with the gas flow. However, they will tend to fall and block the catalyst surface when distrubed.

Flyash buildup is not a problem on plate-type catalyst due to the irregular leading edges. We also plan to place a wire mesh screen cover over the catalyst surface. This mesh screen will catch large ash particles, preventing them from lodging on the catalyst surface and physically blocking channels.

~~In addition to the above mentioned items, each reactor will have provisions for sootblowing on each catalyst layer and the dummy layer. The sootblower~~ design for the large reactors is shown in Figure 6.1-7. The large reactors will use a traversing-type, retractable sootblower to deliver superheated steam from the Unit 5 boiler to the surface of the catalyst. The small reactor sootblower will use air from the service air system and be stroked manually across catalyst layers by plant personnel. Sootblowing will be sequenced from the top to the bottom of the reactors and controlled by the pilot plant control system. Design consideration is being given to allow sootblowing (or brushing) of the reactor walls as the sootblower traverses across the catalyst path.

Sootblowers are the primary concern for air inleakage into the reactors. All possible precautions to minimize air inleakage will be incorporated into the final reactor design. Note that the sootblower can be fully retracted out of the gas path to provide as smooth an inner reactor surface as possible.





SOOTBLOWER DESIGN CRITERIA:

STEAM TEMP AFTER EXPANSION: 260°C (500°F)
STEAM PRESSURE AFTER EXPANSION: 4-6 BARS (60-90 PSI)
NOZZEL DIAMETER: 5.6 MM (.2205 INCHES)
DISTANCE BETWEEN NOZZELS: 150 MM (5.8 INCHES)
DISTANCE FROM NOZZEL TO TOP OF CATALYST: 500 MM (19.7 INCHES)
CRITERIA: LESS THAN 10°C BETWEEN SOOTBLOWING MEDIUM AND BULK GAS TEMPERATURE

Figure 6.1-7. Sootblower design for large reactors.

EXHIBIT 6.1-A

DIMENSIONS OF THE CATALYST MODULES
FOR EACH CATALYST SUPPLIER

Intracompany Memo — Southern Company Services

DATE: 04-Mar-1991 10:46am CST

RE: Module dimensions 3/4/91

FROM: G. S. Ranhotra
Research & Environmental Affairs
8-821-6624

TO: MAXWELL, J. DOUG

We have obtained revised module dimensions from all suppliers who were originally not in accordance with cross-sections we had selected. Recall that the dimensions selected were based on the initial review of vendor responses.

Large Reactor Module Dimensions

Catalyst	Length (clearance)	Width (clearance)	Depth	No. of Layers	Eff. Volume
SCS Recomm	1.354 m	1.048 m	-	-	-
Vendor Responses					
NSKK	1.354 m	1.048 m	1.100 m	3	3.026 m^3
Siemens	1.354 m (0.010 m)	0.954 m (0.003 m)	1.170 m	2	2.3 m^3
Noxeram	1.354 m (0.010 m)	1.048 m (0.010 m)	1.150 m	3	3.026 m^3

Small Reactor Module Dimensions

Catalyst	Length (clearance)	Width (clearance)	Depth	No. of Layers	Eff. Volume
SCS Recomm	0.318 m	0.318 m	-	-	-
Vendor Responses					
Synox	0.318 m (0.010 m)	0.318 m (0.010 m)	1.150 m	3	0.19 m^3
H. Zosen	0.318 m (0.003 m)	0.318 m (0.003 m)	1.130 m	3	0.25 m^3
Norton	0.318 m	0.318 m	0.889 m	4	0.283 m^3
H. Topsoe	0.321 m (0.002 m)	0.321 m (0.002 m)	0.650 m for 1st & 3rd 1.207 m for 2nd	3	0.189 m^3
Engelhard	0.318 m	0.318 m	0.381 m or 0.762 m for the two double module layers	3	0.1178 m^3
Engelhard	0.318 m	0.318 m	0.381 m	2	0.053 m^3

Even though module dimensions are similar now, the vendors differ on their recommendations for clearance. It would appear that a clearance between the module and reactor of 0.010 m on each side would satisfy all suppliers. This would also allow us to accommodate Topsoe's slightly larger module. Guide vanes may be required for the Siemens catalyst or, since it is the only large plate catalyst, the reactor could be designed for it alone.

cc: HEALY, EDWARD C.
BOWERS, KERRY W.
SEARS, ROD E.

EXHIBIT 6.1-B

PRELIMINARY REACTOR HEAT LOSS CALCULATIONS

CALCULATION

A COMPUTER PROGRAM, TUTCO HEAT, WAS USED TO PERFORM THE HEAT LOSS CALCULATIONS. THE METHODOLOGY IS DESCRIBED IN ASTM C-680 AND USES ALL THREE MODES OF HEAT TRANSFER. THIS PROGRAM IS USED TO PERFORM HEAT LOSS CALCULATIONS ON POWER PLANT DUCTWORK.

TWO CRITERIA APPLY:

(A) REACTOR HEAT LOSS MUST BE MINIMIZED TO MAINTAIN BULK GAS TEMPERATURE DOWN THE REACTOR LENGTH.

(B) REACTOR SURFACE TEMPERATURE MUST BE MAINTAINED BELOW 140°F FOR PERSONNEL PROTECTION.

TWO CASES WHERE EXAMINED:

SUMMER - AMBIENT TEMP ASSUMED: 90°F
WIND VELOCITY ASSUMED: 0 MPH
MAXIMUM PROCESS TEMP ASSUMED: 720 °F

VARIABLES: INSULATION THICKNESS, PROCESS TEMP, WIND VELOCITY

WINTER - AMBIENT TEMP ASSUMED: 30°F
WIND VELOCITY ASSUMED: 20 MPH
MAXIMUM PROCESS TEMP ASSUMED: 720°F

VARIABLES: - SAME AS ABOVE.

~~THE FOLLOWING ASSUMPTIONS APPLY:~~

(1) THE MAXIMUM PROCESS TEMP OF 720°F GIVES THE LARGEST TEMPERATURE GRADIENT BETWEEN THE PROCESS GAS AND AMBIENT AIR. THEREFORE, THE HIGHEST HEAT LOSS WOULD BE EXPECTED AT THIS TEMP.

(2) THE SUMMER CONDITION REPRESENTS THE WORST CASE FOR INSULATION SURFACE TEMPERATURE. (i.e. @ 0 mph WIND) A CHECK WAS MADE TO INSURE THAT INCREASING WIND VELOCITY DURING SUMMER TO 20 mph DID NOT EXCEED MAXIMUM HEAT LOSS. DESIGN SURFACE TEMP < 140°F

(3) THE WINTER CONDITION REPRESENTS THE WORST CASE FOR HEAT LOSS DUE TO LARGE THERMAL GRADIENT (ΔT = 720 − 30 = 690) AND CONVECTIVE LOSSES (WIND SPEED @ 20 mph) DESIGN HEAT LOSS < 55 BTU/FT²/HR

(4) RADIATION LOSS WAS ASSUMED TO BE THE SAME FOR WINTER + SUMMER CONDITIONS. EMISSIVITY WAS ASSUMED @ .25 WHICH IS TYPICAL FOR OXIDIZED ALUMINUM LAGGING ON DUCTWORK INSULATION.

(5) MINERAL FIBER INSULATION, TYPICAL OF POWER PLANT INSULATION, WAS ASSUMED.

(6) ASSUMED CONDUCTIVE HEAT LOSS THROUGH REACTOR WALL (CARBON STEEL) IS NEGLIGIBLE AND OUTER REACTOR WALL TEMP EQUALS BULK GAS TEMP.

(7) ASSUMED NEGLIGIBLE HEAT OF REACTION TO SUSTAIN GAS TEMPERATURE.

(8) ~~THE GEOMETRY USED TO MODEL THE SCR REACTORS~~ WAS A VERTICAL FLAT SURFACE.

(9) LARGE REACTOR DIMENSIONS ARE: 3' x 4' x 50'
SMALL REACTOR DIMENSIONS ARE: 1' x 1' x 50'

(10) ASSUME MAXIMUM HEAT LOSS (i.e. @ TOP OF REACTOR) IS CONSTANT DOWN THE ENTIRE LENGTH OF REACTOR. THIS ASSUMPTION WAS MADE (1) TO PREVENT AN ITERATIVE PROCEDURE TO CALCULATE AVG HEAT LOSS, (2) PROVIDE A SLIGHTLY CONSERVATIVE ANSWER

(11) FLUE GAS HEAT CAPACITY ASSUMED TO BE .27 BTU/lb.°F FROM FIGURE BELOW.

Steam / Temperature, surface and pressure drop calculations

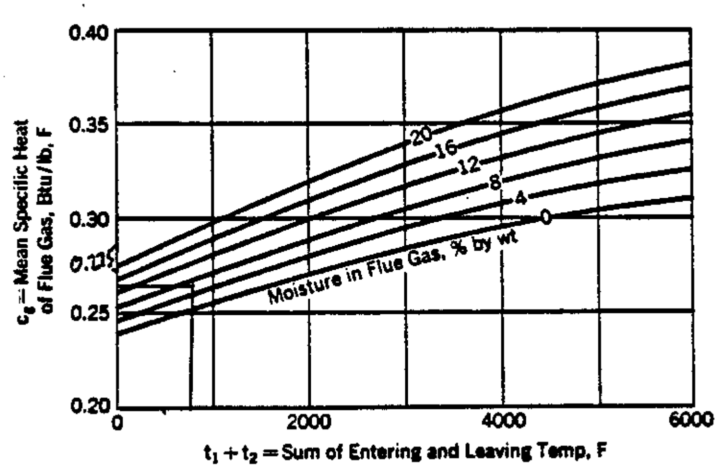


Fig. 10 Approximate mean specific heat, c_g, of flue gases.

FROM UNIT 5 COMBUSTION CALC (SCR MASS BALANCE)

WT H_2O = 45465 #/HR
WT TOTAL = 815474 #/HR

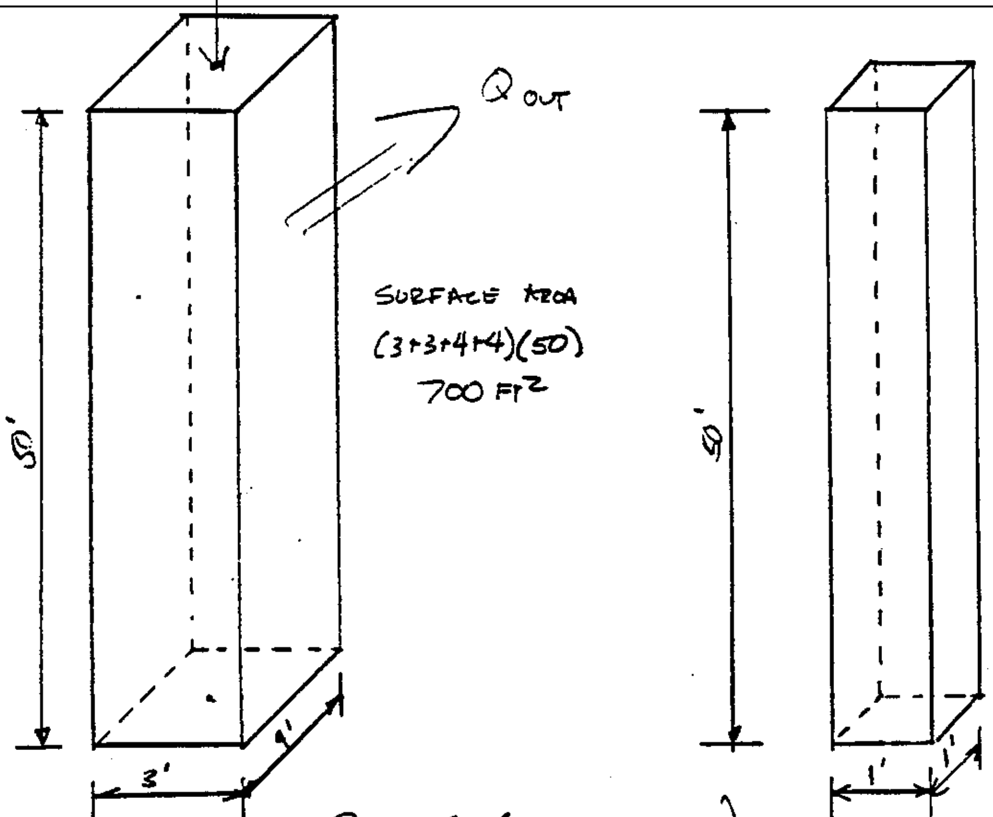
≈ 6% MOISTURE BY WEIGHT

SOURCE: B+W STEAM BOOK

(12) ASSUME NO AIR IN-LEAKAGE TO DILUTE TEMP.

Project	Prepared By	Date
DOE SCR PROJECT	ECA	8/22/98
Subject/Title	**Reviewed By**	**Date**
PRELIMINARY HEAT LOSS CALCS FOR SCR REACTORS	[illegible]	8/29/90
	Calculation Number	**Sheet**
	90206PE-1	7 of 23

$Q_1 = m\,C_p\,(T_{GAS_1} - T_{AMBIENT})$



SURFACE AREA
$(3+3+4+4)(50)$
$700\ FT^2$

SURFACE AREA
$(1+1+1+1)(50)$
$200\ FT^2$

$Q_2 = m\,C_p\,(T_{GAS_2} - T_{AMBIENT})$

LG REACTOR

$$Q_1 - Q_2 = m\,C_p\,(T_{GAS_1} - T_{GAS_2}) \qquad (10)$$

FROM TABLE ON NEXT PAGE, SELECT CRITERIA TO SATISFY HEAT LOSS < 55 BTU/HR/FT² AND SURFACE TEMP < 140°F

∴ @ 6" INSULATION THICKNESS

SUMMER: HEAT LOSS = 47.4 BTU/HR/FT² 138°F SURFACE TEMP
WINTER: HEAT LOSS = **51.5 BTU/HR/FT²** 48°F SURFACE TEMP

→ SAY 52 BTU/HR/FT²

Design Calculations

Southern Company Services

Project	Prepared By	Date
DOE SCR PROJECT	EGA	8/22/90
Subject/Title	**Reviewed By**	**Date**
PRELIMINARY HEAT LOSS CALCS FOR SCR REACTORS	[signature]	8/29/90
	Calculation Number	**Sheet**
	90706PE-1	8 of 23

SUMMER 90°F AMBIENT, 20 mph wind

	4" THK	5" THK	6" THK
720°F	72.9 113°F	58.6 110°F	48.9 107°F
700°F	69.3 112°F	55.6 109°F	
620°F	55.8 109°F	44.8 106°F	

SURFACE TEMP <140 + HL <55

WINTER 30°F AMBIENT, 20 mph wind

	4" THK	5" THK	6" THK
720°F	76.8 55°F	61.6 51°F	51.5 48°F
700°F			
620°F			

HEAT LOSS <55
SURFACE TEMP <140

SUMMER 90°F, AMBIENT, 0 mph wind

	4" THK	5 THK	6 THK
720°F	69.8 156°F	56.5 146°F	47.4 138°F
700°F			
620°F			

SURFACE TEMP <140°F
HEAT LOSS < 55

(upper value in cell) – HEAT LOSS (BTU/HR/FT²)
(lower value in cell) – SURFACE TEMP (°F)

Form No. 9-324A

∴ TOTAL HEAT LOSS ON LG RXR

$$\frac{52\ BTU}{HR\ FT^2}\Big|\ 700\ FT^2 = 36{,}400\ BTU/HR$$

FROM EQN (10)

$$\Delta\dot{Q} = \dot{m}\, C_p\, \Delta T$$

FROM SCR MASS BALANCE, LG REACTOR FLOW IS 275,332 #/HR

$$\therefore (T_{GAS_1} - T_{GAS_2}) = \frac{36400\ BTU}{HR}\Big|\frac{HR}{275332\ lb}\Big|\frac{lb\ °F}{.27\ BTU}$$

$$(T_{GAS_1} - T_{GAS_2}) = .5$$

∴ GAS TEMP @ TOP OF RXR 720°F
GAS TEMP @ BOTTOM OF RXR 719.5 °F ←

TOTAL HEAT LOSS FOR SM RXR

$$\frac{52\ BTU}{HR\ FT^2}\Big|\ 200\ FT^2 = 10400\ \frac{BTU}{HR}$$

APPROXIMATING FLOW FOR SMALL RXRS. (MASS BALANCE SHOWS SM RXR ON UWTG WHICH HAS HIGHER NH3/AIR FLOW)

$$\frac{275{,}332\ \#/HR}{5000\ SCFM} \propto \frac{X\ \#/HR}{400\ SCFM} \Rightarrow X = 22{,}027\ \#/HR$$

Design Calculations | Southern Company Services

Project	Prepared By	Date
DOE SCR PROJECT	ECA	8/22/90
Subject/Title	Reviewed By	Date
PRELIMINARY HEAT LOSS CALCS FOR SCR REACTOR	[illegible]	8/29/90
	Calculation Number	Sheet
	90206PE-1	10 of 23

$\therefore \Delta Q = \dot{m} C_p \Delta T$

$$(T_{GAS_1} - T_{GAS_2}) = \frac{10400\ \text{BTU}}{\text{HR}} \cdot \frac{\text{HR}}{22027\ \text{lb}} \cdot \frac{\text{lb}\ ^\circ\text{F}}{.27\ \text{BTU}}$$

$$(T_{GAS_1} - T_{GAS_2}) = 1.75\ ^\circ\text{F}$$

$\therefore$ GAS TEMP @ TOP OF SMALL RXR = 720°F
GAS TEMP @ BOTTOM OF SMALL RXR = 718°F

$$\Delta T \approx \left(\frac{720-718}{720}\right) \times 100\% \approx .28\%\ \text{DIFFERENCE}$$

CONCLUSION

BASED ON 6" THK MINERAL FIBER INSULATION, THE BULK GAS TEMP DROP ACROSS BOTH LARGE & SMALL RXR IS ACCEPTABLE GIVEN THAT ALL HEAT IS LOST THROUGH RXR WALL. INSULATION SURFACE TEMP IS ALSO OK FOR PERSONNEL PROTECTION.

6.2 MAJOR EQUIPMENT

Table 6.2-1 (Sheet 1 of 2)

Area 400 Major Equipment

AREA	DESCRIPTION	EQUIPMENT NO.
400	SCR reactor A	RXR-401A
400	SCR reactor B	RXR-401B
400	SCR reactor C	RXR-401C
400	SCR reactor D	RXR-401D
400	SCR reactor E	RXR-401E
400	SCR reactor F	RXR-401F
400	SCR reactor G	RXR-401G
400	SCR reactor H	RXR-401H
400	SCR reactor J	RXR-401J
400	Reactor A typical dummy layer (flow straightener)	DL-401A
400	Reactor B typical dummy layer (flow straightener)	DL-401B
400	Reactor C typical dummy layer (flow straightener)	DL-401C
400	Reactor D typical dummy layer (flow straightener)	DL-401D
400	Reactor E typical dummy layer (flow straightener)	DL-401E
400	Reactor F typical dummy layer (flow straightener)	DL-401F
400	Reactor G typical dummy layer (flow straightener)	DL-401G
400	Reactor H typical dummy layer (flow straightener)	DL-401H
400	Reactor J typical dummy layer (flow straightener)	DL-401J
400	Reactor A first layer catalyst basket	CB-401A
400	Reactor B first layer catalyst basket	CB-401B
400	Reactor C first layer catalyst basket	CB-401C
400	Reactor D first layer catalyst basket	CB-401D
400	Reactor E first layer catalyst basket	CB-401E
400	Reactor F first layer catalyst basket	CB-401F
400	Reactor G first layer catalyst basket	CB-401G
400	Reactor H first layer catalyst basket	CB-401H
400	Reactor J first layer catalyst basket	CB-401J
400	Reactor A second layer catalyst basket	CB-402A
400	Reactor B second layer catalyst basket	CB-402B
400	Reactor C second layer catalyst basket	CB-402C
400	Reactor D second layer catalyst basket	CB-402D
400	Reactor E second layer catalyst basket	CB-402E
400	Reactor F second layer catalyst basket	CB-402F
400	Reactor G second layer catalyst basket	CB-402G
400	Reactor H second layer catalyst basket	CB-402H
400	Reactor J second layer catalyst basket	CB-402J
400	Reactor A third layer catalyst basket	CB-403A
400	Reactor B third layer catalyst basket	CB-403B
400	Reactor C third layer catalyst basket	CB-403C
400	Reactor D third layer catalyst basket	CB-403D
400	Reactor E third layer catalyst basket	CB-403E
400	Reactor F third layer catalyst basket	CB-403F
400	Reactor G third layer catalyst basket	CB-403G
400	Reactor H third layer catalyst basket	CB-403H
400	Reactor J third layer catalyst basket	CB-403J

Table 6.2-1 (Page 2 of 2)

400	Reactor A fourth layer catalyst basket	CB-404A
400	Reactor B fourth layer catalyst basket	CB-404B
400	Reactor C fourth layer catalyst basket	CB-404C
400	Reactor D fourth layer catalyst basket	CB-404D
400	Reactor E fourth layer catalyst basket	CB-404E
400	Reactor F fourth layer catalyst basket	CB-404F
400	Reactor G fourth layer catalyst basket	CB-404G
400	Reactor H fourth layer catalyst basket	CB-404H
400	Reactor J fourth layer catalyst basket	CB-404J

7.0 AREA 500: SCR REACTOR OUTLET TO PILOT APH OUTLET

Area 500 is from the outlet of the large SCR reactors to the pilot scale air preheaters (APH) outlet, which are primarily the APHs for the large reactors. The objective of Area 500 is to simulate full scale APH operation downstream of an SCR unit.

7.1 DESCRIPTION

Three air preheaters (APH) consist of two rotary designs and one heat pipe design. Each APH can be isolated and the gas flow bypassed around the APH during high ammonia slip testing and water washing of the unit, while the SCR ~~reactors are on-line. A water cooled tube-in-shell heat exchanger will be used in the bypass of the APH, reducing the temperature of the flue from~~ 700° F to 200° F and preventing damage to the flue gas ID fans. The APH can be isolated with dampers at both the inlet and outlet. The fan for the air side of the APHs will be induced-draft, thereby reducing the differential pressure across the hot end of the APH and minimizing the air-in leakage. A list of major equipment for Area 500 is on page 7.2-1.

7.1.1 Flue Gas/Air Interface with Gulf Power Company Plant Crist

Extracting flue gas from in front of the Unit 5 air heater was calculated to potentially exacerbate an existing problem average with cold-end temperatures on the plant air heater. (Refer to EXHIBIT 7.1-A for this analysis.) After reviewing many alternatives with Gulf Power Company, the option in Figure 7.1-1 was selected. The flue gas and air are reinjected at the same points as originally designed. However, air supplied to the pilot plant air heater is provided from the Unit 5 forced draft fan discharge, instead of ambient air as originally planned. (See EXHIBIT 7.1-B for the technical rationale behind this decision, and for some of the design specifications required for taking from and returning air to the plant's forced draft system.)

7.1.2 Ammonium Bisulfate Formation

Slip NH_3 is a concern in the application of SCR to coal-fired boilers. The combined presence of NH_3, SO_3, and H_2O may lead to the formation and condensation of ammonium bisulfate (NH_4HSO_4) (ABS) and ammonium sulfate $(NH_4)_2SO_4$ on downstream equipment. The chemistry of these reactions are shown below:

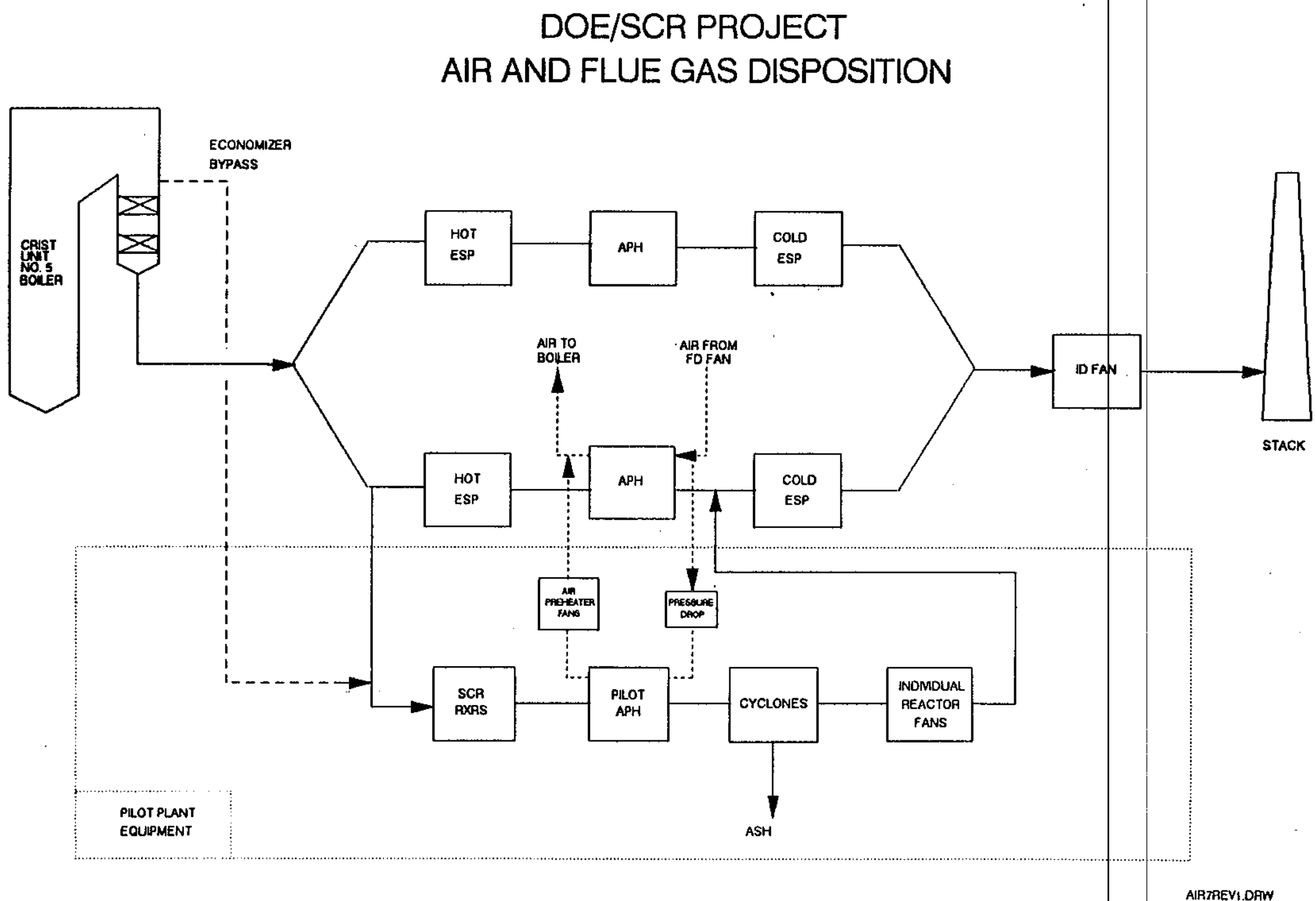


Figure 7.1-1. Plant Crist air heater.

$$2NH_3 + SO_3 + H_2O \text{ -------> } (NH_4)_2SO_4 \qquad (3)$$

$$NH_3 + SO_3 + H_2O \text{ -------> } NH_4HSO_4 \qquad (4)$$

Figure 7.1-2 shows the equilibrium diagram for the formation of ammonium sulfate compounds. As this diagram shows, three factors contribute to NH_4HSO_4 formation: NH_3 and SO_3 concentrations, and temperature. Because it contains V_2O_5, SCR catalyst has a tendency to promote SO_2 oxidation to SO_3. Figure 7.1-3 shows a typical curve for SO_2 conversion to SO_3, as a function of temperature for a particular catalyst formulation. The effect of temperature is also influenced by the quantity of vanadium, tungsten, and other catalytically active metals in the catalyst. Space velocity also influences SO_2 to SO_3 conversion, as shown in Figure 7.1-4. The combustion of low-sulfur coal typically results in less than 3 to 8 ppm SO_3 formation in the boiler. Moreover, the SO_2 concentration in the flue gas is often less than 600 ppm. Thus, NH_3 slip is of less concern, since the total SO_3 content of the flue gas leaving the SCR is also relatively low (i.e., ~3 to 8 ppm). However, U.S. high-sulfur coal with high Fe_2O_3 content may form as much as 30 ppm SO_3 in the boiler. This, combined with as much as one percent conversion of the SO_2 in the flue gas to SO_3 over the SCR catalyst, can lead to substantial problems with ammonium bisulfate formation, if the NH_3 slip is not kept to the lowest values practicable. NH_4HSO_4 will form as a sticky condensate, and will deposit in the intermediate sections of the power plant air preheater. Once deposited, the NH_4HSO_4 may corrode the underlying metal, or collect and trap flyash, causing decreased heat transfer performance and increased pressure losses. Dewpoint correlations for sulfuric acid, ABS, and others are also shown in the informal notes in EXHIBIT 7.1-C.

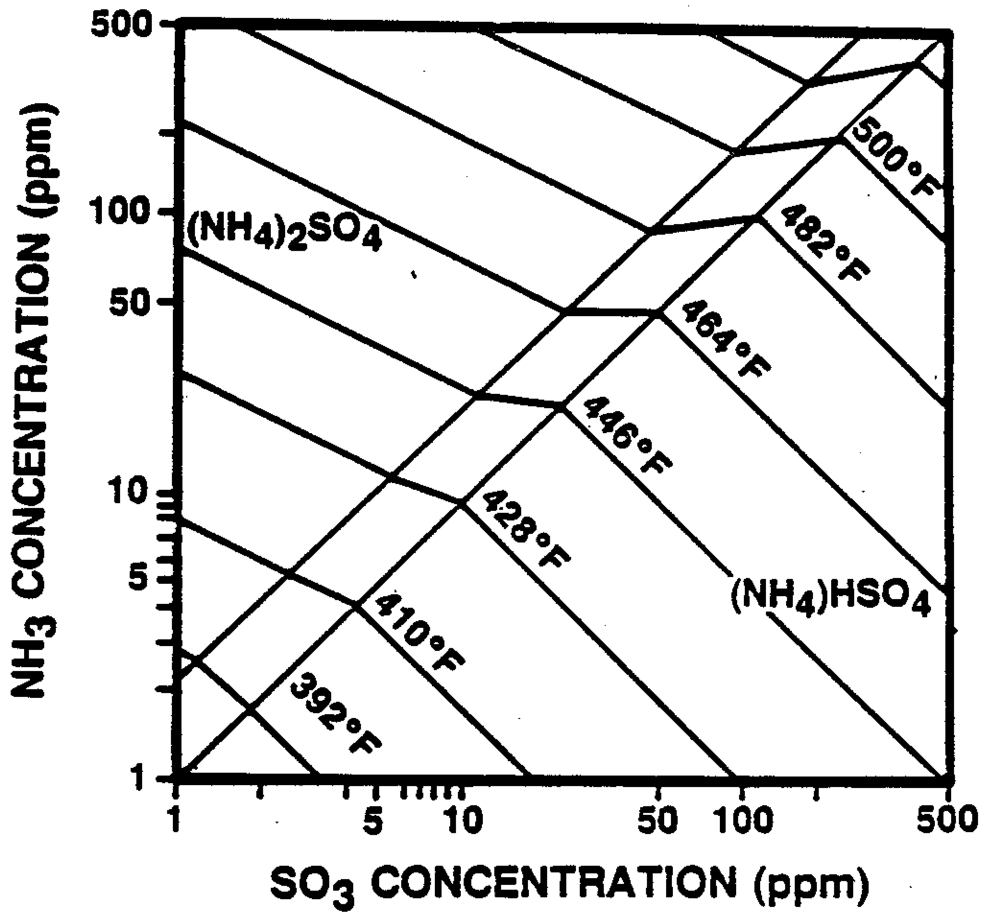


Figure 7.1-2. Equilibrium diagram for the formation of ammonia sulfate compounds.

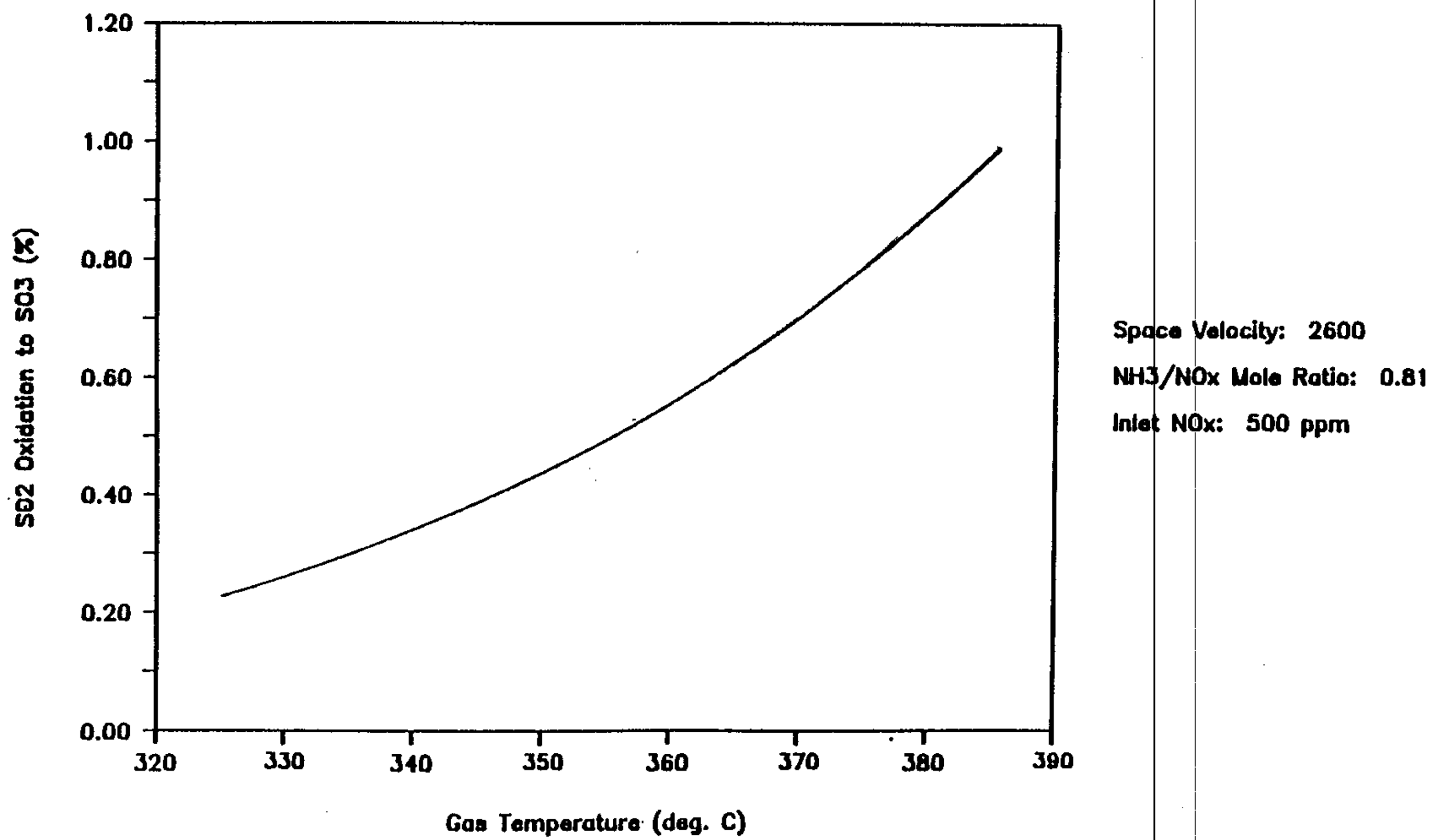


Figure. 7.1-3. Typical curves for SO_2 conversion to SO_3.

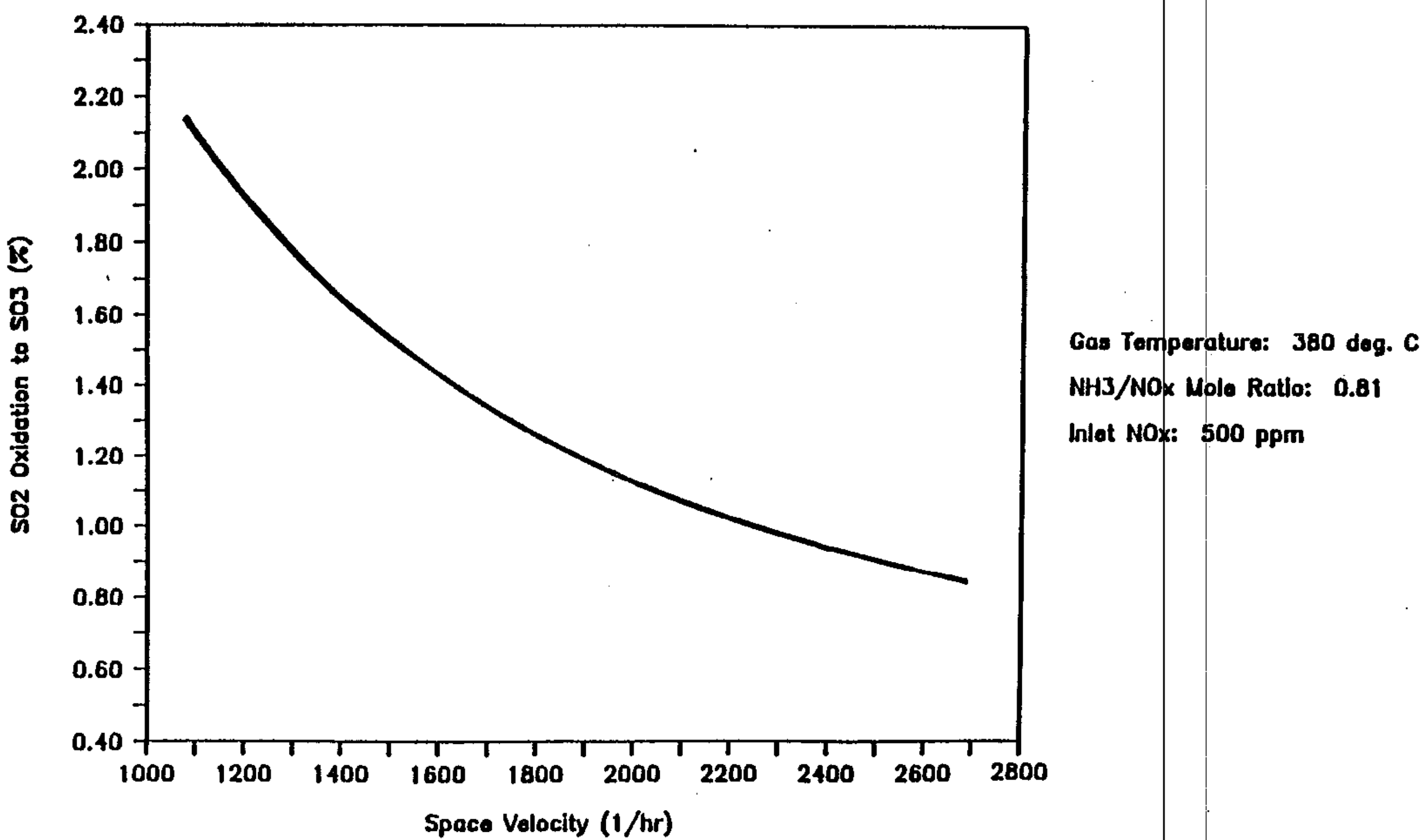


Figure 7.1-4. Diagram showing how space velocity influences SO_2 to SO_3 conversion.

EXHIBIT 7.1-A

ANALYSIS OF DOE SCR PROJECT HEAT RATE AND AVERAGE COLD END TEMPERATURE IMPACTS TO UNIT 5

Intracompany Memo Southern Company Services

DATE: November 7, 1990

RE: DOE SCR Project
Heat Rate/Cold End Average Impacts

FROM: M. V. Balch MVB

TO: E. C. Healy

Attached is an examination of the heat rate and cold end average temperature impacts on Crist 5 due to the DOE SCR Project. Please note the following:

1. The dollar value of the heat rate impact given ($39,430) is strictly an impact based on extraction of flue gas in front of the hot side ESP. The effect of injecting hot air from the SCR Project (which will lessen the effect) and use of steam coils to provide cold side protection have not been evaluated. This cannot be done without further examination of steam coil capability.

2. Heat rate of 11,000 BTU/kwh, which you provided, was utilized at both max and min load. These net plant heat rates should be verified. Net plant heat rate at minimum load is likely to be higher than 11,000 BTU/kwh. The economic impact of a higher heat rate at minimum load will not be great because of the few hours the unit is projected to operate at minimum load.

The recommendation given in the report is contingent on further examination of steam coil capability and I. D. fan capability.

I will be happy to discuss the attached report and the recommended actions at your convenience.

attachment

MVB/ab
ECH.DOC

DOE SCR PROJECT
HEAT RATE AND COLD END AVERAGE IMPACTS

INTRODUCTION

At the request of E. C. Healy, the impact of operations on the Gulf Power Company Plant Crist Unit 5 due to extraction of flue gas for use in the SCR Project was examined.

Flue gas from the Unit 5 boiler is split before passing through a hot side precipitator, two air preheaters (one per side), and a cold side precipitator before being combined again at the induced draft fan. For the SCR Project, 86,201 lb/hr of flue gas is to extracted from the duct on one side in front of the hot side precipitator. Plans are to reinject the flue gas into the duct on the same side in front of the cold side precipitator. The gas that will be reinjected will be 95,214 lb/hr at 300°F. The reinjected flow is greater than the flow extracted due to air inleakage from a air heater involved with the SCR Project.

BASIS OF EXAMINATION

The following information was provided for use in this examination:

1. Full load flue gas flow from boiler is 904,022 lb/hr including 5,464 lb/hr of ash. Low load flue gas flow from boiler is 655,416 lb/hr including 3,994 lb/hr of ash.

2. Net plant heat rate is 11,000 BTU/kwh. Net generation at full load is 83 MW and net generation at low load is 45 MW.

3. Coal HHV is 12,200 BTU/lb. Coal analysis is carbon, 67.80 %; hydrogen, 4.6 %; nitrogen, 1.4 %; sulfur, 2.9 %; chlorine, 0.25 %; oxygen, 5.65 %; water, 7.9 %; and ash, 9.5 %.

4. Flue gas temperature in the hot side precipitator averages 650°F at full load and 592°F at low load.

5. Flue gas is to be extracted from one side in front of the hot side precipitator at the flow rate of 86,201 lb/hr at all unit loads.

6. The SCR Project will be in operation during the years 1992 and 1993.

The following assumptions were made:

1. Air preheater performance is as predicted in the boiler contract data.

2. Air temperature at the inlet to the air preheater is 100°F. This is per the original boiler contract and assumes either that hot air from the boiler house space is being used for combustion air or steam coil air heaters are used to preheat the combustion air. If atmospheric air without preheat is entering the air preheater, performance will be worse than predicted during this examination.

HEAT RATE IMPACT

Air preheater performance was modeled at full and low loads with and without flue gas being extracted for the SCR Project. The results of the model can be found on the attached table "Crist Unit 5 Air Preheater Performance". Please note that the results of the model are approximate due to the minimum information available and assumptions which had to be made.

The model showed a loss in air temperature at the air preheater outlet of 3°F at full load and 53°F at minimum load. This results in an increase of unit heat rate of 4 BTU/kwh at full load and 98 BTU/kwh at low load. The value of the heat rate increase for the years 1992 and 1993 is $39,430 (present worth dollars in 1990).

COLD END AVERAGE TEMPERATURE

The original design coal for Crist Unit 5 contained 0.8 percent sulfur. Operation utilizing this coal would require a minimum cold end average temperature, the average of the inlet air and outlet flue gas temperatures of the air preheater, of 155°F. The coal now being fired contains 2.9 percent sulfur and requires a minimum cold end average temperature of 183°F. Cold end average temperature is specified to protect the cold end of the air preheater from corrosion due to temperatures below the acid dew point temperature.

Based on air preheater performance modeled from the boiler contract data, flue gas temperatures at the hot side precipitator reported at full and minimum load, and an assumed air temperature entering the air preheater of 100°F, cold end average temperatures for Crist 5 are calculated as follows:

Full load - 183°F
Minimum load - 154°F

The calculated cold end average temperatures indicated that there is a cold end average temperature problem at minimum load under present operation.

If the cold end average temperature is calculated with the flue gas being extracted for the SCR Project, the cold end average temperatures are as follows:

Full load - 139°F
Minimum load - 115°F

Additionally, the flue gas temperature exiting the air preheater are calculated as 177°F at full load and 130°F at minimum load.

Please note that based on the criteria used for this examination, there is a flue gas temperature problem on Crist 5 at lower loads during normal operations. Extracting flue gas in front of the air preheater only increases what is apparently an existing problem.

HOT AIR INJECTION

There is 66,204 lb/hr of air at 600°F available from the SCR Project which could be injected into the duct in front of the air preheater to replace the flue gas which is to be extracted. If this is done, it is likely that the flue gas discharged from the SCR Project will have to be injected directly into the stack to keep from overloading the induced draft fan. Since this flue gas would not pass through an ESP, the affect on particulate discharge for the unit will need to be examined if this scenario is implemented.

If this scenario is used, at full load the cold end average temperature will be 171°F which is 12°F lower than normal operation but 32°F higher than the cold end average temperature if flue gas is extracted and not replaced with the hot air. At minimum load the cold end average temperature is 139°F which is much too low.

If the flue gas/hot air mixture could be raised in temperature to 730°F, the cold end average temperature could be maintained at 183°F. Unfortunately, to do this would require raising the temperature of the hot air to 1200°F before injecting it into the duct. This is not practical.

RECOMMENDATION

To maintain the minimum cold end average temperature required for the coal being fired in Crist 5, additional heat must be added to either the flue gas prior to entry into the air preheater, to the air prior to entry into the air preheater, or a combination of the two.

As was stated above, injecting the hot air available from the SCR Project helps the situation, but alone is not adequate. This is all that is practical to do to the flue gas. If the existing steam coils are capable, the duty of the steam coils can be increased to raise the air temperature entering the air preheater. With the hot air injection, the air inlet temperature required at full load would be 113°F. With the hot air injection, the air inlet temperature required at minimum load would be 148°F.

This scenario is dependent on steam coil capability being available. It is also dependent on the ability to discharge the flue gas from the SCR Project directly into the stack (if induced draft fan capability will not handle the additional load).

Please note that the analysis performed for this examination is based on limited operational data and will have some margin for error. The expected error, though, should not be enough to change the basic recommendation stated above. It would probably be wise to see if additional operational data is available to verify the air preheater model used and to investigate the steam coil capability of the unit.

CRIST5.DOC

Crist Unit 5 Air Preheater Performance

(flue gas extracted in front of hot side ESP, reinjected after air preheater)

Specific heat air =	0.24							
Specific heat gas =	0.27							
Unit load (%)	25	50	75	100	Max Load	Max Load w/extract	Min Load	Min Load w/extract
Steam generation (lb/hr)	200000	400000	550000	582000				
Air entering air preheater (lb/hr)	280000	521000	673000	700000	830834	830834	614772	614772
Flue gas entering air preheater (lb/hr)	300961	561460	726142	755754	898558	726156	651422	479020
Flue gas leaving air preheater (corrected)	340000	611000	799500	832000				
Air temperature (deg F)								
entering air preheater	100	100	100	100	100	100	100	100
leaving air preheater	525	580	596	598				
Flue gas temp (deg F)								
entering air preheater	535	605	645	650	650	650	592	592
leaving air preheater (uncorrected)	242	245	260	262				
leaving air preheater (corrected)	211	225	242	244				
Cair =	67200	125040	161520	168000	199400	199400	147545	147545
Cgas =	81259	151594	196058	204054	242611	196062	175884	129335
Cmin =	67200	125040	161520	168000	199400	196062	147545	129335
Effectiveness =	0.977	0.950	0.910	0.905	0.850	0.860	0.930	0.940
Calculated Values:								
Flue gas leaving air preheater (deg F)					266	177	208	130
Air leaving air preheater (deg F)					568	565	558	505
Cold end average temp (deg F)	171	173	180	181	183	139	154	115

Crist Unit 5 Air Preheater Performance

(flue gas extracted in front of hot side ESP, reinjected after air preheater)								
Specific heat air =	0.24							
Specific heat gas =	0.27							
Unit load (%)	25	50	75	100	Max Load	Max Load w/extract	Min Load	Min Load w/extract
Steam generation (lb/hr)	200000	400000	550000	582000				
Air entering air preheater (lb/hr)	280000	521000	673000	700000	830834	830834	614772	614772
Flue gas entering air preheater (lb/hr)	300961	561460	726142	755754	898558	726156	651422	479020
Flue gas leaving air preheater (corrected)	340000	611000	799500	832000				
Air temperature (deg F)								
entering air preheater	100	100	100	100	100	148	100	140
leaving air preheater	525	580	596	598				
Flue gas temp (deg F)								
entering air preheater	535	605	645	650	650	650	592	592
leaving air preheater (uncorrected)	242	245	260	262				
leaving air preheater (corrected)	211	225	242	244				
Cair =	67200	125040	161520	168000	199400	199400	147545	147545
Cgas =	81259	151594	196058	204054	242611	196062	175884	129335
Cmin =	67200	125040	161520	168000	199400	196062	147545	129335
Effectiveness =	0.977	0.950	0.910	0.905	0.850	0.860	0.930	0.940
Calculated Values:								
Flue gas leaving air preheater (deg F)					266	218	208	167
Air leaving air preheater (deg F)					568	572	558	512
Cold end average temp (deg F)	171	173	180	181	183	183	154	154

Crist Unit 5 Air Preheater Performance

(flue gas extracted in front of hot side ESP, reinjected after air preheater)

Specific heat air = 0.24

Specific heat gas = 0.27

Unit load (%)	25	50	75	100	Max Load	Max Load w/extract	Min Load	Min Load w/extract
Steam generation (lb/hr)	200000	400000	550000	582000				
Air entering air preheater (lb/hr)	280000	521000	673000	700000	830834	830834	614772	614772
Flue gas entering air preheater (lb/hr)	300961	561460	726142	755754	898558	726156	651422	479020
Flue gas leaving air preheater (corrected)	340000	611000	799500	832000				
Air temperature (deg F)								
entering air preheater	100	100	100	100	100	148	100	170
leaving air preheater	525	580	596	598				
Flue gas temp (deg F)								
entering air preheater	535	605	645	650	650	650	592	592
leaving air preheater (uncorrected)	242	245	260	262				
leaving air preheater (corrected)	211	225	242	244				
Cair =	67200	125040	161520	168000	199400	199400	147545	147545
Cgas =	81259	151594	196058	204054	242611	196062	175884	129335
Cmin =	67200	125040	161520	168000	199400	196062	147545	129335
Effectiveness =	0.977	0.950	0.910	0.905	0.850	0.860	0.930	0.940
Calculated Values:								
Flue gas leaving air preheater (deg F)					266	218	208	195
Air leaving air preheater (deg F)					568	572	558	518
Cold end average temp (deg F)	171	173	180	181	183	183	154	183

Crist Unit 5 Air Preheater Performance

(w/600 deg air reinjected in front of air preheater)

	25	50	75	100	Max Load	Max Load w/extract	Min Load	Min Load w/extract
Specific heat air =	0.24							
Specific heat gas =	0.27					0.268		0.266
Unit load (%)	25	50	75	100	Max Load	Max Load w/extract	Min Load	Min Load w/extract
Steam generation (lb/hr)	200000	400000	550000	582000				
Air entering air preheater (lb/hr)	280000	521000	673000	700000	830834	830834	614772	614772
Flue gas entering air preheater (lb/hr)	300961	561460	726142	755754	898558	858564	651422	611428
Flue gas leaving air preheater (corrected)	340000	611000	799500	832000				
Air temperature (deg F)								
entering air preheater	100	100	100	100	100	100	100	100
leaving air preheater	525	580	596	598				
Flue gas temp (deg F)								
entering air preheater	535	605	645	650	650	642	592	595
leaving air preheater (uncorrected)	242	245	260	262				
leaving air preheater (corrected)	211	225	242	244				
Cair =	67200	125040	161520	168000	199400	199400	147545	147545
Cgas =	81259	151594	196058	204054	242611	230095	175884	162640
Cmin =	67200	125040	161520	168000	199400	199400	147545	147545
Effectiveness =	0.977	0.950	0.910	0.905	0.850	0.850	0.930	0.930
Calculated Values:								
Flue gas leaving air preheater (deg F)					266	243	208	177
Air leaving air preheater (deg F)					568	561	558	560
Cold end average temp (deg F)	171	173	180	181	183	171	154	139

Crist Unit 5 Air Preheater Performance

(hot air reinjected, steam coil duty increased)

	25	50	75	100	Max Load	Max Load w/extract	Min Load	Min Load w/extract
Specific heat air =	0.24							
Specific heat gas =	0.27					0.268		0.266
Unit load (%)	25	50	75	100	Max Load	Max Load w/extract	Min Load	Min Load w/extract
Steam generation (lb/hr)	200000	400000	550000	582000				
Air entering air preheater (lb/hr)	280000	521000	673000	700000	830834	830834	614772	614772
Flue gas entering air preheater (lb/hr)	300961	561460	726142	755754	898558	858564	651422	611428
Flue gas leaving air preheater (corrected)	340000	611000	799500	832000				
Air temperature (deg F)								
entering air preheater	100	100	100	100	100	113	100	148
leaving air preheater	525	580	596	598				
Flue gas temp (deg F)								
entering air preheater	535	605	645	650	650	642	592	595
leaving air preheater (uncorrected)	242	245	260	262				
leaving air preheater (corrected)	211	225	242	244				
Cair =	67200	125040	161520	168000	199400	199400	147545	147545
Cgas =	81259	151594	196058	204054	242611	230095	175884	162640
Cmin =	67200	125040	161520	168000	199400	199400	147545	147545
Effectiveness =	0.977	0.950	0.910	0.905	0.850	0.850	0.930	0.930
Calculated Values:								
Flue gas leaving air preheater (deg F)					266	252	208	218
Air leaving air preheater (deg F)					568	563	558	564
Cold end average temp (deg F)	171	173	180	181	183	183	154	183

Crist Unit 5 Air Preheater Performance

(flue gas extracted in front of hot side ESP, hot air injected between FD fan and air heater)

Specific heat air =	0.24							
Specific heat gas =	0.27							
Unit load (%)	25	50	75	100	Max Load	Max Load w/extract	Min Load	Min Load w/extract
Steam generation (lb/hr)	200000	400000	550000	582000				
Air entering air preheater (lb/hr)	280000	521000	673000	700000	830834	830834	614772	614772
Flue gas entering air preheater (lb/hr)	300961	561460	726142	755754	898558	726156	651422	479020
Flue gas leaving air preheater (corrected)	340000	611000	799500	832000				
Air temperature (deg F)								
entering air preheater	100	100	100	100	100	180	100	208
leaving air preheater	525	580	596	598				
Flue gas temp (deg F)								
entering air preheater	535	605	645	650	650	650	592	592
leaving air preheater (uncorrected)	242	245	260	262				
leaving air preheater (corrected)	211	225	242	244				
Cair =	67200	125040	161520	168000	199400	199400	147545	147545
Cgas =	81259	151594	196058	204054	242611	196062	175884	129335
Cmin =	67200	125040	161520	168000	199400	196062	147545	129335
Effectiveness =	0.977	0.950	0.910	0.905	0.850	0.860	0.930	0.940
Calculated Values:								
Flue gas leaving air preheater (deg F)					266	246	208	231
Air leaving air preheater (deg F)					568	577	558	524
Cold end average temp (deg F)	171	173	180	181	183	213	154	220

EXHIBIT 7.1-B

TECHNICAL COMPARISON OF FLUE GAS AND AIR DISPOSITION

SCS DOE Selective Catalytic Reduction Project
Technical Comparison of
Flue Gas and Air Disposition

INTRODUCTION

This document provides a technical discussion of the option that will be used to integrate the SCR pilot plant APHs with Plant Crist Unit 5. A technical description is followed by advantages and disadvantages.

Discussions with Roy Ward indicate that Gulf Power Company (Gulf) is concerned about possible air imbalance issues with integration of the heated air back to the Unit 5 draft system. We would plan to either reinject the heated air from the pilot plant before the existing air flow measurement device, or provide additional air measurement to ensure that the total air going to the boiler is unchanged for a given boiler load. The pilot plant air fan will basically operate at 0 percent, 33 percent, 67 percent, or 100 percent of design flow, depending on the various combinations of pilot air preheater in and out of service. From a control point of view, the total amount of air to the boiler would be the same, regardless of the source of the air. As Roy suggested, we would trip the pilot plant air fan at the same time the Unit 5 FD fan trips.

Air flow through the pilot air heaters will be varied to move the ammonium bisulfate condensation zone; small inaccuracies with the damper position may invalidate a long term test.

We believe that Gulf's desire to maximize the heat recovery, by returning the hot air to the combustion air system, can be achieved by this option. This can best be visualized as operating the pilot scale air heaters in parallel with the Unit 5 air heaters, using two FD fans in series, the plant FD fan and the pilot plant air preheater fan.

HEATED AIR AND FLUE GAS INTEGRATION

The flue gas is reinjected back to the Unit 5 draft system before the cold-side ESP. Air is provided to the pilot plant APHs from the Unit 5 FD fan. A damper and/or perforated plate is installed in the supply ductwork to provide the required pressure drop, approximately 20 in. W.G., in order to control the pilot scale air heater leakage. The heated air pressure is boosted by the pilot plant air preheater fan and returned to the Unit 5 APH on the air outlet side.

The flue gas is reinjected downstream of the Unit 5 APH and upstream of the cold-side ESP. The State of Florida has approved this design, and no additional particulate collection would be required other than that already proposed. Also, because the gas would be introduced upstream of the Unit 5 ID fan, the negative pressure would assist the pilot plant flue as booster fans in meeting the specified static boost. The tie-ins for the air ductwork will be more difficult retrofit due to two air ducts, a supply and a return, required for this option.

Inserting a damper and/or perforated plant, assuming it could achieve the required pressure drop and flow, would eliminate the excessive air leakage of the pilot scale air preheaters brought about by Unit 5 FD fan static discharge pressure. However, the air preheater fan would be required to return the heated air back to the combustion air system.

Due to more extensive integration into Unit 5 operation, the control system will be capable of coordinating the Unit 5 FD fan with the pilot plant air fan. It should be pointed out that there may be times when the pilot plant is operating and unable to send heated air back to the draft system. During these transient conditions, the Unit 5 APH cold-end temperature may drop below design conditions. Also, air flow is a major parameter in testing the pilot scale air preheaters. Therefore, there may be times when the air flow back to Unit 5 will be slightly more, or slightly less, that the design flow.

<u>Advantages</u>

1. This option is Gulf Power Company's preferred method of integration of the pilot plant with Unit 5.

2. A more simple pilot plant design, by eliminating the need for a baghouse and booster fan.

3. Reinjection of the flue gas in this manner has already been approved by the State and would not require any further permit work.

4. Reinjection of the heated air on the outlet air side of the Unit 5 APH would bring about greater recovery of heat from the pilot plant.

5. No increase in ash handling design since baghouse is deleted.

6. No increase in air requirement for pulsing bags.

Disadvantages

1. The air preheater fan must be retained in order to provide enough static pressure for heated air reinjection back into the Unit 5 combustion air system.

2. This option does not provide maximum operating flexibility for pilot plant because of a higher degree of integration. However, the operational constraints on the pilot plant are acceptable.

3. Because the pilot plant is more integrated with Unit 5, increased coordination between the host unit and the pilot plant will be required.

4. Operation and control of Unit 5 FD fan would have to be investigated and factored into pilot plant control system design. Coordination between Unit 5 FD fan and the pilot plant air preheater fan would be required.

5. Very difficult retrofit for ductwork tie-ins ahead of the cold-side ESP, FD fan outlet, and Unit 5 APH outlet, which requires supply and return duct to pilot plant APH. Also, this requires damper and/or perforated plant to provide a 20 in. W.G. pressure drop.

EXHIBIT 7.1-C

DEWPOINT CORRELATIONS FOR SULFURIC ACID, ABS, AND OTHERS (INFORMAL NOTES)

Design Calculations

Southern Company Services

Project	Prepared By R. Rankotra	Date
Subject/Title	Reviewed By	Date 5/1
	Calculation Number	Sheet / of

To Avoid ABS or AS condensation:

AS (Ammonium sulfate)

Have thermodynamic data which can be used to develop equation for various levels of H_2O, NH_3, SO_3.

$$\ln\left[\frac{1}{(y_{H_2O})(y_{SO_3})(y_{NH_3})^2}\right] =$$

$$108.696 + \frac{[-107.814 + 3.958\times10^{-3}(T-298)]}{1.987\times10^{-3}}\left[\frac{1}{298} - \frac{1}{T}\right]$$

where y respresents the mole fraction present in the gas phase at the dewpoint and T is in degrees Kelv

ABS (Ammonium bisulfate)

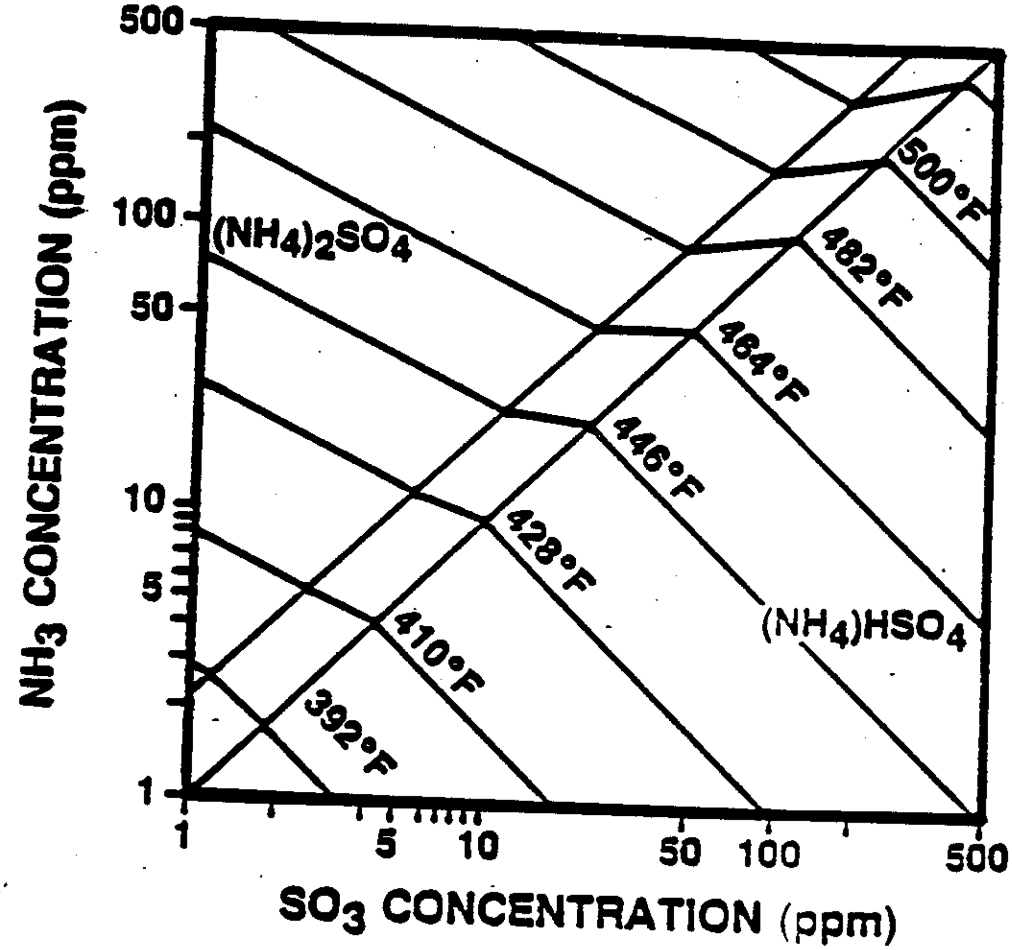
There is not enough data available, but the attached Figure can be used for a water level of 10 vol %.

Form No. 9-324A

Figure 1

Conditions for the Formation of Ammonium Sulfate/Bisulfate

for 10% H_2O



Water condensation:

The dewpoint for a gas containing moisture can be determined from an expression for water vapor pressure as a function of temperature. Note this assumes that water is the only condensing species; any other condensibles should have been removed prior to this point.

Attached is a copy of steam tables for pressures lower than atmospheric. A sample calculation for determining the dewpoint using these tables is given below.

What is the condensation temp of 9% (volume) water in flue gas?

9% of 14.7 psia = 1.323 psia
(1 atmosphere)

Looking up this pressure on the second column of the table we find the dewpoint lies between 110°F and 112°F.

A crude approximation can also be determined from the equation shown below.

$$\ln P_{H_2O} = 14.462 - \frac{5367.3}{T}$$

P_{H_2O} (atm)
T (degrees Kelvin)

So for $P_{H_2O} = 0.09$, $T = 318.2K = 112.9°F$

Table 1. Saturated Steam: Temperature Table

Temp Fahr t	Abs Press. Lb per Sq In. p	Specific Volume Sat. Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat. Vapor v_g	Enthalpy Sat. Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat. Vapor h_g	Entropy Sat. Liquid s_f	Entropy Evap s_{fg}	Entropy Sat. Vapor s_g	Temp Fahr t
32.0*	0.08859	0.016022	3304.7	3304.7	-0.0179	1075.5	1075.5	0.0000	2.1873	2.1873	32.0*
34.0	0.09600	0.016021	3061.9	3061.9	1.996	1074.4	1076.4	0.0041	2.1762	2.1802	34.0
36.0	0.10395	0.016020	2839.0	2839.0	4.008	1073.2	1077.2	0.0081	2.1651	2.1732	36.0
38.0	0.11249	0.016019	2634.1	2634.2	6.018	1072.1	1078.1	0.0122	2.1541	2.1663	38.0
40.0	0.12163	0.016019	2445.8	2445.8	8.027	1071.0	1079.0	0.0162	2.1432	2.1594	40.0
42.0	0.13143	0.016019	2272.4	2272.4	10.035	1069.8	1079.9	0.0202	2.1325	2.1527	42.0
44.0	0.14192	0.016019	2112.8	2112.8	12.041	1068.7	1080.7	0.0242	2.1217	2.1459	44.0
46.0	0.15314	0.016020	1965.7	1965.7	14.047	1067.6	1081.6	0.0282	2.1111	2.1393	46.0
48.0	0.16514	0.016021	1830.0	1830.0	16.051	1066.4	1082.5	0.0321	2.1006	2.1327	48.0
50.0	0.17796	0.016023	1704.8	1704.8	18.054	1065.3	1083.4	0.0361	2.0901	2.1262	50.0
52.0	0.19165	0.016024	1589.2	1589.2	20.057	1064.2	1084.2	0.0400	2.0798	2.1197	52.0
54.0	0.20625	0.016026	1482.4	1482.4	22.058	1063.1	1085.1	0.0439	2.0695	2.1134	54.0
56.0	0.22183	0.016028	1383.6	1383.6	24.059	1061.9	1086.0	0.0478	2.0593	2.1070	56.0
58.0	0.23843	0.016031	1292.2	1292.2	26.060	1060.8	1086.9	0.0516	2.0491	2.1008	58.0
60.0	0.25611	0.016033	1207.6	1207.6	28.060	1059.7	1087.7	0.0555	2.0391	2.0946	60.0
62.0	0.27494	0.016036	1129.2	1129.2	30.059	1058.5	1088.6	0.0593	2.0291	2.0885	62.0
64.0	0.29497	0.016039	1056.5	1056.5	32.058	1057.4	1089.5	0.0632	2.0192	2.0824	64.0
66.0	0.31626	0.016043	989.0	989.1	34.056	1056.3	1090.4	0.0670	2.0094	2.0764	66.0
68.0	0.33889	0.016046	926.5	926.5	36.054	1055.2	1091.2	0.0708	1.9996	2.0704	68.0
70.0	0.36292	0.016050	868.3	868.4	38.052	1054.0	1092.1	0.0745	1.9900	2.0645	70.0
72.0	0.38844	0.016054	814.3	814.3	40.049	1052.9	1093.0	0.0783	1.9804	2.0587	72.0
74.0	0.41550	0.016058	764.1	764.1	42.046	1051.8	1093.8	0.0821	1.9708	2.0529	74.0
76.0	0.44420	0.016063	717.4	717.4	44.043	1050.7	1094.7	0.0858	1.9614	2.0472	76.0
78.0	0.47461	0.016067	673.8	673.9	46.040	1049.5	1095.6	0.0895	1.9520	2.0415	78.0
80.0	0.50683	0.016072	633.3	633.3	48.037	1048.4	1096.4	0.0932	1.9426	2.0359	80.0
82.0	0.54093	0.016077	595.5	595.5	50.033	1047.3	1097.3	0.0969	1.9334	2.0303	82.0
84.0	0.57702	0.016082	560.3	560.3	52.029	1046.1	1098.2	0.1006	1.9242	2.0248	84.0
86.0	0.61518	0.016087	527.5	527.5	54.026	1045.0	1099.0	0.1043	1.9151	2.0193	86.0
88.0	0.65551	0.016093	496.8	496.8	56.022	1043.9	1099.9	0.1079	1.9060	2.0139	88.0
90.0	0.69813	0.016099	468.1	468.1	58.018	1042.7	1100.8	0.1115	1.8970	2.0086	90.0
92.0	0.74313	0.016105	441.3	441.3	60.014	1041.6	1101.6	0.1152	1.8881	2.0033	92.0
94.0	0.79062	0.016111	416.3	416.3	62.010	1040.5	1102.5	0.1188	1.8792	1.9980	94.0
96.0	0.84072	0.016117	392.8	392.9	64.006	1039.3	1103.3	0.1224	1.8704	1.9928	96.0
98.0	0.89356	0.016123	370.9	370.9	66.003	1038.2	1104.2	0.1260	1.8617	1.9876	98.0
100.0	0.94924	0.016130	350.4	350.4	67.999	1037.1	1105.1	0.1295	1.8530	1.9825	100.0
102.0	1.00789	0.016137	331.1	331.1	69.995	1035.9	1105.9	0.1331	1.8444	1.9775	102.0
104.0	1.06965	0.016144	313.1	313.1	71.992	1034.8	1106.8	0.1366	1.8358	1.9725	104.0
106.0	1.1347	0.016151	296.16	296.18	73.99	1033.6	1107.6	0.1402	1.8273	1.9675	106.0
108.0	1.2030	0.016158	280.28	280.30	75.98	1032.5	1108.5	0.1437	1.8188	1.9626	108.0
110.0	1.2750	0.016165	265.37	265.39	77.98	1031.4	1109.3	0.1472	1.8105	1.9577	110.0
112.0	1.3505	0.016173	251.37	251.38	79.98	1030.2	1110.2	0.1507	1.8021	1.9528	112.0
114.0	1.4299	0.016180	238.21	238.22	81.97	1029.1	1111.0	0.1542	1.7938	1.9480	114.0
116.0	1.5133	0.016188	225.84	225.85	83.97	1027.9	1111.9	0.1577	1.7856	1.9433	116.0
118.0	1.6009	0.016196	214.20	214.21	85.97	1026.8	1112.7	0.1611	1.7774	1.9386	118.0
120.0	1.6927	0.016204	203.25	203.26	87.97	1025.6	1113.6	0.1646	1.7693	1.9339	120.0
122.0	1.7891	0.016213	192.94	192.95	89.96	1024.5	1114.4	0.1680	1.7613	1.9293	122.0
124.0	1.8901	0.016221	183.23	183.24	91.96	1023.3	1115.3	0.1715	1.7533	1.9247	124.0
126.0	1.9959	0.016229	174.08	174.09	93.96	1022.2	1116.1	0.1749	1.7453	1.9202	126.0
128.0	2.1068	0.016238	165.45	165.47	95.96	1021.0	1117.0	0.1783	1.7374	1.9157	128.0
130.0	2.2230	0.016247	157.32	157.33	97.96	1019.8	1117.8	0.1817	1.7295	1.9112	130.0
132.0	2.3445	0.016256	149.64	149.66	99.95	1018.7	1118.6	0.1851	1.7217	1.9068	132.0
134.0	2.4717	0.016265	142.40	142.41	101.95	1017.5	1119.5	0.1884	1.7140	1.9024	134.0
136.0	2.6047	0.016274	135.55	135.57	103.95	1016.4	1120.3	0.1918	1.7063	1.8980	136.0
138.0	2.7438	0.016284	129.09	129.11	105.95	1015.2	1121.1	0.1951	1.6986	1.8937	138.0
140.0	2.8892	0.016293	122.98	123.00	107.95	1014.0	1122.0	0.1985	1.6910	1.8895	140.0
142.0	3.0411	0.016303	117.21	117.22	109.95	1012.9	1122.8	0.2018	1.6534	1.8852	142.0
144.0	3.1997	0.016312	111.74	111.76	111.95	1011.7	1123.6	0.2051	1.6759	1.8810	144.0
146.0	3.3653	0.016322	106.58	106.59	113.95	1010.5	1124.5	0.2084	1.6684	1.8769	146.0
148.0	3.5381	0.016332	101.68	101.70	115.95	1009.3	1125.3	0.2117	1.6610	1.8727	148.0
150.0	3.7184	0.016343	97.05	97.07	117.95	1008.2	1126.1	0.2150	1.6536	1.8686	150.0
152.0	3.9065	0.016353	92.66	92.68	119.95	1007.0	1126.9	0.2183	1.6463	1.8646	152.0
154.0	4.1025	0.016363	88.50	88.52	121.95	1005.8	1127.7	0.2216	1.6390	1.8606	154.0
156.0	4.3068	0.016374	84.56	84.57	123.95	1004.6	1128.6	0.2248	1.6318	1.8566	156.0
158.0	4.5197	0.016384	80.82	80.83	125.96	1003.4	1129.4	0.2281	1.6245	1.8526	158.0
160.0	4.7414	0.016395	77.27	77.29	127.96	1002.2	1130.2	0.2313	1.6174	1.8487	160.0
162.0	4.9722	0.016406	73.90	73.92	129.96	1001.0	1131.0	0.2345	1.6103	1.8448	162.0
164.0	5.2124	0.016417	70.70	70.72	131.96	999.8	1131.8	0.2377	1.6032	1.8409	164.0
166.0	5.4623	0.016428	67.67	67.68	133.97	998.6	1132.6	0.2409	1.5961	1.8371	166.0
168.0	5.7223	0.016440	64.78	64.80	135.97	997.4	1133.4	0.2441	1.5892	1.8333	168.0
170.0	5.9926	0.016451	62.04	62.06	137.97	996.2	1134.2	0.2473	1.5822	1.8295	170.0
172.0	6.2736	0.016463	59.43	59.45	139.98	995.0	1135.0	0.2505	1.5753	1.8258	172.0
174.0	6.5656	0.016474	56.95	56.97	141.98	993.8	1135.8	0.2537	1.5684	1.8221	174.0
176.0	6.8690	0.016486	54.59	54.61	143.99	992.6	1136.6	0.2568	1.5616	1.8184	176.0
178.0	7.1840	0.016498	52.35	52.36	145.99	991.4	1137.4	0.2600	1.5548	1.8147	178.0

*The states shown are m

Table 1. Saturated Steam: Temperature Table—*Continued*

Temp Fahr t	Abs Press. Lb per Sq In. p	Specific Volume Sat. Liquid v_f	Specific Volume Evap v_{fg}	Specific Volume Sat. Vapor v_g	Enthalpy Sat. Liquid h_f	Enthalpy Evap h_{fg}	Enthalpy Sat. Vapor h_g	Entropy Sat. Liquid s_f	Entropy Evap s_{fg}	Entropy Sat. Vapor s_g	Temp Fahr t
180.0	7.5110	0.016510	50.21	50.22	148.00	990.2	1138.2	0.2631	1.5480	1.8111	180.0
182.0	7.850	0.016522	48.172	48.189	150.01	989.0	1139.0	0.2662	1.5413	1.8075	182.0
184.0	8.203	0.016534	46.232	46.249	152.01	987.8	1139.8	0.2694	1.5346	1.8040	184.0
186.0	8.568	0.016547	44.383	44.400	154.02	986.5	1140.5	0.2725	1.5279	1.8004	186.0
188.0	8.947	0.016559	42.621	42.638	156.03	985.3	1141.3	0.2756	1.5213	1.7969	188.0
190.0	9.340	0.016572	40.941	40.957	158.04	984.1	1142.1	0.2787	1.5148	1.7934	190.0
192.0	9.747	0.016585	39.337	39.354	160.05	982.8	1142.9	0.2818	1.5082	1.7900	192.0
194.0	10.168	0.016598	37.808	37.824	162.05	981.6	1143.7	0.2848	1.5017	1.7865	194.0
196.0	10.605	0.016611	36.348	36.364	164.06	980.4	1144.4	0.2879	1.4952	1.7831	196.0
198.0	11.058	0.016624	34.954	34.970	166.08	979.1	1145.2	0.2910	1.4888	1.7798	198.0
200.0	11.526	0.016637	33.622	33.639	168.09	977.9	1146.0	0.2940	1.4824	1.7764	200.0
204.0	12.512	0.016664	31.135	31.151	172.11	975.4	1147.5	0.3001	1.4697	1.7698	204.0
208.0	13.568	0.016691	28.862	28.878	176.14	972.8	1149.0	0.3061	1.4571	1.7632	208.0
212.0	14.696	0.016719	26.782	26.799	180.17	970.3	1150.5	0.3121	1.4447	1.7568	212.0
216.0	15.901	0.016747	24.878	24.894	184.20	967.8	1152.0	0.3181	1.4323	1.7505	216.0
220.0	17.186	0.016775	23.131	23.148	188.23	965.2	1153.4	0.3241	1.4201	1.7442	220.0
224.0	18.556	0.016805	21.529	21.545	192.27	962.6	1154.9	0.3300	1.4081	1.7380	224.0
228.0	20.015	0.016834	20.056	20.073	196.31	960.0	1156.3	0.3359	1.3961	1.7320	228.0
232.0	21.567	0.016864	18.701	18.718	200.35	957.4	1157.8	0.3417	1.3842	1.7260	232.0
236.0	23.216	0.016895	17.454	17.471	204.40	954.8	1159.2	0.3476	1.3725	1.7201	236.0
240.0	24.968	0.016926	16.304	16.321	208.45	952.1	1160.6	0.3533	1.3609	1.7142	240.0
244.0	26.826	0.016958	15.243	15.260	212.50	949.5	1162.0	0.3591	1.3494	1.7085	244.0
248.0	28.796	0.016990	14.264	14.281	216.56	946.8	1163.4	0.3649	1.3379	1.7028	248.0
252.0	30.883	0.017022	13.358	13.375	220.62	944.1	1164.7	0.3706	1.3266	1.6972	252.0
256.0	33.091	0.017055	12.520	12.538	224.69	941.4	1166.1	0.3763	1.3154	1.6917	256.0
260.0	35.427	0.017089	11.745	11.762	228.76	938.6	1167.4	0.3819	1.3043	1.6862	260.0
264.0	37.894	0.017123	11.025	11.042	232.83	935.9	1168.7	0.3876	1.2933	1.6808	264.0
268.0	40.500	0.017157	10.358	10.375	236.91	933.1	1170.0	0.3932	1.2823	1.6755	268.0
272.0	43.249	0.017193	9.738	9.755	240.99	930.3	1171.3	0.3987	1.2715	1.6702	272.0
276.0	46.147	0.017228	9.162	9.180	245.08	927.5	1172.5	0.4043	1.2607	1.6650	276.0
280.0	49.200	0.017264	8.627	8.644	249.17	924.6	1173.8	0.4098	1.2501	1.6599	280.0
284.0	52.414	0.01730	8.1280	8.1453	253.3	921.7	1175.0	0.4154	1.2395	1.6548	284.0
288.0	55.795	0.01734	7.6634	7.6807	257.4	918.8	1176.2	0.4208	1.2290	1.6498	288.0
292.0	59.350	0.01738	7.2301	7.2475	261.5	915.9	1177.4	0.4263	1.2186	1.6449	292.0
296.0	63.084	0.01741	6.8259	6.8433	265.6	913.0	1178.6	0.4317	1.2082	1.6400	296.0
300.0	67.005	0.01745	6.4483	6.4658	269.7	910.0	1179.7	0.4372	1.1979	1.6351	300.0
304.0	71.119	0.01749	6.0955	6.1130	273.8	907.0	1180.9	0.4426	1.1877	1.6303	304.0
308.0	75.433	0.01753	5.7655	5.7830	278.0	904.0	1182.0	0.4479	1.1776	1.6256	308.0
312.0	79.953	0.01757	5.4566	5.4742	282.1	901.0	1183.1	0.4533	1.1676	1.6209	312.0
316.0	84.688	0.01761	5.1673	5.1849	286.3	897.9	1184.1	0.4586	1.1576	1.6162	316.0
320.0	89.643	0.01766	4.8961	4.9138	290.4	894.8	1185.2	0.4640	1.1477	1.6116	320.0
324.0	94.826	0.01770	4.6418	4.6595	294.6	891.6	1186.2	0.4692	1.1378	1.6071	324.0
328.0	100.245	0.01774	4.4030	4.4208	298.7	888.5	1187.2	0.4745	1.1280	1.6025	328.0
332.0	105.907	0.01779	4.1788	4.1966	302.9	885.3	1188.2	0.4798	1.1183	1.5981	332.0
336.0	111.820	0.01783	3.9681	3.9859	307.1	882.1	1189.1	0.4850	1.1086	1.5936	336.0
340.0	117.992	0.01787	3.7699	3.7878	311.3	878.8	1190.1	0.4902	1.0990	1.5892	340.0
344.0	124.430	0.01792	3.5834	3.6013	315.5	875.5	1191.0	0.4954	1.0894	1.5849	344.0
348.0	131.142	0.01797	3.4078	3.4258	319.7	872.2	1191.1	0.5006	1.0799	1.5806	348.0
352.0	138.138	0.01801	3.2423	3.2603	323.9	868.9	1192.7	0.5058	1.0705	1.5763	352.0
356.0	145.424	0.01806	3.0863	3.1044	328.1	865.5	1193.6	0.5110	1.0611	1.5721	356.0
360.0	153.010	0.01811	2.9392	2.9573	332.3	862.1	1194.4	0.5161	1.0517	1.5678	360.0
364.0	160.903	0.01816	2.8002	2.8184	336.5	858.6	1195.2	0.5212	1.0424	1.5637	364.0
368.0	169.113	0.01821	2.6691	2.6873	340.8	855.1	1195.9	0.5263	1.0332	1.5595	368.0
372.0	177.648	0.01826	2.5451	2.5633	345.0	851.6	1196.7	0.5314	1.0240	1.5554	372.0
376.0	186.517	0.01831	2.4279	2.4462	349.3	848.1	1197.4	0.5365	1.0148	1.5513	376.0
380.0	195.729	0.01836	2.3170	2.3353	353.6	844.5	1198.0	0.5416	1.0057	1.5473	380.0
384.0	205.294	0.01842	2.2120	2.2304	357.9	840.8	1198.7	0.5466	0.9966	1.5432	384.0
388.0	215.220	0.01847	2.1126	2.1311	362.2	837.2	1199.3	0.5516	0.9876	1.5392	388.0
392.0	225.516	0.01853	2.0184	2.0369	366.5	833.4	1199.9	0.5567	0.9786	1.5352	392.0
396.0	236.193	0.01858	1.9291	1.9477	370.8	829.7	1200.4	0.5617	0.9696	1.5313	396.0
400.0	247.259	0.01864	1.8444	1.8630	375.1	825.9	1201.0	0.5667	0.9607	1.5274	400.0
404.0	258.725	0.01870	1.7640	1.7827	379.4	822.0	1201.5	0.5717	0.9518	1.5234	404.0
408.0	270.600	0.01875	1.6877	1.7064	383.8	818.2	1201.9	0.5766	0.9429	1.5195	408.0
412.0	282.894	0.01881	1.6152	1.6340	388.1	814.2	1202.4	0.5816	0.9341	1.5157	412.0
416.0	295.617	0.01887	1.5463	1.5651	392.5	810.2	1202.8	0.5866	0.9253	1.5118	416.0
420.0	308.780	0.01894	1.4808	1.4997	396.9	806.2	1203.1	0.5915	0.9165	1.5080	420.0
424.0	322.391	0.01900	1.4184	1.4374	401.3	802.2	1203.5	0.5964	0.9077	1.5042	424.0
428.0	336.463	0.01906	1.3591	1.3782	405.7	798.0	1203.7	0.6014	0.8990	1.5004	428.0
432.0	351.00	0.01913	1.30266	1.32179	410.1	793.9	1204.0	0.6063	0.8903	1.4966	432.0
436.0	366.03	0.01919	1.24887	1.26806	414.6	789.7	1204.2	0.6112	0.8816	1.4928	436.0
440.0	381.54	0.01926	1.19761	1.21687	419.0	785.4	1204.4	0.6161	0.8729	1.4890	440.0
444.0	397.56	0.01933	1.14874	1.16806	423.5	781.1	1204.6	0.6210	0.8643	1.4853	444.0
448.0	414.09	0.01940	1.10212	1.12152	428.0	776.7	1204.7	0.6259	0.8557	1.4815	448.0
452.0	431.14	0.01947	1.05764	1.07711	432.5	772.3	1204.8	0.6308	0.8471	1.4778	452.0
456.0	448.73	0.01954	1.01518	1.03472	437.0	767.8	1204.8	0.6356	0.8385	1.47[illegible]	456.0

Acid (H_2SO_4) Dewpoint:

As of this time, I only have the formula on the next page for sulfuric acid dewpoint. Note that p_{SO_3} is not actually the concentration of SO_3 at the dewpoint but the initial concentration in the hot flue gas. By the time the dewpoint is reached, the majority of SO_3 would be converted to H_2SO_4 (based on thermo calculations).

The equation gives the dewpoint in degrees C. Also base 10 log is used in this expression and the partial pressures are in atmospheres.

Sample calc: For 9% H_2O and 50 ppm SO_3 initially

$$T(°C) = 203.25 + 27.6 \log_{10}(0.09) + 10.83 \log_{10}(50\times10^{-6}) + 1.06\left[\log_{10}(50\times10^{-6}) + 8\right]^{2.19}$$

$$= 146.4\,°C = 295.5\,°F$$

Design Calculations

Project: Acid Dewpoints	Prepared By: Daniel Price	Date: 9/18/87
Subject/Title: Acid Dewpoint Temperatures	Reviewed By	Date
	Calculation Number	Sheet of

Table III

SO_3 ppm	Predicted Dewpoint Temp °F ASPEN	FORMULA*
61.9	301.5	298.9
48.2	295.5	294.8
34.5	292	289.3
20.8	283.5	281.1
5.65	264.5	261.3
5.12	262	—
2.77	256	251.3
.001	—	171

* This formula is a curve-fit of Müllers data using a technique presented by R.S. Totman (Hydrocarbon Processing July 1987 pg. 55)

base 10

$$t\,(^\circ C) = 203.25 + 27.6 \log pH_2O + 10.83 \log pSO_3 + 1.06 (\log pSO_3 + 8)^{2.19}$$

pH_2O, pSO_3 are partial pressures in atmosphere

Assume $pSO_3 = pH_2SO_4$

7.2 MAJOR EQUIPMENT

7.2.1 Rotary Air Heaters

The design features that must be maintained to achieve a good simulation for a rotary air heater are listed below:

a. Identical mass flow rate of flue gas per unit frontal area of air heater surface
b. Identical heating element basket design, spacing, and materials
c. Identical element depth, or the length of air heater in the direction of flow.

A specially modified size 9 Ljungstrum-type vertical shaft air heater manufactured by ABB Air Preheater Inc., formally C-E Preheater Company, will be used for the two rotary APHs. The size 9 APH is similar in basic design to the large Ljungstrum APH that exits in many coal-fired power plants. With a wheel diameter of 5 ft, the mass flow rate of flue gas per rotor frontal area is in the same range as that of typical large electric utility boilers. The element depth of the size 9 heater is 72 in., which compares favorably with the 90- to 96-in. basket depth found in larger Ljungstrum APH. The size 9 heater will also accept the same types of baskets that are used in large APH. Therefore, aspects of deposition and cleaning related to basket geometry and materials can be readily duplicated.

One aspect of simulation that is not considered adequate in the standard size 9 APH is the fluid mechanics of gas flow entering the APH. Because of the large ratio of shaft diameter to wheel diameter for the size 9 APH, versus a large APH, the entrance flange openings on the size 9 unit are somewhat more constricted. This could have a significant effect on gas-side inlet flow distributions and deposition patterns. In order to mitigate this potential problem, the entrance flanges will be widened and extended, providing a larger opening and a more direct path for the air and flue gas entering and exiting the APH. This modification is shown in Figure 7.2-1. The requirement for

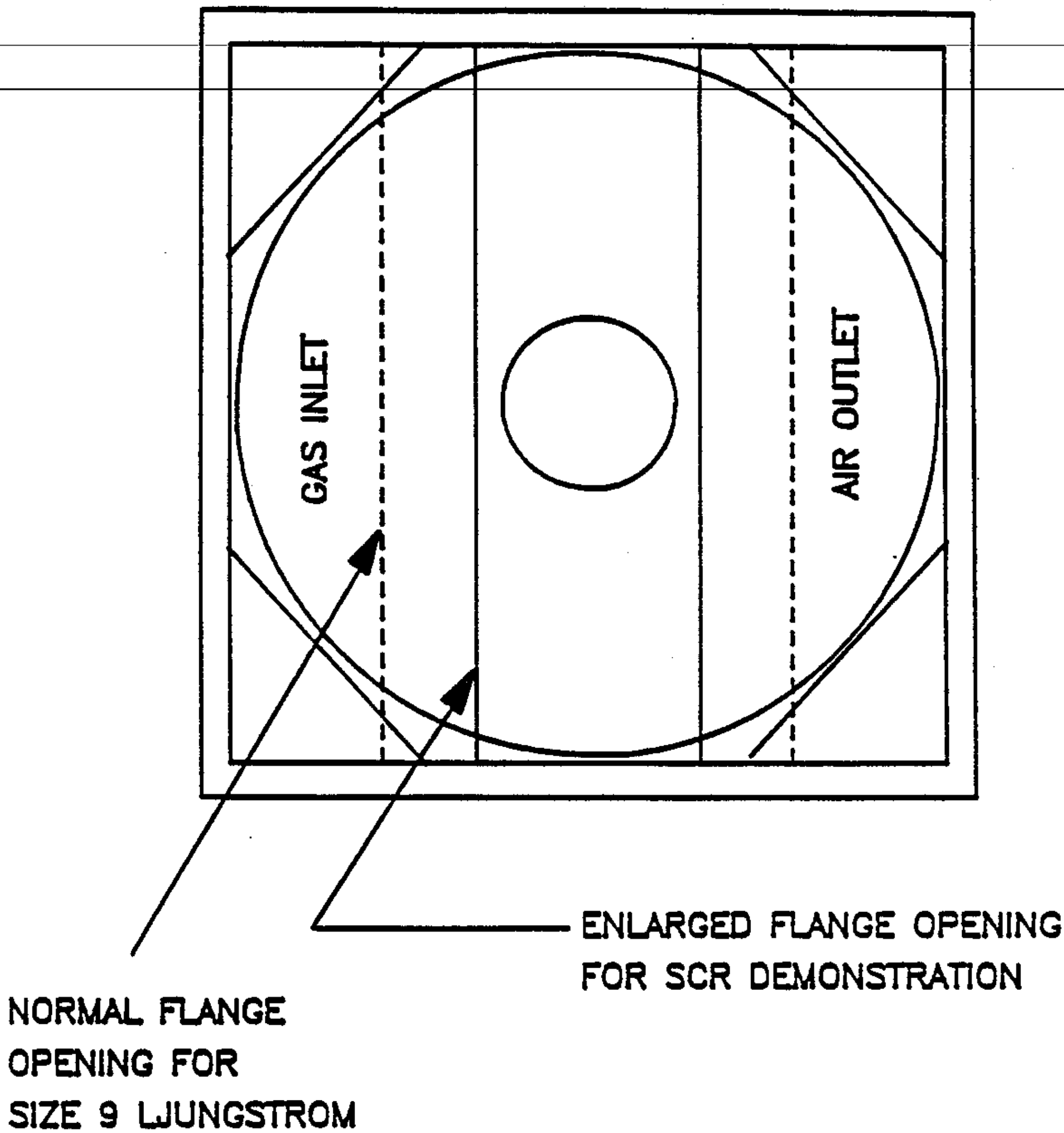


Figure 7.2-1. Air and flue gas entering and exiting the air preheaters.

matching element metal temperatures in the size 9 APH with those in large APHs requires a change in the typical operation of the APH. Normally, small rotary air heaters rotate at a faster rate than larger air heaters due to mechanical considerations. This means that the elements of smaller APH experience a smaller temperature swing as the baskets rotate. The size 9 APH will be equipped with a variable speed drive to allow temperature swings to match typical large APH, which is ± 30° F. The variable speed feature will also allow the rotor speed to be increased as necessary to simulate sootblowing.

APH leakage of air into the gas stream is a function of the area of the seal opening and the static pressure differential across the seals. Small APH have more sealing length per unit volume than large rotary APH. The estimate air in-leakage for the size 9 rotary APH will be nominally 20 percent. Most of the air leakage is across the cold-end radial seal, and therefore would not affect NH_4HSO_4. However, hot-end leakage is significant, and this leakage could affect the NH_4HSO_4 deposition as a result of either concentration or temperature affects. In order to provide flexibility in setting the quantity of air in-leakage, the air handling systems for each APH will be designed for air-side static pressure to be varied to within approximately 1 in. H_2O of the gas-side static pressure by utilizing an induced draft fan.

Design and performance details for the two rotary APH are shown in Table 7.2-1. The major APH issues with the SCR pilot-plant are deposition, corrosion, and cleanability which impact the segmentation, design, and materials of the APH rotor baskets. Each of the two rotary APH will have a different rotor selection, as shown in Table 7.2-2.

The first selection is used extensively in Europe and has two layers of elements rather than the conventional three. The hot-end layer is of conventional undulating design (DU), fabricated from low alloy steel (Figure 7.2-2). This type of element has superior heat transfer characteristics, but is more prone to deposition because of tighter passages and increased turbulence, and is difficult to clean. The second layer in the first

Table 7.2-1

Ljungstrum Air Heater Performance

Air heater manufacturer	C-E Air Preheater
Air heater size/type	Size 9/VI (vertical, gas flow down)
Number of element sectors	12

	(Trisector) Selection 1	(Bisector) Selection 2
Flows (lb/hr):		
Air Entering	23,850	27,757
Air Leaving	18,250	22,357
Gas Entering	24,934	24,934
Gas Leaving	30,534	30,334
Temperatures (°F):		
Air Entering	100	100
Air Leaving	633	579
Gas Entering	700	700
Gas Leaving Uncorr.	334	298
Gas Leaving Corr.	293	264
Pressure Differentials (in. H_2O):		
Air-side Pressure Drop	1.60	1.80
Gas-side Pressure Drop	2.85	2.50
Hot-end Differential	1.00	1.00
Cold-end Differential	5.45	5.30

Table 7.2-2

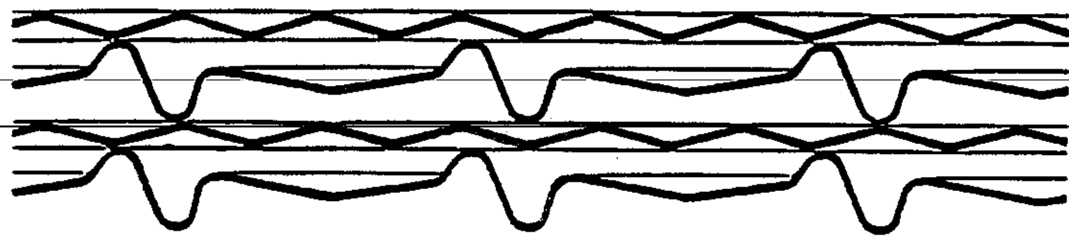
Rotary Air Heater Rotor Designs

Selection 1:

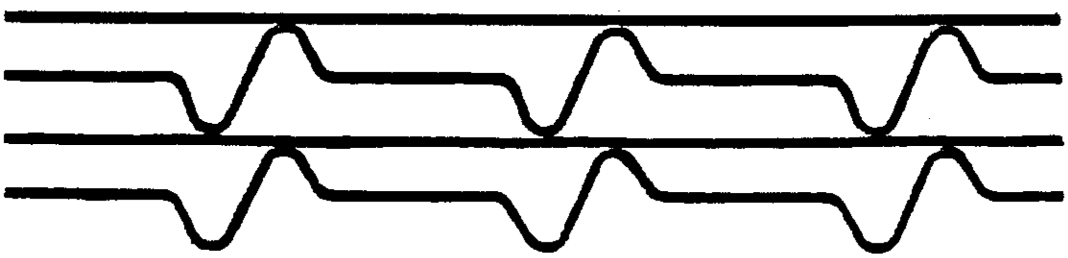
Layer	Depth	Design	Material
Hot End	30"	DU	Low alloy corrosion resistant steel
Cold End	42"	NF-3.5	Low alloy corrosion resistant steel

Selection 2:

Layer	Depth	Design	Material
Hot End	18"	DU	Low alloy corrosion resistant steel
Intermediate	42"	NF-3.5	Low alloy corrosion resistant steel
Cold End	12"	NF-3.5	Low alloy corrosion resistant steel



"DU" Type Element



"NF" Type Element

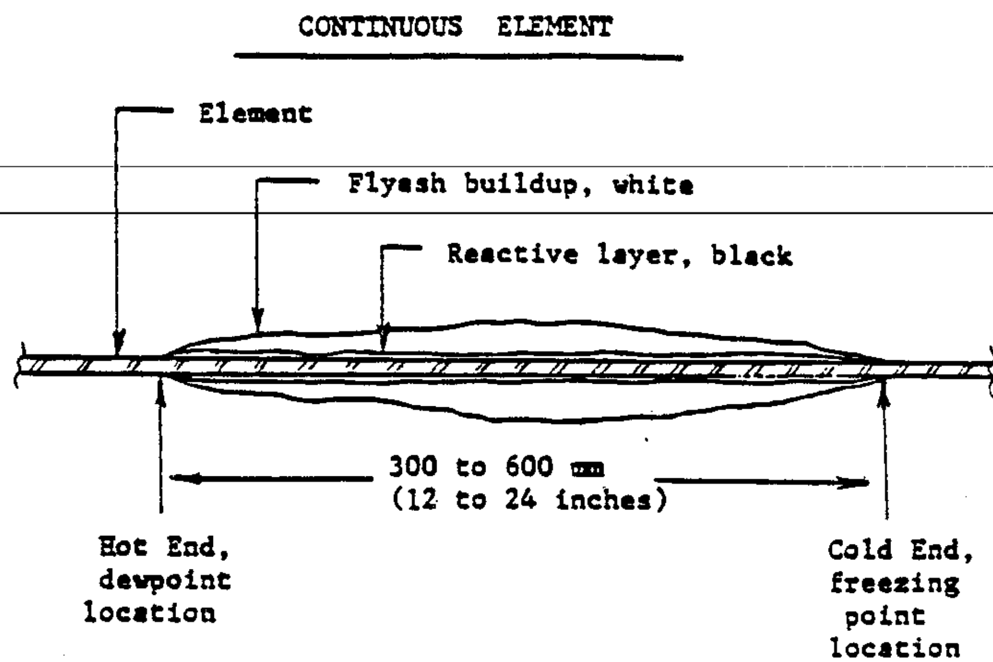
Figure 7.2-2. Element design used in rotary air preheaters.

selection is a notched-flat (NF) design, as shown in Figure 7.2-2, and is fabricated from Corten or enamel coated carbon steel. The NF element has lower turbulence and larger openings and are less apt to form deposits than the DU-type. The NF elements are more easily cleaned by the cold-end sootblower. The cleanability is enhanced by using one deep cold-end layer for the two layers, one intermediate and one cold, typically installed in utility APH. The continuous element ensures that sootblowing steam will penetrate to the deposit and will not lose effectiveness by expanding into a gap between elements. The use of two layers in the region of NH_4SO_4 deposition has been shown to result in deposit buildup at the junction between elements, as shown in Figure 7.2-3.

The second selection, shown in Table 7.2.2, consist of three layers. The hot-end layer is of conventional DU design, and is manufactured from low alloy steel. The intermediate layer of 42 in. NF design can be either fabricated from Corten or enamel coated carbon steel. The cold end layer has a typical depth of 12 in. NF design, and can also be fabricated from Corten or enamel on carbon steel.

Both of the rotary APHs will have access on the air-side of the APH for side removal of the elements. Each APH will incorporate steam sootblowers at the hot-end and the cold-end of the APH, with steam conditions specified at 250-psi and 650° F. Precautions will need to be taken to ensure that the sootblowing steam is dry after expansion through the sootblower nozzle. The stimulus for sootblowing of a full-scale APH is for the small APHs to be rotated at several times the rate of a full-scale unit. This brings about the desired rate of steam flow per unit area, at the frontal surface of the element. Therefore, it will be necessary to increase the rotational rate of the small-scale APH prior to sootblowing and reduce the rate after.

Water washing of the rotary APH will be required more frequently with the SCR pilot-plant than for a typical power plant. Each APH will be equipped with water-wash manifolds at both the hot-end and the cold-end of the heater, for



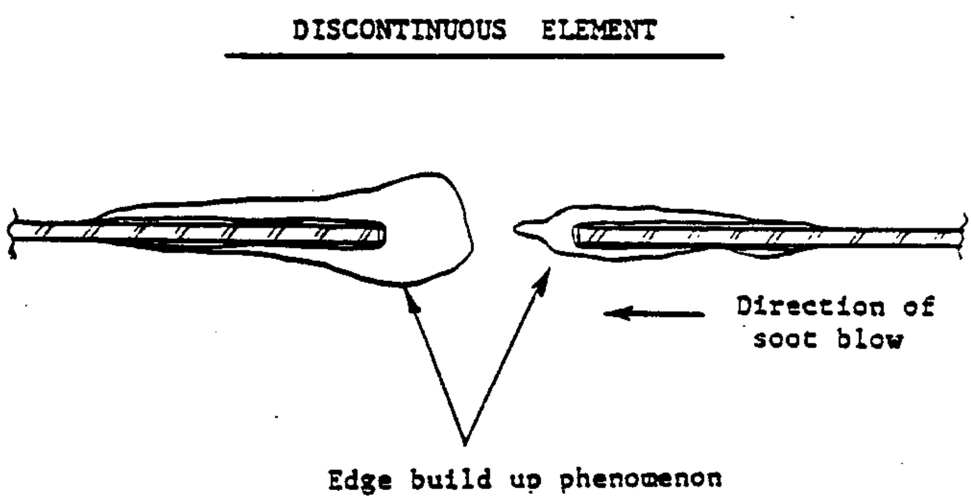


Figure 7.2-3. Japanese experience with deposit accumulation patterns.

removal of soluble deposits such as NH_4HSO_4. Drains will need to be provided in the exit duct work to remove wash water from each of the APHs.

The bid proposals from ABB containing specification details are given in EXHIBIT 7.2-A (Bisector), and EXHIBIT 7.2-B (Trisector). Comments on the transfer of ammonia from the flue gas side to the air side of the APH are given in EXHIBIT 7.2-C.

7.2.2 Heat Pipe Air Preheater

Heat pipe APHs have recently entered the utility market as an alternative to rotary APHs. The heat pipe APHs consist of bundles of individual, sealed heat pipes which conduct heat from flue gas in one passage to air in an adjacent passage, as indicated in Figure 7.2-4. The specifications of the heat pipe APH designed by ABB Air Preheater Inc. (formally C-E Air Preheater Company) are given in Table 7.2-3. The unit consists of 328 individual heat pipes in an in-line arrangement to facilitate cleaning. The heat pipes are arranged on a square pitch of 3.75 in. The heat pipes are finned to ensure effective heat transfer. The heat pipe will be fabricated from Corten. The working fluid in the heat pipe will be naphthalene in the hot-end and toluene in the cold-end.

The preliminary heat pipe APH design is equipped with five sootblower cavities, with a total of ten sootblowers provided. The heat pipe APH is also equipped with cold-end and hot-end manifolds for water washing. Drains will be provided in the exit duct work for drainage of the APH wash water.

Details of the heat pipe specifications are shown in EXHIBIT 7.2-E, and the heat pipe proposal bid package from ABB Air Preheater, Inc. (EXHIBIT 7.2-D) contains information on the fire hazard risk for the working fluids contained in the heat pipe. These show that such a risk is very low, and no fires have been propagated on any of the over 500 heat exchangers ABB has placed into operation.

7.2.3 Hot Air Fan

One hot air fan is used to pull ambient air through the two Ljungstrum air heaters and the single heat pipe air heater. This heated air is reinjected into the main unit secondary air supply after the main unit air heater. Detailed specifications are shown in EXHIBIT 7.2-F.

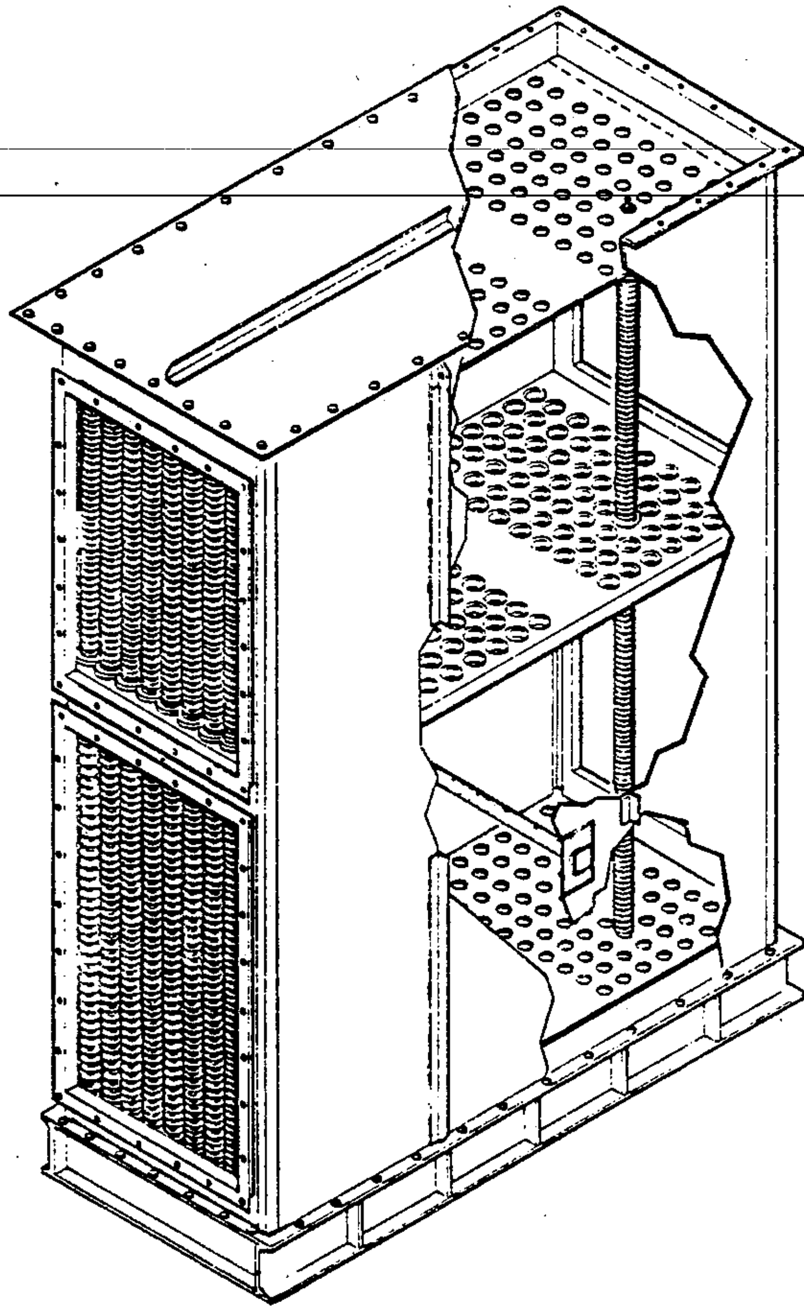


Figure 7.2-4. Typical heat pipe heat exchanger construction.

Table 7.2-3

Specifications/Performance of Heat Pipe Heat Exchanger

Design:

Total Number of Heat Pipes	328
Pipe o.d. (in.)	2.0
Fin Density (fins per inch)	3.0 gas/3.0 air
Fin Type	Solid
Tube Arrangement	In-Line
Transverse Pitch (in.)	3.75
Longitudinal Pitch (in.)	3.75
Total Gas-side Surface Area (sq. ft.)	10,057
Total Air-side Surface Area (sq. ft.)	4,076
Total Unit Approximate Weight (lb.)	54,100 with transitions

Performance:

	Flue Gas	Combustion Air
Flow Rate (lb/hr)	24,934	21,759
Entering Temp. (°F)	700	100
Leaving Temp. (°F)	300	588
Pressure Drop (in. H_2O)	1.60	3.00
Avg. Specific Heat (Btu/lb°F)	0.263	0.247
Heat Recovered (MMBtu/hr)	2.69	
Minimum Metal Temp. (°F)	277	

Table 7.2-4

Listing of Major Equipment in Area 500

Area	Description	Equipment No.
500	Reactor train A air preheater (APH)	APH-501A
500	Reactor train B air preheater(APH)	APH-501B
500	Reactor train C air preheater (APH)	APH-501C
500	Reactor train A APH bypass heat exchanger	HX-501A
500	Reactor train B APH bypass heat exchanger	HX-501B
500	Reactor train C APH bypass heat exchanger	HX-501C
500	Reactor train A APH inlet isolation damper	DMP-501A
500	Reactor train B APH inlet isolation damper	DMP-501B
500	Reactor train C APH inlet isolation damper	DMP-501C
500	Reactor train A APH bypass isolation damper	DMP-502A
500	Reactor train B APH bypass isolation damper	DMP-502B
500	Reactor train C APH bypass isolation damper	DMP-502C
500	Reactor train A APH outlet isolation damper	DMP-503A
500	Reactor train B APH outlet isolation damper	DMP-503B
500	Reactor train C APH outlet isolation damper	DMP-503C
500	Reactor train A air preheater (APH) motor	MTR-501A
500	Reactor train B air preheater (APH) motor	MTR-501B
500	APH hot air fan	F-502
500	APH hot air fan motor	MTR-502
500	Perforated plate/oriface	FE-501
500	Reactor train A APH air inlet damper	DMP-504A
500	Reactor train B APH air inlet damper	DMP-504B
500	Reactor train C APH air inlet damper	DMP-504C
500	Reactor train A bypass outlet damper	DMP-505A
500	Reactor train B bypass outlet damper	DMP-505B
500	Reactor train C bypass outlet damper	DMP-505C

EXHIBIT 7.2-A

BID PROPOSALS FROM ABB AIR PREHEATER INC. CONTAINING SPECIFICATION DETAILS (BISECTOR)

ECH

ABB AIR PREHEATER INC.
WELLSVILLE, NEW YORK

CONFIDENTIAL

LJUNGSTROM® AIR PREHEATER

SOUTHERN COMPANY SERVICES, INC.
BIRMINGHAM, ALABAMA

FOR

DEPARTMENT OF ENERGY
SCR DEMONSTRATION PROJECT
PLANT CRIST #5
GULF POWER COMPANY
PENSACOLA, FLORIDA

PROPOSAL: 8049-F
MARCH 21, 1991

ABB
ASEA BROWN BOVERI

March 21, 1991

Southern Company Services, Inc.
Post Office Box 2625
Birmingham, AL 35202

Attention: Mr. Michael Steppe
Project Purchasing Manager

Gentlemen:

Department of Energy
SCR Demonstration Project
Plant Crist #5
Pensacola, Florida
Your Reference: SCR-701
Our Reference: 8049-F

We are pleased to submit our Proposal 8049-F, dated March 21, 1991 covering one size 9-VIK-72 LJUNGSTROM air preheater for use at the Department of Energy, SCR Demonstration Project, Plant Crist #5, Pensacola, Florida.

We have reviewed the following documents received with this request:

- Letter dated March 5, 1991, 2 pages.
- General Specifications for Small AC Induction Motors, 14 pages.
- General Specification for Small AC Induction Motor, Fractional to 100 HP Variable Speed controllers
- Supplemental Specification for SCS/DOE ICCT Selective Catalytic Reduction (SCR) Project, 10 pages.
- Vendor Document Submittal Schedule, 3 pages.
- Vendor Deviation Request form, 1 page.
- Drawing submittal specification, 1 page.
- Instructions for Supplying Installation/Erection Drawings, 1 page.
- Quality Assurance Specification (SQAR2), 8 pages.
- Proposal form, 17 pages.
- General Conditions of Contract, 10 pages.

ABB Air Preheater Inc.

Andover Road
Post Office Box 372
Wellsville, New York 14895

Telephone (716) 593-2700

Fax (716) 593-2721

DOE Special Conditions, Attachments A and B - A) 4 pages, B) 7 pages General Arrangement Drawings:

EPS-4029-122	Rev. A
-121	Rev. B
-120	Rev. B
-119	Rev. B
-118	Rev. B
-117	Rev. B
-116	Rev. B
-115	Rev. B

The comments and/or exceptions are listed beginning with page 7 of this proposal.

If you have any questions concerning this proposal or if we any be of further assistance, please contact Mr. Larry Crast.

Very truly yours,

ABB AIR PREHEATER INC.

T. G. Mergler

T. G. Mergler
Manager, Project Management
Heat Recovery Products

TGM:JSW:sg

DJG 3/26/91
ECH 3/26/91

PRICING

Ljungstrom® Air Preheater

Proposal: 8049-F

FIRM PRICE THROUGH FEBRUARY 1, 1992 For one size 9-VIK-72 LJUNGSTROM air preheater, f.o.b., Pensacola, Florida, (freight prepaid and billed back) (net) .... [redacted]

Any contract resulting from this proposal will include a one-day equipment field-inspection prior to initial start-up by our technical service representative who will give release for operation of the equipment in accordance with the Seller's operating and maintenance manual.

OPTIONAL PRICING

Two retract sootblowers for one air preheater, f.o.b., Pensacola, Florida (freight prepaid and billed back) (net)............ [redacted]

CONDITIONS OF SALE

Comments and/or exceptions concerning your General Conditions of the contract, 10 pages, are noted beginning with page 5 of this proposal. We have quoted a firm price through February 2, 1992. If for any reason beyond the control of the Seller shipment cannot be made within the date specified, the price will be subject to the attached Material and Labor Adjustment Clause, Form GS-349-8.

PREDICTED PERFORMANCE

This performance is for one (1) size 9-VIK-72 LJUNGSTROM air preheater per boiler. The pressure drops are based on an elevation of 100 feet.

Fuel: Eastern Bituminous Coal

LOAD	
FLOWS — LBS./HR.	
AIR ENTERING	23850.
AIR LEAVING	18250.
GAS ENTERING	24934.
GAS LEAVING	30534.
TEMPERATURES — DEG. F.	
AIR ENTERING	100.
AIR LEAVING	633.
GAS ENTERING	700.
GAS LEAVING UNCORR.	334.
GAS LEAVING CORR.	293.
PRESSURE DIFF. — IN. WG.	
PRESSURE DROP AIR	1.60
PRESSURE DROP GAS	2.85
HOT END DIFFERENTIAL	1.00
COLD END DIFFERENTIAL	5.45

PERFORMANCE GUARANTEE

We guarantee that, if the LJUNGSTROM air preheater size 9-VIK-72 is installed in accordance with our plans and specifications and provided uniform air and gas flow distributions, when in a clean condition and delivering 18,250 pounds of air per hour at an entering temperature of 100 °F, the air preheater will reduce the temperature of 24,934 pounds of gas per hour from an entering temperature of 700 °F to an average exit temperature of 334 °F ±10°F, based on firing bituminous coal with a specific heat ratio of 0.938, with an average air pressure loss of not more than 1.60 inches WG and an average draft loss not more than 2.85 inches WG (based on a site elevation of 100 ft. above sea level). All other performance data that is listed in this proposal or in any contract that results from this proposal is our estimate of expected performance and is not guaranteed. Our liability under this guarantee shall be limited to, at our option, the necessary repairs, replacements, or modifications to permit such performance or, in lieu thereof, may pay the Purchaser as liquidated damages in full satisfaction of the failure to meet this Performance Guarantee, a negotiated sum not to exceed the contract price.

The test limitation period for this guarantee shall expire upon the earlier of either 120 days from the initial operation but no later than December 15, 1991. If the Performance Tests are not completed before the expiration of the Test Limitation Period, defined above, the equipment shall be deemed to have satisfied the Performance Guarantees, and the Seller shall have no further obligations under this Performance Guarantee. To establish noncompliance, the Purchaser shall, at his expense, conduct a test in accordance with the Air Heater Test Code, ASME PTC 4.3.

The ABB Air Preheater Incorporated-designated representative must certify that the air preheater overall unit condition is acceptable for testing prior to actual testing. This service is available at a per diem rate.

SCOPE OF SUPPLY

Equipment Included - (per air preheater)

- Heat Transfer Surface
- Main rotor drive w/variable speed electric motor including controller
- Bearings with oil bath (hot end bearing includes water jacket for cooling)
- Two stationary water washing devices
- Two retractable cleaning devices (Gas Inlet & Outlet)
- Low alloy steel in rotor & cold end conn. plate
- Primer paint
- One observation port (for cold end)
- One Vapor-proof light (for cold end)
- Insulation anchors
- Four (4) access doors
- Coupling guards
- Air Seal Piping
- Duct connections
- Operation and maintenance instructions (10 sets)
- Installation instructions and drawings (4 sets)

Exclusions

Equipment not included:

- Special tools
- Foundation or anchor bolts
- Insulation or lagging
- Dampers and controls
- Ductwork
- Structural or support steel
- Walkways or ladders
- Sight gauges
- Piping, valves, fittings (unless previously described)
- Electrical connections, starters and controls (unless previously described)
- Erection assistance (unless previously described)

DATA TABLE

General

All of the figures listed on this table are for one (1) air preheater.

Size/Type: 9-VIK-72 DeNox

Approximate weight (lbs): 23,330

Effective heat transfer area (sq ft): 5,703

Maximum gas inlet temperature (°F): 850

Maximum air-to-gas pressure differential (psig): 1.00

Maximum terminal duct pressure (psig): 1.00

Heat Transfer Surface

Hot end element - 30"-#22 USG low alloy steel - side removal baskets
Cold end element - 42"-#22 USG low alloy steel - side removal baskets

Electrical Requirements

The following devices will require a 480 V, 3 ph, 60 Hz power supply:

* 1.5 HP variable speed main rotor drive motor (1-req'd)
* 0.6 HP retractable soot blower motor (2-req'd)
* Variable speed auxiliary rotor drive control panel

Water Requirements

The following devices require fresh water at the quantities, pressures and temperatures listed:

* Water washing pipes (2-req'd): 15 gpm each @ 75 psig
* Hot End Bearing water jacket (1-req'd): 3 gpm @ 150 psig & 105°F

Steam Requirements

Each soot blower requires 43 lbs/min of superheated steam at 200 psig with 275°F of superheat throughout a 10 minute blowing cycle three times per day.

Sealing Air Requirements

The following devices require air for sealing purposes tapped off the air inlet duct at the quantities listed:

* Hot end trunnion air seal (1-req'd): 100#/HR.

COMMENTS AND/OR EXCEPTIONS TO CUSTOMER SPECIFICATIONS

The following are our commercial and technical comments relative to the specifications referred to in our cover letter.

Commercial

General Conditions of the Contract

The following comments concerning the General Conditions of the Contract are considered a part of our proposal.

Page 2, Escalation, Paragraph 10

Our proposal is firm through February 2, 1992; however, if for any reason beyond the control of the Seller shipment cannot be made within the date specified, the price will be subject to the attached Material and Labor Adjustment Clause, Form GS-349-8 dated May 5, 1989. However, we can use the date of the bill of lading, as you suggest. Escalation is unlimited, but has averaged approximately 3.5 percent per year in recent years.

Page 3, Changes, Paragraph 13

We request the following understanding be included in your paragraph 13, Changes:

1. We will not make changes in the equipment unless you and we have executed a written change order for such change.
2. The change order may include a price adjustment for any added cost that is required by the change.
3. If the change impairs our ability to satisfy our obligations to you, including meeting shipment schedules and performance guarantees, the change order will include the appropriate modifications to the agreement.

Page 4, Warranty, Paragraphs 18 and 19

We agree with your paragraph 19, Warranty, but request that the following note be inserted:

We will have no obligation under paragraphs 18 and 19 if:

1. You fail to operate or maintain the equipment in accordance with generally approved industry practice or

2. You fail to operate or maintain the equipment in accordance with our instructions or

3. You fail to give us written notice within ten days of your discovery of a defect or

4. The equipment has been altered or repaired by someone other than us or

5. The defect relates to corrosion, erosion, fouling, and/or plugging of the equipment or to a fire or explosion.

The expressed warranties that are shown in your paragraphs 18 and 19 are the only warranties that we will make; there are no implied warranties of merchantability or fitness for a particular purpose. Boiler/air preheater performance testing will be in accordance with the performance guarantee that is included elsewhere in this proposal and will not be for ABB Air Preheater Inc.'s account.

Pages 4-5, Patents, Paragraph 20

We agree with your paragraph 20 concerning patents except for the last sentence that indicates that we will replace equipment that is furnished by others. We request that this sentence be deleted from the final contract conditions of sale.

Page 5, Liability of the Vendor, Paragraph 21

We agree in principle with your paragraph 21, but request the following changes to make it acceptable to us:

> The Vendor shall indemnify and hold harmless the Purchaser and its representatives, agents, and employees from and against any and all demands, claims, suits, or actions of any character presented or brought on account of any injuries, losses, or damages as a result of claims for personal injury or wrongful death made against Purchaser by persons other than employees of Purchaser or jobsite owner, to the extent that such claims arise from the negligent acts of Vendor.
>
> In the event a claim is presented to the Purchaser for which the Purchaser will seek indemnification under this clause, the Purchaser shall notify the Vendor, in writing, within thirty days of the receipt of such claim by the Purchaser; failure to so notify shall relieve the Vendor of any and all liability under this clause.
>
> The liability of the Vendor to the Purchaser and/or owner, regardless of the number and nature of claims, arising out of the acts or omissions of the Vendor resulting or alleged to have resulted in property damage shall be the lesser of the actual cost of repairing and/or replacing said property damage or the contract price. The Vendor shall not be liable to the Purchaser and/or owner for loss of anticipated profits, loss by reason of plant shutdown, nonoperation or increased expenses of operation of other equipment, or consequential or incidental loss or damage of any nature arising from any cause whatsoever by reasons of the acts or omissions of the Vendor.

Pages 8-9, Deferment, Paragraph 31

We agree with this paragraph except that in reference to "Payments" you indicate that if the equipment is delayed up to twelve months from the scheduled contract delivery date, the storage charges will be added to the actual contract invoice price. We would like to take exception to this procedure and advise that if delivery is delayed by the Purchaser, the Vendor will be paid in full at the time of the contract delivery (when storage begins). The storage charges will subsequently be invoiced separately at the end of the storage period.

Page 9, Limitation of Liability, Paragraph 32

We agree with your Limitation of Liability paragraph as written, but request that the following sentence be added at the end:

> The Vendor's liability to the Purchaser under this agreement or under any cause of action relating to this agreement, whether based on contract, warranty, tort (including negligence), strict liability, indemnity, or otherwise, shall not exceed the price of the equipment.

Technical

General Specification For Rotary Type Air Preheaters

Pages 2 & 3, Section 2.1:

There are no codes or standards that apply specifically to the LJUNGSTROM air preheaters. Our equipment is designed in accordance with commonly accepted industry practices and sound engineering judgement. In establishing design and fabrication practices we are guided by the requirements of the AISC, ASME, AWS, and NEMA specifications and we use almost exclusively ASTM designated materials, however; we cannot claim that our equipment, methods and procedures comply in all respects with all of the codes listed. With regard to NFPA, we feel the need for fire detection and suppression systems on a test heater are an unnecessary expense. Therefore we have not complied with this code. If there are specific sections of any of the codes listed with which we are to comply, please identify these and we can review them to determine if we are, or can be, in compliance.

Page 3, Section 2.2, Item 2.2.4:

All comments and exceptions to these specifications will be made in this proposal document. The Vendor Deviation Request Form will be used only during the contract phase and only for deviations from previously agreed upon terms.

Page 5, Section 3.4, Item 3.4.7:

We are offering equipment with surface preparation in accordance with our standard procedures. This includes a combination of power tool and hand tool cleaning.

Page 6, Section 4.0, Item 4.1.1:

All welds and welding procedures used to fabricate the LJUNGSTROM air preheater are in accordance with AWS D1.1 and all welders are qualified under AWS D1.1.

Page 6, Section 4.0, Item 4.1.2:

All welding procedures,NDE, heat treating, and other manufacturing processes used in the fabrication of the LJUNGSTROM air preheater will be available for customer review at our facilities. This review is for information and instruction only. The processes are not subject to customer approval. ABB Air Preheater Inc. does not accept the responsibility for the costs of plant visits made by customer/buyer personnel.

Page 6, Section 4.0, Item 4.2:

We are offering equipment fully assembled in our shop (except for soot blowers) minimizing field erection and handling. However, we are not familiar with the specific hoistway and access restraints at your plant. We therefore cannot comment as to our compliance with this criteria.

Page 6, Section 4.0, Item 4.5:

As previously stated, we are offering equipment with surface preparation in accordance with our standard procedures. This includes a combination of power tool and hand tool cleaning.

Page 7, Section 4.0, Item 4.6:

The entire LJUNGSTROM air preheater will be manufactured and assembled in Wellsville, New York.

Page 7, Section 5.0, Item 5.1:

The fully assembled state of the LJUNGSTROM air preheater greatly simplifies the field erection of the equipment. Field Erection Procedure manuals will be provided early in the contract phase of this project.

Page 8, Section 6.0, Items 6.1.1 & 6.1.2:

A pre-manufacturing design review meeting may be held at our facilities for the purpose of review and discussion of the test procedures if the customer desires. As stated previously, ABB Air Preheater Inc. does not accept the responsibility for costs of plant visits made by customer personnel.

Pages 8 & 9, Section 6.2, Items 6.2.1:

Manufacturing schedules may be provided for scheduling inspections at our facilities. As stated previously, ABB Air Preheater Inc. does not accept the responsibility for costs of plant visits made by customer personnel.

Page 10, Section 6.2, Item 6.2.4:

As previously stated, a pre-manufacturing design review meeting may be held at our facilities for the purpose of review and discussion of the test procedures including nondestructive tests if the customer desires. These reviews are for information only and are not for approval of said procedures. Again, ABB Air Preheater Inc. does not accept the responsibility for any costs incurred by such plant visits.

Page 10, Section 6.3, Item 6.3.1.4:

Over the years we have established a list of reputable vendors from whom we purchase the materials and component parts required for the fabrication of the LJUNGSTROM air preheater. All of these vendors are subjected to periodic audits by our QA/QC department. However, we do not permit direct audits of our subcontractors by customer personnel.

Page 11, Section 6.4, Item 6.4.7:

Performance testing of the LJUNGSTROM air preheater is to be conducted in accordance with ASME PTC 4.3. An outline of the guidelines for this air preheater testing is included with this proposal.

Page 12, Section 7.0, Item 7.1.1:

Two controlled copies of our Quality Control Manuals will be provided to cover all three proposals (two LJUNGSTROMS and one Q-Pipe).

Pages 12 thru 15, Section 8.0:

We will submit all prints, manuals, and documents required for the erection, operation, and maintenance of the LJUNGSTROM air preheater. This will be done in accordance with a mutually agreed upon schedule during the contract phase of the project. Our Technical Services Department will furnish the following to fulfill these requirements.

1. Installation and erection instructions.

    A. Four (4) Field Erection Procedures (FEP) Manuals.

    B. Four (4) sets of air preheater master packing lists.

    C. Four (4) sets of erection drawings folded with title block showing, not included in FEP Manual covers, in approximately three (3) sizes: 14" x 10", 9" x 12", and 8-1/2" x 11".

2. Operation and maintenance instructions.

    A. Ten (10) Operation and Maintenance Manuals.

    B. Preliminary manuals may be sent early for information purposes only, not approval. These may be "typical" manuals.

    C. In general, vendor information will be included as received from our vendors.

    D. We will include sketches of various serviceable components; however, full size equipment drawings folded for manual insertion are not included.

3. If the above does not satisfy your requirements, additional manuals and/or prints, reproducibles, or aperture cards of drawings can be supplied at additional cost.

As stated above, all other documentation that is not proprietary in nature will be available for review at our facilities in Wellsville, N.Y. Visits made by customer/buyer personnel are made at their own expense. Of the documents and drawings mentioned above, only the General Arrangement drawing is subject to approval. All other materials are for information and review only.

<u>Page 13, Section 8.2, Item 8.2.1.3:</u>

We will supply WPS's and PQR's if required, however, we do not furnish weld maps.

Page 14, Section 8.2, Item 8.2.2:

As previously stated, all comments and exceptions to these specifications will be made in this proposal document. The Vendor Deviation Request Form will be used only during the contract phase and only for deviations from previously agreed upon terms.

Page 15, Section 9.0, Item 9.2.2:

If initial performance test data is deemed to be of unacceptable accuracy by both Purchaser and ABB Air Preheater Inc., we reserve the right to disqualify the independent testing agency for future testing. Another mutually acceptable testing agency, or ABB API if acceptable to the Purchaser, will be selected to conduct any additional testing deemed necessary.

Page 16, Section 10.0:

All ship loose parts of the LJUNGSTROM air preheater will be adequately labeled or tagged for easy installation in the field. The only ship loose items are the soot blowers.

Pages 16 & 17, Section 11.0:

The air preheater and associated components will be prepared and packaged in a manner that will insure protection against adverse elements during shipment and reasonable storage. This primarily involves the application of plastic covered plywood covers to the duct openings. The red oxide primer provides sufficient protection to the external casing.

If there is to be an extended period of time before the LJUNGSTROM air preheater is placed in service or erected, it is preferred that the unit be stored indoors if space is available. Outdoor storage can be achieved with proper protection.

The LJUNGSTROM air preheater should be uniformly supported on blocks or beams at all support points. The air preheater should be positioned above the affects of surface moisture. Periodic inspection of all painted surfaces should be done to limit rusting. Defects in painted surfaces should be cleaned and repainted as required.

It is acceptable for the element surfaces of the air preheater to show a slight coating of surface rust. However, if the air heater is to be stored for an extended period, the element should be sprayed with an appropriate protective, rust inhibiting oil of the type shown in the list below. Protective covers are placed over the hot end duct openings and shipped with the air preheater, however, additional covering, such as the use of tarps, may be desirable to protect the unit. Periodic checks should be made of the covering for deterioration, and of the element for evidence of rusting. If rusting is observed, the areas should be resprayed with a protective oil.

ANTI-RUST OILS FOR USE ON ELEMENT

If there is to be an extended period of time before the LJUNGSTROM air preheater is placed in service or erected, you might consider spraying the surface with one (1) of the oils listed below to retard rusting.

Kendall - Kencote 60

Gulf No-Rust "C" Polar Type Rust Preventative

BP - Energol -- CPF-C-3

Texas Rust Proof Oil No. 564

Tidewater Oil Company - Tycol Anorustol No. 38

Texaco No. 1052 - Metal Protective Oil

Mobil - Mobilarama 245 - Low Flash Point

A pressure type spray can of one or two gallon capacity is suitable for applying the anti-rust oil.

Supplemental Specification for Rotary Type Air Preheater

Page 8, Section 9.0, Item 9.1.2

The LJUNGSTROM air preheater selection is based on an air leaving flow of 18,250 for 2 layer lbs./hr. The air leaving flow is the actual air flow passing through the air preheater and that required for proper boiler operation.

Page 8, Section 9.0, Item 9.2

In response to the request for a performance guarantee, we are offering thermal performance, air side and gas side pressure drop guarantees as shown in the section of our proposal entitled "Performance Guarantee". Air and gas flow guarantees are not included since the system air and gas flows are dependent upon boiler and not air preheater operation.

Our thermal performance guarantee is based on the gas out temperature which is the utility standard for thermal performance determination as established by the boiler test code ASME PTC 4.1, supplemented by PTC 4.3 for Air Heaters.

General Specification for Small AC Induction Motors

SCS Small Motor Specification Data Sheet:

The motor data sheets will be completed and submitted during the contract phase of this project after our motor vendor finalizes the selection.

DJH 3/26/91
ECH 3/26/91

INQUIRY NO. SCR - 701

PROPOSAL

FROM

VENDOR'S NAME: ABB Air Preheater Inc.

VENDOR'S ADDRESS: Andover Road
Wellsville, NY 14895

FOR

ROTARY TYPE AIR PREHEATERS

FOR

SCS/DOE ICCT SELECTIVE CATALYTIC REDUCTION PROJECT

LOCATED AT

PLANT CRIST UNIT 5

OF

GULF POWER COMPANY

1.0 SCOPE

In accordance with your Inquiry No. SCR-701 for Southern Company Services and having invited proposals for furnishing rotary type air preheaters subject to all the conditions and requirements of the commercial terms and conditions and of the specifications and supplementary documents, we propose to furnish and to deliver the equipment specified for the prices quoted as follows:

2.0 PRICING

2.1 Proposal I - Air Preheater No. 1: 8049-F

For the equipment and material as specified, f.o.b. (as per Supplemental Specification):

Air Preheater with Rotor Design 1	$ [redacted]
Transition Ducts - Purchaser's Option	$ [redacted]
Sootblowers - Purchaser's Option	$ [redacted]
Total, Air Preheater No. 1	$ [redacted]

2.2 Proposal II – Air Preheater No. 2: 8049-E

DJH 3/26/91
ECH 3/26/91

For the equipment and material as specified,
f.o.b. (as per Supplemental Specification):

Air Preheater with Rotor Design 2	$[redacted]
Transition Ducts – Purchaser's Option	$[redacted]
Sootblowers – Purchaser's Option	$[redacted]
Total, Air Preheater No. 2	$[redacted]

2.3 Proposal III – Replacement Baskets for Air Preheater No.1:

For the equipment and material as specified,
f.o.b. (as per Supplemental Specification):

Replacement Baskets for Air Preheater with Rotor Design 1:

Layer	Material	Price per Basket
Hot End – Purchaser's Option	Open hearth	$[redacted]
	Cor-Ten	$[redacted]
Cold End – Purchaser's Option	Cor-Ten	$[redacted]
	Glass enamel on steel	$[redacted]
	409 SS	$[redacted]
	Mixture of Cor-Ten, 409 SS and glass enamel on steel	[redacted]

2.4 Proposal IV – Replacement Baskets for Air Preheater No. 2:

For the equipment and material as specified,
f.o.b. (as per Supplemental Specification):

Replacement Baskets for Air Preheater with Rotor Design 2:

Layer	Material	Price per basket
Hot End – Purchaser's Option	Open hearth	[redacted]
	Cor-Ten	[redacted]

OJG 3/26/91
ECH 3/26/91

Intermediate – Purchaser's Option	Cor-Ten	[redacted]
	Glass enamel on steel	[redacted]
	409 SS	[redacted]
Cold End – Purchaser's Option	Cor-Ten	[redacted]
	Glass enamel on steel	$[redacted]
	409 SS	$[redacted]
	Mixture of Cor-Ten, 409 SS and glass enamel on steel	$[redacted]

2.5 Proposal V – Other Optional Equipment or Materials:

For other optional equipment or materials, f.o.b. (as per Supplemental Specification):

__________ $__________

__________ $__________

__________ $__________

2.6 Estimated manhours required for installation per air preheater: __________

2.7 If required, we will furnish a service engineer for receipt of equipment and materials, inspection, erection supervision, etc., under the following terms and conditions:

Our proposal price includes a fiel[d] inspection prior to initial startu[p] by our Technical Service Represen-tative. Should additional service [be] required, refer to the attached WT[...] form for rate and charges.

2.8 Proposal validity

This proposal is valid for acceptance by the Purchaser until the following date: June 21, 1991

2.9 Cancellation

2.9.1 The latest date for cancelling this contract without incurring charges other than engineering is: 8-1-91 based on 5-1-91 purchase ord[e]

DJG 3/26/91

2.9.2 Charges with respect to cancellation prior to the date given in 2.9.1 above will be as follows: [redacted]

ECA 3/26/91

2.10 Deferment

In the event of deferment up to twelve months as covered in the commercial terms and conditions the price adjustment will be: Will not exceed 10% of purchase price

3.0 ESCALATION

3.1 Material prices quoted are:

Firm or Subject to Escalation: Firm thru 2-2-92

3.2 For escalated prices, the following shall apply:

a) Indices to be used

b) Starting date of escalation

c) Ending date of escalation

d) Limits of escalation

e) Method of calculating escalation

We have quoted a firm price through February 2, 1992. If for any reason beyond the control of the Seller shipment cannot be made withi[n] the date specified, the price will b[e] subject to the attached Material and Labor Adjustment Clause, Form GS-349 copy attached.

4.0 QUALITY ASSURANCE

In addition to the Quality Assurance Documentation required by the specifications, we will furnish the following additional information which is generated as a result of our Quality Assurance Program:

5.0 SCHEDULE

5.1 We will start engineering upon receipt of a verbal award and written confirmation (yes or no): **Yes**

5.2 Outline drawings of the equipment will be furnished within the following number of days after award: **28**

5.3 We will complete all necessary engineering within the following number of days after award: **90**

5.4 We will start manufacturing within the following number of of days after award: **180**

5.5 We will start shipment of the items covered by this inquiry, within the following number of days after award: **220**

5.6 We will complete shipment of all items covered by this inquiry within the following number of days after award: **250**

Above dates are based on 5-1-91 purchase order.

6.0 DESCRIPTIVE DATA AND ENGINEERING INFORMATION

The following descriptive information and design data are furnished in connection with the equipment and material offered in this proposal:

6.1 Air Preheater No. 1 (Rotor Design 1):

6.1.1 Heat transfer surface – square feet:

Layer	Fill Type	Square Feet
Hot End	DU	1878
Cold End	NF 3.5	3825

6.1.2 Casing and transition ducts:

Design temperature for casing and ducts – degrees F: **850**

Design pressure for casing and ducts – inches WG: **27.7**

6.1.3 Rotor drive unit:

Maximum rotor speed – rpm: **.63**

Minimum rotor speed – rpm: **.30**

Variable speed motor:

Manufacturer: **Reliance**

Type	Poly phase squirrel cage induction
Horsepower	1.5
Voltage	460
Accessories supplied	Motor
	Variable speed controller
Speed reducer:	
Manufacturer	Falk
Type	Helical bevel gear
Coupling:	
Manufacturer	Falk
Type	Grid type
6.1.4 Soot blowers	
Number supplied	Two
Type	Retractable
Manufacturer	Copes-Vulcan
Capacity – lbs/hr steam	2580
Design steam conditions – lb/hr, psig, degrees F	2580 @ 200 psig, 300°F. superheat
Steam required for one blow – lb/hr	430 lb.
Amount of steam per unit area of rotor surface – lb/hr per square foot	25.56 lb./ft.^{2}
Power requirements	480 volt/3 ph./60 Hz.
Accessories supplied	Soot blower
	Popet Valve
	Motor starter w/manual start-stop
	Air seal wall box

6.1.5 Water wash system

Number of systems supplied	Two
Number of nozzels	6 nozzles/pipe
Type	Converging
Manufacturer	Steinen
Capacity – lbs/hr water	7502.4
Water pressure requirement – psig	75

6.1.6 Weights

Total weight – pounds	23,328
Weight of support bearing assembly – pounds	300
Weight of guide bearing assembly – pounds	300
Weight of rotor drive unit – pounds	1600
Weight of heaviest hot end basket – pounds	293
Weight of heaviest cold end basket – pounds	531
Weight of heaviest piece – pounds	23,328
Weight of empty rotor – pounds	3,000
Weight of soot blowers – pounds	1,000 ea.

6.1.7 Materials

	ASME Type
Hot end basket material	ASTM A-588
Cold end basket material	ASTM A-588
Casing material	ASTM A-36
Support structure and alignment bracing material	ASTM A-588
Other material:	

6.1.8 Power requirements – hp

Drive motor	1.5
Sootblowers	0.6
Other	

6.1.9 Water requirements – gpm

Bearings	3
Water wash system	30
~~Other~~	

6.1.1 0 Operating Conditions

Recommended maximum operating temperature – degrees F	850
Maximum recommended operating hours exceeding above temperature – hrs	0
Never to exceed temperature limit – degrees F	850

6.1.1 1 Predicted performance

Flue gas flow – lbs/hr	24,934
Air flow rate – lbs/hr	18,250
Flue gas inlet temperature – degrees F	700
Flue gas outlet temperature – degrees F	334 unc./293 corr.
Air inlet temperature – degrees F	100
Air outlet temperature – degrees F	579
Draft loss gas side – inches wg	2.50
Draft loss air side – inches wg	1.80
Face velocity, gas side – ft/sec	30.1
Face velocity, air side – ft/sec	10.3
Thermal duty – Btu/hr	2,378,751

6.1.1 2 Guaranteed performance

Flue gas outlet temperature – degrees F	334
Air outlet temperature – degrees F	Not guaranteed

Draft loss gas side – inches wg: 2.85

Draft loss air side – inches wg: 1.60

6.2 Air Preheater No. 2 (Rotor Design 2):

6.2.1 Heat transfer surface – square feet:

Layer	Fill Type	Square Feet
Hot End	DU	1127
Intermediate	NF 3.5	3825
Cold End	NF 3.5	987

6.2.2 Casing and transition ducts:

Design temperature for casing and ducts – degrees F: 850

Design pressure for casing and ducts – inches WG: 27.7

6.2.3 Rotor drive unit:

Maximum rotor speed – rpm: .63

Minimum rotor speed – rpm: .30

Variable speed motor:

Manufacturer: Reliance

Type: Poly phase squirrel cage induction

Horsepower: 1.5

Voltage: 460

Accessories supplied: Variable speed controller

Speed reducer:

Manufacturer: Falk

Type: Helical bevel gear

Coupling:

Manufacturer: Falk

Type	Grid type

6.2.4 Soot blowers

Number supplied	Two
Type	Retractable
Manufacturer	Copes-Vulcan
Capacity – lbs/hr steam	2580
Design steam conditions – lb/hr, psig, degrees F	2580 @ 200 psig, 300°F. superheat
Steam required for one blow – lb/hr	430 lbs.
Amount of steam per unit area of rotor surface – lb/hr per square foot	25.56 lb./ft.^{2}
Power requirements	480 volt/3 ph./60 Hz.
Accessories supplied	Soot blower
	Popet Valve
	Motor starter w/manual
	push button start-stop
	air seal wall box

6.2.5 Water wash system

Number of systems supplied	Two
Number of nozzels	6 nozzles/pipe
Type	Converging
Manufacturer	Steinen
Capacity – lbs/hr water	7502.4
Water pressure requirement – psig	75

6.2.6 Weights

Total weight – pounds	24,651
Weight of support bearing assembly – pounds	300
Weight of guide bearing assembly – pounds	300

Weight of rotor drive unit – pounds	1600
Weight of heaviest hot end basket – pounds	183
Weight of heaviest intermediate basket – pounds	531
Weight of heaviest cold end basket – pounds	220
Weight of heaviest piece – pounds	24,651
Weight of empty rotor – pounds	3,300
Weight of soot blowers – pounds	1,000 ea.

6.2.7 Materials

	ASME Type
Hot end basket material	ASTM A-588
Intermediate basket material	ASTM A-588
Cold end basket material	ASTM A-588
Casing material	ASTM A-36
Support structure and alignment bracing material	ASTM A-588
Other material:	

6.2.8 Power requirements – hp

Drive motor	1.5
Sootblowers	0.6
Other	

6.2.9 Water requirements – gpm

Bearings	3
Water wash system	30
Other	

6.2.1 0 Operating Conditions

Recommended maximum operating temperature – degrees F	850

Maximum recommended operating hours exceeding above temperature – hrs	0
Never to exceed temperature limit – degrees F	850

6.2.1 1 Predicted performance

Flue gas flow – lbs/hr	24,934
Air flow rate – lbs/hr	22,357
Flue gas inlet temperature – degrees F	700
Flue gas outlet temperature – degrees F	298 unc./264 corr.
Air inlet temperature – degrees F	100
Air outlet temperature – degrees F	579
Draft loss gas side – inches wg	2.50
Draft loss air side – inches wg	1.80
Face velocity, gas side – ft/sec	30.1
Face velocity, air side – ft/sec	17.6
Thermal duty – Btu/hr	2,607,384

6.2.1 2 Guaranteed performance

Flue gas outlet temperature – degrees F	298
Air outlet temperature – degrees F	Not guaranteed
Draft loss gas side – inches wg	2.50
Draft loss air side – inches wg	1.80

6.3 Codes and Standards

The following codes and standard apply to the equipment and materials supplied:

American Society of Mechanical Engineers (ASME)	Revision or Addendum
Boiler and Pressure Vessel Code, Section I, Power Boilers	N.A.
Boiler and Pressure Vessel Code, Section II, Material Specifications	N.A.
Boiler and Pressure Vessel Code, Section V, Nondestructive Examination	N.A.
Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications	12-31-90

B31.1 Power Piping	N.A.
PTC 4.1 – Steam Generating Units	N.A.
PTC 4.1a – ASME Test Form for Abbreviated Efficiency Test	N.A.
PTC 4.1b – ASME Test Form for Abbreviated Efficiency Test	N.A.
PTC 4.3 – Air Heaters	

American Society for Testing and Materials (ASTM)

Annual Book of ASTM Standards	1990

American Institute of Steel Construction (AISC)

Manual of Steel Construction	9th Edition

American Welding Society (AWS)

AWS Structural Welding Code	D1.1-90

American National Standards Institute (ANSI)

American National Standard Minimum Design Loads for Buildings and Other Structures	A-58.1-1982

American Gear Manufacturer's Association (AGMA)

	N.A.

National Fire Protection Association (NFPA)

	N.A.

National Electrical Manufacturer's Association (NEMA)

NEMA MG-1	1983

National Electrical Safety Code (NESC)

	N.A.

National Electrical Code (NEC)

National Electric Code Manual	1990

Steel Structures Painting Council (SSPC)

SP2	Latest Rev.

Code of Federal Regulations (CFR)

OSHA 29CFR — 1990

Other Codes and Standards:

6.4 Name and location of fabricators: ABB Air Preheater Inc.
Wellsville, NY

6.5 Shipment will be made by rail or motor freight: Motor freight

6.6 Description of proposed support system and alignment bracing: The Ljungstrom Air Preheater will be supported at four points located on the sides near the bottom of the air preheater. One foot is completely fixed to the support steel. The remaining 3 support feet have slidin pads which are guided to allow for thermal growth.

6.7 Predicted performance curves for variation in air flow, including location of ammonium bisulfate condensation zone, are included in the proposal on Page: During contract phase

6.8 Description of specific procedures and requirements for performance testing including number and length of tests, instrumentation, and data required is included on Page: See attachments to proposal "Outline of Guidelines for Air Preheater Testing ASME Code Testing".

6.9 Description of method of correction of performance test results for comparison to design. Vendor shall provide a sample calculation to show each step of correcting each tested value to the specific design points for comparison with guarantees. Included in proposal on Page: Section 7 ASME PTC 4.3

6.10 Description of preparation of shipment, cleaning, and jobsite storage requirements: Cite comment on pages 14 and 15 of the proposal.

6.11 Description of mandatory requirements and recommendations for field cleaning: Mandatory requirements - none Recommendations - minimum of one time per eight hour shift or as required.

6.12 Any requirements, restrictions, and recommendations concerning the location and use of Vendor supplied sootblowers or any additional sootblowing equipment required: The sootblowing equipment provided in this proposal is complete. No additional equipment is required. The location of the soot blowers is specified in the contract drawin[g]

6.13 List of special tools, devices, and wrenches furnished: There are no special tools or devices required.

6.14 Recommendations for installation of equipment and materials found on Page: Provided in Field Erection Procedures during the contract phase.

7.0 EXCEPTIONS

7.1 We have reviewed your specifications and all related attachments. Unless specific exceptions are listed below (or included in our proposal and referenced below), it is undersood that all of the provisions contained therein are acceptable to us.

Without exceptions: ______

With exceptions as follows: See pages 7 thru 16 of the proposal for comments and exceptions.

7.2 The Vendor Document Submittal Schedule has been reviewed and the required documentation and submittal dates (time frames) are acceptable to us unless listed below:

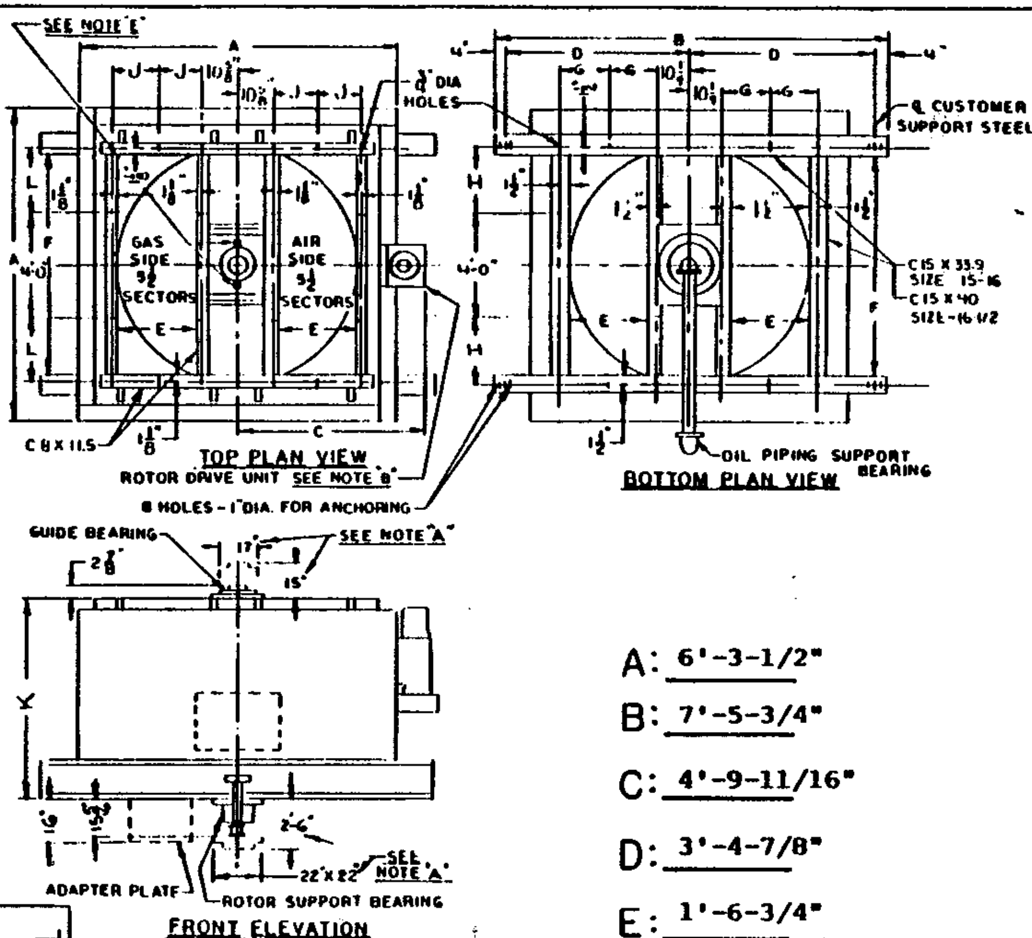
Refer to page 12 of the proposal.

8.0 SIGNATURE

SIGNATURE	T. G. Mergler (signed) T. G. Mergler
TITLE	Manager, Project Management
NAME OF COMPANY	ABB Air Preheater, Inc.
TELEPHONE NUMBER	716-593-2700 Extension 403
FAX NUMBER	716-593-7566
DATE	3-21-91

MDN/mdn
F: AIRPREHT.WK1
2/29/91

ENGINEERING STANDARDS MANUAL-PREHEATERS
THE AIR PREHEATER COMPANY
WELLSVILLE, NEW YORK



CLEANING EQUIPMENT

ADAPTER PLATE TO HOUSE SINGLE NOZZLE CLEANING DEVICE. LOCATE IN GAS OUTLET.

NOTE "A"

SPACES SHOWN FOR ACCESS TO AND REMOVAL OF THE BEARINGS. IMMOVABLE STRUCTURES SUCH AS STEEL WORK, EXPANSION JOINTS, ETC. SHOULD NOT ENCROACH ON THESE SPACES. LIGHT STRUCTURES SUCH AS DUCT WALLS MAY BE CUT IF NECESSARY TO PROVIDE SPACE.

NOTE "B"

1 1/2 HP MASTER "XL" TRIPLE PARALLEL GEARHEAD SPEED REDUCER. 11 RPM OUTPUT; 1140 RPM MOTOR USED ON SIZE 15. 2 HP MASTER "XL" TRIPLE PARALLEL GEARHEAD SPEED REDUCER, 13.5 RPM OUTPUT; 1750 RPM MOTOR USED ON SIZES 15-1/2 - 16-1/2.

NOTE "C"

EXPANSION JOINTS TO BE PROVIDED IN THE GAS INLET, GAS OUTLET, AND AIR OUTLET DUCTS. LOCATE TO PREVENT TRANSMISSION OF EXCESSIVE FORCES TO THE DUCT CONNECTING FLANGES OF THE HEATER. EXPANSION JOINTS NOT PROVIDED BY THE AIR PREHEATER COMPANY.

NOTE "D"

COLD END AND HOT INTERMEDIATE ELEMENTS ARE PACKED IN REVERSIBLE BASKETS FOR SIDE REMOVAL. HOT END ELEMENT IS PACKED IN REVERSIBLE BASKETS FOR DUCT REMOVAL.

NOTE "E"

GUIDE BEARING TO BE WATER COOLED.

A: 6'-3-1/2"

B: 7'-5-3/4"

C: 4'-9-11/16"

D: 3'-4-7/8"

E: 1'-6-3/4"

F: 4'-5-1/2"

G: 1'-9-3/4"

H: 2'-4-1/4"

J: 1'-9"

K: 10'-4-3/4"

L: 2'-3-7/8"

CUSTOMER: Southern Company Services

PROPOSAL: 8049-F

SIZE: 9-VIK-72 DeNox

BEARING SERIES: 55

NOT TO BE USED FOR CONSTRUCTION PURPOSES

TITLE: OUTLINE AND PRINCIPAL DIMENSIONS TYPE V-IK, V-KX CASE II

DATE ISSUED:

DATE ALTERED:

DR:

CK:

DES:

SECTION: 3.2.1.3

SHEET:

ALTERATION:

FORM 259-1

PRINTED IN U.S.A

EXHIBIT 7.2-B

BID PROPOSALS FROM ABB AIR PREHEATER INC. CONTAINING SPECIFICATION DETAILS (TRISECTOR)

FC14

ABB AIR PREHEATER INC.
WELLSVILLE, NEW YORK

CONFIDENTIAL

LJUNGSTROM® AIR PREHEATER

SOUTHERN COMPANY SERVICES, INC.
BIRMINGHAM, ALABAMA

FOR

DEPARTMENT OF ENERGY
SCR DEMONSTRATION PROJECT
PLANT CRIST #5
GULF POWER COMPANY
PENSACOLA, FLORIDA

PROPOSAL: 8049-E
MARCH 21, 1991

ABB
ASEA BROWN BOVERI

March 21, 1991

Southern Company Services, Inc.
Post Office Box 2625
Birmingham, AL 35202

Attention: Mr. Michael Steppe
Project Purchasing Manager

Gentlemen:

Department of Energy
SCR Demonstration Project
Plant Crist #5
Pensacola, Florida
Your Reference: SCR-701
Our Reference: 8049-E

We are pleased to submit our Proposal 8049-E, dated March 21, 1991 covering one size 9-VIK-72 LJUNGSTROM air preheater for use at the Department of Energy, SCR Demonstration Project, Plant Crist #5, Pensacola, Florida.

We have reviewed the following documents received with this request:

- Letter dated March 5, 1991, 2 pages.
- General Specifications for Small AC Induction Motors, 14 pages.
- General Specification for Small AC Induction Motor, Fractional to 100 HP Variable Speed controllers
- Supplemental Specification for SCS/DOE ICCT Selective Catalytic Reduction (SCR) Project, 10 pages.
- Vendor Document Submittal Schedule, 3 pages.
- Vendor Deviation Request form, 1 page.
- Drawing submittal specification, 1 page.
- Instructions for Supplying Installation/Erection Drawings, 1 page.
- Quality Assurance Specification (SQAR2), 8 pages.
- Proposal form, 17 pages.
- General Conditions of Contract, 10 pages.

ABB Air Preheater Inc.

Andover Road
Post Office Box 372
Wellsville, New York 14895

Telephone (716) 593-2700

Fax (716) 593-2721

DOE Special Conditions, Attachments A and B - A) 4 pages, B) 7 pages General Arrangement Drawings:

EPS-4029-122	Rev. A
-121	Rev. B
-120	Rev. B
-119	Rev. B
-118	Rev. B
-117	Rev. B
-116	Rev. B
-115	Rev. B

The comments and/or exceptions are listed beginning with page 7 of this proposal.

If you have any questions concerning this proposal or if we any be of further assistance, please contact Mr. Larry Crast.

Very truly yours,

ABB AIR PREHEATER INC.

T. G. Mergler, sg

T. G. Mergler
Manager, Project Management
Heat Recovery Products

TGM:JSW:sg

PRICING

Ljungstrom® Air Preheater

Proposal: 8049-E

FIRM PRICE THROUGH FEBRUARY 1, 1992 For one size 9-VIK-72 LJUNGSTROM air preheater, f.o.b., Pensacola, Florida, (freight prepaid and billed back) (net) .... [redacted].)

Any contract resulting from this proposal will include a one-day equipment field-inspection prior to initial start-up by our technical service representative who will give release for operation of the equipment in accordance with the Seller's operating and maintenance manual.

OPTIONAL PRICING

Two retract sootblowers for one air preheater, f.o.b., Pensacola, Florida (freight prepaid and billed back) (net)............. [redacted]

CONDITIONS OF SALE

Comments and/or exceptions concerning your General Conditions of the contract, 10 pages, are noted beginning with page 5 of this proposal. We have quoted a firm price through February 2, 1992. If for any reason beyond the control of the Seller shipment cannot be made within the date specified, the price will be subject to the attached Material and Labor Adjustment Clause, Form GS-349-8.

PREDICTED PERFORMANCE

This performance is for one (1) size 9-VIK-72 LJUNGSTROM air preheater per boiler. The pressure drops are based on an elevation of 100 feet.

Fuel: Eastern Bituminous Coal

LOAD		
FLOWS	LBS./HR.	
AIR ENTERING	27757.	↙ VARIED BY ABB
AIR LEAVING	22357.	← } SAME AS SPEC
GAS ENTERING	24934.	← } SAME AS SPEC
GAS LEAVING	30334.	↖ VARIED BY ABB
TEMPERATURES	DEG. F.	
AIR ENTERING	100.	
AIR LEAVING	579.	
GAS ENTERING	700.	
GAS LEAVING UNCORR.	298.	
GAS LEAVING CORR.	264.	
PRESSURE DIFF.	IN. WG.	
PRESSURE DROP AIR	1.80	
PRESSURE DROP GAS	2.50	
HOT END DIFFERENTIAL	1.00	
COLD END DIFFERENTIAL	5.30	

PERFORMANCE GUARANTEE

We guarantee that, if the LJUNGSTROM air preheater size 9-VIK-72 is installed in accordance with our plans and specifications and provided uniform air and gas flow distributions, when in a clean condition and delivering 22,357 pounds of air per hour at an entering temperature of 100 °F, the air preheater will reduce the temperature of 24,934 pounds of gas per hour from an entering temperature of 700 °F to an average exit temperature of 298 °F ±10°F, based on firing bituminous coal with a specific heat ratio of 0.938, with an average air pressure loss of not more than 1.80 inches WG and an average draft loss not more than 2.50 inches WG (based on a site elevation of 100 ft. above sea level). All other performance data that is listed in this proposal or in any contract that results from this proposal is our estimate of expected performance and is not guaranteed. Our liability under this guarantee shall be limited to, at our option, the necessary repairs, replacements, or modifications to permit such performance or, in lieu thereof, may pay the Purchaser as liquidated damages in full satisfaction of the failure to meet this Performance Guarantee, a negotiated sum not to exceed the contract price.

The test limitation period for this guarantee shall expire upon the earlier of either 120 days from initial operation but no later than December 15, 1992. If the Performance Tests are not completed before the expiration of the Test Limitation Period, defined above, the equipment shall be deemed to have satisfied the Performance Guarantees, and the Seller shall have no further obligations under this Performance Guarantee. To establish noncompliance, the Purchaser shall, at his expense, conduct a test in accordance with the Air Heater Test Code, ASME PTC 4.3.

The ABB Air Preheater Incorporated-designated representative must certify that the air preheater overall unit condition is acceptable for testing prior to actual testing. This service is available at a per diem rate.

NEED TO DEFINE COST FOR THIS.

SCOPE OF SUPPLY

Equipment Included - (per air preheater)

- Heat Transfer Surface
- Main rotor drive w/variable speed electric motor including controller
- Bearings with oil bath (hot end bearing includes water jacket for cooling)
- Two stationary water washing devices
- Two retractable cleaning devices (Gas Inlet & Outlet)
- Low alloy steel in rotor & cold end conn. plate
- Primer paint
- One observation port (for cold end)
- One Vapor-proof light (for cold end)
- Insulation anchors
- Four (4) access doors
- Coupling guards
- Air Seal Piping
- Duct connections
- Operation and maintenance instructions (10 sets)
- Installation instructions and drawings (4 sets)

Exclusions

Equipment not included:

- Special tools
- Foundation or anchor bolts
- Insulation or lagging
- Dampers and controls
- Ductwork
- Structural or support steel
- Walkways or ladders
- Sight gauges
- Piping, valves, fittings (unless previously described)
- Electrical connections, starters and controls (unless previously described)
- Erection assistance (unless previously described)

NEED TERMINAL BLOCKS FOR TERMINATION.

DATA TABLE

General

All of the figures listed on this table are for one (1) air preheater.

Size/Type: 9-VIK-72 DeNox

Approximate weight (lbs): 24,651

Effective heat transfer area (sq ft): 5,939

Maximum gas inlet temperature (°F): 850

Maximum air-to-gas pressure differential (psig): 1.00

Maximum terminal duct pressure (psig): 1.00

Heat Transfer Surface

Hot end element - 18"-#22 USG low alloy steel - side removal baskets
Cold int. element - 42"-#22 USG low alloy steel - side removal baskets
Cold end element - 12"-#18 USG low alloy steel - side removal baskets

Electrical Requirements

The following devices will require a 480 V, 3 ph, 60 Hz power supply:

* 1.5 HP variable speed main rotor drive motor (1-req'd)
* 0.6 HP retractable soot blower motor (2-req'd)
* Variable speed auxiliary rotor drive control panel

Water Requirements

The following devices require fresh water at the quantities, pressures and temperatures listed:

* Water washing pipes (2-req'd): 15 gpm each @ 75 psig
* Hot End Bearing water jacket (1-req'd): 3 gpm @ 150 psig & 105°F

Steam Requirements

Each soot blower requires 43 lbs/min of superheated steam at 200 psig with 275°F of superheat throughout a 10 minute blowing cycle three times per day.

Sealing Air Requirements

The following devices require air for sealing purposes tapped off the air inlet duct at the quantities listed:

* Hot end trunnion air seal (1-req'd): 100#/HR.

COMMENTS AND/OR EXCEPTIONS TO CUSTOMER SPECIFICATIONS

The following are our commercial and technical comments relative to the specifications referred to in our cover letter.

Commercial

General Conditions of the Contract

The following comments concerning the General Conditions of the Contract are considered a part of our proposal.

Page 2, Escalation, Paragraph 10

Our proposal is firm through February 2, 1992; however, if for any reason beyond the control of the Seller shipment cannot be made within the date specified, the price will be subject to the attached Material and Labor Adjustment Clause, Form GS-349-8 dated May 5, 1989. However, we can use the date of the bill of lading, as you suggest. Escalation is unlimited, but has averaged approximately 3.5 percent per year in recent years.

Page 3, Changes, Paragraph 13

We request the following understanding be included in your paragraph 13, Changes:

1. We will not make changes in the equipment unless you and we have executed a written change order for such change.

2. The change order may include a price adjustment for any added cost that is required by the change.

3. If the change impairs our ability to satisfy our obligations to you, including meeting shipment schedules and performance guarantees, the change order will include the appropriate modifications to the agreement.

Page 4, Warranty, Paragraphs 18 and 19

We agree with your paragraph 19, Warranty, but request that the following note be inserted:

We will have no obligation under paragraphs 18 and 19 if:

1. You fail to operate or maintain the equipment in accordance with generally approved industry practice or

2. You fail to operate or maintain the equipment in accordance with our instructions or

3. You fail to give us written notice within ten days of your discovery of a defect or (30 DAYS?)

4. The equipment has been altered or repaired by someone other than us or

5. The defect relates to corrosion, erosion, fouling, and/or plugging of the equipment or to a fire or explosion.

The expressed warranties that are shown in your paragraphs 18 and 19 are the only warranties that we will make; there are no implied warranties of merchantability or fitness for a particular purpose. Boiler/air preheater performance testing will be in accordance with the performance guarantee that is included elsewhere in this proposal and will not be for ABB Air Preheater Inc.'s account.

Pages 4-5, Patents, Paragraph 20

We agree with your paragraph 20 concerning patents except for the last sentence that indicates that we will replace equipment that is furnished by others. We request that this sentence be deleted from the final contract conditions of sale.

Page 5, Liability of the Vendor, Paragraph 21

We agree in principle with your paragraph 21, but request the following changes to make it acceptable to us:

> The Vendor shall indemnify and hold harmless the Purchaser and its representatives, agents, and employees from and against any and all demands, claims, suits, or actions of any character presented or brought on account of any injuries, losses, or damages as a result of claims for personal injury or wrongful death made against Purchaser by persons other than employees of Purchaser or jobsite owner, to the extent that such claims arise from the negligent acts of Vendor.
>
> In the event a claim is presented to the Purchaser for which the Purchaser will seek indemnification under this clause, the Purchaser shall notify the Vendor, in writing, within thirty days of the receipt of such claim by the Purchaser; failure to so notify shall relieve the Vendor of any and all liability under this clause.
>
> The liability of the Vendor to the Purchaser and/or owner, regardless of the number and nature of claims, arising out of the acts or omissions of the Vendor resulting or alleged to have resulted in property damage shall be the lesser of the actual cost of repairing and/or replacing said property damage or the contract price. The Vendor shall not be liable to the Purchaser and/or owner for loss of anticipated profits, loss by reason of plant shutdown, nonoperation or increased expenses of operation of other equipment, or consequential or incidental loss or damage of any nature arising from any cause whatsoever by reasons of the acts or omissions of the Vendor.

Pages 8-9, Deferment, Paragraph 31

We agree with this paragraph except that in reference to "Payments" you indicate that if the equipment is delayed up to twelve months from the scheduled contract delivery date, the storage charges will be added to the actual contract invoice price. We would like to take exception to this procedure and advise that if delivery is delayed by the Purchaser, the Vendor will be paid in full at the time of the contract delivery (when storage begins). The storage charges will subsequently be invoiced separately at the end of the storage period.

Page 9, Limitation of Liability, Paragraph 32

We agree with your Limitation of Liability paragraph as written, but request that the following sentence be added at the end:

> The Vendor's liability to the Purchaser under this agreement or under any cause of action relating to this agreement, whether based on contract, warranty, tort (including negligence), strict liability, indemnity, or otherwise, shall not exceed the price of the equipment.

Technical

General Specification For Rotary Type Air Preheaters

Pages 2 & 3, Section 2.1:

There are no codes or standards that apply specifically to the LJUNGSTROM air preheaters. Our equipment is designed in accordance with commonly accepted industry practices and sound engineering judgement. In establishing design and fabrication practices we are guided by the requirements of the AISC, ASME, AWS, and NEMA specifications and we use almost exclusively ASTM designated materials, however; we cannot claim that our equipment, methods and procedures comply in all respects with all of the codes listed. With regard to NFPA, we feel the need for fire detection and suppression systems on a test heater are an unnecessary expense. Therefore we have not complied with this code. If there are specific sections of any of the codes listed with which we are to comply, please identify these and we can review them to determine if we are, or can be, in compliance.

Page 3, Section 2.2, Item 2.2.4:

All comments and exceptions to these specifications will be made in this proposal document. The Vendor Deviation Request Form will be used only during the contract phase and only for deviations from previously agreed upon terms.

Page 5, Section 3.4, Item 3.4.7:

We are offering equipment with surface preparation in accordance with our standard procedures. This includes a combination of power tool and hand tool cleaning.

Page 6, Section 4.0, Item 4.1.1:

All welds and welding procedures used to fabricate the LJUNGSTROM air preheater are in accordance with AWS D1.1 and all welders are qualified under AWS D1.1.

Page 6, Section 4.0, Item 4.1.2:

All welding procedures,NDE, heat treating, and other manufacturing processes used in the fabrication of the LJUNGSTROM air preheater will be available for customer review at our facilities. This review is for information and instruction only. The processes are not subject to customer approval. ABB Air Preheater Inc. does not accept the responsibility for the costs of plant visits made by customer/buyer personnel.

Page 6, Section 4.0, Item 4.2:

We are offering equipment fully assembled in our shop (except for soot blowers) minimizing field erection and handling. However, we are not familiar with the specific hoistway and access restraints at your plant. We therefore cannot comment as to our compliance with this criteria.

Page 6, Section 4.0, Item 4.5:

As previously stated, we are offering equipment with surface preparation in accordance with our standard procedures. This includes a combination of power tool and hand tool cleaning.

Page 7, Section 4.0, Item 4.6:

The entire LJUNGSTROM air preheater will be manufactured and assembled in Wellsville, New York.

Page 7, Section 5.0, Item 5.1:

The fully assembled state of the LJUNGSTROM air preheater greatly simplifies the field erection of the equipment. Field Erection Procedure manuals will be provided early in the contract phase of this project.

Page 8, Section 6.0, Items 6.1.1 & 6.1.2:

A pre-manufacturing design review meeting may be held at our facilities for the purpose of review and discussion of the test procedures if the customer desires. As stated previously, ABB Air Preheater Inc. does not accept the responsibility for costs of plant visits made by customer personnel.

Pages 8 & 9, Section 6.2, Items 6.2.1:

Manufacturing schedules may be provided for scheduling inspections at our facilities. As stated previously, ABB Air Preheater Inc. does not accept the responsibility for costs of plant visits made by customer personnel.

Page 10, Section 6.2, Item 6.2.4:

As previously stated, a pre-manufacturing design review meeting may be held at our facilities for the purpose of review and discussion of the test procedures including nondestructive tests if the customer desires. These reviews are for information only and are not for approval of said procedures. Again, ABB Air Preheater Inc. does not accept the responsibility for any costs incurred by such plant visits.

Page 10, Section 6.3, Item 6.3.1.4:

Over the years we have established a list of reputable vendors from whom we purchase the materials and component parts required for the fabrication of the LJUNGSTROM air preheater. All of these vendors are subjected to periodic audits by our QA/QC department. However, we do not permit direct audits of our subcontractors by customer personnel.

Page 11, Section 6.4, Item 6.4.7:

Performance testing of the LJUNGSTROM air preheater is to be conducted in accordance with ASME PTC 4.3. An outline of the guidelines for this air preheater testing is included with this proposal.

Page 12, Section 7.0, Item 7.1.1:

Two controlled copies of our Quality Control Manuals will be provided to cover all three proposals (two LJUNGSTROMS and one Q-Pipe).

Pages 12 thru 15, Section 8.0:

We will submit all prints, manuals, and documents required for the erection, operation, and maintenance of the LJUNGSTROM air preheater. Our Technical Services Department will furnish the following to fulfill these requirements.

1. Installation and erection instructions.

   A. Four (4) Field Erection Procedures (FEP) Manuals.

   B. ~~Four (4) sets of air preheater master packing~~ lists.

   C. Four (4) sets of erection drawings folded with title block showing, not included in FEP Manual covers, in approximately three (3) sizes: 14" x 10", 9" x 12", and 8-1/2" x 11".

2. Operation and maintenance instructions.

   A. Ten (10) Operation and Maintenance Manuals.

   B. Preliminary manuals may be sent early for information purposes only, not approval. These may be "typical" manuals.

   C. In general, vendor information will be included as received from our vendors.

   D. We will include sketches of various serviceable components; however, full size equipment drawings folded for manual insertion are not included.

3. If the above does not satisfy your requirements, additional manuals and/or prints, reproducibles, or aperture cards of drawings can be supplied at additional cost.

As stated above, all other documentation that is not proprietary in nature will be available for review at our facilities in Wellsville, N.Y. Visits made by customer/buyer personnel are made at their own expense. Of the documents and drawings mentioned above, only the General Arrangement drawing is subject to approval. All other materials are for information and review only.

<u>Page 13, Section 8.2, Item 8.2.1.3:</u>

We will supply WPS's and PQR's if required, however, we do not furnish weld maps.

Page 14, Section 8.2, Item 8.2.2:

As previously stated, all comments and exceptions to these specifications will be made in this proposal document. The Vendor Deviation Request Form will be used only during the contract phase and only for deviations from previously agreed upon terms.

Page 15, Section 9.0, Item 9.2.2:

Consistent w/ unless ABB can show some reason//

If initial performance test data is deemed to be of unacceptable accuracy by both Purchaser and ABB Air Preheater Inc., we reserve the right to disqualify the independent testing agency for future testing. Another mutually acceptable testing agency, or ABB API if acceptable to the Purchaser, will be selected to conduct any additional testing deemed necessary.

Page 16, Section 10.0:

All ship loose parts of the LJUNGSTROM air preheater will be adequately labeled or tagged for easy installation in the field. The only ship loose items are the soot blowers.

Pages 16 & 17, Section 11.0:

The air preheater and associated components will be prepared and packaged in a manner that will insure protection against adverse elements during shipment and reasonable storage. This primarily involves the application of plastic covered plywood covers to the duct openings. The red oxide primer provides sufficient protection to the external casing.

If there is to be an extended period of time before the LJUNGSTROM air preheater is placed in service or erected, it is preferred that the unit be stored indoors if space is available. Outdoor storage can be achieved with proper protection.

The LJUNGSTROM air preheater should be uniformly supported on blocks or beams at all support points. The air preheater should be positioned above the affects of surface moisture. Periodic inspection of all painted surfaces should be done to limit rusting. Defects in painted surfaces should be cleaned and repainted as required.

It is acceptable for the element surfaces of the air preheater to show a slight coating of surface rust. However, if the air heater is to be stored for an extended period, the element should be sprayed with an appropriate protective, rust inhibiting oil of the type shown in the list below. Protective covers are placed over the hot end duct openings and shipped with the air preheater, however, additional covering, such as the use of tarps, may be desirable to protect the unit. Periodic checks should be made of the covering for deterioration, and of the element for evidence of rusting. If rusting is observed, the areas should be resprayed with a protective oil.

ANTI-RUST OILS FOR USE ON ELEMENT

If there is to be an extended period of time before the LJUNGSTROM air preheater is placed in service or erected, you might consider spraying the surface with one (1) of the oils listed below to retard rusting.

Kendall - Kencote 60

Gulf No-Rust "C" Polar Type Rust Preventative

BP - Energol -- CPF-C-3

Texas Rust Proof Oil No. 564

Tidewater Oil Company - Tycol Anorustol No. 38

Texaco No. 1052 - Metal Protective Oil

Mobil - Mobilarama 245 - Low Flash Point

A pressure type spray can of one or two gallon capacity is suitable for applying the anti-rust oil.

Supplemental Specification for Rotary Type Air Preheater

Page 8, Section 9.0, Item 9.1.2

The LJUNGSTROM air preheater selection is based on an air leaving flow of 22,357 for 3 layer lbs./hr. The air leaving flow is the actual air flow passing through the air preheater and that required for proper boiler operation.

Page 8, Section 9.0, Item 9.2

In response to the request for a performance guarantee, we are offering thermal performance, air side and gas side pressure drop guarantees as shown in the section of our proposal entitled "Performance Guarantee". Air and gas flow guarantees are not included since the system air and gas flows are dependent upon boiler and not air preheater operation.

Our thermal performance guarantee is based on the gas out temperature which is the utility standard for thermal performance determination as established by the boiler test code ASME PTC 4.1, supplemented by PTC 4.3 for Air Heaters.

General Specification for Small AC Induction Motors

SCS Small Motor Specification Data Sheet:

The motor data sheets will be completed and submitted during the contract phase of this project after our motor vendor finalizes the selection.

DJG 3/26/91
FCat 3/26/91

INQUIRY NO. SCR - 701

PROPOSAL

FROM

VENDOR'S NAME: ABB Air Preheater Inc.

VENDOR'S ADDRESS: Andover Road
Wellsville, NY 14895

FOR

ROTARY TYPE AIR PREHEATERS

FOR

SCS/DOE ICCT SELECTIVE CATALYTIC REDUCTION PROJECT

LOCATED AT

PLANT CRIST UNIT 5

OF

GULF POWER COMPANY

1.0 SCOPE

In accordance with your Inquiry No. SCR-701 for Southern Company Services and having invited proposals for furnishing rotary type air preheaters subject to all the conditions and requirements of the commercial terms and conditions and of the specifications and supplementary documents, we propose to furnish and to deliver the equipment specified for the prices quoted as follows:

2.0 PRICING

2.1 Proposal I - Air Preheater No. 1: 8049-F

For the equipment and material as specified, f.o.b. (as per Supplemental Specification):

Air Preheater with Rotor Design 1	$ [redacted]
Transition Ducts - Purchaser's Option	$ [redacted]
Sootblowers - Purchaser's Option	$ [redacted]
Total, Air Preheater No. 1	$ [redacted]

2.2 Proposal II – Air Preheater No. 2: **8049-E**

DJG 3/26/91
ECA 3/26/91

For the equipment and material as specified,
f.o.b. (as per Supplemental Specification):

Air Preheater with Rotor Design 2	$[redacted]
Transition Ducts – Purchaser's Option	$[redacted]
Sootblowers – Purchaser's Option	$[redacted]
Total, Air Preheater No. 2	$[redacted]

2.3 Proposal III – Replacement Baskets for Air Preheater No.1:

For the equipment and material as specified,
f.o.b. (as per Supplemental Specification):

Replacement Baskets for Air Preheater with Rotor Design 1:

Layer	Material	Price per Basket
Hot End – Purchaser's Option	Open hearth	[redacted]
	Cor-Ten	[redacted]
Cold End – Purchaser's Option	Cor-Ten	[redacted]
	Glass enamel on steel	[redacted]
	409 SS	[redacted]
	Mixture of Cor-Ten, 409 SS and glass enamel on steel	[redacted]

2.4 Proposal IV – Replacement Baskets for Air Preheater No. 2:

For the equipment and material as specified,
f.o.b. (as per Supplemental Specification):

Replacement Baskets for Air Preheater with Rotor Design 2:

Layer	Material	Price per basket
Hot End – Purchaser's Option	Open hearth	[redacted]
	Cor-Ten	[redacted]

DJG 3/26/91
ECH 3/26/91

Intermediate - Purchaser's Option	Cor-Ten	[redacted]
	Glass enamel on steel	[redacted]
	409 SS	[redacted]
Cold End - Purchaser's Option	Cor-Ten	[redacted]
	Glass enamel on steel	[redacted]
	409 SS	[redacted]
	Mixture of Cor-Ten, 409 SS and glass enamel on steel	[redacted]

2.5 Proposal V - Other Optional Equipment or Materials:

For other optional equipment or materials, f.o.b. (as per Supplemental Specification):

________________ $________________

________________ $________________

________________ $________________

2.6 Estimated manhours required for installation per air preheater: ________________

2.7 If required, we will furnish a service engineer for receipt of equipment and materials, inspection, erection supervision, etc., under the following terms and conditions:

Our proposal price includes a field inspection prior to initial startup by our Technical Service Representative. Should additional service required, refer to the attached WTR form for rate and charges.

2.8 Proposal validity

This proposal is valid for acceptance by the Purchaser until the following date: June 21, 1991

2.9 Cancellation

2.9.1 The latest date for cancelling this contract without incurring charges other than engineering is: DJG 3/26/91 — 8-1-91 based on 5-1-91 purchase or

2.9.2 Charges with respect to cancellation prior to the date given in 2.9.1 above will be as follows: ECH 3/26/91 — [redacted]

2.10 Deferment

In the event of deferment up to twelve months as covered in the commercial terms and conditions the price adjustment will be: Will not exceed 10% of purchase price

3.0 ESCALATION

3.1 Material prices quoted are:

Firm or Subject to Escalation: Firm thru 2-2-92

3.2 For escalated prices, the following shall apply:

a) Indices to be used

b) Starting date of escalation

c) Ending date of escalation

d) Limits of escalation

e) Method of calculating escalation

We have quoted a firm price through February 2, 1992. If for any reason beyond the control of th Seller shipment cannot be made with the date specified, the price will subject to the attached Material an Labor Adjustment Clause, Form GS-34 copy attached.

4.0 QUALITY ASSURANCE

In addition to the Quality Assurance Documentation required by the specifications, we will furnish the following additional information which is generated as a result of our Quality Assurance Program:

5.0 SCHEDULE

5.1	We will start engineering upon receipt of a verbal award and written confirmation (yes or no):	Yes
5.2	Outline drawings of the equipment will be furnished within the following number of days after award:	28
5.3	We will complete all necessary engineering within the following number of days after award:	90
5.4	We will start manufacturing within the following number of of days after award:	180
5.5	We will start shipment of the items covered by this inquiry, within the following number of days after award:	220
5.6	We will complete shipment of all items covered by this inquiry within the following number of days after award:	250

Above dates are based on 5-1-91 purchase order.

6.0 DESCRIPTIVE DATA AND ENGINEERING INFORMATION

The following descriptive information and design data are furnished in connection with the equipment and material offered in this proposal:

6.1 Air Preheater No. 1 (Rotor Design 1):

6.1.1 Heat transfer surface - square feet:

Layer	Fill Type	Square Feet
Hot End	DU	1878
Cold End	NF 3.5	3825

6.1.2 Casing and transition ducts:

Design temperature for casing and ducts - degrees F	850
Design pressure for casing and ducts - inches WG	27.7

6.1.3 Rotor drive unit:

Maximum rotor speed - rpm	.63
Minimum rotor speed - rpm	.30

Variable speed motor:

Manufacturer	Reliance

Type	Poly phase squirrel cage induction
Horsepower	1.5
Voltage	460
Accessories supplied	Motor
	Variable speed controller

Speed reducer:	
Manufacturer	Falk
Type	Helical bevel gear
Coupling:	
Manufacturer	Falk
Type	Grid type

6.1.4 Soot blowers

Number supplied	Two
Type	Retractable
Manufacturer	Copes-Vulcan
Capacity – lbs/hr steam	2580
Design steam conditions – lb/hr, psig, degrees F	2580 @ 200 psig, 300°F. superheat
Steam required for one blow – lb/hr	430 lb.
Amount of steam per unit area of rotor surface – lb/hr per square foot	25.56 lb./ft.^{2}
Power requirements	480 volt/3 ph./60 Hz.
Accessories supplied	Soot blower
	Popet Valve
	Motor starter w/manual start-stop
	Air seal wall box

6.1.5 Water wash system

Number of systems supplied	Two
Number of nozzels	6 nozzles/pipe
Type	Converging
Manufacturer	Steinen
Capacity – lbs/hr water	7502.4
Water pressure requirement – psig	75

6.1.6 Weights

Total weight – pounds	23,328
Weight of support bearing assembly – pounds	300
Weight of guide bearing assembly – pounds	300
Weight of rotor drive unit – pounds	1600
Weight of heaviest hot end basket – pounds	293
Weight of heaviest cold end basket – pounds	531
Weight of heaviest piece – pounds	23,328
Weight of empty rotor – pounds	3,000
Weight of soot blowers – pounds	1,000 ea.

6.1.7 Materials

	ASME Type
Hot end basket material	ASTM A-588
Cold end basket material	ASTM A-588
Casing material	ASTM A-36
Support structure and alignment bracing material	ASTM A-588

Other material:

________________ ________________

________________ ________________

________________ ________________

6.1.8 Power requirements – hp

Drive motor	1.5
Sootblowers	0.6
Other	

6.1.9 Water requirements – gpm

Bearings	3
Water wash system	30
Other	

6.1.1 0 Operating Conditions

Recommended maximum operating temperature – degrees F	850
Maximum recommended operating hours exceeding above temperature – hrs	0
Never to exceed temperature limit – degrees F	850

6.1.1 1 Predicted performance

Flue gas flow – lbs/hr	24,934
Air flow rate – lbs/hr	18,250
Flue gas inlet temperature – degrees F	700
Flue gas outlet temperature – degrees F	334 unc./293 corr.
Air inlet temperature – degrees F	100
Air outlet temperature – degrees F	579
Draft loss gas side – inches wg	2.50
Draft loss air side – inches wg	1.80
Face velocity, gas side – ft/sec	30.1
Face velocity, air side – ft/sec	10.3
Thermal duty – Btu/hr	2,378,751

6.1.1 2 Guaranteed performance

Flue gas outlet temperature – degrees F	334
Air outlet temperature – degrees F	Not guaranteed

Draft loss gas side - inches wg: 2.85

Draft loss air side - inches wg: 1.60

6.2 Air Preheater No. 2 (Rotor Design 2):

6.2.1 Heat transfer surface - square feet:

Layer	Fill Type	Square Feet
Hot End	DU	1127
Intermediate	NF 3.5	3825
Cold End	NF 3.5	987

6.2.2 Casing and transition ducts:

Design temperature for casing and ducts - degrees F: 850

Design pressure for casing and ducts - inches WG: 27.7

6.2.3 Rotor drive unit:

Maximum rotor speed - rpm: .63

Minimum rotor speed - rpm: .30

Variable speed motor:

Manufacturer: Reliance

Type: Poly phase squirrel cage induction

Horsepower: 1.5

Voltage: 460

Accessories supplied: Variable speed controller

Speed reducer:

Manufacturer: Falk

Type: Helical bevel gear

Coupling:

Manufacturer: Falk

Type	Grid type
6.2.4 Soot blowers	
Number supplied	Two
Type	Retractable
Manufacturer	Copes-Vulcan
Capacity – lbs/hr steam	2580
Design steam conditions – lb/hr, psig, degrees F	2580 @ 200 psig, 300°F. superheat
Steam required for one blow – lb/hr	430 lbs.
Amount of steam per unit area of rotor surface – lb/hr per square foot	25.56 lb./ft.^{2}
Power requirements	480 volt/3 ph./60 Hz.
Accessories supplied	Soot blower
	Popet Valve
	Motor starter w/manual
	push button start-stop
	air seal wall box
6.2.5 Water wash system	
Number of systems supplied	Two
Number of nozzels	6 nozzles/pipe
Type	Converging
Manufacturer	Steinen
Capacity – lbs/hr water	7502.4
Water pressure requirement – psig	75
6.2.6 Weights	
Total weight – pounds	24,651
Weight of support bearing assembly – pounds	300
Weight of guide bearing assembly – pounds	300

Weight of rotor drive unit – pounds	1600
Weight of heaviest hot end basket – pounds	183
Weight of heaviest intermediate basket – pounds	531
Weight of heaviest cold end basket – pounds	220
Weight of heaviest piece – pounds	24,651
Weight of empty rotor – pounds	3,300
Weight of soot blowers – pounds	1,000 ea.

6.2.7 Materials

	ASME Type
Hot end basket material	ASTM A-588
Intermediate basket material	ASTM A-588
Cold end basket material	ASTM A-588
Casing material	ASTM A-36
Support structure and alignment bracing material	ASTM A-588

Other material:

6.2.8 Power requirements – hp

Drive motor	1.5
Sootblowers	0.6
Other	

6.2.9 Water requirements – gpm

Bearings	3
Water wash system	30
Other	

6.2.1 0 Operating Conditions

Recommended maximum operating temperature – degrees F	850

Maximum recommended operating hours exceeding above temperature - hrs	0
Never to exceed temperature limit - degrees F	850

6.2.1 1 Predicted performance

Flue gas flow - lbs/hr	24,934
Air flow rate - lbs/hr	22,357
Flue gas inlet temperature - degrees F	700
Flue gas outlet temperature - degrees F	298 unc./264 corr.
Air inlet temperature - degrees F	100
Air outlet temperature - degrees F	579
Draft loss gas side - inches wg	2.50
Draft loss air side - inches wg	1.80
Face velocity, gas side - ft/sec	30.1
Face velocity, air side - ft/sec	17.6
Thermal duty - Btu/hr	2,607,384

6.2.1 2 Guaranteed performance

Flue gas outlet temperature - degrees F	298
Air outlet temperature - degrees F	Not guaranteed
Draft loss gas side - inches wg	2.50
Draft loss air side - inches wg	1.80

6.3 Codes and Standards

The following codes and standard apply to the equipment and materials supplied:

American Society of Mechanical Engineers (ASME)	Revision or Addendum
Boiler and Pressure Vessel Code, Section I, Power Boilers	N.A.
Boiler and Pressure Vessel Code, Section II, Material Specifications	N.A.
Boiler and Pressure Vessel Code, Section V, Nondestructive Examination	N.A.
Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications	12-31-90

B31.1 Power Piping	N.A.
PTC 4.1 - Steam Generating Units	N.A.
PTC 4.1a - ASME Test Form for Abbreviated Efficiency Test	N.A.
PTC 4.1b - ASME Test Form for Abbreviated Efficiency Test	N.A.
PTC 4.3 - Air Heaters	

American Society for Testing and Materials (ASTM)

Annual Book of ASTM Standards	1990

American Institute of Steel Construction (AISC)

Manual of Steel Construction	9th Edition

American Welding Society (AWS)

AWS Structural Welding Code	D1.1-90

American National Standards Institute (ANSI)

American National Standard Minimum Design Loads for Buildings and Other Structures	A-58.1-1982

American Gear Manufacturer's Association (AGMA)

	N.A.

National Fire Protection Association (NFPA)

	N.A.

National Electrical Manufacturer's Association (NEMA)

NEMA MG-1	1983

National Electrical Safety Code (NESC)

	N.A.

National Electrical Code (NEC)

National Electric Code Manual	1990

Steel Structures Painting Council (SSPC)

SP2	Latest Rev.

Code of Federal Regulations (CFR)

OSHA 29CFR — 1990

Other Codes and Standards:

6.4 Name and location of fabricators: ABB Air Preheater Inc.
Wellsville, NY

6.5 Shipment will be made by rail or motor freight: Motor freight

6.6 Description of proposed support system and alignment bracing: The Ljungstrom Air Preheater will b[e] supported at four points located on the sides near the bottom of the ai[r] preheater. One foot is completely fixed to the support steel. The remaining 3 support feet have slidi[ng] pads which are guided to allow for thermal growth.

6.7 Predicted performance curves for variation in air flow, including location of ammonium bisulfate condensation zone, are included in the proposal on Page: During contract phase

6.8 Description of specific procedures and requirements for performance testing including number and length of tests, instrumentation, and data required is included on Page: See attachments to proposal "Outlin[e] of Guidelines for Air Preheater Testing ASME Code Testing".

6.9 Description of method of correction of performance test results for comparison to design. Vendor shall provide a sample calculation to show each step of correcting each tested value to the specific design points for comparison with guarantees. Included in proposal on Page: Section 7 ASME PTC 4.3

6.10 Description of preparation of shipment, cleaning, and jobsite storage requirements: Cite comment on pages 14 and 15 of the proposal.

6.11 Description of mandatory requirements and recommendations for field cleaning: Mandatory requirements - none Recommendations - minimum of one time per eight hour shift or as required.

6.12 Any requirements, restrictions, and recommendations concerning the location and use of Vendor supplied sootblowers or any additional sootblowing equipment required: The sootblowing equipment provided in this proposal is complete. No additional equipment is required. The location of the soot blowers is specified in the contract drawir

6.13 List of special tools, devices, and wrenches furnished: There are no special tools or devices required.

6.14 Recommendations for installation of equipment and materials found on Page: Provided in Field Erection Procedures during the contract phase.

7.0 EXCEPTIONS

7.1 We have reviewed your specifications and all related attachments. Unless specific exceptions are listed below (or included in our proposal and referenced below), it is undersood that all of the provisions contained therein are acceptable to us.

Without exceptions: ____________

With exceptions as follows: See pages 7 thru 16 of the proposal for comments and exceptions.

7.2 The Vendor Document Submittal Schedule has been reviewed and the required documentation and submittal dates (time frames) are acceptable to us unless listed below:

Refer to page 12 of the proposal.

8.0 SIGNATURE T. G. Mergler

TITLE Manager, Project Management

NAME OF COMPANY ABB Air Preheater, Inc.

TELEPHONE NUMBER 716-593-2700 Extension 403

FAX NUMBER 716-593-7566

DATE 3-21-91

MDN/mdn
F: AIRPREHT.WK1
2/29/91

ENGINEERING STANDARDS MANUAL-PREHEATERS
THE AIR PREHEATER COMPANY
WELLSVILLE, NEW YORK

CLEANING EQUIPMENT

ADAPTER PLATE TO HOUSE SINGLE NOZZLE CLEANING DEVICE. LOCATE IN GAS OUTLET.

NOTE "A"

SPACES SHOWN FOR ACCESS TO AND REMOVAL OF THE BEARINGS. IMMOVABLE STRUCTURES SUCH AS STEEL WORK, EXPANSION JOINTS, ETC. SHOULD NOT ENCROACH ON THESE SPACES. LIGHT STRUCTURES SUCH AS DUCT WALLS MAY BE CUT IF NECESSARY TO PROVIDE SPACE.

NOTE "B"

1-1/2 HP MASTER "XL" TRIPLE PARALLEL GEARHEAD SPEED REDUCER. 11 RPM OUTPUT; 1140 RPM MOTOR USED ON SIZE 15. 2 HP MASTER "XL" TRIPLE PARALLEL GEARHEAD SPEED REDUCER, 13.5 RPM OUTPUT; 1750 RPM MOTOR USED ON SIZES 15-1/2 - 16-1/2.

NOTE "C"

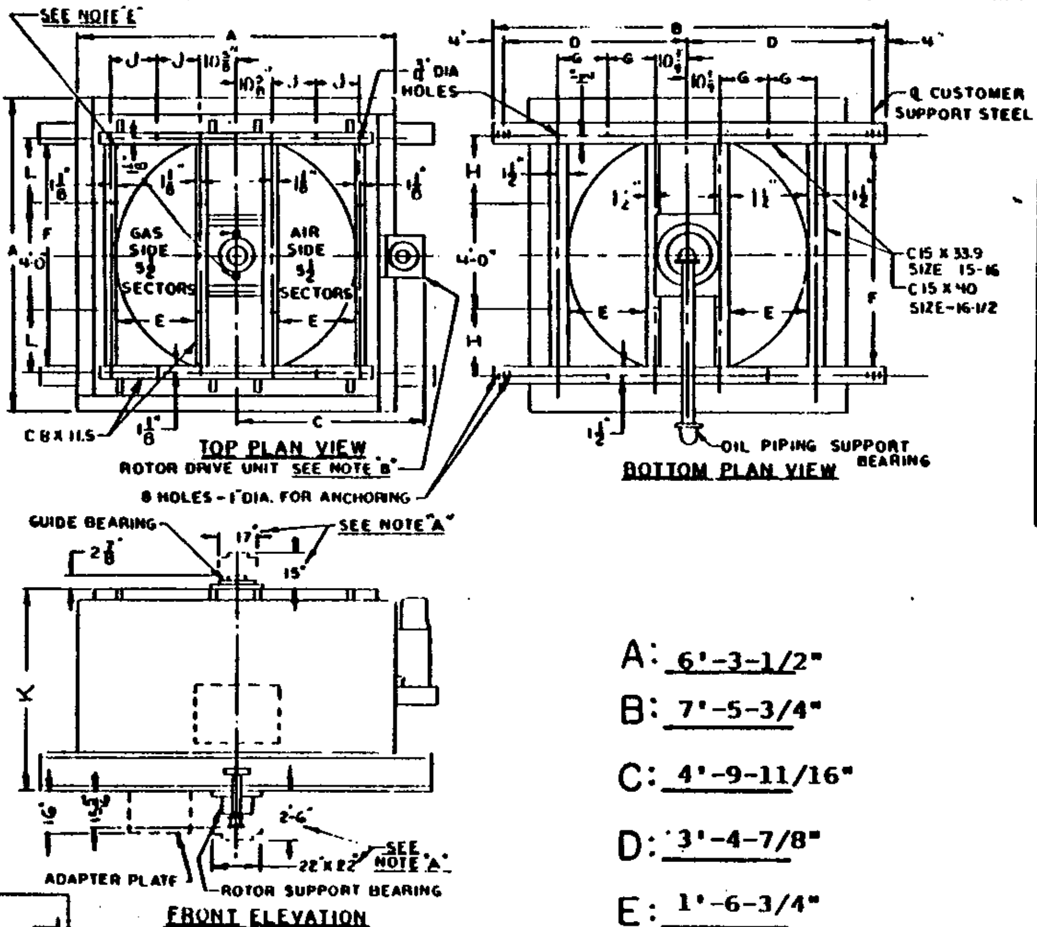
EXPANSION JOINTS TO BE PROVIDED IN THE GAS INLET, GAS OUTLET, AND AIR OUTLET DUCTS. LOCATE TO PREVENT TRANSMISSION OF EXCESSIVE FORCES TO THE DUCT CONNECTING FLANGES OF THE HEATER. EXPANSION JOINTS NOT PROVIDED BY THE AIR PREHEATER COMPANY.

NOTE "D"

COLD END AND HOT INTERMEDIATE ELEMENTS ARE PACKED IN REVERSIBLE BASKETS FOR SIDE REMOVAL. HOT END ELEMENT IS PACKED IN REVERSIBLE BASKETS FOR DUCT REMOVAL.

NOTE "E"

GUIDE BEARING TO BE WATER COOLED.



A: 6'-3-1/2"

B: 7'-5-3/4"

C: 4'-9-11/16"

D: 3'-4-7/8"

E: 1'-6-3/4"

F: 4'-5-1/2"

G: 1'-9-3/4"

H: 2'-4-1/4"

J: 1'-9"

K: 10'-11-5/8"

L: 2'-3-7/8"

NOT TO BE USED FOR CONSTRUCTION PURPOSES.

CUSTOMER: Southern Company Services

PROPOSAL: 8049-E

SIZE: 9-VIK-72 DeNox

BEARING SERIES: 55

TITLE: OUTLINE AND PRINCIPAL DIMENSIONS TYPE VIK, VIKX CASE II

DATE ISSUED:

DATE ALTERED:

DR:

CK:

DES:

SECTION: 3.2.1.3

SHEET:

ALTERATION:

FORM 259-1

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