✓
ENGINEERING

CENC 1197

VOLUME III

**LMFBR
SODIUM HEATED
STEAM GENERATOR
—TEST MODEL—**

AEC CONTRACT AT(11-1)-3031

FEBRUARY 1973

MASTER

CE COMBUSTION DIVISION

COMBUSTION ENGINEERING, INC.

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BLOWDOWN - ISOLATION & DUMP SYSTEM

SIZING

30 MWt MODEL

CONTRACT #7670

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1. Description of the Water/Steam Isolation and Dump System

The steam generator water/steam isolation and dump system (Figure 1) provides for rapid isolation and dump of the steam and water from the superheater and evaporator into a dump tank (item 5) following a major sodium/water reaction (a major sodium/water reaction involves the activation of the sodium secondary relief system). In general, this system is required to minimize the severity of damage to the unit resulting from an internal water/steam-to-sodium leak.

The size of the dump lines (item 2 and 4), dump valves (item 1 and 3), dump tank, vent line (item 7) and vent valves (item 6) are determined on the basis of depressurization of the unit to 150 psig in 5 to 10 seconds after the opening of the quick acting dump valves. Isolation valves are provided on the inlet and outlet pipes of the superheater and evaporator to isolate the superheater and evaporator from the water circulation system. In order to reduce the internal pressure differential in the superheater and evaporator during blowdown, double dump lines are provided for each superheater and evaporator.

In general, the dump system includes a 330 ft³ dump tank which incorporates an atmosphere vent system, a drain valve (item 15) and a safety relief valve (item 9). The isolated fluid trapped in the superheater and evaporator is blown down to the dump tank in 5 to 10 seconds after the closure of the isolation valves and the opening of the dump valves. The pressure in the dump tank (initially at atmospheric pressure) will rapidly rise to cause the water vapor flow out of the vent system (the vent valve is in the open position during the normal operating conditions). The tank pressure will reach a peak value (about 250 psia) and then start to decrease. As the pressure in the superheater and evaporator drops to 150 psig the vent valve closes. A nitrogen gas supply

system provides a nitrogen inert gas to the water/steam side of superheater and evaporator to prevent sodium from backing up into the water piping system. To protect the dump tank against some abnormal condition, a safety valve will be installed on the tank for protecting against overpressure. The water collected in the dump tank can be drained out by the drain valve.

2. Design Analysis of the Evaporator and Superheater Blowdown System

A. Evaporator and superheater blowdown requirement:

The basic requirement for sizing the blowdown piping system is to depressurize the evaporator and superheater from the normal operating pressure to 150 psig in 5 to 10 seconds.

B. Analytical model used for blowdown calculations:

A "WALLSOB" Computer Code developed by the Nuclear Department of Combustion Engineering was used for the blowdown calculation. This Code was developed primarily for PWR blowdown and refilling transient following a loss of coolant accident. The major assumptions in the Code related to our analysis are as follows:

- (1) The code assumes an initially saturated system with a distinct interface between vapor and liquid.
- (2) Critical mass flow is calculated by use of F. J. Moody's maximum two-phase flow model¹ with zero flow resistance factor.

The input and output of this code related to our analysis are:

Input: Total volume of vessel
Volume occupied by steam
Vessel initial pressure
Volume up to the blowdown nozzle on the vessel
Receiver pressure
Vessel cross section area
Blowdown flow area

Output: Pressure transient in the vessel
Blowdown flow transient
Blowdown energy transient

2. Design Analysis of the Evaporator and Superheater Blowdown System (continued)

C. Design Consideration:

The evaporator is initially filled with

Subcooled water (657 F for CR = 5.5)	= 354#
Subcooled water (from 657 F to T_{sat})	= 77#
Saturated water	= 890#
Saturated steam	= 169#

(for calculation see attached sheet no. 2-4)

The superheater is initially filled with

Superheated steam	= 43.3#
Saturated steam	= 140#
Energy Content	= 207.2×10^3 BTU

If the superheater is assumed initially filled with all saturated steam the energy content will be 234×10^3 BTU.

(for calculation see attached sheet no. 5)

Since the above initial conditions deviate from the WALLSOB Code assumption (1), the initial conditions for both the superheater and evaporator must be modified to permit use of this code. However, for the conservative design it can be assumed that the evaporator is initially filled with saturated liquid. Figures 2 and 3 shows two cases investigated by use of the WALLSOB Code. The actual blowdown must be in between these two cases. and close to the liquid blowdown. For the superheater, it is assumed that it is filled with all saturated steam. This is also conservative since the energy content for the all saturated steam case (234×10^3 BTU) is higher than the actual case (207×10^3 BTU).

In order to consider flow resistance of the piping system, the F. J. Moody's frictional maximum two phase flow model² is used. Instead of modifying the WALLSOB Code (assumption 2) a equivalent flow area in input to the code such that the output blowdown flow from the code will be equal to the blowdown flow with resistance.

2. Design Analysis of the Evaporator and Superheater Blowdown System (continued)

D. Design Conditions:

A. Evaporator:

Initial pressure - 2740 psia
Volume = 58 ft³ (for calculation see sheet no. 1)
Blowdown pipe size: 6-5/8" O.D. Schedule 160
Piping loss coefficient = 8.53 (see Sheet no. 6)
Valve loss coefficient = 1.47
Valve flow area = .0645 ft²
Valve opening speed: 0 - 1 second open to .0645 ft² (assume linear speed)
Volume up to the blowdown pipe outlet nozzle = 48 ft³
Vessel average cross section area = 1.38 ft²

B. Superheater:

Initial pressure - 2665 psia
Volume = 25 ft³ (see sheet no. 1)
Blowdown pipe size: 4-1/2 Schedule 160
Piping loss coefficient = 8.98 (see sheet no. 6)
Valve loss coefficient = 3.66
Valve flow area = .0246 ft²
Valve opening speed: 0-1 second open to .0246 ft² (assume linear speed)
Volume up to the blowdown pipe outlet nozzle = 17.3 ft³
Vessel average cross section area = .62 ft²

The blowdown transient curves of pressure, flow and energy for the evaporator and superheater are shown on Figures 4, 5, and 6. For both the evaporator and superheater a constant receiver pressure of 95 psia is assumed during the blowdown. The actual dump tank pressure, of course, will vary during the blowdown. The design of the dump tank and its pressure calculation will be described next.

3. Design Analysis of the Dump Tank and Venting System

A. Design Consideration: The following two requirements should be considered in the sizing of the dump tank and the vent system:

- (1) The tank pressure must be kept below the critical pressure of the evaporator and the superheater (less than approximately half of the evaporator and superheater pressure depending on the line resistance) particularly during the early part of blowdown transient.

3. Design Analysis of the Dump Tank and Venting System (continued)

A. (2) The dump tank should be large enough such that the steam and water separation in the tank can be achieved.

B. Design Conditions:

Either the dump tank volume or the vent system piping must be pre-selected before the other can be calculated to meet the requirements. The selection mainly depends on economical considerations. A 330 ft³ dump tank (7' in diameter and 10' height) is selected for sizing the vent system.

C. Dump tank pressure and vent flow calculation:

from conservation of mass

$$W_{in} - W_V = \frac{dM}{dt} \quad (1)$$

from conservation of energy

$$W_{in} h_{in} - W_V h_V = \frac{dE}{dt} \quad (2)$$

$$V_T = \text{constant} \quad (3)$$

integration of (1) and (2)

$$M = \int_{t_1}^{t_2} W_{in} dt - \int_{t_1}^{t_2} W_v dt \quad (4)$$

$$E = \int_{t_1}^{t_2} W_{in} h_{in} dt - \int_{t_1}^{t_2} W_v h_v dt \quad (5)$$

from (3)/(4)

$$V = \frac{V_T}{M} \quad (ft^3/lb) \quad (6)$$

from (5)/(4)

$$e = \frac{E}{M} \quad (BTU/lb) \quad (7)$$

$$h = e + \frac{P_T V}{J} \quad (8)$$

$$P_T \text{ (tank pressure)} = f(V, h) \quad (9)$$

P_T can be read from the attached curves*³ on sheet no. 9.

The first integral in equation (4) and (5) can be obtained from evaporator and superheater blowdown as shown on Figure 5 and 6.

The only unknown left is vent flow (W_v). In order to calculate the vent flow the following assumptions are made:

- (1) only saturated water vapor flow out of the vent
- (2) Treat the saturated vapor as ideal gas
- (3) Critical flow exists through the vent
- (4) The air in the tank is neglected, with these assumptions, the vent flow can be calculated by the following equation*⁴

$$W_v = .525 Y d_i^2 \sqrt{\frac{\Delta P}{K U_1}} \quad (9)$$

W_v = flow rate (lb/sec)

Y = expansion factor (determined from sheet no. 8)

d_i = pipe inside diameter (in.)

ΔP = critical pressure drop (psi) (determined from sheet no. 8)

K = total loss coefficient of the piping system

U_1 = up-stream specific volume (ft³/lb)

Since W_v also depends on the tank pressure, the tank pressure must be determined by iteration procedures:

- (1) Assume the tank pressure P_T
- (2) Calculate the vent flow W_v , by equation (9)
- (3) Calculate $W_v h_v$ ($h_v = h_g$ @ the assumed P_T)
- (4) Calculate the net mass M in the tank by equation (4)
- (5) Calculate the net energy E in the tank by equation (5)
- (6) Calculate U by equation (6)
- (7) Calculate e by equation (7)
- (8) Calculate h by equation (8)
- (9) Read P_T from Sheet #9 based on h and .
- (10) Compare P_T in Step 9 to the assumed P_T , if they are close enough P_T is determined. Otherwise go back to step 1 and repeat to step 10.

These procedures are required for each time interval selected.

The detailed calculations are shown on sheet no. 7 to 18. The results of the dump tank pressure, vent flow and energy flow out through the vent are plotted on Figures 4, 5, and 6 respectively.

These curves represent the transient condition of the dump tank and vent with the following design:

dump tank volume = 330 ft³

vent line size: 16" O.D. schedule 60

loss coefficient of the vent piping = 2.82

loss coefficient of the vent valve = 3.0

C. Y. Sun
2-13-73

CYS:sw

REFERENCES

- *1 F. J. Moody, "Maximum Flow Rate of A Single Component, Two-Phase Mixture", Journal of Heat Transfer, Trans. ASME, Series C, 87 (February 1965).
- *2 F. J. Moody, "Maximum Two-Phase Vessel Blowdown From Pipes", Journal of Heat Transfer, Trans. ASME, Series C, 88, (August 1966) P. 285.
- *3 Frank O. Ellenwood and Charles O. Mackey, "Thermodynamic Charts, Steam, Water, Amonia, Freon-12, and Mixture of Air and Water Vapor", 1966, 2nd Ed. John Wiley, P. 26.
- *4 "Flow of Fluids Through Valves - Fittings and Pipe", Crane Technical Paper No. 410, P.A-27.

30 Mwt Model
water-side dump system
for
superheater & evaporator

2/7/1973

Figure 1

Figure 2

Figure 4

Figure 5

LMFBR 30 Mw Model
Water-side dump system
Energy transient in the dump
tank during blowdown

Figure 6

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CUSTOMER AEC STEAM GENERATOR CONT. No. 7070 MADE BY CYS DATE 2/14/73
LOCATION LMFBR 20 MWt MODEL DWG. No. _____ CHK'D BY _____ DATE _____

*size selection for
Blowdown piping, dump tank and vent piping*

item	description	quantity	size	design pressure (PSIG)	design (°F) temperature	flow lb/hr
1	evaporator quick-opening dump valve	2	6 $\frac{5}{8}$ " O.D.	2900	688	transient peak 1,020,000/Ea.
(A) 2	evaporator dump line	2	6 $\frac{5}{8}$ " O.D.	2900	688	
3A	superheater quick-opening dump valve	1	4 $\frac{1}{2}$ " O.D.	2840	688	transient peak 136,000
3B	superheater quick-opening dump valve	1	4 $\frac{1}{2}$ " O.D.	2840	960	transient peak 136,000
(B) 4A	superheater dump line	1	4 $\frac{1}{2}$ " O.D.	2840	960	
(B) 4B	superheater dump line	1	4 $\frac{1}{2}$ " O.D.	2840	960	
(C) 5	dump tank	1	330 ft ³	400	445	
6	dump tank vent valve	1	16" O.D.	400	445	transient peak 810,000
7	dump tank vent line	1	16" O.D.	400	445	

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CUSTOMER AEC STEAM GENERATOR CONT. No. 7670 MADE BY CYS DATE 2/14/73
LOCATION LMFBR 30MWt MODEL DWG. No. _____ CHK'D BY _____ DATE _____

Evaporator volume calculation

Based on drawing No. (D-63672717-0, 11/20/72)

① inside bagonet tube

$$V_b = (.785)(.40)^2(32'6" + 36" + 7\frac{1}{2}" + 1'3\frac{1}{2}")(91)(\frac{1}{144}) = 2.98 \text{ ft}^3$$

② annular

$$V_a = (.785) \left[\left(\frac{1.156}{12} \right)^2 - \left(\frac{.781}{12} \right)^2 \right] (32'6" + 36")(91) = 12.8 \text{ ft}^3$$

③ water plenum

$$V_w = (.785) \left(\frac{25}{12} \right)^2 (1'10") = 6.25 \text{ ft}^3$$

④ steam plenum

$$V_s = (.785) \left(\frac{34}{12} \right)^2 (5'11") - (.785) \left(\frac{25}{12} \right)^2 \left(\frac{4.5}{12} \right) = 35.9 \text{ ft}^3$$

$$\text{Total volume} = 57.93 \text{ ft}^3$$

Superheater volume calculation

Based on Drawing No.
(D-63672714-1, 11-10/72)

① inside bagonet tube

$$V_b = (.785)(.636)^2(30'8" + 34" + 6.5" + 11")(37)(\frac{1}{144}) = 2.83 \text{ ft}^3$$

② annular

$$V_a = (.785) \left[(1.308)^2 - (.916)^2 \right] (30'8" + 34")(37)(\frac{1}{144}) = 4.51 \text{ ft}^3$$

③ SH. steam plenum

$$V_{sh} = (.785) \left(\frac{15.5}{12} \right)^2 (1'5") = 1.85 \text{ ft}^3$$

④ saturated steam plenum

$$V_s = (.785) \left(\frac{26}{12} \right)^2 (4'6") - (.785) \left(\frac{15.5}{12} \right)^2 \left(\frac{4.5}{12} \right) = 16.1 \text{ ft}^3$$

$$\text{total volume} = 25.29 \text{ ft}^3$$

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CUSTOMER REC STEAM GENERATOR CONT. NO. 7670 MADE BY CYS DATE 2/14/73
LOCATION LMFBR 30 MW± MODEL DWG. NO. _____ CHK'D BY _____ DATE _____

Initial mass and energy calculation

Evaporator: at 2740 psia saturated condition
 $v_f = .0307$, $v_{fg} = .0777$, $v_g = .1084$
 $h_f = 763$, $h_g = 1064$, $T_{sat} = 682^\circ F$
a, for $CR = 3.5$, $T = 639^\circ F$ ($v = .0251$, $h = 671$)

① subcooled water in bayonet tube and water plenum

$$M_w = (2.98 + 6.25) / .0251 = 368 \#$$

② steam water mixture in the steam plenum

$$\frac{V_m}{M_m} = v_f + (x)(v_{fg})$$

$$\therefore M_m = \frac{V_m}{v_f + (x)(v_{fg})}$$

$$M_m = \frac{35.9}{.0307 + (\frac{1}{3.5})(.0777)} = 680 \#$$

$$M_s = (680)(\frac{1}{3.5}) = 194 \#$$

$$M_w = 486 \#$$

③ mixture in the annular

length for heating to h_f

$$\frac{L_1}{35.5} = \frac{763 - 671}{1064 - 671} = .234$$

Volume of L_1

$$V_{L_1} = (12.8)(.234) = 3 \text{ ft}^3$$

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CUSTOMER AEC STEAM GENERATOR CONT. No. 7670 MADE BY CYS DATE 2/14/73
LOCATION LMFBR 30 MW MODEL DWG. No. _____ CHK'D BY _____ DATE _____

subcooled water in L_1 :

$$M_w = 3 / \frac{1}{2} (.0307 + .0251) = 107 \#$$

mixture in L_2 :

$$M_m = \frac{(12.8 - 3)}{.0307 + (\frac{1}{3.5})(\frac{1}{2})(.0777)} = 234 \#$$

$$M_s = (234)(\frac{1}{3.5 \times 2}) = 33.4 \#$$

$$M_w = 200.6 \#$$

summary: subcooled water (639°F) = 368 #
subcooled water (average) = 107 #
saturated water = 687 #
" steam = 227 #

6, for $CR = 5.5$, $T = 657^\circ F$ ($V = .0260$, $h = 702$)

① subcooled water in the bayonet tube and water plenum:

$$M_w = 9.23 / .0260 = 354 \#$$

② mixture in the steam plenum

$$M_m = \frac{35.9}{.0307 + (\frac{1}{3.5})(.0777)} = 800 \#$$

$$M_s = (800)(\frac{1}{5.5}) = 145 \#$$

$$M_w = 655 \#$$

③ mixture in the annular

$$\frac{L_1}{35.5} = \frac{763 - 701}{1064 - 701} = .17$$

$$V_{L_1} = (12.8)(.17) = 2.18 \text{ ft}^3$$

subcooled water in L_1

$$M_w = 2.18 / \frac{1}{2} (.0307 + .0260) = 77 \#$$

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CUSTOMER AEC STEAM GENERATOR CONT. No. 7670 MADE BY CYS DATE 2/14/73
LOCATION LMFBR 30 MWt MODEL DWG. No. _____ CHK'D BY _____ DATE _____

mixture in L_2 :

$$M_m = \frac{9.8}{.0307 + (\frac{1}{5.5})(\frac{1}{2})(.0777)} = 259 \#$$

$$M_s = (259)(\frac{1}{5.5})(\frac{1}{2}) = 24 \#$$

$$M_w = 235 \#$$

Summary:

$$\text{subcooled water (657°)} = 354 \#$$

$$\text{" " (avg.)} = 77 \#$$

$$\text{saturated water} = 890 \#$$

$$\text{" steam} = 169 \#$$

energy content:

for $CR = 3.5$:

$$\text{subcooled water} = (368)(671) = 247 \times 10^3 \text{ BTU}$$

$$\text{saturated water} = (687)(763) = 525 \times 10^3 \text{ BTU}$$

$$\text{" steam} = (227.4)(1064) = 242 \times 10^3 \text{ BTU}$$

$$\text{Total} = 994 \times 10^3 \text{ BTU}$$

for $CR = 5.5$:

$$\text{sub. water} = (354)(702) = 248 \times 10^3$$

$$\text{sat. "} = (890)(763) = 680 \times 10^3$$

$$\text{" steam} = (169)(1064) = 180 \times 10^3$$

$$\text{Total} = 1108 \times 10^3 \text{ BTU}$$

Volume up to the shutdown outlet nozzle

$$V_N = 58 - (.705)(\frac{34}{12})^2(\frac{15}{12}) = 48 \text{ ft}^3$$

average vessel cross section area based on 42' height

$$A = \frac{58}{42} = 1.38 \text{ ft}^2$$

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COMPONENT AEC STEAM GENERATOR CONT. NO. 7670 MADE BY CYS DATE 2/14/73
LOCATION LMFBR 30 MW MODEL DWG. No. _____ CHK'D BY _____ DATE _____

superheater : at 2665 psia saturated stm.

$$V_g = .115, h_g = 1075$$

@ 2665 psia, 900°F

$$V = .251, h = 1379$$

- ① Sh. steam mass in the plenum and bayonet tube
@ 900°F

$$M_{sh} = (2.83 + 1.85) / .251 = 18.6 \text{ \#}$$

- ② Sh. stm. mass in annular (from T_{sat.} to 900°F)

$$M_{sh} = \frac{4.51}{\frac{1}{2}(.115 + .251)} = 24.7 \text{ \#}$$

- ③ saturated stm. in the plenum

$$M_s = 16.1 / .115 = 140 \text{ \#}$$

Total mass = 183.3 \#

Energy content:

$$\textcircled{1} : 18.6 \times 1379 = 25.6 \times 10^3$$

$$\textcircled{2} : 24.7 \times (1074.8 + 1379) \frac{1}{2} = 30.6 \times 10^3$$

$$\textcircled{3} : 140 \times (1074.8) = 151 \times 10^3$$

$$\text{total} = 207.2 \times 10^3 \text{ BTU}$$

assume sh. contents all sat. stm:

$$M_{sat.} = \frac{25}{.115} = 217 \text{ \#}$$

$$(217)(1074.8) = 234 \times 10^3 \text{ BTU}$$

Volume up to the blowdown outlet nozzle

$$V_N = 25 - (.785) \left(\frac{26}{12} \right)^2 \left(\frac{25}{12} \right) = 17.3 \text{ ft}^3$$

Avg. vessel cross section area (based on 40'5" height)

$$A = \frac{25}{40.42} = .62 \text{ ft}^2$$

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CUSTOMER AEC STEAM GENERATOR CONT. No. 7670 MADE BY CYS DATE 2/14/73
 LOCATION LMFBR 30 MWt MODEL DWG. No. _____ CHK'D BY _____ DATE _____

Loss coefficient calculation

1, Evaporator dump line: (Drawing No. 07670-1F0109-01, 1/17/73
07670-1F0119-01, 1/6/73)

6 $\frac{5}{8}$ " O.D. sch. 160. $A_i = .147 \text{ ft}^2$, $D_i = 5.2"$

Entrance and exit	$K = 1.5$
6 - 90° elbows (6 x .58)	$K = 3.48$
Tee	$K = 1.8$
pipe friction	

$$K = \frac{fL}{D} = \frac{(.0152)(50)(12)}{5.2} = 1.75$$

8.53

required valve K 1.47

required valve flow area .0645 ft^2

2, Superheat dump line: (Drawing No. SAME AS Evaporator's)

4 $\frac{1}{2}$ " O.D. sch. 160. $A_i = .0645 \text{ ft}^2$, $D_i = 3.44"$

Entrance and exit	$K = 1.5$
6 - 90° elbows (6 x .58)	$K = 3.48$
Tee	$K = 1.8$
pipe friction	

$$K = \frac{fL}{D} = \frac{(.0152)(40)(12)}{3.44} = 2.2$$

8.98

required valve K 3.66

required valve flow area .0246 ft^2

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CUSTOMER AEC STEAM GENERATOR CONT. No. 7670 MADE BY CYS DATE 3/14/73
LOCATION LMFBR 30 MWt MODEL DWG. No. _____ CHK'D BY _____ DATE _____

Dump tank vent flow and pressure calculation

Vent line loss coefficient: (Drawing No. same as evaporator's)

16" O.D. sch. 60 pipe: $d_i = 14.69" = 1.224'$, $A_i = 1.18 \text{ ft}^2$
 $d_i^2 = 216 \text{ in}^2$ $f = .0125$

Entrance & exit $K = 1.5$

2 - 45° elbow (2 x .30) $K = .60$

Pipe friction

$$K = \frac{fL}{D} = \frac{(.0125)(70)(12)}{1.224} = .715$$

Vent Valve $= 3.0$

total $= 5.815$

Vent flow equation:

$$W = .525 Y d_i^2 \sqrt{\frac{\Delta P}{K V_i}} \quad (\#/sec)$$

for $K = 5.82$ @ sonic flow, from sheet B

$$Y = .685, \quad \frac{\Delta P}{P_i} = .721$$

$$W = (.525)(.685)(216) \sqrt{\frac{\Delta P}{(5.82) V_i}}$$

$$\therefore \boxed{W = (32.1) \sqrt{\frac{\Delta P}{V_i}}} \quad \text{----- (A)}$$

ASSUME SONIC FLOW

based on $F_r/C_v = 1.3$

P_1 = UPSTREAM PRESSURE

ΔP = CRITICAL PRESSURE DROP

$\frac{P}{P_1}$

EXPANSION FACTOR Y

From "Flow of Fluids Through
Valves, Fittings and Pipe"
CRANE TECHNICAL PAPER
NO. 410 P. A-22

Loss coefficient K

From "Thermodynamic Charts, Steam, Water, Ammonia, Freon-12, and mixture of air and water vapor" — 1966, 2nd ed. by Frank O. Ellenwood and Charles O. Mackey

(26) LOW-QUALITY STEAM

PLATE 10

COMBUSTION ENGINEERING, INC.
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CUSTOMER AEC STEAM GENERATOR CONT. No. 7670 MADE BY CYS DATE 2/14/73
LOCATION LMFBR 30 MWt MODEL DWG. No. _____ CHK'D BY _____ DATE _____

Note :

The calculation procedures of the following sheet (11 to 18) are slightly different from that outlined in the write-up.

In sheet No. 11-18 it is assumed

$$h(\text{enthalpy}) = e(\text{specific internal energy}).$$

While in the write-up

$$h = e + \frac{P_T v}{J}$$

Therefore, for the first second (0-1) P_{T1} has been recalculated (sheet No. 19-21) to follow the write-up procedures. Since the difference is small

$$P_{T1} = 146 \text{ psia (sheet 21)}$$

$$P_{T1} = 139 \text{ psia (sheet 12)}$$

Correction of the the other sheets (12-18) is not necessary.

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CUSTOMER REC STEAM GENERATOR CONT. No. 7670 MADE BY CYS DATE 2/14/73
LOCATION LMFBR 30 MWt MODEL DWG. No. _____ CHK'D BY _____ DATE _____

0-1 second

Mass in the tank:

$$\left. \begin{array}{l} \text{from evap. } M_{ei} = 300^{\#} \\ \text{from sh. } M_{si} = 46^{\#} \end{array} \right\} \text{ (from Figure 5)}$$

Energy in the tank:

$$\left. \begin{array}{l} \text{from evap. } E_{ei} = 220 \times 10^3 \text{ BTU} \\ \text{from sh. } E_{si} = 47 \times 10^3 \text{ BTU} \end{array} \right\} \text{ (from Figure 6)}$$

$$\left. \begin{array}{l} h = \frac{267 \times 10^3}{346} = 772 \text{ BTU/\#} \\ v = 330/346 = .945 \text{ ft}^3/\# \end{array} \right\} \text{ go to sheet 9}$$

↑
dump tank vol.

P_t (tank press.) = 255 psia ----- this is the non-

venting condition, use approx. half of this

value as the first guess to calculate the

vent flow.

calculate vent flow:

① assume $P_{t1} = 120$ psia (from stm. table $v_g = 3.73 \text{ ft}^3/\#$
 $h_g = 1190 \text{ BTU/\#}$)

$$\Delta P = (.721)(P_t) = 86.5 \text{ psi}$$

from eq. (A)

$$W_v = (32.1) \sqrt{\frac{\Delta P}{v_1}} = (32.1) \sqrt{\frac{86.5}{3.73}} = 155 \text{ \#/sec.}$$

mass out through vent

$$M_o = \frac{1}{2} (155 + 0) (1) = 78^{\#}$$

Energy out through vent

$$E_o = (78)(1190) = 93.5 \times 10^3 \text{ BTU}$$

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Mass and energy left in the tank

$$M_T = 346 - 78 = 268 \text{ \#}$$

$$E_T = (267 - 93.5) \times 10^3 = 173.5 \times 10^3 \text{ BTU}$$

$$h = 173.5 \times 10^3 / 268 = 648 \text{ BTU/\#}$$

$$V = 330 / 268 = 1.23 \text{ ft}^3/\text{\#}$$

} go to sheet 9

$$P_{t1} = 151 \text{ psia, try again}$$

$$\textcircled{2} \text{ assume } P_{t1} = 140 \text{ psia } (V_g = 3.22, h_g = 1193)$$

$$\Delta P = (0.721)(140) = 101 \text{ psi}$$

$$\rightarrow W_{v1} = (32.1) \sqrt{\frac{101}{3.22}} = 180 \text{ \#/sec}$$

$$M_o = \frac{1}{2}(180) = 90 \text{ \#}$$

$$E_o = (90)(1193) = 107.3 \times 10^3$$

$$\rightarrow M_{T1} = (346 - 90) = 256$$

$$\rightarrow E_{T1} = (267 - 107.3) \times 10^3 = 159.7 \times 10^3$$

$$h = 159.7 \times 10^3 / 256 = 624$$

$$V = 330 / 256 = 1.28$$

} go to sheet 9

$$\rightarrow P_{t1} = 139 \text{ psia O.K.}$$

$$Q_{out} = (180)(1193) = 215 \times 10^3 \text{ BTU/sec.}$$

1-2 second

$$M_{oi} = 506 \text{ \#}$$

$$M_{si} = 59 \text{ \#}$$

$$E_{oi} = 390 \times 10^3$$

$$E_{si} = 59 \times 10^3$$

$$\} M_{i2} = 565 \text{ \#}$$

$$\} E_{i2} = 457 \times 10^3 \text{ BTU}$$

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LOCATION LMFBR 30 MWt MODEL DWG. NO. _____ CHK'D BY _____ DATE _____

$$M_T = M_{i2} + M_{T1} = 565 + 256 = 821 \text{ #}$$

$$E_T = E_{i2} + E_{T1} = (457 + 160) \times 10^3 = 617 \times 10^3 \text{ BTU}$$

① assume $P_{t2} = 250 \text{ psia}$ ($U_g = 1.843$, $h_g = 1201$)

$$\Delta p = (250)(.721) = 180$$

$$W_{v2} = (32.1) \sqrt{\frac{180}{1.843}} = 317 \text{ #/sec.}$$

$$M_o = \frac{1}{2}(W_{v2} + W_{v1})(1) = \frac{1}{2}(317 + 180)(1) = 248 \text{ #}$$

$$E_o = (248)(1201) = 298 \times 10^3 \text{ BTU}$$

$$M_T = 821 - 248 = 573$$

$$E_T = (617 - 298) \times 10^3 = 319 \times 10^3$$

$$h = 319 \times 10^3 / 573 = 556$$

$$U = 330 / 573 = .575$$

$\therefore P_{t2} = 212 \text{ psia}$, try again

② assume $P_{t2} = 230 \text{ psia}$ ($U_g = 2$, $h_g = 1200$)

$$\Delta p = (.721)(230) = 160$$

$$\rightarrow W_{v2} = (32.1) \sqrt{\frac{160}{2}} = 288 \text{ #/sec.}$$

$$M_o = \frac{1}{2}(288 + 180) = 234$$

$$E_o = (234)(1200) = 281 \times 10^3$$

$$\rightarrow M_{T2} = (821 - 234) = 587 \text{ #}$$

$$\rightarrow E_{T2} = (617 - 281) \times 10^3 = 336 \times 10^3$$

$$h = 336 \times 10^3 / 587 = 573$$

$$U = 330 / 587 = .562$$

$\rightarrow P_{t2} = 230 \text{ psia}$ O.K.!

$$Q_o = (288)(1200) = 346 \times 10^3 \text{ BTU/sec.}$$

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2-3 second

$$\left. \begin{array}{l} M_{ei} = 415 \\ M_{si} = 34 \end{array} \right\} M_{i3} = 449$$

$$\left. \begin{array}{l} E_{ei} = 305 \times 10^3 \\ E_{si} = 40 \times 10^3 \end{array} \right\} E_{i3} = 345 \times 10^3$$

$$M_T = 449 + 587 = 1036 \text{ \#}$$

$$E_T = (345 + 336) \times 10^3 = 681 \times 10^3$$

① assume $P_{T3} = 210$ ($V_g = 2.18$, $h_g = 1199$)

$$\Delta P = (.721)(210) = 151.4$$

$$W_{V3} = (32.1) \sqrt{\frac{151.4}{2.18}} = 268 \text{ \#/sec.}$$

$$M_o = \frac{1}{2}(268 + 288) = 278$$

$$E_o = (278)(1199) = 333 \times 10^3$$

$$M_T = (1036 - 278) = 758$$

$$E_T = (681 - 333) \times 10^3 = 348 \times 10^3$$

$$\left. \begin{array}{l} h = 348 \times 10^3 / 758 = 459 \\ v = 330 / 758 = .435 \end{array} \right\}$$

$$P_{t3} = 173 \text{ psia, try again}$$

② assume $P_{T3} = 184 \text{ psia}$ ($V_g = 2.48$, $h_g = 1197$)

$$\Delta P = (.721)(184) = 132.7$$

$$\rightarrow W_{V3} = (32.1) \sqrt{\frac{132.7}{2.48}} = 235 \text{ \#/sec.}$$

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$$M_o = (\frac{1}{2})(235 + 288) = 261.5$$

$$E_o = (261.5)(1197) = 313 \times 10^3$$

$$\rightarrow M_{T3} = (1036 - 261.5) = 774.5$$

$$\rightarrow E_{T3} = (681 - 313) \times 10^3 = 368 \times 10^3$$

$$h = 368 \times 10^3 / 774.5 = 475$$

$$V = 330 / 774.5 = .426$$

$$\rightarrow P_{t3} = 187 \text{ psia} \quad \text{OK!}$$

$$Q_o = (235)(1197) = 281 \times 10^3 \text{ BTU/sec}$$

3-4 second

$$\left. \begin{array}{l} M_{oi} = 300 \\ M_{si} = 19.5 \end{array} \right\} M_{i4} = 319.5$$

$$\left. \begin{array}{l} E_{oi} = 217 \times 10^3 \\ E_{si} = 24 \times 10^3 \end{array} \right\} E_{i4} = 241 \times 10^3$$

$$M_T = 319.5 + 774.5 = 1094$$

$$E_T = (368 + 241) \times 10^3 = 609 \times 10^3$$

① assume $P_{t4} = 150 \text{ psia}$ ($V_g = 3.01$, $h_g = 1194$)

$$\Delta P = (.721)(150) = 108.2$$

$$W_{13} = (32.1) \sqrt{\frac{108.2}{3.01}} = 193 \text{ #/sec.}$$

$$M_o = (\frac{1}{2})(193 + 235) = 214 \text{ #}$$

$$E_o = (214)(1194) = 255.5 \times 10^3 \text{ BTU}$$

$$M_T = (1094 - 214) = 880$$

$$E_T = (609 - 255.5) \times 10^3 = 353.5 \times 10^3$$

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$$\left. \begin{aligned} h &= 353.5 \times 10^3 / 880 = 402 \\ v &= 330 / 880 = .375 \end{aligned} \right\}$$

$P_{t4} = 141$ psia try again

② assume $P_{t4} = 145$ psia ($v_g = 3.11$, $h_g = 1194$)
 $\Delta p = 104.5$

→ $W_{v4} = 186$ #/sec.

$M_0 = 210.5$

$E_0 = 251.3 \times 10^3$

→ $M_{T4} = (1194 - 210.5) = 883.5$

→ $E_{T4} = (609 - 251.3) \times 10^3 = 357.7 \times 10^3$

$h = 404.9$

$v = .374$

→ $P_{t4} = 144$ psia OK!

$Q_0 = (186)(1194) = 222 \times 10^3$ BTU/sec.

4-5 second

$\left. \begin{aligned} M_{e1} &= 190 \text{ #} \\ M_{s1} &= 12 \text{ #} \end{aligned} \right\} M_{i5} = 202$

$\left. \begin{aligned} E_{e1} &= 135 \times 10^3 \\ E_{s1} &= 14 \times 10^3 \end{aligned} \right\} E_{i5} = 149 \times 10^3$

$M_T = 202 + 883.5 = 1085.5$

$E_T = (149 + 357.7) \times 10^3 = 506.7 \times 10^3$

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① assume $P_{t5} = 100 \text{ psia}$ ($V_g = 4.43$, $h_g = 1187$)
 $\Delta p = (.721)(100) = 72.1$

$\rightarrow W_{v5} = (32.1) \sqrt{\frac{72.1}{4.43}} = 130 \text{ #/sec}$

$M_o = \frac{1}{2}(130 + 186) = 158$

$E_o = (158)(1187) = 187.5 \times 10^3$

$\rightarrow M_{t5} = (1085.5 - 158) = 927.5 \text{ #}$

$\rightarrow E_{t5} = (506.7 - 187.5) \times 10^3 = 319.2$

$h = 319.2 \times 10^3 / 927.5 = 344.2$

$U = 330 / 927.5 = .355$

$\rightarrow P_{t5} = 99 \text{ psia} \quad \text{OK!}$

$Q_o = (130)(1187) = 154.5 \times 10^3 \text{ BTU/sec}$

5-6 second

$M_{ei} = 105$
 $M_{si} = 7.5$ } $M_{i6} = 112.5$

$E_{ei} = 75 \times 10^3$
 $E_{si} = 8 \times 10^3$ } $E_{i6} = 83 \times 10^3$

$M_T = 112.5 + 927.5 = 1040$

$E_T = (83 + 319.2) \times 10^3 = 402.2 \times 10^3$

① assume $P_{t6} = 70 \text{ psia}$ ($V_g = 6.21$, $h_g = 1181$)

$\Delta p = (.721)(70) = 50.5$

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$$\rightarrow W_{v6} = (32.1) \sqrt{\frac{50.5}{6.21}} = 91.7 \text{ \#/sec}$$

$$M_o = \frac{1}{2}(91.7 + 130) = 110.9$$

$$E_o = (110.9)(1181) = 131 \times 10^3$$

$$\rightarrow M_{T6} = (1040 - 110.9) = 929$$

$$\rightarrow E_{T6} = (402.2 - 131) \times 10^3 = 271.2 \times 10^3$$

$$h = 271.2 \times 10^3 / 929 = 282$$

$$V = 330 / 929 = .355$$

$$P_{t6} = 63 \text{ psia}$$

$$\rightarrow \text{use } P_{t6} = 65 \text{ psia}$$

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CUSTOMER REC STEAM GENERATOR CONT. No. 7670 MADE BY CYS DATE 2/14/73
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0 - 1 second

Mass in the tank

$$\left. \begin{array}{l} \text{from evap. } M_{ei} = 300^{\#} \\ \text{from SH. } M_{si} = 46^{\#} \end{array} \right\} \text{from Figure 5}$$

$$M_{i1} = 346^{\#}$$

Energy in the tank

$$\left. \begin{array}{l} \text{from evap. } E_{ei} = 220 \times 10^3 \text{ BTU} \\ \text{from SH. } E_{si} = 47 \times 10^3 \text{ BTU} \end{array} \right\} \text{from Figure 6}$$

$$E_{i1} = 267 \times 10^3 \text{ BTU}$$

$$e = \frac{E_{i1}}{M_{i1}} = \frac{267 \times 10^3}{346} = 772 \text{ BTU/\#}$$

$$v = V_T / M_{i1} = 330 / 346 = .945 \text{ ft}^3/\#$$

calculate vent flow:

① assume $P_T = 200 \text{ psia}$ (from steam table

$$v_g = 2.29 \text{ ft}^3/\#, h_g = 1198 \text{ BTU/\#})$$

$$\Delta p = (.721)(P_T) = 144 \text{ psi}$$

from eq. (A)

$$W_v = (32.1) \sqrt{\frac{\Delta p}{v_g}} = (32.1) \sqrt{\frac{1.44}{2.29}} = 255 \text{ \#/sec.}$$

mass out through vent

$$M_o = \frac{1}{2}(255 + 0)(1) = 127.5^{\#}$$

energy out through vent

$$E_o = (127.5)(1198) = 152.7 \times 10^3 \text{ BTU}$$

Mass and energy left in the tank

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OWNER AEC STEAM GENERATOR CONT. No. 7670 MADE BY CYS DATE 2/14/73
LOCATION LMFBR 30 MW MODEL DWG. No. _____ CHK'D BY _____ DATE _____

$$M_T = 346 - 127.5 = 218 \text{ \#}$$

$$E_T = (267 - 152.7) \times 10^3 = 114.3 \times 10^3 \text{ BTU}$$

$$e = \frac{E_T}{M_T} = \frac{114.3 \times 10^3}{218} = 524.3 \text{ BTU}$$

$$v = \frac{V_T}{M_T} = \frac{330}{218} = 1.51 \text{ ft}^3/\text{\#}$$

$$h = e + \frac{P_T v}{J} = 524 + \frac{(200)(144)(1.51)}{778} = 580 \text{ BTU/\#}$$

$P_T = f(h, v)$ from curve on sheet 9

$P_T = 110 \text{ psia}$ try again

② assume $P_T = 150 \text{ psia}$ ($v_g = 3.01$, $h_g = 1194$)
 $\Delta p = (0.721)(150) = 108 \text{ psi}$

$$W_v = (32.1) \sqrt{\frac{108}{3.01}} = 192 \text{ \#/sec}$$

$$M_0 = \frac{1}{2}(192) = 96 \text{ \#}$$

$$E_0 = (96)(1194) = 114.6 \times 10^3$$

$$M_T = 346 - 96 = 250$$

$$E_T = (267 - 114.6) \times 10^3 = 152.4 \times 10^3$$

$$e = 152.4 \times 10^3 / 250 = 609.6$$

$$v = 330 / 250 = 1.32$$

$$h = 609.6 + (0.185)(150)(1.30) = 646.2$$

from sheet 9

$P_T = 144 \text{ psia}$, try again

③ assume $P_T = 147 \text{ psia}$ ($v_g = 3.07$, $h_g = 1194$)
 $\Delta p = (0.721)(147) = 106 \text{ psi}$

$$W_v = (32.1) \sqrt{\frac{106}{3.07}} = 189 \text{ \#/sec.}$$

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CUSTOMER AEC STEAM GENERATOR CONT. No. 7670 MADE BY CYS DATE 2/14/73
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$$M_o = \frac{1}{2}(189) = 94.5$$

$$E_o = (94.5)(1194) = 112.8 \times 10^3$$

$$M_T = 346 - 94.5 = 252$$

$$E_T = (267 - 112.8) \times 10^3 = 154.2 \times 10^3$$

$$e = 154.2 \times 10^3 / 252 = 611.9 \text{ BTU/lb}$$

$$v = 330 / 252 = 1.31$$

$$h = 611.9 + (.185)(147)(1.31) = 647.5$$

from sheet 9

$$P_{T1} = 146 \text{ psia} \quad \text{OK!}$$

**RELIEF VALVE & SILENCERS
SIZING**

(STEAM SIDE OVERPRESSURE PROTECTION SYSTEM)

30 MWt Model

CONTRACT 7670

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RELIEF VALVE & SILENCER SIZING

1. General Description of the Overpressure Relief Analysis

(Reference Figure 1 for location of relief valves, etc.)

Provisions for overpressure protection of the steam/water side components of the sodium heated 30 MMt steam generator model have been considered, and safety relief valves have been selected in accordance with the requirements of Section I of the ASME Boiler and Pressure Vessel Code, 1971 Edition.

In general, the requirements of paragraph PG-67.2 of Section I have been followed in that the safety relief valves shall be sized to a capacity to discharge all of the steam that can be generated without allowing the pressure to rise to more than 6% above the highest pressure at which any valve is set and in no case more than 6% above the maximum allowable working pressure or design pressure. Since each sodium heated component of the steam/water side is also completely isolable by quick closing isolation valves, overpressure protection relief valves are required to be installed on each of these components (evaporator and superheater). Section I also requires at least two safety valves to be installed on steam generating units of more than 500 sq. ft. of heating surface.

In determining the relief capacity required for the evaporator and superheater components, within the isolation valves, the following logic was applied since there are no precise rules to follow in Section I to make this calculation. Each component (evaporator and superheater) was considered to be isolated on the steam/water side by the quick closing isolation valves while the sodium flow continues to transfer heat to the isolated component. In this case the quick opening dump valves are not considered to be open since this is a

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LOCATION _____ DWG. No. 07670-1F0109 CHK'D BY _____ DATE _____

30 MWE MODEL
STEAM/WATER ISOLATION AND DUMP
SYSTEM AND PRESSURE RELIEF SYSTEM

FIGURE 1

malfunction type of operating condition. Thus, the sodium heated component is bottled up on the steam/water side while the sodium flow system continues to add heat and thus produces the overpressure condition. For this condition the relief capacity required to prevent the pressure rise from exceeding 6% above the design pressure of the respective component was calculated, and these calculations are included in the third part of this report. The second part of this report summarizes the design conditions and capacities for all relief valves and silencers included in the overpressure protection system.

The water recirculation system which includes the sodium heated evaporator also includes a steam drum, a circulation pump and connecting lines. This system generates a steam-water mixture in the sodium heated evaporator and this mixture passes to the steam drum to be separated into saturated steam and saturated water. Thus, the steam drum being an unfired pressure vessel which generates steam could be classified under Section I rules as an unfired steam boiler, in which case Section I states that the relieving capacity shall be determined by the manufacturer. If the steam drum and evaporator components are classified as a steam generating system, then the intent of Section I would be that the total relieving capacity of this system should not be less than the maximum designed steaming capacity as determined by the manufacturer. Thus, this is the intent that was applied to determine the capacity of the safety valve on the steam drum, so that the combined relieving capacity of all the spring loaded safety valves on the steam drum and evaporator is not less than the maximum designed steaming capacity which is 133,000 lb/hr. The capacity of the superheater is not permitted to be included because of the isolation valve which is located between the steam drum and the superheater.

In addition to the spring loaded safety valve, a 1% electromatic relief valve is located on the drum for operational control purposes. The capacity of this valve is in addition to the requirements of Section I.

The steam/water isolation and dump system includes a dump tank which also generates low pressure steam during the actuation of the steam/water dump system by the flashing of high pressure saturated water or steam-water mixtures to the lower pressure contained in the dump tank. This tank under Section I rules must also be protected against a possible overpressure condition. The relieving capacity of the required safety relief valve (which is in addition to the operational vent valve) is established by considering the worst possible malfunction of the isolation and dump valves so that all the steam that is generated is continuously passed to the dump tank. Using this logic, the dump tank safety relief valve is sized for the maximum designed steaming capacity of the evaporator-superheater or 133,000 lb/hr at the design pressure of the dump tank or 400 psi and saturated steam.

The location of the evaporator and superheater safety valves is such that one valve is located at the inlet and one valve is located at the outlet. Also, the two evaporator relief valves are set at the same pressure, and also the two superheater relief valves are set at the same pressure. In this way both the superheater or evaporator relief valves will be actuated together in order to minimize the internal pressure gradient across the heat absorbing bayonet tube elements. This same reasoning was also applied to require both inlet and outlet dump lines for both the evaporator and superheater components.

2. Summary of Safety Relief Valve and Silencer Criteria

The following tabulation gives the selected safety valve design or set pressure, safety valve design temperature, and the required safety valve and silencer relief flow capacity (reference Figure 1 for general location by item number):

<u>Component</u>	<u>Safety Valve Quantity & Item No.</u>	<u>Silencer Quantity & Item No.</u>	<u>Relief Valve Set Pressure PSIG</u>	<u>Design Temp. °F</u>	<u>Flow Capacity lb/hr</u>
Evaporator	2 - (11)	2 - (12)	2900	688	39,000/ea.
Superheater	2 - (13)	2 - (14)	2840	960	16,000/ea.
Steam Drum/ Spring Loaded	1 - (16)	1 - (17)	2840	688	56,000
Steam Drum/ Electromatic- Relief	1 - (18)	1 - (19)	2840	688	13,000
Dump Tank	1 - (9)	1 - (10)	400	445	133,000

Note: The actual valve size and silencer design will be determined by the valve or silencer manufacturer to meet the above conditions.

3. Calculations

Attached are three calculation sheets showing the actual analysis work performed to arrive at the relief valve flow capacity for both the evaporator and the superheater relief valves (Ref. Figure 1, Items 11 and 13).

Since the relief flow discharged by a popped safety valve presents a highly transient condition, a simplified, but conservative, type of solution was applied. Considering the isolation valves to be closed with the heat flow from the sodium continuing, a steady state energy balance was performed to calculate the required relief flow rate at a 6% overpressure condition. This

is a maximum instantaneous value which does not consider the energy or mass released during the rise in pressure or the reduction in the overall heat transfer due to the stoppage of the steam/water flow by the closing of the isolation valves.

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Evaporator and superheater pressure relief valve flow capacity calculation:

1, Evaporator:

for an open system of thermodynamics

Since $\dot{m}_i = 0$,

$$\dot{W}_{out} = 0$$

neglect the kinetic and potential energy

$$\therefore \dot{Q}_{in} = \dot{m}_o h_o + \frac{du}{dt}$$

When the evaporator reaches the design pressure, the relief valve will open, the stored energy will not change, hence

$$\dot{Q}_{in} = \dot{m}_o h_o$$

$$\dot{m}_o = \frac{\dot{Q}_{in}}{h_o}$$

(1)

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CUSTOMER _____ CONT. No. 7670 MADE BY CYS DATE 2/6/73
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Evaporator:

$$\text{Volume} = 58 \text{ ft}^3$$

CR = 5.5 (For maximum energy holdup)

heat input to evaporator = 19.7 mwt

initial mass in the evaporator (refer to evaporator
clump system analysis):

saturated steam = 169 #

saturated water = 1105 #

total = 1271 #

$$V_i = 58 / 1271 = 0.0455 \text{ ft}^3/\text{LB}$$

evaporator design pressure = 2900 psig
at 6% over pressure:

$$P_o = (2900)(1.06) + 2900 = 3074 \text{ psig}$$

from steam table: @ 3089 psia

$$V_f = 0.0362, \quad V_{fg} = 0.0396$$

$$h_f = 821 \text{ BTU/\#}, \quad h_{fg} = 177$$

since $V_i = V_o$

$$x_o = \frac{0.0455 - 0.0362}{0.0396} = 0.234$$

$$h_o = (821) + (0.234)(177) = 862 \text{ BTU/\#}$$

from (1)

$$\dot{m}_o = \frac{(19.7)(3413)(1000)}{862} = 77,900 \text{ \#/HR}$$

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER _____ CONT. No. 7670 MADE BY CYS DATE 2/6/73
LOCATION _____ DWG. No. _____ CHK'D BY BFL DATE 2/6/73

superheater :

design pressure = 2840 psig

heat input = 10.3 mwt

@ 2665 psia initial operating pressure

$v_1 = .115 \text{ ft}^3/\text{LB}$ (assume saturated steam)

@ 6% over pressure

$$P_o = (2840)(.06) + 2840 = 3010 \text{ psig}$$

Since $v_1 = v_o$

from superheated steam table

$$h_o = 1106 \text{ BTU/LB}$$

$$\dot{m}_o = \frac{(10.3)(3413)(1000)}{1106} = 31,700 \text{ \#/HR}$$

60 " I.D. STEAM DRUM ANALYSES

LMFBR 30 MWT MODEL

CONTRACT NO. 7670

COMBUSTION ENGINEERING, INC.

Form FA-324(4-71)

DRUM DATA SHEET 1 OF 3

Data Sheet Comp. Code No. 01-86-1701

Customer LMFBR 30 MWT STM. GENERATOR Contract No. 7670

Plant Location CITY STATE OR COUNTRY Construction Rules A.S.M.E.

Stamping Pressure (Boiler Design) 2840 P.S.I. Year Built 1973

60" I.D. Drum With Hemispherical Hd. Mat'l. NOTE #2 Drum Comp. Code No. 01-02-1001

Thickness Values For 16" Dia. Manhole	
Drum I.D.	* "b"
34"	.050"
35"	.048"
36"	.046"
42"	.040"
48"	.035"
54"	.032"
60"	.030"
66"	.028"
70"	.026"
72"	.026"

Description	Thickness For One Shell	Thin Of Two Thickness Shell	HEMISPHERICAL HEAD DATA				
			PLAIN HEAD		MANHEAD WITH 16" DIA. OPENING		
Formula	$t = \frac{PR}{SE - 0.6P}$		$t = \frac{PR}{SE - 0.6P}$	$t_2 = \frac{PL}{2SE_1}$	$t = \frac{PR}{SE_1 - 0.6P}$	$t_2 = \frac{PL}{2SE_1 - 2P}$	$t_3 = 2t_2 + b$
Theoretical Thickness	$t+a = 6.625$	$t+a =$	$t =$	$t_2 =$	$t = 5.525$	$t_2 = 2.529$	$t_3 = 5.088$
Nominal Thickness	6.625						
H							
S	17124				17124	17124	
R	30				30		
L						30	
E	Long. 1.0 (Note 1) Circ. (Note)	Long. (Note) Circ. (Note)	$E_1 =$	$E_1 =$	$E_1 = 1.0$	$E_1 = 1.0$	
a	1.100		NOTES: 1. BASED ON OPENINGS COMPENSATION. 2. MAT'L SA-387-D NORMALIZED AND TEMPERED				

P = Design Pressure (PSI) (Including H For Lower Drum Only)
 S = Maximum Allowable Unit Working Stress (PSI) Per Table PG-23.1, ASME Code.
 E = Efficiency Of Longitudinal Joints Or Ligaments Between Openings In Shell.
 E_1 = Efficiency Of Weakest Joint Used In Forming The Head Including The Joint To The Shell.
 t = Minimum Thickness Of Straight Flange On Head Plate Or Shell Plate In Weakest Course, inches.
 t_2 = Minimum Thickness Required For A Plain Hemispherical Head.
 t_3 = Minimum Inherent Thickness Required For Hemispherical Head With M.H. Opening.
 R = Inside Radius Of Weakest Course Of Shell Or Drum In Inches.
 L = Radius To Which The Head Is Formed, Measured On The Concave Side Of The Head, inches.
 H = Hydrostatic And Pump Head Pressure (PSI) To Be Considered When Calculating Lower Drum.
 a = Additional Thickness Required To Reinforce Tube Nozzles.
 b = Additional Thickness Required To Replace Metal Removed For M.H. Gasket Surface.

PROJ. 900-130

* See St'd. Inst. #4-64 SI-1.9
 ** See St'd. Inst. #1-64 SI-1.9

Made By L.F. 2-2-73
 Checked By R.L. Date 2-13-73

DRAWING NO. 07670-1A1471-00

REV.

MASTER

ATTACHMENT #11 SI 37-69 INDEX NO. SI 1.10

1471

THIS FORM REPLACES PREVIOUS STANDARD FORM NO. 130-97-C

CALCULATION SHEET

For 60" I.D. STEAM DRUMSheet 2 of 3LMFBRContract No. 767030MWT STEAM GENERATORReference Drawing 07670-1E1402SHELL PLATE

$$t = \frac{PR}{SE - 0.6P} + C \quad t = \frac{2840 \times 30.00}{17124 \times 1.0 - 0.6 \times 2840} + 0 = 5.525$$

ADDITIONAL THK. REQD FOR OPENINGS COMPENSATION = 1.10"

$$\text{SHELL THK.} = 5.525 + 1.100 = 6.625"$$

HEAD PLATE

$$t_2 = \frac{P \cdot L}{2SE - 0.2P} = \frac{2840 \times 30.0}{2 \times 17124 \times 1.0 - 0.2 \times 2840} = 2.529$$

$$t_3 = 2t_2 + b = 2 \times 2.529 + .030 = 5.088$$

MANHOLE COVER PLATE

$$t_c = D \sqrt{CP/S}$$

$$t_c = 17.0 \sqrt{\frac{.3 \times 2840}{17124}} = 3.791$$

USE 4.00 THK. PL

PROJ. 900-130

Made By L.F. 2-6-73Checked By RBL Date 2-13-73

REV.

DRAWING NO. 07670-1A1472-00

60" I.D. STEAM DRUM

LMFBR - 30 MWT STEAM GENERATOR

5.0" O.D. RELIEF TUBE NIPPLES

Sheet 3 Of 3

Contract No. 7670

Reference Drawing 07670-1E1402

USE 6.0" O.D. x 1.75 MIN. WALL SA-335 P-22

$$T_{NR} = \frac{P \times D_1}{2 \times S - 1.2 P} = \frac{2840 \times 3.75}{2 \times 15000 - 1.2 \times 2840} = .401$$

$$\frac{S_N}{S_H} = \frac{15000}{17124} = .876$$

REMOVE RING BY
BORING OUT TO 3.75" ϕ

$$A_R = 3.50 \times 5.525 = 19.337$$

$$A_1 = 2.812 \times 2 \times .724 \times .876 = 3.567$$

$$A_2 = (19.00 - 3.75) \times 1.10 + (.435 \times .25) = 16.884$$

$$A_w = .375 \times .5 \times .5 \times 2 \times .876 = \frac{.164}{20.615}$$

$$W = 19.337 - 16.884 = 2.453$$

$$A = 1.57 \times (3.75 + 1.125) \times 1.125 \times .60 \times .876 = 4.525$$

$$A + B \rangle w$$

$$B = 1.57 \times 6.0 \times .375 \times .49 \times .876 = 1.515$$

$$= 1.515$$

$$C = 1.57 \times (3.75 + 1.125) 1.125 \times .70 \times .876 = 5.280$$

$$c > w$$

$$NAR = .70 \times 20.75 \times 5.525 = 80.250$$

$$NA = (20.75 - 3.75) 6.625 + (.25 \times 5.525) = 114.006 > NAR$$

CIRC @ 15° $15^\circ \text{ ARC} = \frac{3.1416 \times 33.312 \times 15}{180} = 8.721$ MID. R = 33.312"

$$A_R = (3.5 \times .5 \times 5.525) = 9.668$$

$$A_1 = (8.721 - 3.5) \times 2.762 + (8.721 - 3.75) \times 1.10 = 19.888 > A_R$$

PROJ. 900-130

Made By 1.F. 2-6-73

Checked By RGL Date 2.13.73

REV.

DRAWING NO. 07670-1A1473-00

INDEX NO. SD 1 10

COMBUSTION ENGINEERING, INC.

Form SFA328 (1-64)

CALCULATION SHEET

60" I.D. STEAM DRUM

Sheet 1 of 7

Contract No. 7670

LMFBR - 30 MWT STM. GENERATOR

Reference Drawing 07670-1E1402

SHELL PLATE

$$t = \frac{PR}{SE - .6P} + C \quad t = \frac{2840 \times 30.0}{17124 \times 1.0 - 0.6 \times 2840} + 0 = 5.525$$

15420

ADDITIONAL THK. REQD FOR OPENINGS COMPENSATION = 1.100"

$$SHELL THK = 5.525 + 1.100 = 6.625$$

HEAD PLATE

$$t_2 = \frac{PL}{2SE - 0.2P} = \frac{2840 \times 30.0}{2 \times 17124 \times 1.0 - 0.2 \times 2840} = 2.529$$

33680

$$t_3 = 2t_2 + b = 2 \times 2.529 + .030 = 5.088$$

M.H. COVER PLATE

$$t_c = D \sqrt{CP/S} = 17.0 \sqrt{\frac{.3 \times 2840}{17124}} = 3.791$$

Use 4.00

PROJ. 900-130

Made By I.F. 2-9-73

Checked By R.B.L. Date 2-12-73

DRAWING NO. CUST 1 OF 7

INDEX NO SD 110

Form SFA328 (1-64)

FOR 60" I.D. STEAM DRUM 6'-6" ϕ TO ϕ W.

Sheet 2 of 7

Contract No. 7670

Reference Drawing

MATERIAL: SHELL PLATE SA-387 - D NORM. & TEMP.

HEAD PLATE SA-387.- D - - - -

1 - DOWNCOMER 8,625 O.D. SCH. 160 SA-335 P-22

1 - FEED WATER 6.625 O.D.

6 - RELIEF TUBES 5.0" O.D. x .480 M.W.T. SA-213 T-22

3 - STM, CONN. 3.5" O.D., .340 M.W.T. — — —

$$\frac{S_H}{S_S} = \frac{15000}{17124} = .876$$

CONSTRUCTION RULES A.S.M:E SECT. I

PROJ. 900-130

Made By J.F. 2-7-73
Checked By R.E.L. Date 2-12-73

~~ENCLOSURE~~ SHEET 2 OF 7

COMBUSTION ENGINEERING, INC.

Form SFA328 (1-64)

CALCULATION SHEET

60" I.D. STEAM DRUM

Sheet 3 Of 7

LMFBR - 30MWT STEAM GENERATOR

Contract No. 7670

3.5 STM. CONN.

Reference Drawing 07670-1E1402

$$T_{NR} = \frac{2840 \times 2.75}{2 \times 15000 - 1.2 \times 2840} = .294$$

$$\frac{S_H}{S_S} = \frac{15000}{17124} = .876$$

$$A_R = (2.75 \times 5.525) + (3.5 - 2.75) \times .38 = 15.479$$

$$A_1 = (17.25 - 2.75) \times 1.10 = 15.950$$

$$A_2 = 1.562 \times 2 \times .331 \times .876 = 0.906$$

$$A_3 = (.655 + .38) \times .262 \times 2 \times .876 = 0.476$$

$$A_W = .5 \times .375 \times .375 \times 2 \times .876 = 0.123$$

$$17.455$$

$$W = 15.479 - 15.950 = 0$$

$$A = 1.57 \times (2.75 + .625) \times .625 \times .60 \times .876 = 1.740 \quad A+B > W$$

$$B = 1.57 \times 4.0 \times .375 \times .49 \times .876 = 1.010 \quad C > W$$

$$C = 1.57 \times (2.75 + .625) \times .625 \times .70 \times .876 = 2.030$$

CIRC @ 15°

$$15^\circ \text{ ARC} = \frac{3.1416 \times 38.312 \times 15}{180} = 8.72$$

$$A_2 = (2.75 \times .5 \times 5.525) + (.38 \times .262 \times 2) = 7.798$$

$$A_1 = (8.721 - 2.75) \times .3853 + N_{022} = 22.95 \quad A_1 > A_R$$

$$A_2 =$$

PROJ. 900-130

Made By 1.1
Checked By RBL Date 2-12-73

DRAWING NO. CHEET 3 OF 7

COMBUSTION ENGINEERING, INC.

CALCULATION SHEET

For 60 I.D. STEAM DRUM
LMFBR 30-MWT STM. GENERATOR
8.625 DOWNCOMER NOZZ,

Sheet 4 of 7
 Contract No. 7670
 Reference Drawing _____

STATIC H.D. $\frac{166-0}{106-6} = 59.5 \text{ FT}$

$$59.5 \times .214 = 13 \text{ PSI}$$

DOWNCOMER B.W.E

$$t_{\text{MIN}} = \frac{2875 \times 8.625}{30000 + .8 \times 2875} = .768$$

$$\text{SCH 160} = .793 \text{ MIN}$$

$$T_{\text{HR}} = \frac{2840 \times 6.75}{30000 - 1.2 \times 2840} = .721$$

$$\frac{S_N}{S_s} = \frac{15000}{17124} = .876$$

$$A_R = 12.75 \times 5.525 = 70.444$$

$$A_1 = (26.00 - 12.75) \times 1.10 = 14.575$$

$$A_2 = [6.625 \times 2 \times 3.00 - (.75 \times .75)] \times .876 = 34.327$$

$$A_3 = 7.50 \times 2 \times 2.279 \times .876 = 29.946$$

$$78.848$$

$$W = 70.444 - 14.575 = 55.869$$

$$A = 1.57 \times .49 \times 12.75 \times .5 \times .876 = 4.296$$

$$B = 1.57 \times .74 \times 12.75 \times 6.342 = 93.944$$

$$D = 1.57 \times .70 \times (6.75 + 3.00) \times 3.0 \times .876 = 28.159$$

$$A + B > W \quad A + D > W_1$$

$$W_1 = 55.869 - 34.327 = 21.542$$

AV. GROOVE WELD

$$\frac{6.06 + 6.625}{2} = 6.342$$

PROJ. 900-130

Made By LP
 Checked By RBL Date 2-12-73

DRAWING NO. 7670-73 SHEET 4 OF 7

COMBUSTION ENGINEERING, INC.

Form SFA328 (1-64)

CALCULATION SHEET

For 60" I.D. STEAM DRUM

Sheet 5 of 7

LMFBR 30MWT STM. GENERATOR

Contract No. 7670

6" FEED NOZZLE

Reference Drawing

$$T_{RN} = \frac{2840 \times 6.188}{2 \times 15000 - 1.2 \times 2840} = .663$$

166'-0"
- 101'-4"
64'-8"

26592 64.67 x .214 = 13.84 PSI

$$L_P = \frac{2855 \times 6.625}{30000 \times 1 + 0.8 \times 2855} = .586$$

32284

$$6" \text{ SCH. 160} = .629$$

$$\frac{S_N}{S_s} = \frac{15000}{17124} = .876$$

$$A_R = 10.188 \times 5.525 = 56.288$$

$$A_1 = (23.438 - 10.188) 1.10 - (2 \times 2.714 \times .906 \times .5) = 12.112$$

$$A_2 = (3.75 + 6.625) \times 2 \times .876 \times 2.00 = 36.354$$

$$A_3 = 1.337 \times 5.00 \times 2 \times .876 = 11.712$$

$$A_w = 60.178$$

$$W = 56.288 - 12.112 = 44.176$$

$$W_1 = 44.176 - (2.0 \times 6.625 \times 2 \times .876) = 20.962$$

$$A = 2 \times 1.57 \times 10.188 \times .5 \times .49 \times .876 = 6.865$$

$$D = 3.14 \times (6.188 + 2.0) \times 2.0 \times .70 \times .876 = 31.531$$

$$B = 1.57 \times 10.188 \times 6.625 \times .74 = 78.415$$

$$D > W_1 \quad A+B > W$$

$$NAR = .7 \times 25.0 \times 5.525 = 96.687$$

$$NA = [25.0 - \frac{1}{2}(10.188 + 12.75)] \times 6.625 + (2.0 + 3.0) 6.625 \times .876$$

$$NA = 118.66$$

PROJ. 900-130

Made By 2-7-77
Checked By RBL Date 2-12-73

DRAWING NO. SHEET 5 OF 7

COMBUSTION ENGINEERING, INC.

CALCULATION SHEET

For 60" I.D. STEAM DRUM Sheet 6 Of 7
LMFBR 30 MWT STM. GENERATOR Contract No. 7670
DRUM WEIGHT Reference Drawing _____

$$\text{SHELL } \pi \times 3.1416 \times (36.625^2 - 30.0^2) \times 78.0 \times .2833 = 30,641$$

$$\text{HEAD } \pi \times 3.1416 \times \frac{4}{3} (35.104^3 - 30.0^3) \times .2833 + = 19,293$$

$$+ 3.1416 \times 6 (35.525^2 - 30.0^2) \times .2833 = 1,933$$

51,867

NOZZLES

$$\text{DOWNCOM. } 1 \times 91.90 \times 10.5 \times .2833 = 273.$$

$$\text{FEED } 1 \times 60.69 \times 13.5 \times .2833 = 232.$$

$$\text{RELIEF } 6 \times 18.65 \times 6.0 \times .2833 = 190.$$

$$\text{S.H. } 3 \times 6.62 \times 6.0 \times .2833 = 34.$$

$$\text{S.V. } 2 \times 7.5 \times 10.0 \times .2833 = 43.$$

52,639

HOLES:

$$1 \times 35.72 \times 6.625 \times .2833 = 67.14$$

$$1 \times 30.07 \times 6.625 \times .2833 = 56.37$$

$$6 \times 9.65 \times 6.625 \times .2833 = 108.70$$

$$3 \times 5.95 \times 6.625 \times .2833 = 33.50$$

- 265.71

INTERNALS

2,500

WEIGHT TOTAL = 54,874

USE 55,000 Lb

PROJ. 900-130

Made By L.F.
 Checked By R.B.L. Date 2-12-73

DRAWING NO. SHEET 6 OF 7

COMBUSTION ENGINEERING, INC.

CALCULATION SHEET

For 60" I.D. STEAM DRUM

Sheet 7 Of 7

LMFBR 30MWT STEAM GENERATOR

Contract No. 7670

5 O.D. RELIEF TUBE NIPPLES

Reference Drawing

USE 6.0" O.D. x 1.75 MIN. WALL SA-335 P-22

$$T_{NR} = \frac{2840 \times 3.75}{30000 - 1.2 \times 2840} = .401$$

$$\frac{S_H}{S_S} = \frac{15000}{17124} = .876$$

REMOVE RING
BY BORING OUT TO 3.75" ϕ

$$A_R = 3.50 \times 5.525 = 19.337$$

$$A_1 = 2.812 \times 2 \times .724 \times .876 = 3.567$$

$$A_2 = (19.00 - 3.75) \times 1.100 + (.435 \times .25) = 16.884$$

$$A_w = .375 \times .5 \times .5 \times 2 \times .876 = \frac{.164}{20.615}$$

$$W = 19.337 - 16.884 = 2.453$$

$$A = 1,57 \times (3,75 + 1,125) \quad 1,125 \times 0,60 \times 0,876 = 4,525 \quad A+B > w$$

$$B = 1.57 \times 6.0 \times .375 \times .49 \times .876 = 1.515 \text{ C} > W$$

$$C = 1,57 \times (3,75 + 1,125) \quad 1,125 \times 70 \times 876 = 5.280$$

$$NAR = .70 \times 20.75 \times 5.525 = 80.250$$

$$NA = (20.75 - 3.75)6.625 + .25 \times 5.525 = 114.006 > N.A.R$$

PROJ. 900-130

Made By _____
Checked By R B L Date 2-12-73

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER _____ CONT. No. _____ MADE BY _____ DATE _____
LOCATION _____ DWG. No. _____ CHK'D BY _____ DATE _____

PRELIMINARY
STRUCTURAL ANALYSIS
OF
PIPING SYSTEM
FOR
30 MW STEAM GENERATOR
PROJ. #900-130
REF. CONTR. #7670

PREPARED BY:

L.H. KHANT

C.C. KOSTUKEVICH

W.D. MICHAELIAN

A.P. WIVAGG

CHECKED BY:

E.D. SSINEGURSKI

FEBRUARY 16, 1973

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER LMFBR CONT. No. PR 900-130 MADE BY _____ DATE 2-16-73
LOCATION _____ DWG. No. _____ CHK'D BY _____ DATE _____

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3. CALCULATION OF FEED WATER LINE 16-23

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DISCHARGE LINE & DUMP LINE 31-41

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& DUMP LINE 51-65

6. CALCULATION OF S.H. INLET LINE &

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7. CALCULATION OF S.H. OUTLET LINE &

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8. S.H. SODIUM INLET LINE

111-115

9. SODIUM CROSSOVER LINE

121-129

10. EVAPORATOR SODIUM OUTLET LINE

131-135

11. 16" O.D. VENT LINE FROM STEAM/WATER

SH. 1 DUMP TANK

141-145

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFER CONT. No. PR 900-130 MADE BY ES DATE 2-16-73
LOCATION _____ DWG. No. _____ CHK'D BY _____ DATE _____

PAGE 2

12. 12³/₄" O.D. VENT LINE FROM SODIUM/
WATER REACTION RELIEF VENT TANK 151-156

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER LMFBR CONT. No. PR 900-130 MADE BY E.S. DATE 2-15-73
LOCATION _____ DWG. No. _____ CHK'D BY _____ DATE _____

Abstract

This analysis presents the preliminary analysis of the piping lines listed in table of contents. The stresses listed are those resulting from the pressure, weight flexibility analysis and static seismic analysis of the piping systems.

The stresses listed are satisfactory and meet the appropriate allowables from the Power Piping Code B 31.1.0.1967. Ref. 1.

Maximum forces and moments acting from the piping system due to expansion, weight, and static equivalent seismic loading acting on the equipment or structural steel required for their design are tabulated for each respective piping.

All piping analysis except sizing of piping were performed using Piping Flexibility Analysis Program MEL-21. Ref. 5.

All sizing of Piping was made, when required, as per Power Piping Code B 31.1.0. Ref. 1.

Where necessary information was missing assumptions were made as indicated in the calculations.

Copies of piping analysis (Machine outputs) are available on request.

7670

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.CUSTOMER LMFBR 30MWT STM. BLK. CONT. NO. PR 900-130 MADE BY APW DATE 2-15-73
LOCATION REFERENCE LIST DWG. No. _____ CHK'D BY _____ DATE _____REFERENCES:

1. USA STANDARDS COMMITTEE B31
CODE OF PRESSURE PIPING 104.1.2(a)
2. C.E. DRAWING 07670-1F-0109
3. C.E. DRAWING 07670-1E-0131
4. C.E. DRAWING 07670-1E-0132
5. MEC-21/7094 PIPING FLEXIBILITY
ANALYSIS PROGRAM
6. WATER-SIDE DUMP SYSTEM FOR THE
EVAPORATOR & SUPERHEATER LETTER
OF 1-8-73 BY C. Y. SUN
7. ORDERING DATA - SODIUM HEATED
STEAM GENERATOR - APPX. 30 MW STM. GEN.
FOR TEST. AT SCTA OCT. 72 REF: ROTE4-16T
NUCLEAR COMP. DEPT., CHATT. TENN.
8. 30MWT MODEL CONT 7670 LETTER
FBR-72-292/11406 DATED 12-29-72
BY J. P. PETREX
9. NUCLEAR PROP. ENG. LETTER BY G.E. ST. CIN
DATED 1-26-72 BY R. C. KEIRSTEAD
10. CONT. PERFORM. DESIGN MEMO BY
R. C. KEIRSTEAD ON FLUID PROPERTIES
DATED 1-31-72

7670

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFER 30MW ST. BLR CONT. NO. PR 900-130 MADE BY APIW DATE 2-16-73
 LOCATION REFERENCE LIST DWG. No. _____ CHK'D BY _____ DATE _____

REFERENCES (CONT.)

22. FLEXIBILITY ANALYSIS OF DOWNCOMER, PUMP DISCH. LINE (EVAP. INLET LINE) & DUMP LINE (COMPUTOR OUTPUT NUAW1)
23. WEIGHT ANALYSIS OF DOWNCOMER, PUMP DISCH. LINE, & DUMP LINE (COMPUTOR OUTPUT NUAW1)
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31. 6" FEED NOZZLE CALCULATION SHEET #5 FOR 60" I.D. ST. DRUM MADE BY I.F. DATED 2-7-73
32. 8.625" DOWNCOMER NOZZLE CALCULATION SHEET #4 FOR 60" I.D. ST. DRUM MADE BY I.F. DATED 1-10-73

7670

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR 30MWT STM.BLR CONT. No. PR 900-130 MADE BY APW DATE 2-15-73LOCATION REFERENCE LIST DWG. No. _____ CHK'D BY _____ DATE _____REFERENCES (CONT.)

11. WATER-STEAM DUMP SYSTEM LETTER
BY B.F. LOVE DATED 2-7-73.
12. C/E DESIGN STANDARD (PIPING INSULATION)
SS-6.13.29 DWG B-993-202
13. ASME BOILER AND PRESSURE VESSEL CODE
SECTION I - POWER BOILERS
14. FLEXIBILITY ANALYSIS OF SODIUM CROSSOVER
LINES (COMPUTOR OUTPUT NUAW2)
15. WEIGHT ANALYSIS OF SODIUM CROSSOVER
LINES (COMPUTOR OUTPUT NUAW2)
16. SEISMIC ANALYSIS OF SODIUM CROSSOVER
LINES X-Y DIRECTION (COMPUTOR OUTPUT
NUAW2)
17. SEISMIC ANALYSIS OF SODIUM CROSSOVER
LINES Y-Z DIRECTION (COMPUTOR OUTPUT
NUAW2)
18. FLEXIBILITY ANALYSIS OF FEEDWATER LINE
(COMPUTOR OUTPUT NUAW4)
19. WEIGHT ANALYSIS OF FEEDWATER LINE
(COMPUTOR OUTPUT NUAW4)
20. SEISMIC ANALYSIS OF FEEDWATER LINE
X-Y DIRECTION (COMPUTOR OUTPUT NUAW4)
21. SEISMIC ANALYSIS OF FEEDWATER LINE
Y-Z DIRECTION (COMPUTOR OUTPUT NUAW4)

7670

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR 30 MWT STM. BCR CONT. No. PR 900-130 MADE BY APW DATE 2-16-73LOCATION REFERENCE LIST DWG. No. _____ CHK'D BY _____ DATE _____REFERENCES (CONT.)

33. FLEXIBILITY ANALYSIS OF SODIUM OUTLET LINE (COMPUTOR OUTPUT NUCK3)
34. FLEXIBILITY ANALYSIS OF SODIUM INLET LINE (COMPUTOR OUTPUT NUCK4)
35. FLEXIBILITY ANALYSIS OF SH. INLET LINE WITH DUMP LINE (COMPUTOR OUTPUT NUM01)
36. FLEXIBILITY ANALYSIS OF SH. INLET LINE WITH DUMP LINE, WITH VALVE ON DUMP LINE OPEN AND SHUT (COMPUTOR OUTPUT NUM02)
37. FLEXIBILITY ANALYSIS OF SH. INPUT LINE WITH DUMP LINE FOR SEISMIC LOADING IN X-Y PLANE AND IN Z-Y PLANE. (COMPUTOR OUTPUT NUM03)
38. FLEXIBILITY ANALYSIS OF SH. OUTLET LINE WITH DUMP LINE (COMPUTOR OUTPUT NUM04)
- 150 (39. FLEXIBILITY ANALYSIS OF 16" OD VENT LINE FROM STEAM-DUMP TANK; SEISMIC LOADING IN X-Y PLANE (COMPUTOR OUTPUT NUAL 4)]
40. FLEXIBILITY ANALYSIS OF 16" OD VENT LINE FROM STEAM WATER-DUMP TANK; THERMAL EXPANSION. (COMPUTOR OUTPUT NUAL 5)
41. FLEXIBILITY ANALYSIS OF 16" OD VENT LINE FROM STEAM WATER-DUMP TANK; DEAD LOAD. (COMPUTOR OUTPUT NUAL 6)

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COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.C. MER LMFBR 30 MWT STM. GEN. CONT. NO. 000-130 MADE BY APW DATE 2-16-73
LOCATION REFERENCE LIST DWG. No. CHK'D BY DATEREFERENCES (CONT.)

- 1
3
0 [42. FLEXIBILITY ANALYSIS OF 16" OD VENT LINE FROM
STEAM-WATER DAMP. TANK; SEISMIC LOADING IN
Z-Y PLANE. (COMPUTOR OUTPUT NUAL7)]
43. FLEXIBILITY ANALYSIS OF 12 $\frac{3}{4}$ " OD VENT LINE FROM
SODIUM-WATER REACTION RELIEF VENT TANK; DEAD LOAD.
(COMPUTOR OUTPUT NUAL7)
44. FLEXIBILITY ANALYSIS OF 12 $\frac{3}{4}$ " OD VENT LINE FROM
SODIUM-WATER REACTION RELIEF VENT TANK; THERMAL.
(COMPUTOR OUTPUT NUAL8).
45. FLEXIBILITY ANALYSIS OF 12 $\frac{3}{4}$ " OD VENT LINE FROM
SODIUM-WATER REACTION RELIEF VENT TANK;
SEISMIC IN Z-Y PLANE. (COMPUTOR OUTPUT NUAL8)
46. FLEXIBILITY ANALYSIS OF 12 $\frac{3}{4}$ " OD VENT LINE FROM
SODIUM-WATER REACTION RELIEF VENT TANK;
SEISMIC IN X-Y PLANE (COMPUTOR OUTPUT NUAL1).

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COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.CUSTOMER UNITED STATES STEEL CORP. CONT. NO. PS 300-130 MADE BY APW DATE 2-6-73
LOCATION FLEETLINE DWG. NO. AW-4 CHK'D BY ES DATE 2-6-73PIPING DIAGRAMFOR DIMENSIONS SEE
REF. # 2, 3, 4

7670 COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER LMFER 30MWT MODEL CONT. No. PR 900 130 MADE BY APW DATE 2-13-73
LOCATION FEEDWATER LINE DWG. No. _____ CHK'D BY ES DATE 2-16-73

ALLOWABLE EXPANSION
STRESS

NW4

REF. 13 PART 102.3.2
C. EXPANSION STRESSES

$$S_A = F(1.25 S_C + 0.25 S_H)$$

$$F = 1 \text{ REF. 13 TABLE 102.3.2 (C) } \quad 7000 \text{ CYCLES}$$

$$S_C = 15 \text{ KSI} \quad S_H = 15 \text{ KSI} \quad \text{REF. 1 (TABLE PG. 23.1)}$$

S_A = ALLOWABLE EXP. STRESS

$$S_A = 1(1.25 \times 15 + .25 \times 15) = 22.50 \text{ KSI}$$

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COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFB32 30MWT MODEL CONT. No. PR 900-130 MADE BY APW DATE 2-14-73
 LOCATION FEEDWATER LINE DWG. No. _____ CHK'D BY ES DATE 2-14-73
SEISMIC LOADING AW 4

$6\frac{5}{8}$ " ϕ FEED LINE $5.615 \times .2236 = 1.2555$ #/IN

10.188" ϕ NOZZLE @ DRUM $16.329 \times .2236 = 3.6511$ #/IN

SLOPE ON NOZZLE $9.238 \times .2236 = 2.0767$ #/IN

VALVE $\frac{400}{24}$ # $= 16.6667$ #/IN

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COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER LMFBR 30MW MODEL CONT. No. PR 900-130 MADE BY APW DATE 2-14-73
 LOCATION FEEDWATER LINE DWG. No. _____ CHK'D BY ES DATE 2-17-73
SEISMIC LOADING AW 4

$6\frac{5}{8}$ " ϕ FEED LINE $5.615 \times .2236 = 1.2555$ #/IN

10.188" ϕ NOZZLE @ DRUM $16.329 \times .2236 = 3.6511$ #/IN

SLOPE ON NOZZLE $9.238 \times .2236 = 2.0767$ #/IN

VALVE $\frac{400}{24}$ # $= 16.6667$ #/IN

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COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR 30MW MODEL CONT. No. PR 900-130 MADE BY APW DATE 2-14-73
 LOCATION FEEDWATER LINE DWG. No. _____ CHK'D BY ES DATE 2-17-73
SEISMIC LOADING AW 4

6 5/8" b FEED LINE

$$5.615 \times .2236 = 1.2555 \text{ #/IN}$$

10.188" d NOZZLE @ DRUM

$$16.329 \times .2236 = 3.6511 \text{ #/IN}$$

SLOPE ON NOZZLE

$$9.238 \times .2236 = 2.0767 \text{ #/IN}$$

VALVE

$$\frac{400 \text{ #}}{24 \text{ v}}$$

$$= 16.6667 \text{ #/IN}$$

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COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFB2 - 30MWT MODEL CONT. No. PR 900-130 MADE BY APD DATE 2-12-73
 LOCATION FEEDWATER LINE DWG. No. _____ CHK'D BY ES DATE 2-12-73

<u>FEED. LINE</u>		6 5/8" ϕ .864" wall		
	DENSITY #/IN ³	AREA IN ²	#/IN	
PIPE	.283	15.638	4.425	
FLUID	.029	18.826	1545	
INS * * * 2 1/2"	.009	71.669	.645	
		TOTAL	5.615	
EQUIVALENT DENSITY =		$\frac{5.615}{15.638}$	= .359 #/IN ³	

<u>NOZZLE @ DRUM</u>		10.188" ϕ 2.00" wall		
	DENSITY #/IN ³	AREA IN ²	#/IN	
PIPE	.283	51.463	14.561	
FLUID	.029	30.075	1872	
INS * * * 2 1/2"	.009	99.664	.896	
		TOTAL	16.329	
EQU DENSITY =		$\frac{16.329}{51.463}$	= .317 #/IN ³	

<u>SLOPE ON NOZZLE</u>		8.188" ϕ 1.269" wall		
	DENSITY #/IN ³	AREA IN ²	#/IN	
PIPE	.283	27.586	7.806	
FLUID	.029	25.073	1727	
INS * * * 2 1/2"	.009	83.955	.1755	
		TOTAL	9.258	
EQU. DENSITY =		$\frac{9.258}{27.586}$	= .336 #/IN ³	

SCAFF $\approx$ FEEDLINE

** INS. REF. 12

CHART FOR SELECTION OF INS. THICK.

7670 COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER LMFR 30MWT MODEL CONT. No. PR 900-130 MADE BY APIU DATE 2-1-73
LOCATION FEEDWATER LINE DWG. No. _____ CHK'D BY ES DATE 2-1-73

ANKER MOVEMENTS

AW-4

ANKER 1 5

$$\begin{aligned}\Delta X &= 0 \\ \Delta Y &= .16790'' \\ \Delta Z &= .11191''\end{aligned}$$

ANKER 2 105

$$\begin{aligned}\Delta X &= 0 \\ \Delta Y &= 0 \\ \Delta Z &= 0\end{aligned} \left. \begin{array}{l} \\ \\ \end{array} \right\} \begin{array}{l} \text{NOT AVAILABLE} \\ \text{ASSUMED CLOSE TO } 0'' \end{array}$$

ANKER 1

DRUM SAT. TEMP. = 675°F (REF. 7 FIG. 4)

$$\Delta X = 0$$

$$\Delta Y = -3.125 \times .05373 = -.16790''$$

$$\Delta Z = -2.083 \times .05373 = -.11191''$$

7670 COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER L.M.FBR 30 MWT MODEL CONT. NO. PR 900-130 MADE BY APW DATE 2-6-73
 LOCATION FEEDWATER LINE DWG. No. _____ CHK'D BY ES DATE 2-1-73

CODE CALL. FOR PIPE WALL

FEEDWATER LINE TO STEAM DRUM

REF. 5. PAGE 10FZ ITEM 1

REF.

6 $\frac{5}{8}$ " O.D. DOUBLE EXTRA STRONG

DESIGN PRESS = 3000 PSIG TEMP. = 485°F

MATL. = ASTM-106-B

REF. 1 PART 27.2.2

$$t = \frac{PD}{2SE + 2YP} + C$$

PART 27.3 & 4

P = 3000 PSIG D = 6.625" WALL = .864"

E = 1 (NOTE 1) C = 0 (NOTE 3)

Y = 0.4 (NOTE 6)

S = 15 KSI (TABLE PG 22.1)

$$t = \frac{3000 \times 6.625}{2 \times 15000 \times 0.4 \times 3000} + 0 = .613" < .864"$$

XKS OK

7670

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.CUSTOMER UMFBR 30MWT STM. BLR CONT. NO. PR 900-130 MADE BY APW DATE 2-16-73
LOCATION FEEDWATER LINE DWG. No. _____ CHK'D BY _____ DATE _____ANALYSIS RESULTS

FLEXIBILITY

PT.	FORCES LB			MOMENTS FT.LB.		
	K	Y	Z	X	Y	Z
5	115	720	25	4720	-135	-3246
105	-115	-49	-26	1158	-1372	-1169
155	115	49	25	403	-1341	-572
160	-115	-49	-25	-349	1289	633

REF#18 MAX. STRESS = 3802 PSI @ POINT 20
ALLOWABLE STRESS = 22500 PSI

WEIGHT

5	-0	-902	19	-868	201	544
105	-2	-658	-17	1236	-68	667
155	2	692	17	-1226	347	-2442
160	-2	-292	-17	1232	-383	3825

REF#19

SH 22

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COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

OWNER LMFBIR 30 MW ST. GEN. CONT. NO. PR 900-130 MADE BY APW DATE 2-16-73
 LOCATION FEEDWATER LINE DWG. No. _____ CHK'D BY _____ DATE _____

ANALYSIS RESULTS

SEISMIC (X-Y DIRECTION)

PT.	FORCES LB.			MOMENTS FT. LB.		
	X	Y	Z	X	Y	Z
5	19	64	2	419	-90	161
105	-19	-3	-2	79	-312	24
155	19	3	2	21	-184	-215
160	-19	-3	-2	-21	179	214

REF #20

SEISMIC (Y-Z DIRECTION)

5	-1	20	5	-92	195	-148
105	1	5	-5	-156	256	169
155	-1	-5	5	30	-95	-46
160	1	5	-5	-28	84	35

REF #21

SH 23

7670

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR-30MWT MODEL CONT. No. PR 900-130 MADE BY APW DATE 1-26-71LOCATION DOWNCOMER, PUMP DISCH. DWG. No. _____ CHK'D BY AW 1 DATE 1-26-71LINE & DUMP LINE

ANKR-1 1
 ANKR-2 20
 ANKR-3 75

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COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER LMF 12-30 MWT MODEL CONT. No. PR900-130 MADE BY APW DATE 2-10-73
 LOCATION DCOMER PUMP DISCHARGE DWG. No. _____ CHK'D BY ES DATE 2-10-73

EQUIVALENT DENSITY CALC.

<u>DCOMER TO PUMP</u> $8\frac{5}{8}" \phi$.906" WALL			<u>AWI</u>
	DENSITY #/IN ³	AREA IN ²	#/IN
PIPE	.283	21.972	6.218
FLUID	.022	36.447	.801
INS** 3"	.009	109.568	.986
TOTAL			8.005 #/IN

$$\text{EQUIV. DENSITY} = \frac{8.005 \text{ #/IN}}{21.972 \text{ IN}^2} = .364 \text{ #/IN}^3$$

<u>PUMP DISCH LINE</u> $8\frac{5}{8}" \phi$ $1\frac{5}{16}"$ WALL			
	DENSITY #/IN ³	AREA IN ²	#/IN
PIPE	.283	22.610	6.355
FLUID	.022	35.809	.781
INS** 3"	.009	109.568	.986
TOTAL			8.171 #/IN

$$\text{EQUIV. DENSITY} = \frac{8.171}{22.610} = .361 \text{ #/IN}^3$$

<u>DRUM NOZZLE</u> $12" \phi$ 2.625" WALL			
	DENSITY #/IN ³	AREA IN ²	#/IN
PIPE	.283	77.325	21.882
FLUID	.022	35.787	.787
INS** 3"	.009	177.177	1.594
TOTAL			24.263 #/IN

$$\text{EQUIV. DENSITY} = \frac{24.263}{77.325} = .313 \text{ #/IN}^3$$

<u>SLOPE ON NOZZLE</u> $10.313" \phi$ 1.781" WALL			
	DENSITY #/IN ³	AREA IN ²	#/IN
PIPE	.283	47.739	13.510
FLUID	.022	35.787	.787
INS** 3"	.009	125.479	1.129
TOTAL			15.426 #/IN

$$\text{EQUIV. DENSITY} = \frac{15.426}{47.739} = .323 \text{ #/IN}^3$$

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COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR 30MW MODEL CONT. No. PR 900-130 MADE BY APW DATE 2-14-73
 LOCATION DCOME12A PUMP DISCHARGE DWG. No. _____ CHK'D BY ED DATE 2-14-73

EQUIVALENT DENSITY CALC. (CONT.)

AWIDUMP LINE 6 5/8" ϕ

.718 WALL

	DENSITY #/IN ³	AREA IN ²	#/IN
PIPE	.283	13.325	3.770
FLUID	.022	21.139	.465
INS * K 3"	.009	90.716	.816
		TOTAL	<u>5.051</u>

$$\text{EQUIV DENSITY} = \frac{5.051}{13.325} = .379 \text{ \#/IN}^3$$

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COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER LMFBR-30MWT MODEL CONT. NO. PR 900-130 MADE BY APW DATE 1-24-77
 LOCATION DWNCONV & PUMP DISCH. LINES DWG. No. _____ CHK'D BY ES DATE 1-25-77

ANKR-1 5 ΔX — .0 AWI
 (ANKR MOVEMENTS) ΔY — +.28286
 ΔZ — -.09512
 ANKR-2 20 ΔX — +.08125
 ΔY — -.11418
 ΔZ — -.07265
 ANKR-3 75 ΔX — .0
 ΔY — -.16787
 ΔZ — .0

ANKR-1

 ΔZ EVAPORATOR INLET FLUID TEMP. = 675° (REF. 7 FIG. 4)

$$.05372 \times 1.7708 = .09512$$

ΔY EVAP. INLET FLUID TEMP. = 675° (REF. 7 FIG. 4)
 SODIUM & GAS TEMP. = 860° (REF. 7 FIG. 4)

$$.05372 \times 2.4375 + .07366 \times 2.0625 = .28286$$

ANKR-2

TEMP = 445° (REF. 11 ITEM 5)

$$\Delta X \ 2.6094 \times .03114 = +.08125$$

$$\Delta Y \ 3.6667 \times .03114 = -.11418$$

$$\Delta Z \ 2.3333 \times .03114 = -.07265$$

ANKR-3

 ΔY DRUM FLUID TEMP. = 675° (REF. 7 FIG. 4)

$$.05372 \times 3.125 = .16787$$

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COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMF13K-30 MWT MODEL CONT. No. PR 900-130 MADE BY APW DATE 1-23-73
 LOCATION DCOMER 2 PUMP DISCH LINES DWG. No. _____ CHK'D BY ES DATE 1-25-73

CODE CALC FOR PIPE WALL
 PUMP DISCHARGE LINE

AWI

REF. 5 PAGE 1 OF 2 ITEM 5

8 $\frac{5}{8}$ " O.D. 15 $\frac{1}{16}$ " WALL (AVG.)
 MATL. SA 335 P-22 DESIGN PRESS. 2900 PSIG
 DESIGN TEMP. 688°F

REF. 1 PART 27.2.2

$$t = \frac{PD}{2SE + 2YP} + C$$

PART 27.3 & 4

P = 2900 PSIG D = 8.625"
 E = 1 (NOTE 1) C = 0 (NOTE 3)
 Y = 0.4 (NOTE 6)
 S = 15 KSI (TABLE DG 23.1)

$$t = \frac{2900 \times 8.625}{2 \times 15000 \times 1 + 2 \times 0.4 \times 2900} + 0 = .773" < .9375"$$

t = MIN. REQUIRED THICKNESS

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COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMF BR - 30 MWT MODEL CONT. NO. PR 900-130 MADE BY APIU DATE 1-23-73
 LOCATION DOWNCOMER & PUMP DISCH LINE DWG. No. _____ CHK'D BY ES DATE 1-25-73

CODE CALL FOR PIPE WALL
DOWNCOMER

AWI

REF. 5. PAGE 1 OF 2 ITEM 3

8 5/8" O.D. SCH. 160 .906" WALL
 MATL. SA 335 P-22 DESIGN PRESS. 2875 PSIG
 DESIGN TEMP. 688°F

REF. 1 PART 27.2.2

$$t = \frac{PD}{2SE + 2YP} + C$$

PART 27.3 & 4

P = 2875 PSIG

D = 8.625"

E = 1 (NOTE 1)

C = 0 (NOTE 3)

Y = 0.4 (NOTE 6)

S = 15100 SI (TABLE PG 23.1)

$$t = \frac{2875 \times 8.625}{2 \times 15000 \times 1 + 2 \times 0.4 \times 2875} + 0 = .767" < .906"$$

t = MIN. REQUIRED THICKNESS

< .793

7670 COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBIR 30MW T STM. GPN. CONT. No. PR 900-130 MADE BY APW DATE 2-15-73
 LOCATION DCOMMERZ PUMP DISCIT DWG. No. _____ CHK'D BY ES DATE 2-15-73

AWI

$$8\frac{5}{8}" \phi \text{ DCONCER TO PUMP } 8.005 \times .2236 = 1.7899 \text{ \# / IN}$$

.364

$$8\frac{5}{8}" \phi \text{ PUMP. DISCH. LINE } 8.171 \times \text{ " } = 1.8270$$

.361

$$12" \phi \text{ DRUM NOZZLE } 24.263 \times \text{ " } = 5.4252$$

.313

$$\text{SLOPE ON NOZZLE } 15.426 \times \text{ " } = 3.4492$$

.313

$$6\frac{5}{8}" \phi \text{ PUMP LINE } 5.055 \times \text{ " } = 1.1302$$

.379

PUMP		$\frac{60000 \text{ \#}}{25875}$	= 231.8640
.211	$2\frac{17}{32}"$	0.4449	
1.792	$1'-9\frac{1}{2}"$	3.2101	
1.000	$1'-0"$	1.0000	
		<u>4.6550</u>	
	$25875"$	$2'-1\frac{7}{8}"$	

$$8" \text{ VALVE } \frac{1600 \text{ \#}}{24 \text{ "}} = 66.6667$$

$$6" \text{ VALVE } \frac{700 \text{ \#}}{24 \text{ "}} = 29.1667$$

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COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

 CUSTOMER LMFBR 30MWT STM. 6EN CONT. No. PR 900-130 MADE BY APW DATE 2-16-73
 LOCATION DCOMER, PUMP DISCH. LINE DWG. No. _____ CHK'D BY ES DATE 2-16-73
& DUMP LINE
ANALYSIS RESULTS
 ANALYSIS POINT LOCATION & DESCRIPTION
 FOR ORIENTATION SEE PIPING DIAGRAM

PT.	X	Y	Z	LOCATION DESCRIPTION
10	-25.00	-49.667	-2917	EVAPORATOR WATER INLET NOZZLE
20	2.609	-60.667	19.083	EVAPORATOR INLET TO DUMP TANK
55	-17.750	-53.750	-5.00	INLET EVAPORATOR QUICK OPENING DUMP VALVE
60	-19.750	-53.750	-5.000	OUTLET " "
75	0	-3.125	0	DCOMER OUTLET NOZZLE AT DRUM
115	0	-58.50	0	INLET CIRCULATING PUMP
120	-17.92	-59.500	-1.211	OUTLET " "
125	-6.859	-59.500	-5.828	INLET CONTROL VALVE
130	-8.383	-59.500	-7.122	OUTLET " "
145	-20.333	-49.667	-10.583	INLET EVAPORATOR INLET QUICK CLOSING VALVE
150	-20.333	-49.667	-10.583	OUTLET " "

REF. # 22, 23, 24, & 25

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COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBIR 30 MWT STM-GPM CONT. NO. PR 900-130 MADE BY APW DATE 2-16-73
 LOCATION DUMPER, PUMP DISCH & DUMPLINES DWG. NO. _____ CHK'D BY ES DATE 2-16-73

ANALYSIS RESULTS

FLEXIBILITY (COLD DUMP COND.)

PT	FORCES LB.			MOMENTS FT. LB.		
	X	Y	Z	X	Y	Z
10	-464	-1143	-168	-2441	3055	-16916
20	28	-14	-10	-294	-557	-195
55	-28	14	10	-127	-330	297
60	28	-14	-10	127	350	-326
75	435	1157	178	-2621	-210	8544
115	-435	-1157	-178	-7257	210	15590
120	435	1157	178	7191	-433	-13951
125	-435	-1157	-178	-687	-1106	8085
130	435	1157	178	-810	1398	-6320
145	-435	-1157	-178	6571	-774	-11800
150	435	1157	178	-6571	418	14116

REF # 22

MAX. STRESS = 6818 PSI @ PT. 155
 ALLOWABLE STRESS = 22500 PSI

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COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBIC 30MWT STM. GEN. CONT. NO. PR 900-430 MADE BY APW DATE 2-16-73
 LOCATION DCOMER, PUMP DISCH & DUMP LINE DWG. NO. _____ CHK'D BY ES DATE 2-16-73

ANALYSIS RESULTS

FLEXIBILITY (HOT DUMP COND.)

	FORCES LB.			MOMENTS FT. LB.		
PT.	X	Y	Z	X	Y	Z
10	-1114	-957	-639	980	9733	-18774
20	680	-185	468	-2214	-8631	-5064
55	-680	185	-468	988	1765	-483
60	680	-185	468	-988	-2701	62
75	433	1143	171	-2339	-132	3471
115	-433	-1143	-171	-7155	132	15501
120	433	1143	171	7085	-348	-13826
125	-433	-1143	-171	-664	-1216	8093
130	433	1143	171	-815	1515	-6351
145	-433	-1143	-171	6457	-966	-11567
150	433	1143	171	-6457	623	13856

REF # 22

MAX. STRESS = 6699 PSI @ PT. 155

ALLOWABLE STRESS = 22500 PSI

WINDSOR, CONN.

ANKR - 1	5
2	20
3	165
4	195
5	215
6	245
7	265
8	295

PIPING DIAGRAM

FOR DIMENSIONS SEE
REF. # 2, 3, 4

FRONT

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COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFB2-30MWT MODEL CONT. NO. PR-900-130 MADE BY APW DATE 2-8-73
 LOCATION EVAP OUTLET LINE DWG. No. _____ CHK'D BY ES DATE 2-10-73

EQUIVALENT DENSITY CALC.AIN3EVAP OUTLET RELIEF TUBES 5"φ

	DENSITY #/IN ³	AREA IN ²	#/IN
TUBE	.283	6.818	1.929
FLUID	.005	12.819	.064
INS ** 2 1/2" THK	.009	58.913	.530
TOTAL			2.523 #/IN

$$\text{EQUIVALENT DENSITY} = \frac{2.523 \text{ #/IN}}{6.818 \text{ IN}^2} = .370 \text{ #/IN}^3$$

EVAP. OUTLET DISTB HOR 12 3/4"φ

	DENSITY #/IN ³	AREA IN ²	#/IN
PIPE	.283	41.091	11.628
FLUID	.005	85.599	.427
INS ** 3" THK	.009	148.460	1.336
TOTAL			13.391 #/IN

$$\text{EQU. DENSITY} = \frac{13.391 \text{ #/IN}}{41.091 \text{ IN}^2} = .325 \text{ #/IN}^3$$

EVAP. OUTLET LINE

8 5/8"φ

15/16 wall

	DENSITY #/IN ³	AREA IN ²	#/IN
PIPE	.283	22.610	6.398
FLUID	.005	35.809	.179
INS ** 3"	.009	109.568	.986
TOTAL			7.563 #/IN

$$\text{EQUIVALENT DENSITY} = \frac{7.563 \text{ #/IN}}{22.610 \text{ IN}^2} = .334 \text{ #/IN}^3$$

** REF. 12 CHART FOR SELECTION OF PIPE INS. THK.
 SH. #52

7670

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR - 30 MW T MODEL CONT. NO. PR 900-130 MADE BY APW DATE 2-9-73
 LOCATION EVAP OUTLET LINE DWG. No. _____ CHK'D BY ES DATE 2-10-73

EQUIVALENT DENSITY CALCAW312³ TO 8⁵/₈ REDUCER

	DENSITY #/IN ³	AREA IN ²	#/IN
PIPE	.283	31.275	8.850
FLUID	.005	58.419	1292
INS * * 3"	.009	129.004	<u>1.161</u>
		TOTAL	10.303 #/IN

$$\text{EQUIVALENT DENSITY} = \frac{10.303 \text{ #/IN}}{31.275 \text{ IN}^2} = .329 \text{ #/IN}^3$$
EVAP OUTLETDUMP LINES 6⁵/₈"

	DENSITY #/IN ³	AREA IN ²	#/IN	
PIPE	.283	13.325	3.770	
FLUID	.005	21.139	.105	
INS * * 3"	.009	102.897	<u>.926</u>	
		TOTAL	4.801	#/IN

$$\text{EQUIVALENT DENSITY} = \frac{4.801}{13.325} = .360 \text{ #/IN}^3$$

SH.53

SP 11581A

** REF. 12 CHART FOR SELECTION OF PIPE INS. THICK.

7670

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.CUSTOMER LMFBK 30MNT MODEL CONT. No. 7670 MADE BY APU DATE 2-13-71
LOCATION EVAPORATOR OUTLET LINE DWG. No. _____ CHK'D BY ES DATE 2-14-73

SEISMIC LOADING

AW3

5" ϕ RELIEF TUBES	2.523 #/IN	X	.2236	=	.5641 #/IN
12 $\frac{3}{4}$ " ϕ DISTB. HOR	13.391	"	"	=	2.9942
8 $\frac{5}{8}$ " ϕ DISCH LINE	7.563	"	"	=	1.6910
8 $\frac{5}{8}$ " ϕ OUTLET LINE	7.563	"	"	=	1.6910
12 $\frac{3}{4}$ " TO 8 $\frac{5}{8}$ " REDUCER	10.303	"	"	=	2.3037
6 $\frac{5}{8}$ " ϕ DUMP LINE	4.801	"	"	=	1.0735
8" VALVE	$\frac{1600 \#}{24 \#}$			=	66.667 #/IN
6" VALVE	$\frac{700 \#}{24 \#}$			=	29.167

SAFETY VALVE $250 \# \times .2236 = 55.9 \#$

7670

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER LMFER - 30 MWIT MODEL CONT. NO. PR 900-130 MADE BY APW DATE 2-6-73
 LOCATION EVAP. OUTLET LINE DWG. No. _____ CHK'D BY ES DATE 2-10-73
CODE CALL FOR PIPE WALL AW3

EVAPORATOR IN-OUT DUMP LINES - DOWNSTREAM

REF. 11 ITEM 2

6 5/8" O.D. SCH #30

MATL SA-106B (see memo by C.S. PER R.K.)

PRESS = 2900 PSIG

TEMP. = 688 °F

REF. 1 PART 27.2.2.

$$t = \frac{PD}{2SE + 2YP} + C$$

PART 27.34.4

P = 2900 PSIG D = 6.625"

E = 1 (NOTE 1) C = 0 (NOTE 3)

Y = 0.4 (NOTE 6)

S = 15 KSI (TABLE PG 23.1)

$$t = \frac{2900 \times 6.625}{2 \times 15000 \times 1 + 2 \times 0.4 \times 2900} + 0 = .594 \quad \text{SCH #30}$$

4.432

< .718

SCH #160

7670

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER LMFBR-30MW MOD 12 CONT. No. PR 900-130 MADE BY APN DATE 1-31-73
 LOCATION EVAP. OUTLET LINE DWG. No. _____ CHK'D BY ES DATE 2-12-73

ANKR-1	5	ΔX	.14328
		ΔY	.35900
		ΔZ	.0
(ANKR MOVEMENTS) 2	20	X	.0527
		Y -	.0828
		Z -	.0589
3	165	X	.04351
		Y	.16216
		Z	.09290
4	195	X -	.04351
		Y	.16216
		Z	.09290
5	215	X	.04351
		Y	.16216
		Z	.0
6	245	X -	.04351
		Y	.16216
		Z	.0
7	265	X	.04351
		Y	.16216
		Z -	.09290
8	295	X -	.04351
		Y	.16216
		Z -	.09290

AW-3
 T=675 H₂O
 860 Na

T=350°

T=675

ANKR-1

 ΔX EVAP. OUTLET FLUID TEMP. 675° (REF. 7 FIG. 4)

$$.05373 \times 2.6667 = .14328$$

ΔY EVAP. INLET FLUID TEMP 675° { " " }
 SODIUM & GAS TEMP 860° { " " }

$$.05373 \times 3.8542 + .07366 \times 2.0625 = .35900$$

1670

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.CUSTOMER LMF1312-30 MWT MODEL CONT. No. PR 900-130 MADE BY APW DATE 1-31-73
LOCATION EVAP OUTLET LINE DWG. No. _____ CHK'D BY ES DATE 2-12-73ANCHOR MOVEMENTS (CONT.)
ANCHORS-3 THRU 8AW-3TEMP @ DRUM = 675° (REF. 7 FIG. 4)

9.41308	9.98494
$.49485$	$.49485$
9.90785	0.47979

$$\Delta Y \quad 3.0182 \times .05373 = + .16216$$

$$\Delta X \quad .8099 \times .05373 = \pm .04351$$

$$\Delta Z \quad 1.7292 \times .05373 = \pm .09290$$

ANCHOR-2

TEMP @ TRUNK 445° (REF 11. ITEM 5)

$$\Delta X \quad 2.3333 \times .03114 = + .07265$$

$$\Delta Z \quad 2.6094 \times .03114 = - .08125$$

$$\Delta Y \quad 3.6667 \times .03114 = -.11418$$

DESIGN
400 445
PSIG OF

7670

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR - 30 MW T MODEL CONT. No. PR 900-130 MADE BY APW DATE 1-31-73
 LOCATION EVAP. OUTLET LINE DWG. No. _____ CHK'D BY ES DATE 2-12-73

CODE CALC. FOR PIPE WALL
RELIEF TUBES

REF. 5 PAGE 1 OF 2 ITEM 8

5" O.D. .480 MW T

MATL. SA 213 T22 DESIGN PRESS 2840 PSIG

DESIGN TEMP. 688°F

REF. 1 PART 27.2.1

$$t = \frac{PD}{2S + P} + .005D + e$$

PART 27.3 & 4

P = 2840 PSIG D = 5"

S = 15 KSI (TABLE PG 23.1)

e = 0 (NOTE 4)

$$t = \frac{2840 \times 5}{2 \times 15000 + 2840} + .005 \times 5 + 0 = .457" < .480"$$

7670

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER LMFBR-30MW MODEL CONT. No. PR 900-130 MADE BY APW DATE 1-31-73
 LOCATION EVAP. OUTLET LINE DWG. No. _____ CHK'D BY AS DATE 2-12-73

CODE CALL. FOR PIPE WALL

AW 3EVA PORATOR OUTLET LINE

REF. 5 PAGE 1 OF 2 ITEM 6

SAME AS PUMP DISCH. LINE ITEM 5

SEE

"

"

"

CALC. SHEET

EVAPORATOR OUTLET DISTRIBUTION HEADER

REF. 5 PAGE 1 OF 2 ITEM 7

12 $\frac{3}{4}$ " O.D. 10.50" I.D.

MATERIAL SA 387-D DESIGN PRESS 2900 PSIG.

DESIGN TEMP. 688°F

REF. 1 PART 27.2.2

$$t = \frac{PD}{2SE + 2YP} + C$$

PART 27.3 4.4

P = 2900 PSIG

D = 12.75"

E = 1 (NOTE 1)

C = 0 (NOTE 3)

Y = 0.4 (NOTE 6)

S = 17.1 KSI (TABLE PG 23.1) (NORMALIZED STRESS
REF. 9)

$$t = \frac{2900 \times 12.75}{2 \times 17100 \times 1 + 2 \times 0.4 \times 2900} + 0 = 1.012 < 1.125$$

$$\frac{12.75 - 10.50}{2} = 1.125$$

7670

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

TOMER LMFBR 30MWT MODEL PR-900-130 MADE BY APIU DATE 2-13-73
 LOCATION EVAPORATOR OUTLET LINE DWG. No. _____ CHK'D BY ES DATE 2-14-73
& DUMP LINE AW 3

LOADS & DISPLACEMENTS AT HANGER POINTS

STRESS PT. NO.	HGR. NO.	THERMAL LOAD LB	WEIGHT LOAD LB	ABSOLUTE		MVT. IN.
				ΔX	ΔY	ΔZ
47	7	0	-1455	.552	-.092	-.576
35	9	0	-777	.793	-.398	-.500
405	19	0	-2417	.402	.249	-.012
373	20	0	-5606	-.447	1.773	.365
317	21	0	-2247	-.926	1.350	.456

7670

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

 OWNER LMFB2 30MWT STM.GEN. CONT. No. PR 900-130 MADE BY ADW DATE 2-16-73
 LOCATION EVAP. OUTLET LINE & DUMPLINE DWG. No. _____ CHK'D BY ES DATE 2-16-73
ANALYSIS RESULTS
 ANALYSIS POINT LOCATION & DESCRIPTION
 FOR ORIENTATION SEE PIPING DIAGRAM

PT	X	Y	Z	LOCATION DESCRIPTION
10	-22.333	-48.25	0	EVAPORATOR STEAM OUTLET NOZZLE
20	21.333	-61.00	14.141	EVAPORATOR INLET TO DUMP TANK
165	-8.09	3.018	1.729	EVAPORATOR DRUM INLET
195	-8.09	3.018	1.729	" "
215	-8.09	3.018	0	" "
245	-8.09	3.018	0	" "
265	-8.09	3.018	-1.729	" "
295	-8.09	3.018	-1.729	" "
50	-17.750	-52.750	0	OUTLET EVAPORATOR QUICK OPENING DUMP VALVE
55	-19.750	-52.750	0	INLET " "
395	-15.167	-48.250	0	OUTLET EVAPORATOR OUTLET QUICK CLOSING VALVE
400	-17.167	-48.250	0	INLET " "

REF. # 26, 27, 28, & 29

7670

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR 30MWT STM.GEN. CONT. No. PR 900-130 MADE BY APW DATE 2-16-73
 LOCATION EMP. OUTLET LINE & DUMP LINE DWG. No. _____ CHK'D BY ES DATE 2-16-73

ANALYSIS RESULTSFLEXIBILITY (HOT DUMP COND.)

P.T.	FORCES LB.			MOMENTS FT.LB.		
	X	Y	Z	X	Y	Z
10	-4035	-5003	-1516	6600	11594	-56929
20	3121	-1221	1215	-9675	-23364	910
165	-775	1545	40	-2478	57	-7909
195	1825	1086	38	-1777	429	-11723
215	-963	1228	58	-2315	89	-5782
245	1330	841	38	-1774	431	-9309
265	-1232	907	86	-2101	134	-3413
295	729	615	39	-1784	441	-6737
50	-3121	1221	-1215	2419	3624	-2122
55	3121	-1221	1215	-2419	-6055	-321
395	-914	-6225	-301	-1287	243	-1749
400	914	6225	301	1287	-845	14199

MAXIMUM STRESS 20,222 KSI @ POINT 200
 ALLOWABLE STRESS 22.5 KSI

REF. # 26

SH 61

7670

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBIC 30MWT STM. GEN. CONT. No. PR 900-130 MADE BY APW DATE 2-16-73
 LOCATION EVAP. OUTLET LINE AND DUMP LINE SWG. No. _____ CHK'D BY AS DATE 2-16-73

ANALYSIS RESULTS

WEIGHT

PT.	FORCES LB.			MOMENTS FT. LB.		
	X	Y	Z	X	Y	Z
10	87	309	-202	-2624	2462	569
20	-88	-312	-30	-452	714	55
165	69	-316	45	461	337	484
195	152	-296	27	353	228	258
215	2	-274	51	460	342	425
245	-1	-267	27	351	227	382
265	-61	-234	55	449	342	363
295	-159	-236	27	352	225	513
50	89	423	30	-14	-68	325
55	-89	276	-30	14	129	-473
395	-2	327	-232	-2472	1003	2337
400	2	1272	232	2472	-1463	-1392

REF. #27

7670

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR 30MWT STM, GEN. CONT. No. PQ 900-130 MADE BY APW DATE 2-16-73
 LOCATION EVAP. OUTPUT LINE & DUMPLINE DWG. No. _____ CHK'D BY ES DATE 2-16-73

ANALYSIS RESULTS

SEISMIC (X-Y DIRECTION)

PT.	FORCES LB.			MOMENTS FT.LB.		
	X	Y	Z	X	Y	Z
10	3051	-1742	-14	-135	40	-10661
20	141	-70	-3	-294	-588	-80
165	172	-99	-6	56	143	544
195	759	-35	-3	25	107	-376
215	11	-100	9	96	162	956
245	409	-40	-3	26	108	-150
265	-146	-100	24	136	180	1364
295	67	-43	-3	25	107	550
50	299	-150	3	15	10	123
55	-925	463	-3	-15	-4	489
395	578	-506	-17	-136	-81	-5198
400	-2010	1222	17	136	46	6926

REF. # 28

7670

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER LMFBR 30MWT STM GRN CONT. NO. PR 900-130 MADE BY APN DATE 2-16-73
 LOCATION EVAP. OUTLET LINE & DUMPLINE DWG. No. _____ CHK'D BY _____ DATE _____

ANALYSIS RESULTS

PT.	SEISMIC (Y-Z DIRECTION)					
	FORCES LB.			MOMENTS FT.LB.		
	X	Y	Z	X	Y	Z
10	-75	-1473	2813	875	-16077	-9189
20	76	-178	386	-1439	-114	-61
165	110	-59	210	312	1167	117
195	721	-34	188	127	1095	-1166
215	-153	-111	234	393	1196	1072
245	150	-82	188	126	1094	253
265	-405	-160	253	464	1209	1986
295	-425	-132	190	128	1102	1692
50	-76	-42	54	152	980	99
55	76	355	-680	-152	-245	296
395	1	-344	586	3989	-1325	-637
400	-1	1060	-2017	-3989	3929	2042

REF. # 29

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CE 2390 (8/87)

CUSTOMER LMFBC-30MWT MODEL CONT. No. 7670 MADE BY 20.717 DATE 2-7-74
LOCATION S.H. INLET LINE WITH DUMP DWG. No. _____ CHK'D BY CS DATE 2-7-74
LINE

— PUMP
— BURNER

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CE 2390 (B. 67)

CUSTOMER LMFBR-30MW MODEL CONT. No. 7670 MADE BY W.M. DATE 2/12/73
LOCATION SH. INLET LINE WITH DUMPLINE DWG. No. 187 CHK'D BY 187 DATE 2-12-73

CALCULATING t IN PIPING CONSIDERED
FROM "POWER PIPING" SEC. 104

$$t = \frac{PD}{2SE + 2YP} + C \quad E = 1$$

$C = 0$ TABLE 104.1.2(a)1
 $Y = .4$ TABLE 104.1.2(a)2

CALCULATING SAT. STEAM CONN TUBES

$$t = \frac{(2810)(3.5)}{(2)(15,000)(1) + (2)(.4)(2810)} + 0$$

$D = 3\frac{1}{2}"$
 $P = 2810 \text{ psi}$
 $S / S_{SA213T-22} = 15,000 \text{ psi}$
 $\text{@ } 688^\circ$

$= .308" < .340" \text{ O.K.}$

CALCULATING S.H. INLET LINE

$$t = \frac{(2810)(6.625)}{(2)(15,000)(1) + (2)(.4)(2810)} + 0$$

$D = 6\frac{5}{8}"$
 $P = 2810 \text{ psi}$
 $S / S_{SA213T-22} = 15,000 \text{ psi}$
 $\text{@ } 688^\circ$

$= .583" < .6875" \text{ O.K.}$

CALCULATING SAT STEAM COLL HDR

$$t = \frac{(2810)(10.75)}{(2)(15,000)(1) + (2)(.4)(2810)} + 0$$

$D = 10\frac{3}{4}"$
 $P = 2810 \text{ psi}$
 $S / S_{SA213T-22} = 15,000 \text{ psi}$
 $\text{@ } 688^\circ$

$= .946" < 1.125" \text{ O.K.}$

SOLVING t FOR S.H. DUMP LINE

$$t = \frac{(2810)(7.5)}{(2)(15,000)(1) + (2)(.4)(2810)} + 0$$

$D = 7.5"$
 $P = 2810 \text{ psi}$
 $S / S_{SA213T-11} = 15,000 \text{ psi}$
 $\text{@ } 688^\circ$

$.396" \leftarrow \text{USE}$

REVISION OF MAT'L & TEMP ON
SH DUMP LINE 2/12/73

MAT'L: SA213 T22 @ 960°

$$\frac{10}{50} = \frac{\Delta}{3200} \therefore \Delta = 640 \text{ psi}$$

$$\therefore S = 11,000 \text{ psi} - 640 \text{ psi} = 10360 \text{ psi}$$

FINDING NEW VALUE OF Y FROM
TABLE 104.1.2(a)2 "POWER PIPING"

$$\frac{10}{50} = \frac{\Delta}{.2} \therefore \Delta = .04$$

$$\therefore Y = .54$$

$$t = \frac{(2810)(7.5)}{(2)(10360)(1) + (2)(.54)(2810)}$$

$= .537" \leftarrow \text{USE}$

NOTE: ALLOWABLE STRESSES
ARE TAKEN FROM "POWER
BOILER CODE" SECTION I
TABLE PG-23.1

REVISED

See IN
RIGHT UPPER
CORNER

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CE 2390 18/67

CUSTOMER LIMBER-30MINT MODEL CONT. No. 7670 MADE BY W.M. DATE 2/13/71
LOCATION SH. INLET LINE WITH DUMP LINE DWS. No. _____ CHK'D BY ES DATE 2-18-71

MEMBERS OR ANKERS #1, #21, #31,

3 1/2" O.D. SAT.
STEAM CONN.
TUBES.

VIEW REF TO
DWG. # 07670-1E0131-02

FINDING COEFFICIENT OF EXPANSION
FOR STEAM DRUM @ 675° REF:
STD: THERMAL EXPANSION DATA
SI-M-4.2 SKETCH 1

TEMP	α $1/1^{\circ}F$
674°	.05362
675°	α
676°	.05383

$\frac{1}{2} = \frac{\Delta}{.00021} \therefore \Delta = .000105$

$\therefore \alpha = .05373 \text{ } 1/1^{\circ}F$

CALCULATING EXPANSIONS OF
 $Y_1, Y_{21}, Y_{31}, Z_1, \text{ and } Z_{31}$

$Y_1 = Y_{21} = Y_{31} = 3.125(.05373) = .1679"$
 $Z_1 = Z_{31} = 1.729(.05373) = .0929"$

VIEW REF TO
DWG. # 07670-1F0109-02

UNIFLEX-EDMUND MODEL #767D
SH. INLET LINE WITH DUMP LINE
ADJUSTMENTS AT
SUPPLEMENTARY FOR ABOVE
#791

SV. WM. 2-12-73
Checked by
40 D.H.

DATE CHG'D
2-12-73

+ 119-54

(13) 2 1/2" 8N-2A
STUDS

SH 74 of 1

COMBUSTION ENGINEERING, INC.

CE 2390 (8/67)

WINDSOR, CONN.

CUSTOMER LINEAR-30MMIT MODEL CONT. No. 7670 MADE BY W.M. DATE 2/12/72
 LOCATION SH. INLET LINE WITH DUMP LINE DWG. No. _____ CHK'D BY ES DATE 2-12-72

MOVEMENT OF ANKLE #91

CALCULATING "a" DIM.

$$(9'-9\frac{3}{4}") - (5'-8\frac{1}{8}") = 4'-1\frac{5}{8}"$$

$$(4'-1\frac{5}{8}") - (1'-10") = \boxed{2'-3\frac{5}{8}" = "a"}$$

CALCULATING "b" DIM.

$$\text{EL } 116'-11"$$

$$- \text{EL } 110'-0"$$

$$\hline 6'-11"$$

$$(6'-11") - (1'-10") - (2'-3\frac{5}{8}") = \boxed{2'-9\frac{3}{8}" = "b"}$$

CALCULATING Y_a, Y_{101}, X_{101}

$$Y_a = 2.302' (.07366) = .1695"$$

$$Y_{101} = Y_a + 2.781' (.05373) = .3190"$$

$$X_{101} = 1.417' (.05373) = .0761"$$

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CE 2390 18-67

CUSTOMER LMFBR-30 MWIT MODEL CONT. No. 7670 MADE BY W.M. DATE 2-12-71
LOCATION SH. INLET LINE WITH DUMP LINE DWG. No. _____ CHK'D BY ES DATE 2-12-71

MOVEMENT OF ANKER #101

VIEW REF TO
DWG # 07670-1E0132-01

FINDING COEFFICIENT OF EXPANSION
FOR DUMP TANK @ 445° REF:
STD. THERMAL EXPANSION DATA
SI-1A.4.2 SKETCH 1

TEMP	α $\frac{1}{\text{in}}/^\circ\text{F}$
444°	.03105
445°	α
446°	.03123

$$\frac{1}{2} = \frac{\Delta}{.00018} \therefore \Delta = .00009$$

$$\therefore \alpha = .03114 \frac{1}{\text{in}}/^\circ\text{F}$$

CALCULATING "X" COORDINATE
FOR EXPANSION

$$X^2 + (2.333')^2 = 3.5^2$$

$$\therefore X = 2.609'$$

CALCULATING EXPANSIONS OF
 X_{101} , Y_{101} , & Z_{101}

$$X_{101} = 2.609'(.03114) = .0812"$$

$$Y_{101} = 3.667'(.03114) = .1142"$$

$$Z_{101} = 2.333'(.03114) = .0726"$$

VIEW REF. TO
DWG # 07670-1F0109-02

COMBUSTION ENGINEERING, INC.

WINDSOR, CONNECTICUT

Subject: Specification for Insulating and
Finishing Piping

Date: 8-31-73
Index No. SS 6.13.29
Spec. No. 24-63 Rev. 6
Sheet 12 Of 13

CHART FOR SELECTION OF PIPE INSULATION THICKNESS

○ INDICATES INSUL. THK'S.

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CE 2390 (8/67)

CUSTOMER LMR-3000T MCDER CONT. No. 7670 MADE BY W.M. DATE 2/13/71
LOCATION SH. INLET LINE WITH DUMP LINE DWG. No. _____ CHK'D BY ES DATE 2-14-71

S.H. DUMP LINE
CALCULATING WT. DENSITIES
OF PIPE CONSIDERED

$$A_1 = \pi(3.5)(11.5 - 3.5) = 87.9846 \text{ in}^2$$

$$A_2 = \pi(.537)(4.5 - .537) = 6.6857 \text{ in}^2$$

$$A_3 = \pi(1.1713)^2 = 9.2186 \text{ in}^2$$

$$g_1 = A_1 \times .00868 \text{ #/in}^3 = .7635 \text{ #/in}$$

$$g_2 = A_2 \times .28356 \text{ #/in}^3 = 1.8958 \text{ #/in}$$

$$g_3 = A_3 \times .03611 \text{ #/in}^3 = .3329 \text{ #/in}$$

$$2.9922 \text{ #/in} \Rightarrow 35.904 \text{ #/ft}$$

$\rho \text{ #/in}^3$ TO BE USED IN COMPUTER PROGRAM

$$\frac{3.0425 \text{ #/in}}{6.8871 \text{ in}^2} = .442 \text{ #/in}^3$$

SHT STEAM COLL HDR.

$$A_1 = \pi(3.5)(17.75 - 3.5) = 156.6869 \text{ in}^2$$

$$A_2 = \pi(1.125)(10.75 - 1.125) = 39.0176 \text{ in}^2$$

$$A_3 = \pi(4.25)^2 = 56.7450 \text{ in}^2$$

$$g_1 = A_1 \times .00868 \text{ #/in}^3 = 1.3600 \text{ #/in}$$

$$g_2 = A_2 \times .28356 \text{ #/in}^3 = 9.6460 \text{ #/in}$$

$$g_3 = A_3 \times .03611 \text{ #/in}^3 = 2.0491 \text{ #/in}$$

$$13.0551 \text{ #/in} \Rightarrow 156.662 \text{ #/ft}$$

$\rho \text{ #/in}^3$ TO BE USED IN COMPUTER PROGRAM

$$\frac{13.0551 \text{ #/in}}{9.6460 \text{ in}^2} = 1.353 \text{ #/in}^3$$

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CE 2390 (8/67)

CUSTOMER LINE BP-3000WT MEXEL CONT. No. 7670 MADE BY W. J. I. DATE 2/13/72
LOCATION SH. INLET LINE WITH DUMP LINE DWG. No. _____ CHK'D BY ES DATE 2-13-72

SAT. STEAM CONN. TUBES
CALCULATING DENSITIES OF
PIPE CONSIDERED

$$H = \pi L(D-t) \text{ OR } \pi t R^2$$

$$A_1 = \pi(2.5)(8.5-2.5) = 47.1239 \text{ in}^2$$

$$A_2 = \pi(.34)(3.5-.34) = 3.3753 \text{ in}^2$$

$$A_3 = \pi(1.41)^2 = 6.2458 \text{ in}^2$$

$$g_1 = A_1 \times .00868 \text{ \#/in}^3 = .4090 \text{ \#/in}$$

$$g_2 = A_2 \times .28356 \text{ \#/in}^3 = .9571 \text{ \#/in}$$

$$g_3 = A_3 \times .03611 \text{ \#/in}^3 = .2255 \text{ \#/in}$$

$$1.5916 \text{ \#/in} \Rightarrow 19.0992 \text{ \#/ft.}$$

ρ_{in^3} TO BE USED IN COMPUTER PROGRAM

$$\frac{1.5916 \text{ \#/in}}{A_2 = 3.3753 \text{ in}^2} = .472 \text{ \#/in}^3$$

S.H. INLET LINE

$$A_1 = \pi(3)(12.625-3) = 90.7135 \text{ in}^2$$

$$A_2 = \pi(.6875)(6.625-.6875) = 12.8291 \text{ in}^2$$

$$A_3 = \pi(2.625)^2 = 21.6475 \text{ in}^2$$

$$g_1 = A_1 \times .00868 \text{ \#/in}^3 = .7874 \text{ \#/in}$$

$$g_2 = A_2 \times .28356 \text{ \#/in}^3 = 3.6369 \text{ \#/in}$$

$$g_3 = A_3 \times .03611 \text{ \#/in}^3 = .7817 \text{ \#/in}$$

$$5.2055 \text{ \#/in} \Rightarrow 62.4660 \text{ \#/ft.}$$

ρ_{in^3} TO BE USED IN COMPUTER PROGRAM

$$\frac{5.2055 \text{ \#/in}}{12.8291 \text{ in}^2} = .406 \text{ \#/in}^3$$

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CE 2390 18/6

CUSTOMER LINE RE-30110T MODEL CONT. No. 7670 MADE BY W.M. DATE 2/1/77
LOCATION SH. INLET LINE WITH DUMP LINE DWG. No. _____ CHK'D BY _____ DATE _____

CALCULATING SEISMIC LOADING
SAT STEAM CONN. TUBES

$$L = 12.5' + 2.875' = 15.375'$$

$$WT = Lg = (15.375)(19.0992 \text{ #/ft}) = 294 \text{ #}$$

$$HORIZ. SEISMIC = .2 \times 294 \text{ #} = 58.8 \text{ #}$$

$$VERT. SEISMIC = .1 \times 294 \text{ #} = 29.4 \text{ #}$$

$$\cos \alpha = \frac{29.4}{65.74} = .4472$$

$$\cos \theta = \frac{58.8}{65.74} = .8944$$

$$UNIFORM LOAD = \frac{65.74 \text{ #}}{12 \text{ ft} \times 15.375 \text{ ft}} = .3563 \text{ #/in}$$

SAT STEAM COLL. HDR.

$$WT = Lg = (4.458')(156.6612 \text{ #/ft}) = 698 \text{ #}$$

$$HORIZ SEISMIC = .2 \times 698 \text{ #} = 139.6 \text{ #}$$

$$VERT SEISMIC = .1 \times 698 \text{ #} = 69.8 \text{ #}$$

$$UNIFORM LOAD = \frac{156.08 \text{ #}}{12 \times 4.458} = 2.9176 \text{ #/in}$$

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CE 2390 10 '6'

CUSTOMER LMFBR-30MWUT MODER CONT. No. 7670 MADE BY W.M. DATE 2/14/72
LOCATION SH. INLET LINE WITH DUMP LINE DWG. No. _____ CHK'D BY _____ DATE _____

CALCULATING SEISMIC LOADING

$$L = 6.771' + 6.761' + 48.552' + 7.166' + 12.833' = 74.917'$$

$$WT = Lq = (74.917)(62.466) = 4680\#$$

$$HORIZ. SEISMIC = .2 \times 4680\# = 936\#$$

$$VERT. SEISMIC = .1 \times 4680\# = 468\#$$

$$UNIFORM LOAD = \frac{1046.45\#}{12 \times 74.917} = 1.1640\#/IN$$

SAFETY VALVE

$$WT. = 250\#$$

$$VERT. SEISMIC = .1 \times 250\# = 25\#$$

$$HORIZ. SEISMIC = .2 \times 250\# = 50\#$$

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CE 2390 (8/57)

CUSTOMER LINER-30"UT MODEL CONT. No. 7670 MADE BY W.M. DATE 2/4/73
LOCATION SH. INLET LINE WITH DUMP LINE DWG. No. _____ CHK'D BY _____ DATE _____

CALCULATING SEISMIC LOADING

$$L = 3.667' + 8.692' + 5.678' + 7.916' + 8.141' = 34.074'$$

$$WT = Lg = (34.074')(35.9064 \text{ #/ft}) = 1224 \text{ #}$$

$$\text{HORIZ. SEISMIC} = .2 \times 1224 = 244.8 \text{ #}$$

$$\text{VERT. SEISMIC} = .1 \times 1224 = 122.4 \text{ #}$$

$$\text{UNIFORM LOAD} = \frac{273.69 \text{ #}}{12 \times 34.074} = .6690 \text{ #/in}$$

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CE 2390 (6/67)

CUSTOMER LMFBR-30MWT MODEL CONT. No. 7670 MADE BY W.M. DATE 2/16/75
LOCATION S.H. JACKET LINE WITH DUMP LINE DWG. No. _____ CHK'D BY _____ DATE _____

FORCES & MOMENTS ACTING ON SUPERHEATER AT EL 116'-11" INDUCED BY 6 5/8" O.D. SUPERHEATER LINE.				
Pt. #101	DUE TO WEIGHT LOAD	DUE TO THERMAL EXPANSION	DUE TO SEISMIC LOADING	
			X-Y PLANE	Y-Z PLANE
FX	-101	-1033	937	-20
FY	-2206	-437	-594	-493
FZ	-98	-192	-7	876
MX	-543	3493	82	2541
MY	755	-181	375	-6195
MZ	13	-7223	-7200	-3993

NOTE:
FORCES ARE IN
LBS.
MOMENTS ARE IN
FT-LBS.

FORCES & MOMENTS ACTING ON STEAM/WATER DUMP TANK AT EL 105'-4" INDUCED BY 4 1/2" O.D. S.H. DUMP LINE.				
Pt. #101	DUE TO WEIGHT LOAD	DUE TO THERMAL EXPANSION	DUE TO SEISMIC LOADING	
			X-Y PLANE	Y-Z PLANE
FX	108	871	131	34
FY	-266	-533	-104	-118
FZ	102	371	13	166
MX	-384	642	-42	283
MY	798	1665	110	805
MZ	525	506	397	609

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CE 2390 (8/67)

CUSTOMER LINEER-30 MWT MODEL CONT. No. 7670 MADE BY W.M. DATE 2/13/73
 ATION SH. INLET LINE WITH DUMP DWG. No. _____ CHK'D BY _____ DATE _____
LINE

FORCES & MOMENTS ACTING ON STEAM DRUM
AT EL 166'-0" INDUCED BY 3 1/2" O.D. SAT STEAM CONN. TUBES

	DUE TO WEIGHT LOAD	DUE TO THERMAL EXPANSION	DUE TO SEISMIC LOADING		PT. NO.
			X-Y PLANE	Y-Z PLANE	
F_x	17	33	-433	-759	#1
F_y	-157	253	10	-27	
F_z	-1	-59	-1	228	
M_x	10	-683	0	512	
M_y	-12	-245	120	1180	
M_z	132	-1784	1438	2169	
F_x	-2	53	224	-3	#21
F_y	-157	323	-53	-87	
F_z	-1	-59	-1	229	
M_x	10	-684	0	513	
M_y	-12	-246	119	1181	
M_z	182	-2205	-39	533	
F_x	-22	74	945	743	#31
F_y	-157	394	-127	-148	
F_z	-1	-60	-2	229	
M_x	9	-685	-3	513	
M_y	-12	-247	117	1182	
M_z	233	-2632	-1534	-1085

NOTE:

FORCES ARE IN
LBS.

MOMENTS ARE IN
FT-LBS.

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER

WILFRED - 30" DIAM

PROJECT CONT. NO.

76110

MADE BY

W. McDATE

LOCATION

S.H. INLET LINE WITH DUMP

DWG. NO.

CHK'D BY

DATE

2-16-73

CE 2390 (8/67)

LINE

LISTED BELOW ARE THE FORCES AND MOVEMENTS OF THE SUPPORTS ON THE S.H. INLET LINE FROM DUMP AND DUE TO WEIGHT, SEISMIC LOADING, THERMAL EXPANSION.

	DUE TO WEIGHT LOADING				DUE TO THERMAL EXPANSION				DUE TO SEISMIC LOADING IN X-Y PLANE				DUE TO SEISMIC LOADING IN Y-Z PLANE			
	(13)	(52)	(77)	(109)	(13)	(52)	(77)	(109)	(13)	(52)	(77)	(109)	(13)	(52)	(77)	(109)
<i>Δx</i>	—	—	—	—	<i>-.554"</i>	<i>-.311"</i>	<i>.439"</i>	<i>-.011"</i>								
<i>Δy</i>	—	—	—	—	<i>1.808"</i>	<i>2.515"</i>	<i>.205"</i>	<i>.371"</i>								
<i>Δz</i>	—	—	—	—	<i>-.155"</i>	<i>1.037"</i>	<i>.020"</i>	<i>.232"</i>								
<i>Fx</i>	—	—	—	—	—	—	—	—								
<i>Fy</i>	<i>1031#</i>	<i>3551#</i>	<i>423#</i>	<i>701#</i>	—	—	—	—								
<i>Fz</i>	—	—	—	—	—	—	—	—								

FOR WEIGHT LOAD MAX. STRESS AT PT. #126 — *4351 psi*

FOR THERMAL EXPANSION MAX. STRESS AT PT. #131 — *13,453 psi*

FOR SEISMIC X-Y PLANE MAX. STRESS AT PT. # —

FOR SEISMIC Y-Z PLANE MAX. STRESS AT PT. # —

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER IMPERIAL MILLS CONT. NO. 7070 MADE BY WTL DATE 2/14/73
LOCATION S.H. CLAYTON AVE. WITH DRAIN DWG. NO. 18 CHK'D BY 18 DATE 2-14-73
LINE

PIPING DIAGRAM

FOR DIMENSIONS SEE
REF. 1, 2, 3, 4.

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CE 2300 10/57

CUSTOMER LMFR-30MWT MODEL CONT. No. 7670 MADE BY W.M DATE 2/16/73
LOCATION S.H. OUTLET LINE DWG. No. _____ CHK'D BY _____ DATE _____
CALCULATING "t" OF PIPE

"FROM POWER PIPING"
SEC 104.

E=1

C=0 TABLE 104.1.2(a)1

Y=.54 INTERPOLATED FROM TABLE 104.1.2(a)2

OD= 8.625"

DR= 2840 PSI

S= 10360 PSI $\Rightarrow$ SA335 P-22 @ 960°

$$t = \frac{(2840)(8.625)}{(2)(10360)(1) + (2)(.54)(2840)} + 0$$

INTERPOLATED FROM TABLE
PG-23.1 "PUR BOILER CODE"
SECTION I

$$= 1.03" < 1.25" \text{ O.K.}$$

CE 2390 (8/67)

CALCULATING "Z" COORDINATE FOR EXPANSION

CALCULATING EXPANSIONS OF X_n, Y_n, ξ, Z_n

$$z_1 = 2.609'(0.03114) = .0182''$$

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CE 2380 (8/67)

CUSTOMER LIMBER-30MMT MODEL CONT. No. 7670 MADE BY V.M. DATE 2/6/73
LOCATION SH. OUTLET LINE DWG. No. _____ CHK'D BY _____ DATE _____
MOVEMENT OF ANCHOR #1

CALCULATING "C" DIM.

$$(9'-9\frac{3}{4}" - (1'-40") - (2'-3\frac{5}{8}" - (3'-8\frac{1}{4}" = 2'-11\frac{7}{8}"$$

CALCULATING $\frac{1}{2}$ & $\frac{1}{4}$

$$\frac{1}{2} = 2.302'(.07366) = .1695"$$

$$\frac{1}{4} = \frac{1}{2} + 2.989(.05373) = .1606"$$

COMBUSTION ENGINEERING, INC.

WINDSOR, CONNECTICUT

Subject: Specification for Insulating and Finishing Piping

Date: 8-31-70
Index No. SS 6.13.29
Spec. No. 24-65 Rev. 5
Sheet 12 of 13

CHART FOR SELECTION OF PIPE INSULATION THICKNESS

○ INDICATES INSUL. THK'S.

DENSITIES:

ASBESTOS: .28266 #/in³

WATER: .03611 #/in³

INSULATION: .00368 #/in³

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CE 2390 (8/57)

CUSTOMER LINEAR-3000T MODEL CONT. No. 7670 MADE BY W.M. DATE 2/6/73
LOCATION S.H. OUTLET LINE & DUMP LINE DWG. No. _____ CHK'D BY _____ DATE _____

$$A_1 = \pi(3.5)(1.5 - 3.5) = 87.9646 \text{ in}^2$$

$$A_2 = (\pi)(.537)(4.5 - .537) = 6.6857 \text{ in}^2$$

$$A_3 = \pi(1.173)^2 = 4.2866 \text{ in}^2$$

$$g_1 = A_1 \times .00868 = .7635 \text{ #/in}$$

$$g_2 = A_2 \times .28356 = 1.8958 \text{ #/in}$$

$$g_3 = A_3 \times .03611 = .3329 \text{ #/in}$$

$$\underline{2.9922 \text{ #/in}}$$

$$P_{\text{#/in}^3} = \frac{2.9922}{A_2} = .448 \text{ #/in}^3$$

$$A_1 = \pi(3.5)(1.25 - 3.5) = 133.3213 \text{ in}^2$$

$$A_2 = \pi(1.25)(8.625 - 1.25) = 28.9666 \text{ in}^2$$

$$A_3 = \pi(3.0625)^2 = 29.4647 \text{ in}^2$$

$$g_1 = A_1 \times .00868 = 1.1572 \text{ #/in}$$

$$g_2 = A_2 \times .28356 = 8.2123 \text{ #/in}$$

$$g_3 = A_3 \times .03611 = 1.0640 \text{ #/in}$$

$$\underline{10.4335 \text{ #/in}}$$

$$P = \frac{10.4335}{A_2} = .360 \text{ #/in}^3$$

S.H. DUMP LINE

S.H. OUTLET LINE

$$A_1 = \pi(3.5)(1.5 - 3.5) = 99.6529 \text{ in}^2$$

$$A_2 = \pi(1)(5.563 - 1) = 14.3351 \text{ in}^2$$

$$A_3 = \pi(1.1781)^2 = 9.9706 \text{ in}^2$$

$$g_1 = A_1 \times .00868 = .8650 \text{ #/in}$$

$$g_2 = A_2 \times .28356 = 4.0650 \text{ #/in}$$

$$g_3 = A_3 \times .03611 = .3600 \text{ #/in}$$

$$\underline{5.2879 \text{ #/in}}$$

$$P = \frac{5.2879}{A_2} = .369 \text{ #/in}^3$$

$$A_1 = \pi(3.5)(1.3 - 3.5) = 104.4579 \text{ in}^2$$

$$A_2 = \pi(.864)(6.584 - 1.384) = 13.9418 \text{ in}^2$$

$$A_3 = \pi(2.1326)^2 = 14.3335 \text{ in}^2$$

$$g_1 = A_1 \times .00868 = .9067 \text{ #/in}$$

$$g_2 = A_2 \times .28356 = 3.9530 \text{ #/in}$$

$$g_3 = A_3 \times .03611 = .5176 \text{ #/in}$$

$$\underline{5.3773 \text{ #/in}}$$

$$P = \frac{5.3773}{A_2} = .386 \text{ #/in}^3$$

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CE 2380 (6/67)

CUSTOMER

LINEAR-3000WT

MODEL CONT. NO.

76710

MADE BY

WJH

DATE

2/6/73

LOCATION

S.H. OUTLET LINE WITH

DWG. NO.

CHK'D BY

ES

DATE

2/6/73

DUMP LINE

#1 REACTIONS AT SUPERHTR @ EL. 115'-7½" FROM S.H. OUTLET LINE
 #11 REACTIONS AT DUMP TANK @ EL. 105'-4" FROM S.H. DUMP LINE
 #61 REACTIONS AT CONDENSER @ EL. FROM B-2 LINE

	DUE TO WEIGHT LOADING			DUE TO THERMAL EXPANSION			DUE TO SEISMIC LOADING					
							X-Y PLANE			Y-Z PLANE		
PT. NO.	(1)	(11)	(61)	(1)	(11)	(61)	(1)	(11)	(61)	(1)	(11)	(61)
FX	-80	115	-34	-602	1132	-529						
FY	-8389	-158	2154	-2602	-413	621						
FZ	-62	52	8	-519	592	-73						
MX	2252	406	-2423	-1651	2952	-6850						
MY	-1179	649	-550	-11320	7223	-5251						
MZ	12182	-78	681	26416	-624	-607						

FORCES ARE IN
LBS.MOMENTS ARE
IN FT-LBS.

ΔZ	ΔY	ΔX	FZ	FY	FX				
—	—	—	—	1063	—	#29	DUE TO WEIGHT LOADINGS		
—	—	—	—	3325	—	#36			
—	—	—	—	2132	—	#86			
—	—	—	—	624	—	#96			
—	—	—	—	1032	—	#106			
—	—	—	—	657	—	#116			
—	—	—	—	513	—	#136			
1.857"	.654"	.062"	—	—	—	#29	DUE TO THERMAL EXPANSION		
.273"	.046"	-.035"	—	—	—	#36			
1.423"	-.113"	.466"	—	—	—	#86			
1.392"	0.000"	.778"	—	952	—	#96			
1.251"	0.000"	1.871"	—	267	—	#106			
1.249"	0.000"	2.964"	—	203	—	#116			
.900"	0.000"	3.031"	—	132	—	#136			
						#29	DUE TO SEISMIC LOADINGS IN X-Y PLANE		
						#36			
						#86			
						#96			
						#106			
						#116			
						#136			
						#29	DUE TO SEISMIC LOADINGS IN Y-Z PLANE		
						#36			
						#86			
						#96			
						#106			
						#116			
						#136			

LISTED BELOW ARE THE REASONS & MOVEMENTS OF THE SUPPLIES ON THE S.H. QUARTER LINE AND DUMP LINES DUE TO WEIGHT, SENSITIVE HANDLING & OTHER. EXPANSION

DUE TO
WEIGHT LOADINGS

DUE TO THE
 EXTENSION

DUE TO SEISMIC
LOADING IN X-Y PLANE

DOE TO SELECT
LOADING IN Y-Z PLANE

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CONT. No.

.DWG. No.

CHKD BY

11.2

4

STOMER

LOCATION.

LIT-36-30417 MODEL
S.H. OUTLET LINE & DUMP

ENVY

LISTED BELOW ARE THE REPORTS ON \$100,000 INVESTS AT THE SUPPORTS ON THE S.M. OUTLET LINES AND DURING THE DUE TO WEIGHTS SENSING ROLLING \$100,000 EXPANSIVE

LISTED BELOW ARE THE FORCES ON MEMBERS OF THE SUPPORTS ON THE S.H. OUTLET AND MID DUMP ARE DUE TO WEIGHT, SEISMIC LOADING & THERMAL EXPANSION									
ΔZ	ΔY	ΔX	FZ	FY	FX				
—	—	—	—	880	—	#146	DUE TO WEIGHT		
—	—	—	—	1018	—	#166	LOADING		
—	—	—	—	729	—	#186			
—	—	—	—	455	—	#206			
—	—	—	—	1365	—	#216			
—	—	—	—	6978	—	#254			
1.040"	-.407"	1.937"	—	—	—	#146	DUE TO THERMAL		
-1.222"	-1.000"	1.000"	—	—	—	#166	EXPANSION		
-3.091"	-1.501"	-.551"	—	—	—	#186			
-2.192"	-1.263"	-1.407"	—	—	—	#206			
-1.324"	-.812"	-.724"	—	—	—	#216			
-.069"	0.000"	-.631"	—	2996	—	#254			
						#146	DUE TO SEISMIC		
						#166	LD. IN X-Y PLANE		
						#186			
						#206			
						#216			
						#254			
						#146	DUE TO SEISMIC		
						#166	LD. IN Y-Z PLANE		
						#186			
						#206			
						#216			
						#254			

FOR WEIGHT LIFTING MAX. STRESS AT PT # 50 - 5931 PSI.
FOR MAXIMUM EXTENSION MAX STRESS AT PT # 11 - 15314 PSI

DUMP LINE

S. H. OUTLET LINE WITH

DWG. No.

WINDSOR, CONN
MADE IN
CONT. NO.

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.
INDEX CONT. NO. 7670

MADE BY *W. L.*

CHKD BY DATE

DATE _____

CE 2390 (A/67)

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

OWNER LMFBR 30 MW ST. GENR. CONT. NO. 900-130 MADE BY C.K. DATE 2-9-73
LOCATION SUPERHEATER SODIUM INLET LINE DWG. NO. 551-10-P CHK'D BY ES DATE 2-9-73

PIPE SIZING AS PER J.P. PETREK'S SUBMITTAL OF DECEMBER 29, 1972

① ONE 10" SCHL 40 SS-304H 1,000°F DESIGN 100 PSI DESIGN

DATA FOR ANALYSIS:

OD = 10.750"; ID = 10.020"; $t = 0.365"$; SA-312-TP304H;
960°; $S_c = 17,500 \text{ PSI}$; $S_H = 9,860 \text{ PSI}$; $E = 27.4 \times 10^6$; $\mu = 0.292$

MOVEMENT OF "ANCHOR" PT. ⑤ AT INTERM. HEAT EXCHANGER ③-④ ⑤-⑥

VERTICAL ZERO EXP. AT EL. 105'-0"

HORIZONTAL ZERO EXP. IN X AND Z DIRECTION, AT E OR INTERM. HEAT EXCHAN.

$$\text{IN X} \quad \Delta (1'-0") \left(\frac{960}{1109360} \right) = +0.1094"$$

$$\text{IN Y} \quad [(130'-5") - (105'-0")] \left(\frac{960}{1109360} \right) = +2.7796"$$

$$\text{IN Z} \quad = 0"$$

MOVEMENT OF "ANCHOR" PT. ⑩ AT SUPERHEATER ④-⑤ ④-⑥

VERTICAL ZERO EXPANSION AT EL. 111'-0"

HORIZONTAL ZERO EXPANSION IN X AND Z DIRECTION, AT E OR SUPERHEATER

$$\text{IN X AND Z} \quad = 0"$$

$$\text{IN Y} \quad [(111'-10") - (100'-0")] \left(\frac{860}{110324} \right) + [(100'-0") - (76'-3")] \left(\frac{95}{110324} \right) = -3.5370"$$

CE DRAWINGS

SIDE 07670 - 1F0109-01

PLAN 07670 - 1E0131-01

PLAN 07670 - 1E0132-01

#7670 900-130
"SUPERHEATER SODIUM INLET LINE"
FROM: INTERM. HEAT EXCHANGER
TO: SUPERHEATER
BY: C.K. FEB. 9, 1973

SHT. III

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

OWNER LMFBR 30 MWT STM. GEN. CONT. NO. 900-130 MADE BY C.K. DATE 2-9-73
 LOCATION SODIUM INLET LINE DWG. No. 551-10-P CHK'D BY ES DATE 2-9-73

WEIGHT:

PPE: 10.750" OD. x 10.020" ID 490[#]/ft³

SODIUM: 53[#]/ft³

METAL: $\frac{490^{\#}/ft^3}{(144)} \times \frac{\pi}{4} \times (10.750^2 - 10.020^2) = 40.52^{\#}/ft = 3.3768^{\#}/in$

SODIUM: $\frac{53^{\#}/ft^3}{(144)} \times \frac{\pi}{4} \times (10.020^2) = 29.023^{\#}/ft = 2.4186^{\#}/in$

INSULATION THK: 4" $\frac{15^{\#}/ft^3}{(144)} \times \frac{\pi}{4} \times (18.750^2 - 10.750^2) = 19.308^{\#}/ft = 1.6089^{\#}/in$
7.4042[#]/in

SEISMIC LOADING:

HORIZONTAL: $(.2)(7.4043) = 1.4809^{\#}/in$
VERTICAL: $(.1)(7.4043) = 0.7404^{\#}/in$

COMBINED: 1.6557[#]/in

VERTICAL RIGID SUPPORT AT EL. 107'-3" PT. ⑦

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

TOWER LMFBR 30MW STIM-GEN 900-130 MADE BY C.K. DATE 2-14-73

LOCATION SODIUM INLET LINE DWG. NO. 551-10-P CHK'D BY *AS* DATE 2-14-73

THERMAL EXPANSION						DEAD LOAD						SEISMIC LOADING IN X-Y PLANE						SEISMIC LOADING IN Z-Y PLANE																						
#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#													
11	24	40	45	60		75	11	24	40	45	60	72	75	11	24	40	45	60	71	75	11	24	40	45	60	72	75													
Δx	$+\frac{5}{16}$	$-\frac{1}{8}$	$+\frac{7}{16}$	$+\frac{3}{16}$	$+\frac{13}{16}$	$-\frac{3}{16}$	<u>MOVEMENTS IN INCH.</u>																	<u>FORCES IN LBS.</u>																
Δy	$+\frac{15}{16}$	$+3$	$+\frac{11}{16}$	$+\frac{5}{8}$	$+\frac{3}{8}$	0	<u>FORCES SHOWN ARE ACTING</u>																																	
Δz	0	$+\frac{1}{2}$	$-\frac{5}{8}$	$-\frac{1}{8}$	$-\frac{5}{16}$	$-\frac{1}{16}$	<u>ON RESTRAINTS.</u>																																	
F_x																																								
F_y						0	-750	-2,040	-1,860	-670	-1,180	0	-4,800	-780	+300	-520	+180	-570	-1,000	-220	-650	-550	-280	+290	+50															
F_z																																								

FOR THERMAL EXP. MAX. STRESS AT PT. #110 — 2,596 PSI.
 FOR DEAD LOAD MAX. STRESS AT PT. #25 — 1,459 PSI
 FOR SEISMIC IN X-Y PLANE MAX. STRESS AT PT. #105 — 3,670 PSI
 FOR SEISMIC IN Z-Y PLANE MAX. STRESS AT PT. #105 — 6,696 PSI

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

TOMER LMFBR 30MW STM. GEN CONT. NO. 900-130 MADE BY C.K. DATE 2-14-73
LOCATION SODIUM INLET LINE DWG. NO. 551-10-P CHK'D BY ES DATE 2-14-73

F^s & M^s ACTING ON INTERM. HEAT EXCHANGER AT EL. 130'6", INDUCED BY 10 3/4" O.D. SUPERHTR SODIUM INLET LINE 551-10-P. (PT. ⑤)

F^s & M^s ACTING ON SUPERHTR AT EL. 76'3", INDUCED BY 10 3/4" O.D. SUPERHTR SODIUM INLET LINE 551-10-P (PT. ⑩)

	DUE TO THERMAL EXPANSION 960°F	DUE TO DEAD LOAD	DUE TO SEISMIC LOADING IN X-Y PLANE	DUE TO SEISMIC LOADING IN Z-Y PLANE	DUE TO THERMAL EXPANSION 960°F	DUE TO DEAD LOAD	DUE TO SEISMIC LOADING IN X-Y PLANE	DUE TO SEISMIC LOADING IN Z-Y PLANE
F_x	- 66	+ 6	- 681	- 3	+ 66	- 6	- 708	+ 3
F_y	+ 38	+ 275	+ 405	+ 902	- 40	- 906	+ 19	- 89
F_z	+ 27	+ 5	+ 39	- 681	- 27	- 5	- 39	- 673
M_x	- 186	+ 496	+ 1,146	+ 188	- 1,090	- 394	+ 96	+ 428
M_y	+ 292	- 81	- 1,728	- 433	- 579	- 81	+ 3,658	- 7,076
M_z	- 990	+ 219	+ 876	+ 607	- 1,657	+ 848	- 1,475	- 234

FOR THERMAL EXP. MAX. STRESS AT PT. # 110 ——— 2,596 PS

FOR DEAD LOAD MAX. STRESS AT PT. # 25 ——— 1,459 PS

FOR SEISMIC IN X-Y PLANE MAX. STRESS AT PT. # 105 ——— 3,670 PS

FOR SEISMIC IN Z-Y PLANE MAX. STRESS AT PT. # 105 ——— 6,696 PS

10 3/4" OD. SUPERHEATER
SODIUM INLET LINE
551-10-P.

C.E. DRWGS

01670 - IF0109-01
01670 - IE0131-01
01670 - IE0132-01

SUPERHEATER
VERTICAL BESS EXPANSION
AT EL. 111'-10".
HORIZONTAL BESS EXPANSION
AND DIRECTION AT OF
SUPERHTR.

CE POINTS

CUST. POINTS

# 11	-----	CSH-101
# 24	-----	CSH-102
# 40	-----	CSH-401
# 45	-----	CSH-402
# 60	-----	CSH-403
# 71, 72	-----	
# 75	-----

SH-113

C.K. 2-15-73

7670

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER LMFBR-30MWT STM. BLR CONT. NO. PR 900-130 MADE BY APW DATE 1-25-77
LOCATION SODIUM CROSSOVER LINE DWG. No. _____ CHK'D BY ES DATE 2-15-78

PIPING DIAGRAM

AW2

ANCHOR-1
POINT 5
ANCHOR-2
POINT 35

FRONT

FOR DIMENSIONS
SEE REF. # 2, 3, 4

7670

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR-30 MW STIM. BLR. CONT. No PR 900-130 MADE BY APW DATE 2-8-73
 LOCATION SODIUM CROSSOVER LINE DWG. No. _____ CHK'D BY ES DATE 2-15-73

(EQUIVALENT DENSITY CALC.)	DENSITY	AREA	#/IN <u>IN²</u>
PIPE	.283 #/IN ³	5.58 IN ²	1.579
NA *	.031	28.854	1895
INS. **	.009	111.334	1.062
		TOTAL	<u>3.476 #/IN</u>

$$\text{EQUIVALENT DENSITY} = \frac{3.476 \text{ #/IN}}{5.58 \text{ IN}^2} = .622 \text{ #/IN}^3$$

* REF. 10 ITEM 2

** $3\frac{1}{2}$ " INS REF. 12

CHART FOR SELECTION OF PIPE INS. THK.

7670 COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR - 30 MINUT STMIGLR CONT. NO. PR-900-130 MADE BY APW DATE 1-25-73
 LOCATION SODIUM CROSSOVER LINE DWG. No. _____ CHK'D BY ES DATE 2-15-73

DESIGN SIZING OF
 SUPHTR. TO EVAP. SODIUM CROSSOVER LINES

AWZ

REF. 8 ITEM 52

6 5/8" O.D. SCH #40 .280" WALL
 MATL. 2 1/2 CR-1 Mo $\approx$ SA-335 P22
 DESIGN PRESS 100 PSIG DESIGN TEMP. 900°F

REF. 1

$$t = \frac{PD}{2SE + 2YP} + C$$

$$P = 100 \text{ PSIG} \quad D = 6.625"$$

$$E = 1 \text{ (NOTE 1)} \quad C = 0 \text{ (NOTE 3)}$$

$$Y = 0.4 \text{ (NOTE 6)}$$

$$S = 13.1 \text{ KSI (TABLE PG 23.1)}$$

$$t = \frac{100 \times 6.625}{2 \times 13100 \times 1 + 2 \times .4 \times 100} + 0 = .025" < .280"$$

t = MIN. REQ'D THICKNESS

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COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR-30MW STMBLR CONT. No. PR 900-130 MADE BY APW DATE 1-29-73
 LOCATION SODIUM CROSSOVER LINE DWG. No. _____ CHK'D BY ES DATE 2-15-73

ANCHOR MOVEMENTS

AWZ

ANCHOR-1 5 ΔX — +.11049
 ΔY — -.53096
 ΔZ — .0
 ANCHOR-2 35 ΔX — +.13043
 ΔY — -.61843
 ΔZ — .0

ANCHOR-1

ΔY SUPERHEATER OUTLET TEMP $\approx 860^\circ$ (REF. 7 FIG. 4)

$$.07366 \times 7.2083 = .53096$$

 ΔX

$$.07366 \times 1.5000 = .11049$$

ANCHOR-2

ΔY EVAPORATOR INLET TEMP $\approx 860^\circ$ (REF. 7 FIG. 4)

$$.07366 \times 8.3958 = .61843$$

 ΔX

$$.07366 \times 1.7708 = .13043$$

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COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR 30 MWT STMIBLR CONT. NO. PR-900-130 MADE BY APW DATE 2-13-73
LOCATION SODIUM CROSSOVER LINE DWG. No. _____ CHK'D BY ES DATE 2-15-73

AWZ

HANGER REQUIREMENTS

NO HANGERS ARE REQUIRED ON EITHER
SODIUM CROSSOVER LINE

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COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.CUSTOMER LMFBR 30MW STMBLR. CONT. NO. PR 900-130 MADE BY APW DATE 2-12-73
LOCATION SODIUM CROSSOVER LINE DWG. No. _____ CHK'D BY ES DATE 2-15-73DIRECTION OF STATIC LOADING DUE TO
SEISMIC FORCE

AMZ

X-Y PLAIN

$$Y \cos = \cos \Theta = \frac{-0.1}{0.2235} = -0.4474$$

$$X \cos = \cos \alpha = \frac{0.2}{0.2235} = 0.8948$$

Y-Z PLAIN

$$Y \cos = \cos \Theta = \frac{-0.1}{0.2235} = -0.4474$$

$$X \cos = \cos \alpha = \frac{0.2}{0.2235} = 0.8948$$

$$\begin{array}{r} 3.476 \text{ #/IN} \\ \times 0.2236 \\ \hline 0.7768 \end{array}$$

7670 COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBIR 30WWT STM BLR CONT. NO. PR 900-130 MADE BY APW DATE 2-14-73
LOCATION SODIUM CROSSOVER LINE DWG. No. _____ CHK'D BY ES DATE 2-15-73

ALLOWABLE EXPANSION
STRESSAWZ

REF. 1 PART 102.3.2
C. EXPANSION STRESSES

$$S_H = F(1.25 S_C + 0.25 S_H)$$

$$F = 1 \text{ REF 13 TABLE 102.3.2(C) } \quad \begin{array}{l} 7000 \text{ CYCLES} \\ \text{OR LESS} \end{array}$$

$$S_C = 15 \text{ KSI} \quad S_H = 13.1 \text{ KSI} \quad \text{REF. 13 (TABLE PG 23.1)}$$

$S_A = \text{ALLOWABLE EXPANSION STRESS}$

$$S_A = 1(1.25 \times 15 + 0.25 \times 13.1) = 22.02 \text{ KSI} > 7.866 \text{ KSI}$$

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COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR 30 MWT STMIGRV CONT. No. PR 900-130 MADE BY APW DATE 2-16-73
 LOCATION SODIUM CROSSOVER LINES DWG. No. _____ CHK'D BY ES DATE 2-16-73

ANALYSIS RESULTS

SEE PIPING DIAGRAM FOR ORIENTATION

PT		SEISMIC X-Y				SEISMIC Y-Z			
		10	35	10A	35A	10	35	10A	35A
LOCATION DESCRIPTION		SUPERHEATER OUTLET NOZZLE	EVAPORATOR INLET NOZZLE						
	X	2.333	3.333	-2.333	-3.333				
	Y	0	-1.188	0	-1.188				
	Z	0	-9.500	0	-9.500				
FORCES LB.	X	123	128	-123	-128	7	-7	-7	7
	Y	-69	-55	-69	-55	-145	22	-145	22
	Z	3	-3	3	-3	123	128	123	128
MOMENTS FT-LB.	X	-3	22	-3	-22	-344	-435	344	435
	Y	-36	-75	-36	-75	-170	-56	-170	-56
	Z	619	776	619	776	-102	-23	-70	-23
		REF. # 16				REF. # 17			

SH. 128

7670

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

C. ORDER LMF132 30 MWT STM. 60N. CONT. No. PR900-130 MADE BY APW DATE 2-16-73

LOCATION SODIUM CROSSOVER LINES DWG. No. CHK'D BY B DATE 2-16-73

ANALYSIS RESULTS

SEE PIPING DIAGRAM FOR ORIENTATION

PT.	LOCATION DESCRIPTION	FLEXIBILITY				WEIGHT			
		10	35	10A	35A	10	35	10A	35
	SUPER HEATER OUTLET NOZZLE								
	EVAPORATOR INLET NOZZLE								
LOCATION COORDINATES	X	2.333	3.333	-2.333	-3.333				
	Y	0	-1.188	0	-1.188				
	Z	0	-9.500	0	-9.500				
FORCES LB.	X	-2	2	2	-2	3	-3	-3	3
	Y	61	-61	61	-61	-674	-582	-674	-582
	Z	-489	489	-489	489	29	-29	29	-29
MOMENTS FT-LB.	X	2818	-2822	-2818	2822	-76	43	76	-43
	Y	559	-96	559	-96	-25	34	-25	34
	Z	85	-27	85	-27	-1074	-453	-1074	-453

MAX THERMAL STRESS 7.866 KSI ALLOWABLE 22.02 KSI

REF. # 14

REF. # 15

SH. 129

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR 30 MW TEST, GEN. CONT. NO. 900-130 MADE BY C.K. DATE 2-5-73
LOCATION EVAPORATOR SODIUM OUTLET LINE DRAWING NO. SS2-10-P CHK'D BY ES DATE 2-8-73

PIPE SIZING AS PER J.P. PETREX'S SUBMITTAL OF DECEMBER 29, 1972

S(3) ONE 10" SCHL 40 SS-304H 750°F DESIGN 100 PSI DESIGN

DATA FOR ANALYSIS:

OD = 10.750"; ID = 10.020"; $t = 0.365$ "; SA-312-TP304H;

680°F.; $S_c = 17,500$ PSI; $S_H = 11,080$ PSI; $E = 27.4 \times 10^6$; $\nu = 0.292$

MOVEMENT OF "ANCHOR" PT. (5) AT SECONDARY EXP. TANK T-S (3)-(C) (4)-(5)

VERTICAL ZERO EXP. AT EL. 130'-0"

HORIZONTAL ZERO EXP. IN X AND Z DIRECTION, AT C OF TANK

IN X AND Z $(1'-9")(\cdot 07248)^{680^\circ} = (+) \& (-) 0.1268$ ";

IN Y $[(134'-11") - (130'-0")](\cdot 07248)^{680^\circ} = + 0.3564$ ";

MOVEMENT OF "ANCHOR" PT. (10) AT EVAPORATOR (E)-(F) (3)-(4)

VERTICAL ZERO EXP. AT EL. 111'-10"

HORIZONTAL ZERO EXP. IN X AND Z DIRECTION, AT C OF EVAPORATOR

IN X AND Z = 0"

IN Y $[(111'-10") - (100'-0")](\cdot 09592)^{860^\circ} + [(100'-0") - (76'-30")](\cdot 07248)^{680^\circ} = -2.8564$ ";

CE DRAWINGS

SIDE 07670-1F0109-01

PLAN 07670-1E0131-01

PLAN 07670-1E0132-01

#7670 900-130

"EVAPORATOR SODIUM OUTLET LINE"

FROM: EVAPORATOR

TO: SECOND. EXP. TANK TS

BY: C.K., FEB 6, 1973

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR 30 MW TSTM GEN. CONT. NO. 900-130 MADE BY CK DATE 2-6-73
 LOCATION SODIUM OUTLET LINE DWG. NO. 552-10-P CHK'D BY ES DATE 2-8-73

WEIGHT:

PIPE: 10.750" OD. x 10.020" ID. 490 #/ft³

SODIUM: 55 #/ft³

METAL: $\frac{490 \text{ #/ft}^3}{(144)} \times \frac{\pi}{4} \times (10.750^2 - 10.020^2) = 40.52 \text{ #/ft} = 3.3768 \text{ #/in}$

SODIUM: $\frac{55 \text{ #/ft}^3}{(144)} \times \frac{\pi}{4} \times (10.020^2) = 30.1180 \text{ #/ft} = 2.5098 \text{ #/in}$

INSULATION: ^{THK = 3 1/2"}
 $\frac{15 \text{ #/ft}^3}{(144)} \times \frac{\pi}{4} \times (17.750^2 - 10.750^2) = 16.3216 \text{ #/ft} = 1.3601 \text{ #/in}$
7.2467 #/in

SEISMIC LOADING

HORIZONTAL: $(.2)(7.2467) = 1.4493 \text{ #/in}$

VERTICAL: $(.1)(7.2467) = 0.7247 \text{ #/in}$

COMBINED = 1.621 #/in

VERTICAL RIGID SUPPORT AT EL. 109'-6 5/8" PT. (80)

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

FORMER LMFBZ 30MWT STM. GEN CONT. NO. 900-130 MADE BY C.K. DATE 2-15-73
LOCATION SODIUM OUTLET LINE DWG. NO. 552-10-P CHK'D BY EJ DATE 2-15-73

THERMAL EXPANSION					DEAD LOAD					SEISMIC LOADING IN X-Y PLANE					SEISMIC LOADING IN Z-Y PLANE				
#	#	#		#	#	#	#	#81	#	#	#	#	#	#	#	#	#	#	#
40	55	80		111	40	55	80	82	111	40	55	80	81	111	40	55	80	82	111
Δx	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{3}{4}$		$\frac{1}{4}$	<u>MOVEMENTS IN INCH. FORCES IN LBS.</u> <u>FORCES SHOWN ARE ACTING ON RESTRAINTS.</u>													
Δy	$\frac{3}{4}$	$\frac{1}{8}$	0		$2\frac{5}{8}$														
Δz	$\frac{1}{8}$	$\frac{13}{16}$	$\frac{3}{16}$		$\frac{1}{4}$														
F_x																			
F_y			-330		-2,700	-2,030	-2,360	-2,350	-120	-200	-300		-1,200	-260	+100	-300	-200		-200
F_z																			-1,200

MOVEMENTS IN INCH. FORCES IN LBS.
FORCES SHOWN ARE ACTING ON RESTRAINTS.

FOR THERMAL EXP. MAX. STRESS AT PT. # 60 — 4,453 PSI.
FOR DEAD LOAD MAX. STRESS AT PT. # 10 — 4,873 PSI.
FOR SEISMIC IN X-Y PLANE AT PT. # 60 — 4,749 PSI.
FOR SEISMIC IN Z-Y PLANE AT PT. # 10 — 5,544 PSI.

DIMENSIONS SHOWN IN COLD FOR HORIZONTAL SEISMIC GUIDE AT EL. 109'-6 5/8".

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

OWNER LMFBR 30 MW TSTM GEN CONT. NO. 900-130 MADE BY C.K. DATE 2-14-73
LOCATION SODIUM OUTLET LINE DWG. NO. 552-10-P CHK'D BY ES DATE 2-14-73

FORCES IN LBS. MOMENTS IN FT-lbs.

F ^s & M ^s ACTING ON SECONDARY EXP. TANK T-5 AT EL. 134'-11", INDUCED BY EVAPORATOR SODIUM OUTLET LINE 552-10-P. 10 ³ / ₄ " OD. (PT. ⑤)				F ^s & M ^s ACTING ON EVAPORATOR AT EL. 76'-3", INDUCED BY 10 ³ / ₄ " OD EVAPORATOR SODIUM OUTLET LINE 552-10-P. #⑩					
	DUE TO THERMAL EXPANSION 680°F	DUE TO DEAD LOAD	DUE TO SEISMIC LOADING IN X-Y PLANE	DUE TO SEISMIC LOADING IN Z-Y PLANE		DUE TO THERMAL EXPANSION 680°F	DUE TO DEAD LOAD	DUE TO SEISMIC LOADING IN X-Y PLANE	DUE TO SEISMIC LOADING IN Z-Y PLANE
F _x	- 96	+ 43	- 533	- 14		+ 96	- 43	- 611	+ 14
F _y	+ 272	- 1,225	- 204	- 433		+ 53	- 1,079	- 81	- 145
F _z	+ 2	+ 43	+ 3	- 571		- 2	- 43	- 3	- 611
M _x	+ 645	+ 3,726	+ 462	+ 4,709		- 804	+ 204	- 268	+ 2,202
M _y	+ 314	- 512	- 186	- 4,034		+ 340	- 987	- 327	- 4,804
M _z	- 880	+ 5,312	- 1,622	+ 1,866		- 2,328	+ 757	- 1,999	+ 209
FOR THERMAL EXP. MAX. STRESS AT PT. #60				— 4,453 PSI.					
FOR DEAD LOAD MAX. STRESS AT PT. #10				— 4,873 PSI.					
FOR SEISMIC IN X-Y PLANE MAX. STRESS AT PT. #60				— 4,749 PSI.					
FOR SEISMIC IN Z-Y PLANE MAX. STRESS AT PT. #10				— 5,544 PSI.					

SECONDARY EXPANSION TANK T-5.
 VERTICAL ZERO EXP. AT EL. 130'-0".
 HORIZONTAL ZERO EXP. IN X AND Z
 DIRECTION AT E OF TANK.

CE POINTS

CUST. POINTS

# 40	---	CSH-406
# 55	---	CSH-404
# 80, 91, 92	---	TBH-501
# III	---	CSH-237

C.E. DRWGS

07670 - 1F0109-01
 07670 - 1E0131-01
 07670 - 1E0132-01

7670 COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CE 2390 (8/67)

CUSTOMER LMFBR 30MW STEAM GENERATOR CONT. No. 900-130 MADE BY L.K. DATE 2-13-73
LOCATION 16" O.D. VENT LINE FROM DWG. No. _____ CHK'D BY JS DATE 2-13-73
STEAM/WATER DUMP TANK

SKETCH USED IN
MEC-21 PROGRAM

PIPING DIAGRAM

FOR DIMENSIONS
SEE REF. 2, 3, 4

7670

LMFBR

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER 30 MWT STEAM GENERATOR CONT. No. 900-130

MADE BY L.K. DATE 2-15-73

LOCATION 16" O.D. VENT LINE FROM

DWG. No.

CHK'D BY ES

DATE 2-15-73

STEAM/WATER DUMP TANK.

CALCULATING COEFFICIENT OF
EXPANSION FOR STEAM/WATER
DUMP TANK @ 445°FREFERENCE: STD. THERMAL
EXPANSION DATA, SI-14.4.2
SKETCH 1

TEMP. OF

 α IN./FT.

2 < 1 < 444
445
446

0.03105 Δ
 α
0.03123

$$\frac{1}{2} = \frac{\Delta}{.00018} \therefore \Delta = 0.00009$$

$$\therefore \alpha = 0.03114 \text{ IN./FT.}$$

CALCULATING EXPANSION MOVE-
MENTS OF POINT. 5

$$\Delta X_f = 0. \times 0.03114$$

$$= 0$$

$$\Delta Y_f = (115.833 - 109.0) \times 0.03114$$

$$= 6.833 \times 0.03114$$

$$\Delta Y_f = 0.2128"$$

$$\Delta Z_f = 0. \times 0.03114$$

$$= 0$$

VIEW REF. TO
DWG. NO. 07670-1F0109-03

7670

COMBUSTION ENGINEERING, INC.

LMFBR

WINDSOR, CONN.

CUSTOMER 30 MWt STEAM GENERATOR CONT. No. 900-130 MADE BY L.K. DATE 2-15-73
 LOCATION 16" O.D. VENT LINE FROM DWG. No. _____ CHK'D BY [Signature] DATE 2-15-73
STEAM/WATER DUMP TANK

EQUIVALENT WEIGHT DENSITY CALCULATIONS

CALCULATING EQ. WEIGHT DENSITY OF PIPE

$$A = \pi t (D - t) \text{ OR } \pi R^2$$

$$A_1 = \pi \times 2.5 (21 - 2.5) = 145.2987 \text{ IN.}^2$$

$$A_2 = \pi \times 2.41 (16 - 2.41) = 11.9315 \text{ IN.}^2$$

$$A_3 = \pi (7.759)^2 = 189.1304 \text{ IN.}^2$$

$$Q_1 = A_1 \times 0.00868 = 145.2987 \times 0.00868 = 1.2612 \text{ LB/IN.}$$

$$Q_2 = A_2 \times 0.28356 = 11.9315 \times 0.28356 = 3.3833 \text{ LB/IN.}$$

$$Q_3 = A_3 \times 0.03611 = 189.1304 \times 0.03611 = 6.8297 \text{ LB/IN.}$$

$$Q = 11.4742 \text{ LB/IN.}$$

EQ. WEIGHT
DENSITY USED
IN MEC21
PROGRAM

$$\rho = \frac{11.4742}{A_2} = \frac{11.4742}{11.9315} = \underline{0.962 \text{ LB/IN.}^3}$$

7670

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CE 2390 (8/67)

CUSTOMER LMFBR-30MWE STEAM GENERATOR CONT. No. 900-130 MADE BY L.K DATE 2-14-73
 LOCATION 16" O.D. VENT LINE FROM DWG. No. _____ CHK'D BY ES DATE 2-14-73
STEAM/WATER PUMP TANK

POWER BOILERS SEC. I

27.2.2 PAGE. 11

$$t = \frac{PD}{2SE + 2YP} + C$$

SOLVING "t" FOR VENT LINE

$$t = \frac{400 \times 16}{2 \times 15000 \times 1 + 2 \times 4 \times 400} + 0$$

$$t = 0.211" \text{ MIN.}$$

$$= \frac{8}{7} \times 0.211 \text{ NOM.}$$

$$t = 0.241" \leftarrow \text{USE IN MECRI PROGRAM}$$

$$D = 16"$$

$$P = 400 \text{ PSI @ } 445^{\circ}\text{F}$$

$$S = 15000 \text{ PSI @ } 445^{\circ}\text{F}$$

SA-106 B

$$Y = 0.4$$

$$E = 1$$

$$C = 0$$

7670

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER LMFBR-30MW STEAM GENERATOR CONT. No. 900-130 MADE BY L.K. DATE 2-16-73
LOCATION 16" O.D. VENT LINE FROM DWG. No. _____ CHK'D BY ES DATE 2-16-73
STEAM/WATER DUMP TANK

SEISMIC LOADING CALCULATION

WEIGHT $Q = 11.4742 \text{ LB/IN.}$

HORIZONTAL SEISMIC $= 0.2 \times 11.4742 = 2.29484 \text{ LB/IN.}$

VERTICAL SEISMIC $= 0.1 \times 11.4742 = 1.14742 \text{ LB/IN.}$

$$\cos F_x = \cos \alpha = \frac{2.29484}{2.56571} = 0.8944$$

$$\cos F_y = \cos \theta = -\frac{1.14742}{2.56571} = -0.4472$$

$$\cos F_z = 0$$

$$\cos F_x = 0$$

$$\cos F_y = \cos \theta = -\frac{1.14742}{2.56571} = -0.4472$$

$$\cos F_z = \cos \alpha = \frac{2.29484}{2.56571} = 0.8944$$

7670

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR 30MW STEAM GENERATOR CONT. No. 900-130 MADE BY L.K. DATE 2-16-73
 LOCATION 16" O.D. VENT LINE FROM DWG. No. _____ CHK'D BY _____ DATE _____
STEAM/WATER DUMP TANK

FORCES & MOMENT ACTING ON STEAM/WATER
 DUMP TANK AT EL. 115'-10" INDUCED BY
 16" O.D. VENT LINE

POINT NO. 5	DUE TO WEIGHT LOAD	DUE TO THERMAL EXPANSION	DUE TO SEISMIC LOADING	
			X-Y PLANE	Y-Z PLANE
F_x	10	2		
F_y	-6,583	-79		
F_z	43	11		
M_x	-1,870	142		
M_y	0	0		
M_z	427	-32

NOTE:

FORCES ARE
 IN LBS

MOMENTS ARE
 IN FT-LBS

7670 COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STEAM GENERATOR CONT. No. 900-130 MADE BY L.K. DATE 2-16-73
LOCATION 16" O.D. VENT LINE FROM DWG. No. _____ CHK'D BY [Signature] DATE 2/16/73
STEAM/WATER DUMP TANK

EXPANSION MOVEMENTS AT THE SEISMIC GUIDE LOCATION POINT NO. 25			
POINT NO.	ΔX INCH	ΔY INCH	ΔZ INCH
25	0.0	1.308	0.0

SH 1/6

7670

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.CUSTOMER LMFBR 30MW STEAM GENERATOR CONT. No. 900-130 MADE BY L.H. DATE 2-14-73LOCATION 12 3/4" O.D. VENT LINE FROM DWG. No. _____ CHK'D BY _____ DATE _____
SODIUM/WATER REACTION
RELIEF VENT TANKSKETCH USED
IN MEC 21
PROGRAM

7670 COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

OWNER LMFBR 30MW STEAM GENERATOR CONT. No. 900-130 MADE BY L.H. DATE 2-16-73
LOCATION 12³/₄" O.D. VENT LINE FROM SODIUM/WATER REACTION RELIEF VENT TANK DWG. No. CHK'D BY DATE

DESIGN: 12³/₄" O.D. X 0.250" THK
SA-106 B
100 PSI @ 300°F

CALCULATING COEFFICIENT
OF EXPANSION

REF: STD. THERMAL EXPANSION
DATA, SI-14.2.2
SKETCH 1

$$\alpha = 0.0182 \text{ IN./FT @ } 300^{\circ}\text{F}$$

CALCULATING EXPANSION MOVEMENTS
OF POINT 5.

$$\Delta X = 0.0 \times 0.0182 = 0$$

$$\Delta Y = 6.250 \times 0.0182 = 0.1137"$$

$$\Delta Z = 0.0 \times 0.0182 = 0$$

7670

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.CUSTOMER LMFBR-30MW STEAM GENERATOR CONT. No. 900-130 MADE BY L.K. DATE 2-16-73LOCATION 12 3/4" O.D. VENT LINE FROM DWG. No. _____ CHK'D BY _____ DATE _____
SODIUM/WATER REACTION
RELIEF VENT TANKCALCULATING EQUIVALENT WEIGHT
DENSITY OF PIPE

$$AREA = \pi t(D-t) \text{ OR } \pi R^2$$

$$A_1 = \pi \times .25(16.75 - .25) = 92.677 \text{ IN.}^2$$

$$A_2 = \pi \times 25(12.75 - .25) = 9.8175 \text{ IN.}^2$$

$$A_3 = \pi \times (6.125)^2 = 117.8588 \text{ IN.}^2$$

$$Q_1 = A_1 \times 0.00868 = 92.677 \times 0.00868 = .80448 \text{ LB/IN.}$$

$$Q_2 = A_2 \times .28356 = 9.8175 \times .28356 = 2.7839 \text{ LB/IN.}$$

$$Q_3 = A_3 \times 0.03067 = 117.8588 \times 0.03067 = 3.6149 \text{ LB/IN.}$$

$$Q = 7.20328 \text{ LB/IN.}$$

EQ. WEIGHT DENSITY
TO BE USED IN
MEC21 PROGRAM

$$\rho = \frac{Q}{A_2} = \frac{7.20328}{9.8175} = 0.733 \text{ LB/IN.}^3$$

7670

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR 30MWT STEAM GENERATOR CONT. No. 900-130 MADE BY L.K. DATE 2-16-73
 LOCATION 12 3/4" O.D. VENT LINE FROM DWG. No. _____ CHK'D BY _____ DATE _____
SODIUM/WATER REACTION
RELIEF VENT TANK.

CALCULATING SEISMIC LOADING ON PIPE

$$Q = 7.20328 \text{ LB/IN.}$$

$$\begin{aligned} \text{HORIZONTAL SEISMIC LOAD} &= 0.2 \times 7.20328 \\ &= 1.44065 \text{ LB/IN.} \end{aligned}$$

$$\begin{aligned} \text{VERTICAL SEISMIC LOAD} &= 0.1 \times 7.20328 \\ &= .72033 \text{ LB/IN.} \end{aligned}$$

$$\cos F_x = \cos \alpha = \frac{1.44065}{1.610697} = 0.8944$$

$$\cos F_y = \cos \theta = -\frac{.72033}{1.610697} = -0.4472$$

$$\cos F_z = 0$$

$$\cos F_x = 0$$

$$\cos F_y = \cos \gamma = -\frac{.72033}{1.610697} = -0.4472$$

$$\cos F_z = \cos \theta = \frac{1.44065}{1.610697} = 0.8944$$

7670 COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER: MFBR 30 MW STEAM GENERATOR CONT. No. 900-130 MADE BY L.K. DATE 2-16-73
LOCATION: 12 3/4" O.D. VENT LINE FROM DWG. No. _____ CHK'D BY _____ DATE _____

SODIUM/WATER REACTION
RELIEF VENT TANK.

FORCES & MOMENTS ACTING ON
SODIUM/WATER REACTION RELIEF
VENT TANK AT EL 115'3" INDUCED
FROM 12 3/4" O.D. VENT LINE

POINT NO. 5	DUE TO WEIGHT	DUE TO THERMAL EXPANSION	DUE TO SEISMIC LOADING	
			X-Y PLANE	Y-Z PLANE
F _x	3	1	213	0
F _y	-1358	-35	-128	-129
F _z	0	0	0	221
M _x	76	10	11	943
M _y	6	0	-215	45
M _z	45	-19	-876	5

NOTE:
F'S - LBS
M'S - FT-LB

SH 155

7670

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN. PRO.

CUSTOMER UNFBR 30MW STEAM GENERATOR CONT. No. 900-130

MADE BY L.K. DATE 2-10-73

LOCATION 123" O.D. VENT LINE FROM DWG. No.

CHK'D BY 10/ DATE 3-7-73

SODIUM/WATER REACTION
RELIEF VENT TANK

LISTED BELOW ARE FORCES & EXPANSION MOVEMENTS
ON SUPPORT POINTS DUE WEIGHT, THERMAL
EXPANSION & SEISMIC LOADING

	DUE TO WEIGHT		DUE TO THERMAL EXPANSION		DUE TO SEISMIC LOADING X-Y PLANE		DUE TO SEISMIC LOADING Y-Z PLANE	
	SUPP. PT. 20	SUPP. PT. 60	SUPP. PT. 20	SUPP. PT. 60	SUPP. PT. 20	SUPP. PT. 60	SUPP. PT. 20	SUPP. PT. 60
ΔX INCH	-0.001	-0.089	0.001	-0.007	0.003	0.043	-0.001	-0.005
ΔY INCH	0.0	0.0	0.655	1.254	0.0	0.0	0.0	0.0
ΔZ INCH	0.010	-0.016	0.002	0.062	0.001	-0.001	0.002	0.034
W LB	/	/	/	/	/	/	/	/
F_x LB	-2422	-2918	/	/	-227	-280	-466	-0.0
F_z LB	/	/	/	/	/	/	/	/

EXPANSION FORCES & MOVEMENT AT THE GUIDES
DUE TO THERMAL, WEIGHT & SEISMIC LOADING

	DUE TO WEIGHT LOADING		DUE TO THERMAL EXPANSION		DUE TO SEISMIC LOADING X-Y PLANE		DUE TO SEISMIC LOADING Y-Z PLANE	
	GUIDE PT. 15	GUIDE PT. 65	GUIDE PT. 15	GUIDE PT. 65	GUIDE PT. 15	GUIDE PT. 65	GUIDE PT. 15	GUIDE PT. 65
ΔX INCH	-0.007	-0.063	0.001	-0.005	0.0	0.0	-0.001	-0.003
ΔY INCH	0.0	-0.001	0.573	1.118	0.0	0.0	0.0	0.0
ΔZ INCH	0.007	0.0	0.001	0.055	0.001	0.001	0.0	0.0
F_x LB	3	-3	1	-1	437	618	/	/
F_y LB	941	-1318	-35	35	/	/	/	/
F_z LB	0	0	0	0	/	/	397	650

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CE 2390 (8/67)

CUSTOMER LINE BP-301110T MODEL CONT. No. 7670 MADE BY W.M. DATE 2/13/72
LOCATION SH. INLET LINE WITH DUMP LINE DWG. No. _____ CHK'D BY ES DATE 2-13-72

SAT. STEAM COIN TUBES

$$H = \pi t (D - t) \text{ OR } \pi R^2$$

CALCULATING DENSITIES OF
PIPE CONSIDERED

$$A_1 = \pi (2.5) (8.5 - 2.5) = 47.1239 \text{ in}^2$$

$$A_2 = \pi (.34) (3.5 - .34) = 3.3753 \text{ in}^2$$

$$A_3 = \pi (1.41)^2 = 6.2458 \text{ in}^2$$

$$g_1 = A_1 \times .00868 \text{ \#/in}^3 = .4090 \text{ \#/in}$$

$$g_2 = A_2 \times .28356 \text{ \#/in}^3 = .9571 \text{ \#/in}$$

$$g_3 = A_3 \times .03611 \text{ \#/in}^3 = .2255 \text{ \#/in}$$

$$1.5916 \text{ \#/in} \Rightarrow 19.0992 \text{ \#/ft.}$$

ρ_{in^3} TO BE USED IN COMPUTER PROGRAM

$$\frac{1.5916 \text{ \#/in}}{A_2 = 3.3753 \text{ in}^2} = .472 \text{ \#/in}^3$$

S.H. INLET LINE

$$A_1 = \pi (3) (12.625 - 3) = 90.7135 \text{ in}^2$$

$$A_2 = \pi (.6875) (6.625 - .6875) = 12.8241 \text{ in}^2$$

$$A_3 = \pi (2.625)^2 = 21.6475 \text{ in}^2$$

$$g_1 = A_1 \times .00868 \text{ \#/in}^3 = .7874 \text{ \#/in}$$

$$g_2 = A_2 \times .28356 \text{ \#/in}^3 = 3.6369 \text{ \#/in}$$

$$g_3 = A_3 \times .03611 \text{ \#/in}^3 = .7817 \text{ \#/in}$$

$$5.2055 \text{ \#/in} \Rightarrow 62.4660 \text{ \#/ft.}$$

ρ_{in^3} TO BE USED IN COMPUTER PROGRAM

$$\frac{5.2055 \text{ \#/in}}{12.8241 \text{ in}^2} = .406 \text{ \#/in}^3$$

COMBUSTION ENGINEERING, INC. PPOJ 900-130
WINDSOR, CONN.CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-16-71
LOCATION _____ DWG. No. _____ CHK'D BY JDK DATE 2-16-71GENERAL NOTES

1. ALL PRE ENGINEERED TYPE HANGER COMPONENTS SELECTED FROM GRINNELL CATALOG PH-72.
2. HANGER ROD SIZES AND MATERIALS PER CE STD INST NO S1-25-68-4
3. SUPPORT ARRANGEMENTS HAVE BEEN DESIGNED ON A PRELIMINARY BASIS FOR ALL NEW PIPING LINES PER DWGS: 07670-1FO119-02, 07670-1FO109-02, 07670-1EO131-02 AND 07670-1EO132-02.
4. PRELIMINARY DESIGN ARRANGEMENTS FOR SEISMIC GUIDES ARE INCOMPLETE DUE TO INSUFFICIENT TIME.
5. SINCE ONLY PARTIAL INFO HAS BEEN RECEIVED FROM THE STRESS ANALYSIS GROUP MANY HANGER COMPONENTS, INCLUDING SPRING SIZES, ARE BASED ON ESTIMATED LOADS AND PIPING MOVEMENTS.
6. SUPPORT ARRANGEMENTS MAY INDICATE NEW STRUCTURAL STEEL THAT IS NOT SHOWN ON THE NEW STEEL ASSEMBLY DWGS 07670-1C-6950-0 THRU 07670-1C-6956-0 DUE TO INSUFFICIENT TIME.

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

PROJ 900-130

CUSTOMER LMFBR-30 M.W. STEAM GEN. CONT. No. 7670 MADE BY JDK DATE 2-8-73
LOCATION HGR #1 DWG. No. _____ CHK'D BY DWP DATE 2-15-73

NOTE: STOPS MUST BE PROVIDED FOR SAFETY VALVE REACTIONS

ESTD LOAD 7 KIIPS
FOR STL DESIGN
EL 120'-9" RTD 16 1/16"

PRJ 900-130

CUSTOMER

LMFBR-30 M.W. STEAM GEN. WINDS

CONT. No. 1670

MADE BY ✓✓✓

DATE 2-2-73

LOCATION HGR #2 HGR #8

DWG. No.

CHK'D BY

DATE 2-13-1

HGR #2 & #8

COMBUSTION ENGINEERING, INC. PROJ 900-B0
WINDSOR, CONN.

CUSTOMER LMFBR-30 MW STEAM GEN. CONT. No. 7670 MADE BY JDK DATE 1-29-73
LOCATION HGR #3 EVAP-INLET DUMP DWG. No. 07670-1E 0132 CHK'D BY DWP DATE 2-15-73

PLAN

NO STRESS ANALYSIS
DATE 2-15-73 JON

P.P. REVISION
2-8-73
HGR #3

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

PROJ 900-130

CUSTOMER LMFBR 30 M.W. STEAM GEN CONT. NO. 7670 MADE BY LDH DATE 1-29-73
LOCATION HGR # 4 EVAP. INLET DUMP DWG. No. 07670-1E 0132 CHK'D BY DWP DATE 2-15-73

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30-M.W STEAM GEN. CONT. No. 7670 MADE BY JDK DATE 1-29-73
LOCATION HGR # 5 EVAP. INLET DUMP DWG. No. _____ CHK'D BY DWP DATE 2-15-73

*collect around and go to
if spring to large only*

EL 119'-0" T.O.S.

EL 169'-0" T.O.S.

COMBUSTION ENGINEERING, INC. PROJ 900-130

WINDSOR, CONN.

OWNER LMFBR-30MW STEAMGEN

CONT. No. 7670

MADE BY JDX

DATE 1-29-72

LOCATION #6 EVAPOR INLET DUMP

DWG. No.

CHK'D BY DWP

DATE 2-15-73

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

PROJ 900-130

CUSTOMER
LOCATION

LMFBR-30MW-STEAM GEN.

CONT. NO. 7670

MADE BY JOK

DATE 1-30-73

CHK'D BY DWP

DATE 2-4-73

DWG. NO. 07670 IE 6132

STEAM PT #47

HGR #7

HGR #9

WINDSOR, CONN. 1-30-73

CUSTOMER LIFER-30MM STEAM GEN. CONT. No. 7070 MADE BY JK DATE 1-30-73

LOCATION HGR #10 SUPPLY INLET DUMP DWG. No. CHK'D BY DATE

PLAN

THIS HGR IS OUT FOR NOW
STRESS GIVEN 2-13-73

HGP#10

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

PROJ 900-130

LMFBR-301111 STEAM GEN.

CONT. No. 7670

MADE BY JDK DATE 1-30-73

LOCATION HGR # 11 SUPHTR INLET DUMP

DWG. No.

CHK'D BY DWP DATE 2-15-73

1711

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

PROJ 900-130

CUSTOMER LM FBR-30 MW STEAM GEN. CONT. No. 7670 MADE BY JPK DATE 1-30-73
LOCATION HGR #12 SUPHTR OUTLET DUMP DWG. No. 076701E0132 CHK'D BY DWP DATE 2-15-73

Rev. moved from cal line 6
to new Gx 2-9-73 JPK

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

PROJ 900-130

CUSTOMER LMFB R-30MW STEAM GEN CONT. No. 7670 MADE BY JDK DATE 1-31-73
LOCATION HGR # 13 DWG. No. _____ CHK'D BY DWP DATE 2-15-73

REV 2-7-73 JDK

HGR # 13

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

PROJ. 900-130

CUSTOMER **LMFBR-30MW STEAM GEN** CONT. No. **7670** MADE BY **JDK** DATE **2-3-73**
LOCATION **HGR #14 8" 800 SH OUTLET** DWG. No. **7670-1C-6954** CHK'D BY **DWP** DATE **2-14-73**

SINGLE ROLLER CAN'T TAKE THE LOAD
3075 lbs MAX
RECOMMENDED
LOAD

USE DOUBLE ROLLERS
SIZE 12 TO 14 C.T. 6,150 lbs OR
Pg 100 GRINNELL STEEL 26,000 lbs OR

Pipe saddle 165 A

SIZE 12 TO 15

8" 800 SH OUTLET
LINE

NO STEEL ABOVE
SUPPORT FROM
BELOW

10 7/16 TO 16 1/2 SOLT CIRCLE
4 BOLTS 3/4"

SEE PG 25
HGR #14

8 17

COMBUSTION ENGINEERING, INC.

PROJ 900-130

WINDSOR, CONN.

LMFBR-30 MW STEAM GEN

CONT. No.

7670

MADE BY

JDK

DATE

2-3-73

LOCATION

HGR# 27-28

DWG. No.

CHK'D BY

DWP

DATE

2-15-73

COMBUSTION ENGINEERING, INC. *PROJ 900-130*
WINDSOR, CONN.

WINDSOR, CONN.
CUSTOMER LMFBR-30 MW. STEAM GEN CONT. No. 7670 MADE BY JDK DATE 3-5-73
LOCATION HGR # 29 & #30 DWG. No. _____ CHK'D BY DWP DATE 2-15-73

HGR #29 & 30

17 16

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER LMFBR-30 MW STEINIGER CONT. No. 7670 MADE BY JDK DATE 3-5-73
LOCATION HGR # 31, 32, 33, 34 DWG. No. 09670-1F0107-01 CHK'D BY _____ DATE _____

NO SUPPORT
2-13-73 LTR
STRESS
GROUP
MAY 2 1/4" - 110
6 5/8" OD SUPHTR TO EVAP
CROSS OVER LINES
6" SCHED 40
H 31, 32, 33, 34

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

PROJ 900-130

OWNER LMFBR-30 MW STEAM GEN CONT. No. 7670 MADE BY JDK DATE 2-13-73
LOCATION HGR # 36, 37, 38, 39 DWG. No. _____ CHK'D BY DWP DATE 2-15-73
- TO EL 185' 4" approx

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

PROJ 900-130

LMFBR-30MW STEAM GEN. CONT. No. 7670

MADE BY JOK DATE 2-9-73

HGR #35

DWG. No.

CHK'D BY DWP DATE 2-15-73

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

PROJ 900-130

CUSTOMER LMFBR-30 MW STEAM GEN CONT. NO. 7670 MADE BY JDK DATE 1-26-73
LOCATION EVAPOR TO PUMP DWG. No. 07670-1E 031 CHK'D BY DWP DATE 2-14-73

8 $\frac{5}{8}$ " OP PUMP DISCHARGE LINE - 48" BR
 15 $\frac{1}{16}$ " AVG. THK SA 335 P-22 2900 PSIG 688°F ENG LTR
 8.625" OP. X .938" AVG WALL X 6.749" ^{AVG} I.D.

PIPE — 77.0 lbs/FT TABLE MECH. DRESS TUBING
 INSUL — 11.5 lbs/FT 3" THK .016" ALUM LAG. 15 $\frac{1}{16}$ " (0.055(d_o² - d_i²))
 WATER — 15.5 lbs/FT NAVCO or 034 $\frac{1}{2}$ "

$$Z = .098 \left(\frac{d^4 - d_i^4}{d} \right) = .098 \left(\frac{8.625^4 - 6.749^4}{8.625} \right) = .098 (401.062)$$

$$Z = 39.304 \text{ IN}^3$$

§ LTR 12-26-72 = 15,000 PSI. Pg. A-24
 ALLOWABLE
 TENSILE
 @ 688°F
 ASME CODE
 SECTION I

$$\text{MAX SPAN} = .75 \sqrt{\frac{EZ}{4W}} = .75 \sqrt{\frac{15,000 (39.31)}{4 (104)}} = .75 \sqrt{1417.42}$$

$$\text{MAX SPAN} = .75 (37.65) = 28.23 \text{ FT.}$$

MAX SPAN GRINELL 19.00 FT

HGR'S

#1, #2 #8 #14

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

PROJ 900-130

CUSTOMER LMFBR-30 MW STEAM GEN CONT. No. 7670 MADE BY JDX DATE 1-26-73
LOCATION # EVAPOR TO STEAM-WATER DUMP DWG. No. CHK'D BY DWP DATE 2-14-73

6 5/8" O.D. EVAP. INLET DUMP LINE TO STEAM-WATER DUMP TANK
TEMP 688°F ESTIMATED

WATER SIDE DUMP SYSTEM #2 EVAP. DUMP LINE 6" Q.D. SCH. 80

SH #2 (C.Y. SUN) 1-8-73 LTR.

6.625" O.D. X 0.432 AVG THK X 5.761 THEO I.D. 28.57 lbs/ft

PIPE 28.57 lbs/ft TABLE NAVCO
INSUL 3" THK 9.53 lbs/ft - 15 lbs/ft (0.055(d_o^2 - d_i^2)) 15 lbs/ft
WATER 11.29 lbs/ft TABLE NAVCO LTR 1-31-73 62.4 lbs/ft
49.40 lbs/ft OK

Z = 12.22 IN³ NAVCO Pg 12
section modulus, IN³

f LTR 12-26-72 = 15,000 PSI Pg A-24 ??
MAT'L ?? NOT SURE
1-26-73 JDX
OR LTR 12-26-72 RCH
FAP 1-1-73
SA-335-P22 FOR PIPE ??

$$\text{MAX SPAN} = .75 \sqrt{\frac{SZ}{4W}} = .75 \sqrt{\frac{15,000.00 \times 12.22}{(4.00) \times (49.40)}} = .75 (30.45)$$

MAX SPAN = 22.83 FT ???

gravel span 17'0"

HGR #

3.456.79

1921

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

PROJ 900-130

CUSTOMER LMFBR-30 MW STEAM GEN CONT. NO. 7670 MADE BY JDK DATE 2-5-73
LOCATION 12 3/4" OD SCH 20 SODIUM DWG. NO. _____ CHK'D BY DWP DATE 2-14-73

ITEM #11 WATER REACTION DUMP LINES (NEW) ASTM A 106 GR B
TEMP 300°F PRESS 100
12.75 OD X 12.250 I.D. X .250 NOM. WALL

approx. (less than water for the pipe) HGR pg 13

PIPE 33.4 lbs/FT
SODIUM/WATER 53.0 lbs/FT LTR 1-29-73 FOTI LTR 1-31-73 Keirstead
INSUL 16.7 lbs/FT $3 \text{ IN} \times .00545 (d_o^2 - d_i^2) W = \text{lbs/FT} = .0055 (18.75^2 - 12.25^2) 15.00$
 $\times .016 \text{ ALUM LAG } 15 \text{ lbs/FT} = 16.6237 \text{ lbs/FT}$
~~103.1~~ lbs/FT
94.1 lbs/FT LTR 1-29-73 FOTI

Z = 30.2 IN³
section modulus

f LTR 12-26-72 CODE ASME SECT I LTR JAN 4, 1973 Keirstead

S = 15,000 PSI Section I pg A-24 allowable unit stress in tension Section II pg 64

$$\text{MAX SPAN} = .75 \sqrt{\frac{S Z}{4 W}} = .75 \sqrt{\frac{15,000.00 \times 30.20}{4.00 \times 103.10}} = .75 (33.15)$$

MAX SPAN = 24.86 FT

$$\text{WT/FT (SODIUM)} (53 \text{ lbs/FT}) \quad .0055 (d_o^2) 53.0000$$

$$.0055 (12.2500)^2 (53.0000) = 43.6932$$

ck

$$\frac{\text{sodium}}{\text{water}} \frac{53.00 \text{ lbs/FT}^3}{62.40 \text{ lbs/FT}^3} (.34) d_o^2 =$$

$$.8493 (.3400) (12.2500)^2 = 43.323$$

USE 44 lbs/FT

PIPE 33.4
DUMP 44.0
INSUL 16.7
94.1 lbs/FT

HGR * 27, 28, 29, 30

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

PRJ 900-130

CUSTOMER LMFBR-30MW STEAM GEN CONT. No. 7670 MADE BY JDK DATE _____
 LOCATION _____ DWG. No. _____ CHK'D BY DWP DATE 2-14-73

6 $\frac{5}{8}$ OD SUPHTR TO EVAP CROSS OVER LINES6" SCHED 40 900°F 100PSIG. MAT'L 2 $\frac{1}{4}$ Cr-1Mo

PIPE	18.98	lbs/ft
SODIUM	10.80	lbs/ft
INSUL	16.70	lbs/ft
	46.48	lbs/ft

54 $\frac{lbs}{ft}$ 3 LTR. RCK 1-31-73 1-27-73 reinstatedZ = 8.50 IN³
section modulus
$$S_{2 \frac{1}{4} Cr-1Mo} = 13,100 \text{ lb}_f/\text{IN}^2 \text{ ESTI pg A-24 SECTION 7}$$

SMIS
SA 335-P22

$$\text{MAX SPAN} = .75 \sqrt{\frac{S Z}{4W}} = .75 \sqrt{\frac{(13,000.00)(8.50)}{(4.00)(47.00)}} = .75(24.23)$$

$$\text{MAX SPAN} = 18.17 \text{ FT}$$

1423

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.CUSTOMER LMF BR-30MW STEAMER CONT. No. 7670 MADE BY JPK DATE 2-1-73
LOCATION _____ DWG. No. _____ CHK'D BY DWP DATE 2-14-734 1/2" OD SUPHTR. INLET DUMP LINE TO STEAM
WATER DUMP TANK ~~4" SCH 80~~ ^{per J memo 3-6-73} 4" SCH 80

4" O.D. SCH 80 Preliminary Sizing Selection #4

14.98 lbs/FT PIPE

4.98 lbs/FT WATER

7.42 lbs/FT

27.38 lbs/FT

INSUL 3" THK X.OIG ALUM LAG ^{5/8"} _{FT3} .00545 (d_o² - d_i²) W/FT

$$= .0055 (10.50^2 - 4.50^2) (15.00) = 7.42 \text{ lbs/FT}$$

$$Z = .098 \left(\frac{d^4 - d_i^4}{d} \right) =$$

$$Z = 4.27 \text{ IN}^3 \text{ NAVCO Pg 12}$$

$$f = ??$$

2-6-73
MATH UNKNOWN

$$\text{MAX SPAN} = .75 \sqrt{\frac{f Z}{4 W}} = .75 \sqrt{\frac{f (4.27)}{4 (27,380)}} = .75 \sqrt{\quad}$$

HGR # 10, #11, #12, #13

1924

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

PROJ 900-130

CUSTOMER LMFBR-30MW STEANGED CONT. No. 7670 MADE BY JDK DATE 2-12-73
 LOCATION 10 3/4" OD SUPTR. SODIUM INLET DWG. No. 60" O.R. CHK'D BY DWP DATE 2-14-73

10 3/4" OD SCH 40 SUPTR SODIUM INLET LINE

MAT'L SS-304-H TEMP 1000°F PRES 100 PSIG

USE SA 312 PER FOTI TEL. CALL TO KEIRSTEAD 2-12-73

S = 13,700 PSI @ 1000°F ASME CODE SECTION I

10.75 O.D. X 10.020 I.D. X .365 NOM. THK.

PIPE - 40.5 lbs/FT NAUCC Pg 13
 INSUL - 13.7 lbs/FT
 SODIUM - 30.0 lbs/FT
84.2 lbs/FT

 $Z_{\text{section modulus}} = 29.90 \text{ IN}^3$ NAUCC Pg 13

$$\text{MAX SPAN} = .75 \sqrt{\frac{S Z}{4 W}} = .75 \sqrt{\frac{13,700.00 \times 29.90}{4 \times 84.20}} = .75 \sqrt{1216.24}$$

$$\text{WT./FT. (SODIUM)} \left(\frac{53 \text{ lbs}}{\text{FT}^3} \right) \quad .00545 (d_o^2) 53.0 = .0055 (10.0200)^2 53.0000 =$$

$$.0055 (100.4000) 53.0000 = 29.2666$$

$$\text{check } \frac{\text{SODIUM } 53.00}{\text{WATER } 62.40} (.34) d_o^2 = .8493 (.34) (100.40) = 28.9850$$

USE 30 lbs/FT

$$\begin{aligned} \text{WT./FT (INSUL)} &= .00545 (d_o^2 - d_i^2) W \\ &= .0055 (16.75^2 - 10.75^2) 15.00 \\ &= \underline{\underline{13.62 \text{ lbs/FT}}} \end{aligned}$$

ry 23

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

PROJ 900-130

CUSTOMER LMFBR-30 MW STEAM GEN CONT. No. 7670 MADE BY JBL DATE 2-14-73
LOCATION HCR #12 DWG. No. _____ CHK'D BY DWP DATE 2-14-73

SEE P213
HCR #14

3

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR-30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-5-73
LOCATION 6 5/8 OD SUPHTR INL. LINE DWG. No. _____ CHK'D BY JDK DATE 2-15-73

$$OD = 6 \frac{5}{8}''$$

$$WALL = 11/16 \text{ AUG}$$

$$MIN. = .602''$$

$$SA-335-P-22$$

$$2840 \text{ PSI}$$

$$960^\circ$$

$$S_A = 10,360 \text{ PSI}$$

$$WGT/FT \text{ DRY} = 43.62 \text{ \#}/\text{FT}$$

$$WGT/FT \text{ H}_2\text{O} = .34 \left[6.625 - 2(.602) \right]^2 = .34 (5.421)^2 = 9.991 \text{ \#}/\text{FT}$$

$$\text{INSULATION} = 3 \frac{1}{2}'' \text{ THK.}$$

$$WGT/FT \text{ INSUL.} = 5.45 \times 10^{-3} (13.625^2 - 6.625^2) 15 = 11.588 \text{ \#}/\text{FT}$$

$$Z = \frac{\pi (6.625^4 - 5.421^4)}{32 (6.625)} = 15.750 \text{ IN}^3$$

TOTAL WGT/FT

$$9.991$$

$$11.588$$

$$43.620$$

$$65.199$$

USE 65 \#}/\text{FT}

$$\text{SPAN} = .75 \left[\frac{S_A Z}{4 W_S} \right]^{1/2} =$$

$$= .75 \left[\frac{10,360 (15.75)}{4 (62.0)} \right]^{1/2} = 19.237 \text{ FT}$$

SH-1

$$\text{SPAN} = 19.238 \text{ FT GRINNELL SPAN} = 17'-0''$$

SUPHTR
INLE

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR-30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-6-73
LOCATION G⁵/3 SUPHTR INL. LINE DWG. No. _____ CHK'D BY JDK DATE 2-15-73

$$R = 36"$$

$$\theta = 15^\circ$$

$$T = R \tan \frac{\theta}{2}$$

$$T = 36 \tan 7.5^\circ$$

$$T = 36 (.1316) = 4.7376" \approx 4\frac{3}{4}"$$

BEND LINE ELEVATION

$$\tan 15^\circ = \frac{21}{x}$$

$$x = \frac{21.0}{.2679} = 78.3874"$$

$$\frac{78.3874}{4.7376} = 16.5475$$

$$83.1250 = 6' - 11\frac{1}{8}"$$

$$\begin{array}{r} 172'-0" \\ 6'-11\frac{1}{8}" \\ \hline 165'-0\frac{7}{8}" \end{array}$$

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-6-73
LOCATION 6 5/8 SUPHTR INL LINE DWG. No. _____ CHK'D BY 10K DATE 2-15-73

① 4 1/2" DUMP LINE
464# $\approx$.5K 5DK

② 6 5/8" LINE
 $65(6.75) = 438.75$
 $\approx$ 2.44K

③ VALVE -.7K

④ 6 5/8" PIPE
 $(3.25)(65) = 211$ #

⑤ L.R. BEND

$.25(2\pi 3.0)(65) = 306.34$

⑥ SAFETY VALVE
 $P = 250$ # (WGT)
 $R = 6000$ # (REACT)

$$\overset{+}{\curvearrowright} EM @ R_0 = 0 = 1.25(.5) + 3.38(.44) + 4.75(.7) - 6.75 R'_{23} + 2.75(12.25)$$

$$R'_{23} = 5.796K$$

$$\overset{+}{\curvearrowright} EM @ R_{23}'' = 0 = 1.67(.21) + 5.2(.31) - 6.25 R_2$$

$$R_2 = .313$$

$$R_{23}'' = .207$$

$$R_{23} = R_{23}' + R_{23}''$$

$$= 5.796 + .207$$

$$= 6.003$$

#

$$\frac{6003}{200} \text{ HARDWARE}$$

$$6203 =$$

USE 6.5K

SUPHTR
INLET

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

WINDSOR, CONN.

LMFBR-30MW STM GEN CONT. No. 7670

COMER

MADE BY DWP

DATE 2-5-73

LOCATION 65/800 SUPHTR INL LINE

DWG. No.

CHK'D BY VPK

DATE 2-15-73

SP 11581A

N.
I
V

NO STRESS ANALYSIS DATA AVAILABLE

望

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-12-73
LOCATION 6 5/8 OD SUPHTR INL LINE DWG. No. _____ CHK'D BY JMK DATE 2-15-73

SUPPORT #24

PREL. LOADING

$$\begin{array}{r} 163'-0'' \\ 119'-11'' \\ \hline 43'-1'' \end{array}$$
 BELOW

$$\begin{array}{rcl} (43.08') (65.0) & = & 2800.2 \\ (6.5') (65.0) & = & 422.5 \\ (SH-48) R_{24} & = & 566.0 \\ \hline & & 3788.7 \# \\ & & 400.0 \# \text{ SPRING \& HARDWARE} \\ \hline & & 4188.7 \\ & & \underline{\text{USE 4.5K}} \end{array}$$

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE
LOCATION 6 5/8" SUPHTR INL LINE DWG. No. CHK'D BY JOK DATE 2-15-73

① SPRING

$$P = 4,189^{\#} \text{ (ESTIMATED)}$$

$$P/2 \approx 2,100^{\#}$$

$$\text{EXP.} = 2 \frac{1}{2}'' \uparrow \text{ (ESTIMATED)}$$

$$TT = 1.20(2.5) = 3.00''$$

USE SIZE NO. 26,
FIG 80V, TYPE C
2-REQ'D PER SUPPORT

$$B = 2 \frac{3}{4}'' \quad G = 2 \frac{5}{8}''$$

$$RTO = 31 \frac{7}{16} - \frac{3}{2} = 29 \frac{15}{16}''$$

$$\begin{array}{r} 29 \frac{15}{16} \\ - 5 \frac{1}{2}'' \text{ (CONDUCTOR)} \\ \hline 24 \frac{7}{16}'' \\ - 3 \\ \hline 21 \frac{7}{16}'' \end{array} \quad \begin{array}{r} 29 \frac{15}{16} \\ - 3 \\ \hline 26 \frac{15}{16}'' \end{array}$$

② BEAM ATTACH.

WELDED BEAM ATTACH
FIG 66, ROD SIZE = 7/8"
WITH BOLT AND NUT

⑤ HGR STD 40 RISER CLAMP
ASTM A-387 GR D
3/4" X 4" STOCK SIZE
TYPE A, 6 5/8" OD PIPE
3/4" ϕ BOLT, E = 13 1/2"
S = 1 1/4", A = 1 3/4", K = 2 11/16"

③ 1" ϕ HGR ROD, SA-306 GR 70
GOOD FOR 7.23K @ 650°

④ WELDLESS EYE NUT FIG 290
1" ϕ ROD

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

OWNER LMFBR 30 MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-6-73
LOCATION 6 5/8" SUPHTR INL LINE DWG. No. CHK'D BY JOK DATE 2-15-73

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-12-77
LOCATION 6 5/8 SUPHTR INL LINE DWG. No. _____ CHK'D BY JMK DATE 2-15-73
10 3/4 SAT. STEAM COLL. HDR.

① L.R. BEND 6 5/8"

$$.26(2\pi 3.0)(65 \#/\text{Ft}) = 306.3 \#$$

② 6 5/8 LINE

$$(3.8)(65 \#/\text{Ft}) = 247 \#$$

③ 10 3/4" HDR.

OD = 10 3/4, SCH. 160, 688°

INSUL. = 3" THK. ESTIMATED

WGT/Ft DRY = 116

" " WATER = 24.6

" " INSUL. = $5.45 \times 10^{-3} (16.15^2 - 10.75^2) 15 = 13.5$

TOTAL WGT/Ft = 154 #/Ft.

$$(5.0)(154 \#/\text{Ft}) = 770 \#$$

770 HDR
356 3 1/2" TUBES
1,126 #

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR-30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-12-73
LOCATION 10³/₄ SAT STM COLL HDR DWG. No. CHK'D BY JWL DATE 2-15-73

SAT. STM. CONN. TUBES

$$O.D. = 3.5 \times .340 \text{ WALL}$$

$$WGT/FT \text{ DRY} = 11.47 \text{ \#/FT}$$

$$WGT/FT \text{ WATER} = .34 (2.82)^2 = 2.7$$

$$INSUL. = 2 \frac{1}{2} \text{ (ESTIMATED)}$$

$$WGT/FT \text{ INSUL} = 5.45 \times 10^{-3} (8.5^2 - 3.5^2) 15 = 5 \text{ \#/FT}$$

$$\text{TOTAL WGT/FT} = 19.17 \text{ \#/FT}$$

USE 19 \#/FT

LOAD ON THE HDR

$$3(6.25')(19 \text{ \#/FT}) = 356.25 \text{ \#}$$

$$\Sigma M @ R_{24}' = 1.1(.3) + 4.8(.25) + 9.3(1.13) - 10.8 R_{25}$$

$$R_{25} = 1.114 K$$

$$R_{24}' = .566 K$$

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR-30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-13-78
LOCATION 10³/₄ SAT STEAM COLL HDR DWG. No. _____ CHK'D BY JKK DATE 2-15-78

NO STRESS ANALYSIS DATA AVAILABLE

SAT STM
COLL HDR

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR-30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-13-73
LOCATION 10³/₄" SAT. STEAM COLL HDR DWG. No. _____ CHK'D BY JPK DATE 2-15-73

SAT STM
COLL HDR

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

PROJ. 900-130

CUSTOMER LMFBR-30MW STEAM GEN. CONT. No. 7670 MADE BY DWP DATE 2-13-77
LOCATION 10 3/4 SAT STM COLL HDR DWG. No. _____ CHK'D BY JOK DATE 2-15-77

SPRING SIZE

(3)

ESTIMATED LOAD = 1.114 K WET

$$MVT = 1 \frac{3}{4}''$$

$$TT = 1.20(1.75) = 2.100''$$

$$\begin{array}{r} 1.75 \\ .5 \\ \hline 2.25 \end{array}$$

$$TT = 2 \frac{1}{2}''$$

$$P/2 = 1.114/2 = .557 K$$

$$\begin{array}{r} 557 \\ 80 \# \text{ (SPRING)} \\ \hline 637 \# \end{array}$$

TRY HGR SIZE 12
NO GOOD

USE HGR SIZE NO 13
80-V TYPE G

$$C-C = 24 \frac{1}{2}''$$

$$LOAD/SPRING = 637 \#$$

$$TOTAL LOAD = 1274 \#$$

$$TT = 2 \frac{1}{2}''$$

$$CALC TRAVEL = 1 \frac{3}{4}''$$

$$\begin{array}{r} 5 \frac{3}{8} \\ + \frac{1}{16} \\ + \frac{1}{4} \\ \hline 5 \frac{11}{16} \end{array}$$

$$\begin{array}{r} 3 \frac{9}{16} \\ 3 \frac{9}{16} \\ \hline 7 \frac{1}{8} \end{array}$$

$$\begin{array}{r} V = 5 \frac{13}{16} \\ B = 2 \frac{1}{4} \\ \hline 3 \frac{9}{16} \end{array}$$

$$\begin{array}{r} 5 \frac{11}{16} \\ 5 \frac{11}{16} \\ 4 \\ \hline 15 \frac{3}{8} \\ 7 \frac{1}{8} \\ \hline 22 \frac{1}{2} \end{array}$$

$$\begin{array}{r} 10 \frac{3}{4} \\ 6 \frac{4}{8} \\ \hline 16 \frac{3}{4} \\ 4 \\ \hline 7 \frac{1}{8} \\ 23 \frac{7}{8} \\ \hline 24 \frac{1}{2} \end{array}$$

CLEARANCE 1/2

$$24 \frac{1}{2}$$

USE 24 1/2"

SUPHTR
INLET

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR-30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-14-73
LOCATION 10 $\frac{3}{4}$ " SAT STM COLL HDR DWG. No. _____ CHK'D BY VPK DATE 2-15-73

ALL SIZES BASED ON PREL. LOADING
STRESS ANALYSIS DATA NOT AVAILABLE

① WELDED BEAM ATTACH. FIG 66

P=637[#], USE ROD SIZE $\frac{1}{2}$ "
WITH BOLT & NUT
GOOD FOR 1130[#] @ 650°.

⑤ WELDLESS EYE NUT FIG. 290

ROD SIZE = 1"

② 1" ϕ HGR ROD
SA-306-GR 70

P=637[#], ROD GOOD FOR 7.23K

④ PIPE COVERING PROTECTION SADDLE
FIG 164, 10 $\frac{3}{4}$ " O.D. PIPE

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. NO. 7670 MADE BY DWP DATE 2-6-73
LOCATION 8 5/8 EVAP. OUTLET LINE DWG. No. _____ CHK'D BY JDK DATE 2-15-73

OD = $8 \frac{5}{8}$ "
WALL = $1 \frac{5}{16}$ " AVG
SA-335-P-22
2900 PSIG
688°

$$\text{WGT/F}_T \text{ DRY} = 77.01 \text{ \#/F}_T$$

$$\text{MIN. WALL} = .821"$$

$$\text{WGT/F}_T \text{ H}_2\text{O} = .34 \left[8.625^2 - 2(.821) \right]^2 = 16.472 \text{ \#/F}_T$$

$$\text{INSULATION THKNS} = 3"$$

$$\text{WGT/F}_T \text{ INSUL} = 5.45 \times 10^{-3} (14.625^2 - 8.625^2) 15 = 11.4 \text{ \#/F}_T$$

$$\text{TOTAL WGT/F}_T = 77.01 + 16.472 + 11.4 = 104.882 \text{ \#/F}_T$$

USE 105 \#/F_T

GRINNELL SUGGESTED SPAN = 19 FEET

COMBUSTION ENGINEERING, INC. PROJ 900-130

WINDSOR, CONN.

TOMER

LMFBR 30MW STM GEN

CONT. NO. 7670

MADE BY DWP

DATE 2-6-75

LOCATION

8 5/8 EVAP OUTL LINE

DWG. NO.

CHK'D BY JWH

DATE 2-15-75

NOTE: SOME TYPE OF SPRING STOPS ARE REQ'D. DUE TO SAFETY VALVE REACTIONS. NO TIME TO COMPLETE.

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

TOMER LMFB 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-15-73
LOCATION 8 5/8 EVAP OUTL LINE DWG. No. CHK'D BY JDL DATE 2-15-73

SPRING SIZE

PIPE MNT. = $\frac{1}{4}"$ ↑
P = 2417#

USE B-268 TYPE B
HGR SIZE 12

BEAM ATTACH WELD SIZE

$$L = 2(6) = 12"$$

$$\#/\text{IN} = \frac{16,000\#}{12"} = 1,333\#/\text{IN}$$

USE 3/16 WELD, 2,800#/\text{IN}.

EVAP OUTL
LINE

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR-30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-6-71
LOCATION 8 5/8" EVAP OUTL LINE DWG. No. _____ CHK'D BY JRK DATE 2-5-73

SUPPORT #19

① DUMP LINE
6 5/8" WGT/FT = 49.5#/FT
P = 672# + VERT. RUN
P = 672# + 4.0(49.5)
P = 870# USE 1K

② 8 5/8" PIPE
P = (3.75)(105#/FT) = 394# USE .4K

③ SAFETY VALVE

④ SAFETY VALVE

⑤ 8 5/8" PIPE
P = 4.75(105) = 499#
2500#

⑥ EVAP OUTL VALVE

⑦ BEND
P = .25(2 ft) 4.0(105)
P = 660#

EVAP. OUTL
LINE

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-6-73
LOCATION 8 5/8 EVAP OUTL LINE DWG. No. _____ CHK'D BY JPK DATE 2-15-73

SUPPORT #19

$$EM @ R_0 = 0 = 1.5(1.0) + 1.92(.4) + 2.75(12.0) - 3.75 R'_{19}$$

$$R'_{19} = 9.404 K$$

$$EM @ R_{19} = 1.0(6.0) + 2.3(.5) + 2.67(.7) + 7.17(.7) - 8.75 R_2$$

$$R_2 = 1.604 K$$

$$R''_{19} = 6.296 K$$

$$R_{19} = R'_{19} + R''_{19} = 9.404 + 6.296 = 15.700$$

$$\begin{array}{r} 15,700 \text{ }^{\#} \text{ D.L.} \\ \underline{250 \text{ }^{\#} \text{ HARDWARE}} \\ 15,950 \\ \text{USE } \underline{16K} \end{array}$$

EVAP OUTL
LINE

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-8-73
LOCATION 12 3/4 EVAP OUTL LINE DWG. No. _____ CHK'D BY JMK DATE 2-15-73

SH-3

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-8-73
LOCATION 8 3/4 EVAP OUTL LINE DWG. No. _____ CHK'D BY INL DATE 2-15-73

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-15-73
LOCATION 8 5/8" EVAP OUTL LINE DWG. No. _____ CHK'D BY JML DATE 2-15-73

SPRING

$$\text{PIPE MVT} = 1.773" \uparrow$$
$$P = 5,606 \#$$

USE 81-H, TYPE B

$$TT = 1.773(1.20) = 2.127$$

USE $2\frac{1}{2}"$

SIZE #39

RISER CLAMP

HGR STD 40, TYPE A

$$P = 7.5K @ 688^\circ$$

TEMP CORR FACTOR = .8

A-36, PIPE = $8\frac{5}{8}"$

$$D = 6\frac{11}{16}"$$

$$\text{CORR LOAD} = .8(7.5) = 6.0K$$

$$G = \frac{3}{4}" \times 5", F = 1", E = 11"$$

$$\text{MIN } E' = 4.3125 + 1.5 + 1.5(1.875) + 1" = 9.624" < 11.0" \text{ OK}$$

$$S = 1\frac{3}{4}", A = 2\frac{1}{2}", K = 3\frac{7}{16}"$$

WELD FOR BEAM ATTACH.

$$P/\text{IN} = \frac{7,500\#}{5.0"} = 1,500\#/\text{IN}$$

USE $\frac{3}{16}$ FILLET, 2.8K

EVAP OUTL
LINE

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-8-73
LOCATION 8⁵/₈ EVAP OUTL LINE DWG. No. _____ CHK'D BY JMK DATE 2-15-73

SUPPORT # 24

151'-6"
120'-9"
30'-9" VERT.

ESTIMATED LOAD

$$\begin{array}{rcl}
 \text{BELOW} & (30.75')(105) & = 3229 \text{ \#} \\
 & (SH-5B) R_{24}' & = 278 \text{ \#} \\
 & (SH-2B) R_2 & = 1604 \text{ \#} \\
 \text{ABOVE} & (20.0)(105) & = 2100 \text{ \#} \\
 & \hline
 & 7211 \text{ \#} \\
 & 200 \text{ \#} \text{ HARDWARE} \\
 & \hline
 & 7411 \text{ \#} \\
 & \text{USE } \underline{7.5K}
 \end{array}$$

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-8-73
LOCATION 8 5/8 EVAP OUTLET LINE DWG. No. _____ CHK'D BY DK DATE 2-15-73EVAP. OUTL DIST HDR

$$OD = 12\frac{3}{4}$$

$$ID = 10\frac{1}{2}$$

SA-387-D NORMALIZED AND TEMPERED

2900 PSIG

688°

$$AVG WALL = \frac{12.75 - 10.5}{2} = 1.125"$$

$$WGT/FT DRY = 115.6 \text{ \#/FT.}$$

INSULATION = 3" THK. ESTIMATED

$$WGT/FT INSUL = 5.45 \times 10^{-3} (18.75^2 - 12.75^2) 15 = 15.45 \text{ \#/FT.}$$

$$WGT/FT WATER = .34 (10.5)^2 = 37.48 \text{ \#/FT.}$$

$$TOTAL = 115.6 + 15.45 + 37.48 = 168.56$$

$$USE \underline{169} \text{ \#/FT.}$$

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-8-77
LOCATION 8 5/8 EVAP OUTL LINE DWG. No. _____ CHK'D BY VPK DATE 2-15-77
12 3/4 EVAP OUTL DIST HDR

6-5" O.D. RELIEF TUBES

$$OD = 5"$$

$$MW = 480$$

$$WGT/FT DRY = 23.17 \# / FT$$

$$WGT/FT WATER = .34 [5.0 - 2(480)]^2 = 5.55 \# / FT$$

$$INSULATION = 2 \frac{1}{2}" THK ESTIMATED$$

$$WGT/FT INSUL. = 5.45 \times 10^{-3} (10^2 - 5^2) 15 = 6.13 \# / FT$$

$$TOTAL = 23.17 + 5.55 + 6.13 = 34.85 \# / FT$$

USE 35 \# / FT

LOAD ACTING ON THE HDR

$$6 (9.25') (35 \# / FT) = 1942.5$$

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-8-73
 LOCATION 12 3/4" EVAP OUTL DIST HDR DWG. No. _____ CHK'D BY WPR DATE 2-15-73

$$\textcircled{1} \ 8\frac{5}{8} \text{ LINE} \\ (4.25)(105\#/\text{Ft}) = 446.25 \#$$

$$\textcircled{2} \ 5" \text{ RELIEF TUBES} \\ 12\frac{3}{4}" \text{ EVAP OUTL HDR} \\ (5.75)(169) = 971.75 \\ (SH-5A) \ 5" \text{ TUBES} \rightarrow \frac{1942.5}{2914.25}$$

$$\begin{array}{r} \# \\ 3083\# \\ 400 \text{ HARDWARE} \\ \hline 3483\# \\ \text{USE 3.5K} \end{array}$$

$$R_{25} = \frac{2.12(446) + 7.08(2914)}{7.0} = 3082.377 \#$$

$$R_{24} = 277.623 \#$$

EVAP DIST
HDR.

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-12-73
 LOCATION 1234 EVAP OUTL DIST HDR DWG. No. _____ CHK'D BY JDK DATE 2-15-73

① SPRING

$$P = 2,247 \#$$

$$P/2 = 2,247/2 = 1,123.5 \#$$

$$\text{PIPE MWT} = 1.350 \uparrow$$

$$\text{TT} = 1.350(1.20) = 1.620$$

USE 2"

BOV TYPE G

HGR SIZE 16

$$\text{LOAD/SPRING} = 1212 \#$$

$$\text{TOTAL LOAD} = 2414 \#$$

② U-ROD
 $\frac{1}{2}" \phi$, SA-306 GR 70

③ USE $1" \phi$ SA-306 GR 70
 7.23 K @ 650°

④ COLLECTOR
 $M_{MAX} = 17 \text{ IN-K}$
 USE 2-CX5A A-36

⑤ $1" \phi$ ROD, SA-306 GR 70

⑥ WELDLESS EYE NUT
 FIG 290
 ROD SIZE = 1"

⑦ WELDED BEAM ATTACH
 FIG 66, ROD SIZE $\frac{7}{8}"$

$$\frac{1124 \#}{83 \#} = 166/2$$

$$1,207$$

$$\frac{1124 \#}{88 \#} = 176/2$$

$$1212 \#$$

$$\frac{12 \frac{3}{4}}{6} = 18 \frac{3}{4} \text{ "}$$

$$\frac{7 \frac{1}{8}}{8} = 26 \frac{5}{8} \text{ "}$$

$$\frac{1}{2}$$

$$27 \frac{1}{8}$$

USE 28"

$$5 \frac{13}{16} = V$$

$$1 \frac{7}{8} = B$$

$$3 \frac{15}{16}$$

$$6 \frac{30}{16} = 7 \frac{7}{8}$$

$$6 \frac{3}{8}$$

$$+ 1 \frac{1}{16}$$

$$2 \frac{1}{4}$$

$$8 \frac{11}{16}$$

$$17 \frac{3}{8}$$

$$7 \frac{7}{8}$$

$$25 \frac{1}{4}$$

~~USE 26"~~

⑧ FIG 164
 PROTECTION
 SADDLE

EVAP OUTL
 DIST HDR

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-9-77
LOCATION 12 3/4 EVAP OUTL DIST HDR DWG. No. _____ CHK'D BY 10K DATE 2-15-73

P53

COMBUSTION ENGINEERING, INC. PROJ 900-130

WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN

MADE BY DWP DATE 2-9-73

CONT. NO. 7670

LOCATION 12 3/4" EVAP OUTL DIST HDR

CHK'D BY JHK DATE 2-15-73

DWG. No.

SECT. A-A

SH-7

SP 11571A

EVAP OUTL
DIST HDR

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 1-26-73
LOCATION G5/3 FEED WATER LINE DWG. No. _____ CHK'D BY JDK DATE 2-15-73

$$\begin{aligned} OD &= 6.625" \\ ID &= 4.897" \end{aligned}$$

XXS

SA-106-B

3000 PSI

500°

$S_A = 15 \text{ KSI}$

$Z = 20.02 \text{ in}^3$

PREL

$$\begin{aligned} \text{WGT/FT PIPE} &= 53.16 \text{ \#/FT} \\ \text{WGT/FT}_{\text{H}_2\text{O}} &= \frac{8.16}{61.32} \text{ \#/FT} \end{aligned}$$

USE 62 \#/FT

INSULATION THKNS = $2\frac{1}{2}"$

" "

$$\text{WGT/FT} = 5.45 \times 10^{-3} (11.625^2 - 6.625^2) 15 = 7.5 \text{ \#/FT}$$

$$\text{SPAN} = .75 \left[\frac{S_A Z}{4 W_f} \right]^{1/2} = .75 \left[\frac{15,000 (20.02)}{4 (69.5)} \right]^{1/2}$$

$$= .75 [1080.2]^{1/2} = 24.649 \text{ FT}$$

GRINNELL RECOMMENDED SPAN = 17'-0"

COMBUSTION ENGINEERING, INC.

WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-2-73
 LOCATION 6 5/8 FEEDWATER LINE DWG. No. _____ CHK'D BY JDK DATE 2-15-73

PRELIMINARY LOADING

WGT/F_T OF PIPE, WATER AND INSUL. = 69#/F_T.

SUPPORT #15

$$\begin{aligned} .5 (6.0 F_T) (69 \# / F_T) &= 207 \\ .5 (13.5 F_T) (69 \# / F_T) &= 465.75 \\ \hline &672.75 \\ &100 + 15\% \\ \hline &772.75 \# \end{aligned}$$

$$\begin{aligned} &772.75 \# \\ &250.00 \text{ (HARDWARE)} \\ \hline &1022.75 \\ &\underline{\underline{\text{USE } 1025 \#}} \end{aligned}$$

SUPPORT #16

$$\begin{aligned} .5 (13.5 F_T) (69 \# / F_T) &= 465.75 \\ .5 (14.0 F_T) (69 \# / F_T) &= 483.00 \\ \hline &948.75 \\ &142 + 15\% \\ \hline &1090.75 \end{aligned}$$

$$\begin{aligned} &1090.75 \# \\ &250.00 \# \\ \hline &1340.75 \\ &\underline{\underline{\text{USE } 1340 \#}} \end{aligned}$$

SUPPORT #17

$$\begin{aligned} .5 (14.0 F_T) (69 \# / F_T) &= 483.00 \\ (3.75 F_T) (69) &= 258.75 \\ (2 \pi 3.0 / 4) (69) &= 325.20 \\ \hline &1066.95 \\ &160.00 + 15\% \\ \hline &1226.95 \end{aligned}$$

$$\begin{aligned} &1226.95 \# \\ &250.00 \# \\ \hline &1476.95 \\ &\underline{\underline{\text{USE } 1480 \#}} \end{aligned}$$

FEEDWATER
LINE

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-3-73
LOCATION 6 5/8" FEEDWATER LINE DWG. No. _____ CHK'D BY JOK DATE 2-15-73

SUPPORT 18

$$\begin{aligned}
 (50.17 F_T) (69.0 \frac{\#}{F_T}) &= 3461.730 \\
 (21.30/4) (69.0 \frac{\#}{F_T}) &= 325.197 \\
 (4.0 F_T) (69.0 \frac{\#}{F_T}) &= 276.000 \\
 \hline
 &4062.927 \\
 &406 +10\% \\
 \hline
 &4469
 \end{aligned}$$

$$\begin{aligned}
 &4469 \frac{\#}{\#} \\
 &250 \text{ HARDWARE} \\
 \hline
 &4719 \frac{\#}{\#}
 \end{aligned}$$

USE 4720

PER STRESS MEMO
P-5.1K
2-15-73
DWP

FEEDWATER
LINE

COMBUSTION ENGINEERING, INC. PROJ 900-130

WINDSOR, CONN.

LMFBR 30MW STM GEN 7670

MADE BY DWP

DATE 1-27-73

LOCATION 6 5/8" FEEDWATER LINE DWG. NO.

CHKD BY JOK

DATE 2-15-73

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

OWNER LMFBR 30 MW STM GEN CONT. No. 7670 MADE BY DWP DATE 1-29-73
LOCATION G 5/8 FEEDWATER LINE DWG. No. CHK'D BY JPK DATE 2-15-73

PARTIAL STRESS ANALYSIS DATA AVAILABLE

WUOL

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-7-73
LOCATION 6 5/8 FEED WATER LINE DWG. No. _____ CHK'D BY JK DATE 2-15-73

100

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.
OWNER LMFBR 30MW STM GEN 7670 MADE BY DWP DATE 2-2-73
LOCATION 6 5/8 FEEDWATER LINE DWG. No. CHKD BY JOK DATE 2-15-73

FEEDWATER
LINE

SH-S

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

OWNER LMFBR 30MW STM GEN CONT. NO. 7670 MADE BY DWP DATE 2-2-73
LOCATION GS/B FEEDWATER LINE DWG. NO. _____ CHK'D BY JOK DATE 2/5/73

EXISTING RIGID FRAME

EXISTING RIGID FRAME

PARTIAL STRESS ANALYSIS DATA
AVAILABLE.

SH-6

SUPPORT #18
(5.1K PER STRESS ANALYSIS)

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-15-73
LOCATION 6 5/8 FEEDWATER LINE DWG. No. _____ CHK'D BY JDK DATE 2-15-73

HGR STD 40 RISER CLAMP

$P = 5.1K @ 500^{\circ}$

ASTM A-36

TEMP CORR FACTOR = .8

CORR. LOAD = .8(5.1) = 4.08K

$G = 3/4" \times 5"$

$F = 7/8"$, $E = 11"$, $S = 1/2"$, $K = 2 9/16"$

$A = 1 3/4"$

FEEDWATER
LINE

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

PROJ 900-130

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-2-73
LOCATION G5/B FEEDWATER LINE DWG. No. _____ CHK'D BY DK DATE 2-15-73

COMBUSTION ENGINEERING, INC. PROJ 900-130

WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. NO. 7670 MADE BY DWP DATE 2-3-73

LOCATION G 3/8 FEEDWATER LINE DWG. NO. _____ CHECKED BY 10K DATE 2-5-73

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

CUSTOMER LMFBR-30 MW STEAM GEN. CONT. No. 7670 MADE BY JDK DATE 2-15-73
LOCATION SEISMIC GUIDE DWG. No. _____ CHK'D BY DWP DATE 2-16-73

PLAN EL 120'-0

STEEL DNG E303-356- S24

STRESS P. 71

10 3/4" OD SUPERHEATER
& SODIUM INLET LINE

'766

COMBUSTION ENGINEERING, INC.
WINDSOR, CONN.

PROJ 900-130

CUSTOMER LMFBR-30MW STEAM GEN CONT. No. 7670 MADE BY JDK DATE 2-15-73
LOCATION SEISMIC GUIDE EL 170'-6" DWG. No. _____ CHK'D BY DWP DATE 2-16-73

12 3/4" OD VENT LINE
FROM SODIUM/WATER
REACTION RELIEF

COMBUSTION ENGINEERING, INC. *PROJ 900-130*
WINDSOR, CONN.

WINDSOR, CONN.

CUSTOMER LHFBR-30 MW STEAM GEN CONT. No. 7670 MADE BY VOK DATE 2-15-73

LOCATION SEISMIC GUIDE #110'-6" DWG. No. _____ CHK'D BY DWP DATE 2-16-73

12 3/4" OD VENT LINE
FROM SODIUM/WATER
DEBITA TANK

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

STOMER LMFBR-30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-14-77
LOCATION 16" VENT LINE FROM DWG. No. _____ CHK'D BY JDK DATE 2-16-77

STM. WATER DUMP TANK

18'-8"

6'-7"

EL: 189'-4"

NEW

EL: 183'-4"

NEW

EL: 179'-4"

SUPPORT # 41 (7.6K)

EL: 151'-0"

NEW

6'-7"

A (SH-2)

PARTIAL STRESS ANALYSIS
DATA AVAILABLE
INSUFFICIENT TIME TO
COMPLETE GUIDE DESIGN

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-16-73
LOCATION 16" VENT LINE FROM DWG. No. _____ CHK'D BY JD/K DATE 2-16-73
STM WATER DUMP TANK

COMBUSTION ENGINEERING, INC. PROJ 900-130
WINDSOR, CONN.

CUSTOMER LMFBR 30MW STM GEN CONT. No. 7670 MADE BY DWP DATE 2-16-73
LOCATION 16 VENT LINES FROM DWG. No. _____ CHK'D BY JDK DATE 2-16-73
STM WATER DUMP TANK

① SPRING

$$P = 7600/2 = 3,800 \text{ \#}$$

$$\text{PIPE MVT.} = 2.19" \uparrow$$

$$TT = 1.20(2.19) = 2.628$$

USE 3"

81-H TYPE B.
SIZE 35
2-REQD

⑤ WELDLESS EYE NUT
FIG. 290, ROD SIZE = $1\frac{1}{4}"$

② WELDED BEAM ATTACH
FIG. 66, ROD SIZE = $1\frac{1}{8}"$

③ 1" ϕ HGR ROD
SA-306 GR 70, 7.23K @ 650°

④ HGR STD 40 RISER CLAMP
P = 7.6K @ 445°, ASTM A-36
CORR LOAD = 7.6(.8) = 6.08K
D = 13", G = 1x6 TYPE A
E = 21", F = 1" ϕ , A = 2 1/2, S = $1\frac{3}{4}"$
K = $7\frac{1}{8}"$