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SUBJECT: Preliminary HRE-3 Design Data
(Revised to Nov. 15, 1957)

TO: W. R. Gall

FROM: Process Engineering Design Group: J. C. Bolger, E. H. Gift, R. O. Maak,
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PRELIMINARY HRE-3 DESIGN DATA (Revised to Nov. 15, 1957)

NOTE: Asterisks (*) indicate data that has been approved by the HRP Steering Committee.

Data without asterisks is based on physical data not yet confirmed or on equipment designs not yet developed nor approved.

I. GENERAL REACTOR DATA

- A. Type Two-region*; breeding, Th-U²³³*;
internal recombination*; fuel
solution, UO₂SO₄ in D₂O*; blanket
slurry, ThO₂ in D₂O*
- B. Type of Pressurization Gas (oxygen)
- C. Gross Power
- 1. Core power (thermal) Maximum 50-mw*
Design 50-mw*
 - 2. Blanket power (thermal) Maximum 10-mw*
Design 10-mw*
 - 3. Total power (thermal) Design 60-mw*
(electrical) Design ~19-mw
- D. Power Densities and Corrosion Rate (at 60-mw)
- 1. Average power density
 - a. Core 52.6 kw/l*
 - b. Blanket 1.04 kw/l*
 - 2. Power density at Zr-2 wall
 - a. In fuel adjacent to wall 23.0 kw/l
 - b. Within Zr-2 wall 10.6 kw/l
 - 3. Estimated corrosion rate Zr-2⁽¹⁾ 27 mils/yr

(1) If a 5-ft I.D. core vessel is used, the power density at the wall is 10 kw/l; the estimated corrosion rate is 18 mils/yr.

E. Breeding Ratio (estimated)⁽²⁾

Minimum	1.05*
Design	1.09

(2) Assumes equilibrium of higher isotopes, 7% total fission-product poisoning, and an average of 2.25 fast neutrons emitted per thermal neutron capture in U^{233} .

II. CORE SYSTEM DATAA. General

1. Solution properties.

- a. Composition $\text{UO}_2\text{SO}_4 + \text{CuSO}_4 + \text{D}_2\text{SO}_4$ in D_2O^*
- b. Critical concentration
in core at $t_{\text{avg}} = 280^\circ\text{C}$:
- (1) Initial loading (Clean) 4.6 g $\text{U}^{233}/\text{kg D}_2\text{O}$
- (2) Equilibrium 4.8 g $\text{U}^{233}/\text{kg D}_2\text{O}$
+ 0.45 g $\text{U}^{235}/\text{kg D}_2\text{O}$
- c. Analysis at Equilibrium
- Total Uranium 0.0366 molar (10.5 g U/kg D_2O)
- Copper 0.03 molar (2.3 g Cu/kg D_2O)
- Excess Acid 40% (0.027 molar)
- d. Density at 70°F 70.4 lbs/ft³
at 482°F 56.6 lbs/ft³
at 536°F 53.3 lbs/ft³
- e. Thermal conductivity at 70°F 0.35 Btu/hr-ft- $^\circ\text{F}$
at 536°F 0.32 Btu/hr-ft- $^\circ\text{F}$
- f. Viscosity at 70°F 3.06 lbs/hr-ft
at 482°F 0.27 lbs/hr-ft
at 536°F 0.24 lbs/hr-ft
- g. Heat capacity at 70°F 0.99 Btu/lb- $^\circ\text{F}$
avg. from 482 to 536°F 1.24 Btu/lb- $^\circ\text{F}$
- h. Vapor pressure of D_2O over fuel
solution at saturation, at 482°F 576 lbs/in²
at 536°F 940 lbs/in²

- i. Compressibility factor of saturated D_2O
vapor at $536^\circ F$

0.70

2. Solution Decomposition and recombination data.

- a. Decomposition rate of D_2O 1.67 molecules D_2 /100 ev

- b. Rate of formation of D_2 without
internal catalyst 5.13×10^{-5} g-mols D_2 /sec-
mol solution

- c. Rate of formation of O_2 without
internal catalyst 2.56×10^{-5} mols O_2 /sec-
mol solution

- d. Catalyst ($CuSO_4$) concentration
For 100% recombination, minimum 0.18 gm mols/l
design⁽¹⁾ 0.03 gm mols/l

- e. Recombination rate constant with $CuSO_4$
catalyst⁽²⁾
 $D_2 + O_2$ at $482^\circ F$ $k = 0.885$ l/sec-gm mol Cu
at $536^\circ F$ $k = 3.15$ l/sec-gm mol Cu

- f. Henry's Law constants at $536^\circ F$
for D_2 2.25×10^5 lbs/in²-mol fraction
for O_2 2.75×10^5 lbs/in²-mol fraction
g. Heat recombination of D_2 and O_2 105,000 Btu/lb-mol D_2

(1) Excess copper is desired to reduce D_2 partial pressure in pressurizer; this excess results in about 1% poisoning due to Cu.

(2) Rates for D_2 have been assumed as about one-half those for H_2 .

- h. Concentration and partial pressure of dissolved gases at core outlet, at 536°F and 1500 psia total pressure

D ₂ O vapor pressure	940 psia
D ₂ partial pressure	230 psia (0.0427 gm mols/l)
O ₂ partial pressure	330 psia (0.0562 gm mols/l)

3. Operating Temperatures at Design Power of 50-mw in core.

	Maximum	Minimum	Design
Core inlet	-	464°F (240°C)*	482°F (250°C)*
Core outlet	572°F (300°C)*	-	536°F (280°C)*
Core average	572°F (300°C)*	-	536°F (280°C)*
Core ΔT	--	-	54°F (30°C)*

4. Operating Pressure

Normal	1500 psia*
Minimum	1200 psia
Maximum	2000 psia
Design (at 600°F)	2500 psia ^{(1)*}

5. Circulation Rate	2.547 x 10 ⁶ lbs/hr*
at 482°F	5,700 gpm*
at 536°F	6,000 gpm (at pump)*

6. Total Pressure Loss Due to Flow, in High Pressure Core System	37.3 psi (100 ft fluid at 536°F)
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7. Estimated Liquid Volume of High-Pressure Core System	4,000 l
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(1) Design pressure used for stress calculations.

B. Core Vessel

1. Dimensions 4 ft dia sphere*, or
3 ft dia x 6 ft cylinder*
2. Material Zircaloy-2*
3. Wall thickness 0.5 in.
4. Flow pattern Concentric inlet and
outlet at top
5. Core volume ~ 950 l*
6. Pressure loss due to flow
through core 15 ft fluid

C. Main Heat Exchanger

1. Quantity One (Design)*
2. Type Horizontal, U-tube, U-shell
(fuel solution in tubes)
3. Solution temperatures at
50-mw of core power
Inlet to heat exchanger 536°F*
Exit from heat exchanger 482°F*
4. Saturated steam conditions at heat
exchanger exit
At 50-mw core power 450 psia/456°F*
At 25-mw core power 665 psia/497°F
At 5-mw core power 865 psia/527°F
5. Feedwater temperature 360°F

6. Duty , at 50-mw 170.7×10^6 Btu/hr*
7. Steam generation rate ,
at 50-mw core power 195,700 lbs/hr
at 25-mw core power 98,100 lbs/hr
at 5-mw core power 19,700 lbs/hr
8. Design pressure: tube side 2500 psia*
shell side 1250 psia
9. Design temperature 600°F^*
10. Log mean temperature difference
at 50-mw core power 47°F^*
11. Apparent overall heat transfer
coefficient, based on tube O.D. $655 \text{ Btu/hr-ft}^2\text{-}^{\circ}\text{F}$
(75% fouling factor included)
12. Heat transfer surface, based on
tubing O.D. (75% fouling factor
included) $5,550 \text{ ft}^2$
13. Tubes:
- a. Material Type 347 Stainless Steel
 - b. Size, outside dia. 0.5 in.
wall thickness 0.065 in. (#16 BWG)
 - c. Length, average 32 ft
 - d. Number of tubes 1450
 - e. Velocity in tubes 12 ft/sec
 - f. Pressure loss in tubes 14 psi
(36.9 ft of fluid)

14. Shell:

a. Material	Carbon steel
b. Shell thickness	1-1/2 in.
c. Shell outside dia.	3 ft
d. Overall length of shell	~ 16 ft 10 in.

15. Hold-up Volumes

Tube side, total	~ 980 l
Shell side (heat exchanger only)	~ 950 gal

16. Total pressure loss in heat

exchanger (tube side)	~ 17 psi (44.6 ft fluid)

D. Circulating Pump

1. Quantity (design)	One*
2. Type	Canned rotor - Reversing*
3. Capacity, at 100 ft head	6,000 gpm (at 536°F)*
4. Estimated shaft horsepower	
input, at 100 ft head, based on 74%	
impeller efficiency	176 hp
5. Purge water requirements, estimated	
Maximum	1 gpm
Design	0.5 gpm
6. Electrical characteristics	440-V, 60-cycle
	3-phase

E. High Pressure Piping - Core Circulating Loop

1. Design temperature	600°F*
2. Design pressure	2500 psia*
3. Design allowable working stress	14,900 psi
4. Pipe material	Type 347 seamless stainless steel*
5. Pipe size	12-in. Sch. 150*
Outside diameter	12.750 in.*
Inside diameter	10.316 in.*
Flow area	0.580 ft ² *
Wall thickness	1.217 in.*
6. Flow rates at 482°F	5,700 gpm*
at 536°F	6,000 gpm*
7. Velocities at 482°F	23.0 ft/sec*
at 536°F	21.8 ft/sec*
8. Friction losses (at 536°F)	6.7 ft fluid/100 ft
	2.5 psi/100 ft
	2.9 psi/velocity head
9. Friction losses (at 482°F)	6.1 ft fluid/100 ft
	2.4 psi/100 ft
	3.2 psi/velocity head
10. Estimated total friction loss	
in piping and in fittings	20 ft fluid

F. Core Solution Dump Tanks

1. Volume	160 ft ³
2. Arrangement	9 pipe x 10 pipe bank submerged in water

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Core System - Dump Tank
Feed & Cond.
Pumps

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3. Number of pipes 90
4. Length 20 ft
5. Pipe Size 4 in. Sch. 40
6. Pipe Spacing 16.5 in. on center
7. Heat transfer surface 2,130 ft²
8. Material 347 stainless steel
9. Conditions after a dump
 - a. Temperature ~ 212°F
 - b. O₂ partial pressure 28 psi
 - c. D₂ production rate 0.0063 lb mols/min

G. Fuel Feed Pumps

1. Type of pump Diaphragm
2. Capacity Variable 0 to 6 gpm
3. Normal pumping rate 3 gpm
4. Suction conditions 15 psia, 40°C
5. Discharge conditions 1500 psia
6. Type of service Continuous

H. Condensate Pump

1. Type of pump Diaphragm
2. Capacity Variable 0 to 3 gpm
3. Normal pumping rate 1 gpm
4. Fluid Pumped D₂O at 40°C
5. Suction pressure 15 psia
6. Discharge pressure 1550 psia
7. Type of service Continuous

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I. Dump Valve

1. Size 1-1/2 in.
2. Type Remote-operated, non-modulating
3. Throttling pipe 40 ft, 1 in. pipe upstream
60 ft, 1-1/2 in. pipe downstream
4. Flowrate 750 lbs/min
5. Pressure across valve 1500 psi (closed)
(Valve must be capable of closing against pressure)

J. Letdown Valve

1. Size 1/2 in.
2. Type Remote-operated, non-modulating
3. Flowrate 4 gpm at 280°C
4. Pressure across valve 1500 psi (closed)
(Valve must be capable of closing against pressure)
5. Method of regulating flow: Valves to be followed by restrictor tube

III. BLANKET SYSTEM DATA

A. General

1. Slurry properties

a. Composition		$\text{ThO}_2^* + \text{UO}_2 + \text{MoO}_3$ in D_2O^*
b. Slurry concentration		1000 gms Th/kg D_2O
c. Uranium concentration at 10-mw		3 gms $\text{U}^{233}/1$
d. Catalyst concentration, MoO_3		0.05 molar
e. Density,	at 68°F	120.7 lbs/ft ³
	at 536°F	102.3 lbs/ft ³
f. Thermal conductivity at 536°F		0.370 Btu/ft-hr- $^\circ\text{F}$
g. Yield stress, τ_y	Maximum	0.1 lbs/ft ²
	Minimum	0 lbs/ft ²
	Design	0.1 lbs/ft ²
h. Coefficient of rigidity	Maximum	2.42 lbs/hr-ft
(Average, η)	Design	2.42 lbs/hr-ft
i. Heat capacity		
	Average (518°F to 536°F)	0.626 Btu/lb- $^\circ\text{F}$

2. Slurry Decomposition and Recombination Rates

a. Decomposition rate	1.0 molecules $\text{D}_2/100$ ev
b. Rate formation of D_2 without internal catalyst (at 10-mw)	2.05×10^{-6} g mols $\text{D}_2/$ mol slurry-sec
c. Rate formation of O_2 without internal catalyst (at 10-mw)	1.02×10^{-6} gm mols/ mol slurry-sec

d. Recombination rate constant with

0.05 molar MoO_3 as catalyst,⁽¹⁾

at 536°F 129.5 hr⁻¹

at 518°F 123.5 hr⁻¹

e. Concentration and partial pressure

of dissolved gases at blanket outlet,

at 536°F and 1500 psia total pressure

D_2O vapor pressure 940 psia

D_2 partial pressure 25 psia (0.00412 gm mols/l)

O_2 partial pressure 535 psia (0.0808 gm mols/l)

3. Operating Temperature at Design Power of 10-mw

	Maximum	Minimum	Design
Blanket Inlet	-	464°F (240°C)*	518°F (270°C)
Blanket Outlet	572°F (300°C)*	-	536°F (280°C)*
Blanket Average	563°F (295°C)	-	527°F (275°C)
Blanket ΔT	-	-	18°F (10°C)

4. Operating Pressure

Normal	1500 psia*
Minimum	1200 psia
Maximum	2000 psia
Design (at 600°F)	2500 psia*

5. Circulation Rate

	3.69×10^6 lbs/hr
at pump (536°F)	3940 gpm

6. Total Pressure Loss Due to Flow,

high-pressure blanket

60 psia

75 ft fluid at 280°C

(1) $K = \frac{1}{p} \frac{dp}{dt} = 1.67 \times 10^3 e^{-5067/RT}$. (Slurry is 1600°C-fired and activated)

7. Estimated Liquid Volume of high pressure
blanket system

14,500 liters

B. Pressure Vessel

1. Dimensions

9 ft I.D. sphere*
with 60° incl. angle
conical bottom

2. Material

Type 347 stainless steel
clad carbon steel*

3. Wall thickness

~ 4 to 6 in.

4. Flow pattern

Concentric inlet and outlet
at bottom; baffle, or
shroud, for two-pass flow

5. Pressure vessel volume

13,000 l

6. Pressure loss due to flow through vessel

15 ft fluid

C. Main Heat Exchanger

1. Quantity

One (Design)*

2. Type

Vertical, shell and tube
(slurry in tubes)

3. Slurry temperature at 10-mw of
blanket power

Inlet to heat exchanger

536°F*

Outlet of heat exchanger

518°F

4. Saturated steam conditions at heat
exchanger exit,

at 10-mw blanket power

450 psia/456°F*

at 5-mw blanket power

665 psia/497°F

at 1-mw blanket power

865 psia/527°F

5. Feedwater temperature 360°F
6. Duty, at 10-mw 34.1×10^6 Btu/hr*
7. Steam generation rate
 - at 10-mw blanket power 39,100 lbs/hr
 - at 5-mw blanket power 19,600 lbs/hr
 - at 1-mw blanket power 3,900 lbs/hr
8. Design pressure: tube side 2500 psia*
shell side 1250 psia
9. Design temperature 600°F*
10. Log mean temperature difference
at 10-mw blanket power 69.2°F
11. Apparent overall heat transfer
coefficient, based on tube O.D.
(includes 2,000 Btu/hr-ft²-°F scaling coef.) 442 Btu/hr-ft²-°F
12. Heat transfer surface, based on
tubing O.D. 1120 ft²
13. Tubes:
 - a. Material Type 347 stainless steel*
 - b. Size, outside dia. 5/8 in.
wall thickness 0.065 in. (#16 BWG)
 - c. Length, average 15 ft
 - d. Number of tubes 475
 - e. Velocity in tube 14 ft/sec
 - f. Pressure loss in tubes 17 psi
21.3 ft fluid

14. Shell

a. Material	Carbon steel
b. Shell outside diameter	3 ft
c. Overall length of shell	16 ft

15. Hold-up Volumes

a. Tube side, total	270 l

16. Total pressure loss due to flow,	25 psi
tube side	31.4 ft fluid

D. Circulating Pump

1. Quantity (design)	One*
2. Type	Canned rotor*
3. Capacity at 75 ft head	4,000 gpm (at 536°F)
4. Estimated shaft horsepower input,
at 75 ft head, based on 74%
impeller efficiency	190 hp
5. Purge water requirements	
Maximum	2 gpm
Design	1 gpm
6. Electrical characteristics	440-V, 60-cycle
3-phase

E. High Pressure Piping - Pressure Vessel Circulating Loop

1. Design temperature	600°F*
2. Design pressure	2500 psia*
3. Design allowable working stress	14,900 psi

4. Pipe material	Type 347 seamless stainless steel*
5. Pipe size:	10-in. Sch 150*
Outside diameter	10.750 in.*
Inside diameter	8.625 in.*
Flow area	0.405 ft ² *
Wall thickness	1.062 in.*
6. Flow rates, at 518°F	3,915 gpm
at 536°F	3,950 gpm
7. Velocities, at 518°F	21.6 ft/sec
at 536°F	21.8 ft/sec
8. Friction losses (at 536°F)	14.4 ft fluid/100 ft
	11.6 psi/100 ft
	6.0 psi/velocity head
9. Estimated total friction loss in piping and in fittings	29 ft fluid
F. <u>Blanket Slurry Dump Tanks</u>	
1. Number of tanks	Seven
2. Type	Vertical cylinders
	60° conical bottom
3. Diameter	36 in. I.D.
	38 in. O.D.
4. Height straight section	15 ft
5. Volumes, total	840 ft ³
slurry space	420 ft ³

6. Coolant	Tanks submerged in water
7. Resuspension System	D ₂ O steam at 40 psia
8. Pressures: Operating	20 psia
Design	900 psia
- G. Slurry Feed Pumps
1. Type of pump	Diaphragm (or "acid egg")
2. Capacity	Variable 0 to 6 gpm
3. Normal pumping rate	4 gpm
4. Fluid pumped	Slurry, normally at
1500 g Th/Kg D ₂ O
5. Suction conditions	15 psia, 40°C
6. Discharge pressure	1500 psia
7. Type of service	Continuous
- H. Condensate Pump
1. Type of pump	Diaphragm
2. Capacity	Variable 0 to 3 gpm
3. Normal pumping rate	2 gpm
4. Fluid pumped	D ₂ O at 40°C
5. Suction pressure	15 psia
6. Discharge pressure	1500 psia
7. Type of service	Continuous
- I. Dump Valve
1. Size	2 in.
2. Type	Remote-operated, non-
modulating

3. Throttling pipe
40 ft, 1-1/2 in. pipe upstream
60 ft, 2 in. pipe downstream
4. Flow rate
2000 lbs/min.
5. Pressure across valve
1500 psi (closed)
(Valve must be capable
of closing against pressure).

J. Letdown Valve

1. Size
1/2 in.
2. Type
Remote-operated, non-
modulating
3. Flow rate
6 gpm at 280°C
4. Pressure across valve
1500 psi (closed)
(Valve must be capable of
closing against pressure)
5. Method of regulating flow:
Valve to be followed by
restrictor tube

IV. AUXILIARY SYSTEM DATAA. Turbine-Generator System

1. Turbine-generator size	20,000 kw
2. Type	Condensing, direct-connected,
hydrogen-cooled, extracting,
1800 rpm, with moisture
separation (internal or
external)
3. Estimated gross electrical
power generated at 60-mw
reactor power	19,250 kw
4. Generating voltage	13.8 KV
5. Assumed turbine element efficiencies	
High pressure	84.8%
Low pressure	87.2%
Combined electrical &
mechanical efficiencies	96.5%
Exhaust loss	20 Btu/lb
6. Steam to throttle at 60-mw reactor power	450 psia dry and sat.*
234.7 x 10 ³ lbs/hr
7. Exhaust pressure	1.5" Hg abs.
8. Condensing water,
assuming in at 70° F and out at 80° F	31,300 gpm
9. Boiler feedpump, approx.	180 hp

B. Cooling Water

	<u>t_{in}</u>	<u>t_{out}</u>	<u>Flow rate</u>
1. Potable water			
a. Building sanitary	80°F		100 gpm
b. Cooling tower make-up	80°F		300 gpm
c. Demineralized water			
system make-up	80°F		50 gpm
d. Miscellaneous	80°F		<u>100 gpm</u>
	Total estimated		550 gpm
e. Size of main, minimum			8 in.
2. Process water			
a. Turbine condenser	88°F	98°F	32,000 gpm
b. Demineralized water			
heat exchanger	88°F	98°F	4,000 gpm
c. Cell space coolers	88°F	120°F	1,000 gpm
d. Turbine oil cooler			
e. Generator hydrogen cooler			
f. Deaerator vent condenser			
g. Refrigeration condenser			
h. Dump tanks (emergency only)			3,000 gpm
i. Fuel dump tank coolant cond.			
j. Blanket dump tank coolant cond.			
	Total		<u>40,000 gpm</u>
k. Size of main			48 in.
3. Demineralized water			
a. Thermal shield	100°F	-	-
b. Fuel circulating pump	100°F	-	-
c. Blanket circulating pump	100°F	-	-
d. Fuel letdown cooler	100°F	152°F	25 gpm
e. Blanket letdown cooler	100°F	175°F	25 gpm
f. Fuel entrainment separator	100°F	-	-
g. Blanket entrainment			
separator	100°F	-	-
h. Fuel dump tank			
recombiner condenser	100°F	-	-

3. Demineralized water (continued)

	<u>t_{in}</u>	<u>t_{out}</u>	<u>Flow rate</u>
i. Blanket dump tank recombiner condenser	100°F	-	-
j. Fuel evaporator condenser	100°F	-	-
k. Blanket evaporator condenser	100°F	-	-
l. Fuel feed cooler	100°F	150°F	6 gpm
m. Blanket feed cooler	100°F	150°F	8 gpm
n. Fuel system condensate feed cooler	100°F	150°F	2 gpm
o. Blanket system condensate feed cooler	100°F	150°F	4 gpm
p. Fuel sample cooler	100°F	-	-
q. Blanket sample cooler	100°F	-	-
r. Pressure vessel cooler	100°F	-	-
s. Oxygen burner cooler	100°F	130°F	50 gpm
t. Charcoal beds	-	-	-
u. Waste evaporator condenser	-	-	-
v. Fuel dump tank coolant	-	-	-
Total estimated			2,000 gpm

C. Off-Gas System

	<u>Maximum</u>	<u>Design</u>
1. Oxygen Burner		
a. Capacity	20 std cfm	10 std cfm
b. Required H ₂ flow	40 std cfm	20 std cfm
c. Operating pressure		20 psia
d. Design pressure		2,000 psia
e. Cooling water		
Inlet	80°F	80°F
Outlet	110°F	95°F
Flow rate	50 gpm	50 gpm
f. Heat of recombination x 10 ⁻⁵	7.46 Btu/hr	3.73 Btu/hr
g. Total O ₂ in low-pressure system after a dump	3.0 lb mols	-

	<u>Maximum</u>	<u>Design</u>
h. Total time for disposal (per dump)	55 min.	110 min.
i. Total volume of H ₂ O resulting from combustion	13 gal.	
j. Temperature of gases leaving combustion chamber	400°F	240°F
k. Average vapor temperature in condenser	200°F	140°F
l. Temperature of vapor vented to cold traps and charcoal beds	140°F	100°F
m. Volume of gases vented to cold traps	500 cc/min	500 cc/min
n. Activity of gas (gamma)	10 ¹² Mev/cm ³ sec	5 x 10 ¹¹ Mev/cm ³ sec
o. Combustion chamber		
(1) Diameter	19.5 in. I.D.	
(2) Wall thickness	1.5 in.	
(3) Length (not including hemispherical ends)	48 in.	
p. Combustion liner dimensions		
Diameter	18 in. ID	
Heat transfer area	23.7 ft ²	
q. Condenser		
(1) Number tubes	43	
(2) Diameter tubes	1/2 in.	
(3) Wall thickness tubes	16 BWG	
(4) Average length tubes	5 ft	
(5) Heat transfer area (based on O.D.)	30 ft ²	
(6) Shell diameter	12 in O.D.	
(7) Shell thickness	1 in.	

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Auxiliary System - Off-Gas

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D. Steam Service System

1. Estimated size of main from X-10 area 8 in. dia

E. Electrical Distribution

1. Transmission lines 13.8 KV
3-phase, 60-cycle
2. Transformers 450/13,800 V

840 025

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