SEISMIC AND STRUCTURAL ANALYSIS

FOR THE

LACROSSE BOILING WATER REACTOR

SHUTDOWN CONDENSER

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Prepared For
Dairyland Power Cooperative

Project Application	Prepared By	Date
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nes NUCLEAR ENERGY SERVICES, INC.

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1. SUMMARY

This report, prepared for Dairyland Power Cooperative (DPC) presents the results of the structural analysis performed by Nuclear Energy Services, Inc. (NES) to verify the adequacy of the shutdown condenser during the Safe Shutdown Earthquake (SSE). The dead load, live load, pressure, and seismic stresses were found using conventional approximate methods. The main concern comes from local stresses placed on the shutdown condenser during a seismic event.

There are two areas where these local stresses exist, at the saddle supports and at the nozzles. After evaluating the primary stresses on the snutdown condenser, local stresses were evaluated. An in-depth study was made to find local bending stresses generated by the saddle supports during the seismic event. Nozzle loads were also checked with respect to local effects.

This report presents the final results for all parts of the shutdown condenser with the exception of the internals (tube bundle, baffles, tube bundle supports, etc.) and the 14-inch vent line nozzle. These final results indicate that the major structural components will maintain their integrity during the SSE event.

Preliminary analysis of the internals, using simplified analytical methods, indicates that stresses in the tube bundle may exceed their allowable during the SSE event. Further investigation will be required before a conclusion can be made on the internals.

The local stresses generated by the 14-inch diameter vent line will depend on the final support configuration on that line. These stresses will be maintained below allowables by suitable support modifications to the vent line, if required, The 14-inch vent line is the subject of a separate report.

The validity of the results presented in this report is contingent upon completion of the modifications recommended in Reference 4.

2. INTRODUCTION

This report, prepared for Dairyland Power Cooperative (DPC) presents the results of a stress and seismic analysis for the LaCrosse Boiling Water Reactor (LACBWR) shutdown condenser. The LACBWR shutdown condenser was designed and manufactured by the Struthers Wells Corporation of Warren, Pa. in 1964. The condenser is located in the reactor containment building on a platform ten feet above the main floor. Figure 1 shows the shutdown condenser and its location with respect to the containment building.

At the LACBWR plant, the shutdown condenser system provides a backup heat sink for the reactor in the event that the reactor is isolated from the main condenser. The shutdown condenser is automatically started when the reactor building steam isolation valve or turbine building steam isolation valve is not fully open, or when the reactor pressure exceeds 1,325 psig. These are emergency conditions that also provide a scram signal to the reactor safety system.

The shutdown condenser is a horizontal U-tube heat exchanger with reactor steam condensing inside the tubes. Reactor coolant sensible and latent heat is transferred to boiling, demineralized water on the shell side. The shell side vapor is vented directly to the outside atmosphere via the 14" vent line. The heat removal capacity of the shutdown condenser is well in excess of reactor decay heat generation rate for all times following reactor shutdown. The system provides adequate emergency shutdown cooling capability by cooling reactor water to 300° F at a rate of 50° F/hour. However, the normal mode of operation for reactor water cooling below is 470° F is the decay heat cooling system.

Natural circulation is the driving force behind the shutdown condenser system. Steam flows from the main steam lines into the shutdown condenser located ten feet above the main floor of the containment building. Condensate is collected in the lower channel section and is returned to the feedwater lines by gravity flow.

The shutdown condenser is a safety related piece of equipment. Its ability to operate during and after the SSE became an object of review of the LACBWR Safety Review

Committee. This analysis will also form a significant input to the Structural and Seismic Analysis portion of the NRC's Systematic Evaluation Program review of LACBWR.

The LACBWR shutdown condenser was originally designed to ASME Code Section VIII, Division I. Division I of Section VIII does not call for a detailed stress analysis but merely sets the wall thickness necessary to keep the basic hoop stress below the tabulated allowable stress. It does not require a detailed evaluation of the higher more localized stresses which are known to exist, but instead allow for these by the safety factor and a set of design rules. The analysis performed herein uses methods described in the ASME Section VIII Division 2. This provides a means whereby one can evaluate those vessels subject to severe service stresses.

3. DESCRIPTION

The shutdown condenser is a horizontal U-tube heat exchanger. The reactor steam is condensed in the tubes, and the cooling water is evaporated in the shell (see Figure 2). It was designed in accordance with Section VIII, Division I of the ASME Code, as modified by Code Case 1270-N. The tube-side design pressure and temperature are 1415 psia (internal) at a temperature of 650°F. The shell-side design pressure and temperature is 75 psi (Ext), 40 psi (Int) at 275°F. The shutdown condenser was designed to absorb without damage the thermal and physical shock of going from cold shutdown to operation at design condition in five (5) seconds, for 50 cycles during a 20-year unit lifetime.

The basic configuration of the shutdown condenser is shown in Figures 2 and 3. Major dimensions are given and further information is available in Reference 1. The shell of the condenser is made of 5/8-inch SA-285-C carbon steel. The heads at either end are 5/8 inch and 7/16 inch SA-285-C steel. The inlet channel is forged SA-105-2 steel 1-3/4 inch thick with a 15% monel cladding on the inside.

The internal U-tubes are Wolverine type S/T U-tubes 5/8 inch OD x 0.065 inch average wall. They are constructed of 70-30 copper-nickel alloy. The shell is exposed to only minor pressure whereas the tubes and channel inlet are exposed to reactor design pressure of 1415 psia at 650°F.

The shutdown condenser is about 18 feet in length and is supported on two saddles. These saddles are welded to the shell and bolted for support to wide flange beams. Slotted holes are supplied at one support to allow for thermal expansion upon heatup.

There are three nozzles of major interest; the 14-inch diameter vent nozzle, the 6-inch diameter main steam inlet and the 6-inch condensate return line. All of the above items are indicated in Figures 2 and 3. The 14-inch vent line is the topic of a separate report.

4. APPLICABLE CODES, STANDARDS AND SPECIFICATIONS

The following design specification, Regulatory Guides and Codes have been used in the analysis of the shutdown condenser.

1. ASME Boiler and Pressure Vessel Code, Section VIII, Division 1
2. ASME Boiler and Pressure Vessel Code, Section VIII, Division 2
3. American Institute of Steel Construction, Manual of Steel Construction, 8th Edition
4. USNRC Standard Review Plan, Section 3.8.4, Other Category I Structures

5. LOADING CONDITIONS

The loads that were evaluated with respect to the shutdown condenser are as discussed below. The shutdown condenser was designed in accordance with Division 1 of Section VIII of the ASME Pressure Vessel Code as modified by Code Case 1270-N. Secondary stresses were assumed to have been addressed in the original analysis and are not discussed in this report. Fatigue considerations have also been omitted from this report as they have previously been addressed in Reference 2.

Primary stresses were evaluated using the following load conditions; dead load, live load, pressure load, and SSE seismic loads. These loads were combined to evaluate the stresses in the vessel as follows:

$$1.5\, k\, S_m = D.L. + L.L. + P + E$$

Where:

S_m = Stress intensity in tension
k = Factor for load combination
D.L. = Dead Load stress
L.L. = Live Load stress
P = Pressure Load stress
E = Seismic stress due to SSE event

The OBE was not considered since the stresses with the SSE case were within the OBE allowable ($kS_m = 1.0 \times S_m$).

5.1 DEAD LOAD AND LIVE LOAD CONDITION

The following procedure was used to find the maximum dead load stress in the shell or inlet channel. The operating weight of 28 kips was divided into a 22 kip load and a 6 kip load as shown in Appendix A. The stresses were evaluated assuming the tank acted as a simply supported beam. The maximum bending stress in the shell and inlet channel was found by dividing the maximum moment by the appropriate section modulus. The stresses were small (below 1.0 ksi).

5.2 PRESSURE LOADING CONDITION

The internal pressure stresses were calculated using the following formulas from Reference 7.

For a cylindrical shell:

Longitudinal Stress $S_1 = P = \frac{2\,SEt}{R-0.4t}$

Circumferential (hoop) Stress $S_2 = \frac{SEt}{R+0.6t}$

The external pressure was also checked using criteria presented in ASME Division 1 and 2.

5.3 SEISMIC LOADING CONDITION

The seismic stresses were found using the dead load simple beam analysis. Static g-values were found using stiffness calculations contained in Reference 4. A summary of these g-values are included in Appendix A. Seismic bending stresses are a small part of the total primary stress collection.

During a seismic event, the shutdown condenser saddles and nozzles would transfer localized loads to the shell. It is these loads that produce the majority of primary stresses generated in this analysis. These loads were evaluated using more complex methods described in Section 7.

6. STRUCTURAL ACCEPTANCE CRITERIA

The following criteria was used to evaluate the structural acceptance of the shutdown condenser. This is taken from ASME, Section VIII, Division 2, Appendix 4, Figure 4-130-1.

Stress Category	Primary		
	General Membrane	Local Membrane	Bending
Description (For examples, see Table 4-120.1)	Average primary stress across solid section. Excludes discontinuities and concentrations. Produced only by mechanical loads.	Average stress across any solid section. Considers discontinuities but not concentrations. Produced only by mechanical loads.	Component of primary stress proportional to distance from centroid of solid section. Excludes discontinuities and concentrations. Produced only by mechanical loads.
	P_m	P_L	P_b

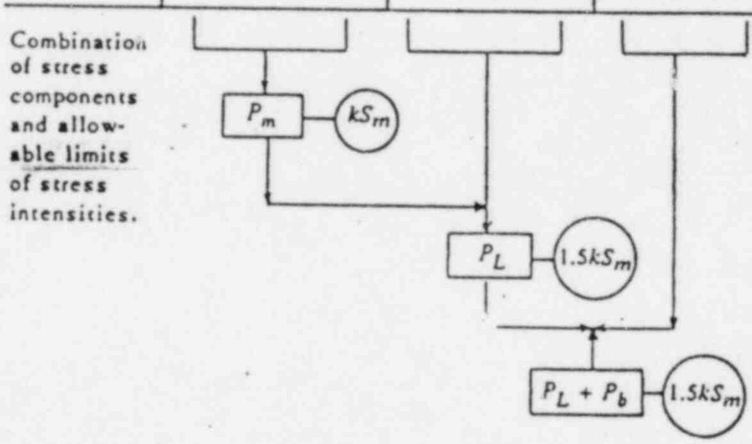

Figure 4-130.1, Stress Categories and Limits of Stress Intensity

The value of S_m is found for the material used in Section AM of Section VIII, Division 2 and are listed below:

For:

SA-285C $S_m =$ 18.3 Ksi @ 200°F / 17.7 Ksi @ 300°F — Table ACS-1

SA-105-2 $S_m =$ 17.4 Ksi @ 650°F — Table ACS-1

The allowable stress intensity for the shell materials (SA-285-C) is:

$$1.5\ kS_m = 1.5 \times 1.2 \times 17.85 = 32.13 \text{ Ksi @ } 275^{o}F$$

The allowable stress intensity for the inlet channel material (SA-105-2) is:

$$1.5\ kS_m = 1.5 \times 1.2 \times 17.4 = 31.32 \text{ Ksi @ } 650^{o}F$$

The value of k is found from Table AD-150.1 (Reference 3, Division 2) reproduced below.

TABLE AD-150-1
STRESS INTENSITY k FACTORS FOR VARIOUS LOAD COMBINATIONS

Condition	Load Combination (See AD-110)	k Factors	Calculated Stress Limit Basis
A.	The design pressure, the dead load of the vessel, the contents of the vessel, the imposed load of the mechanical equipment, and external attachment loads	1.0	Based on the corroded thickness at design metal temperature
B.	Condition A above plus wind load	1.2	Based on the corroded thickness at design metal temperature
C.	Condition A above plus earth-quake load	1.2	Based on the corroded thickness at design metal temperature
D.	Condition A above plus loads resulting from wave action	1.2	Based on the corroded thickness at design metal temperature

Note: The condition of structural instability or buckling must be considered.

7. METHOD OF ANALYSIS

7.1 SHUTDOWN CONDENSER VESSEL ANALYSIS

Analysis of the shutdown condenser included considerations of two basic stress categories. Those two categories are defined as primary stresses and secondary stresses. A brief discussion of these stress categories and how they apply to the vessel is given below.

Secondary stresses are stresses that must satisfy an imposed strain pattern rather than being in equilibrium with an external load. The basic characteristic of secondary stresses is that they are self-limiting. Local yielding and minor distortions can satisfy the discontinuity conditions or thermal expansion which cause the stress to occur. Secondary stresses will not cause catastrophic failure unless fatigue conditions develop. The secondary stresses were evaluated during the original design and will be assumed valid for the purposes of this analysis.

Primary stresses are those developed by the imposed loading which is necessary to satisfy the laws of equilibrium between external and internal forces and moments. The basic characteristic of a primary stress is that it is not self-limiting. If a primary stress exceeds the yield strength of material through the entire thickness, the prevention of failure is entirely dependent on the strain-hardening properties of the material. The primary stresses may cause catastrophic failure or gross distortions to occur.

The primary stresses are further broken down into three sub-categories; general primary membrane stress, local primary membrane stress and primary bending stress.

The general primary membrane stress is one which is so distributed in the structure that no re-distribution of load occurs as a result of yielding. The general primary membrane stress in the shutdown condenser is due to the internal pressures. The pressure will produce a stress completely across the cross-section of the shell.

The second sub-category is the local primary membrane stress. These are stresses produced in the vessel by external loads and moments at a permanent support or at a nozzle connection.

The last sub-category of primary stress is the primary bending stress. These stresses come from the bending of the vessel itself. Their magnitude is proportional to the vessel stiffness properties, weights, and support conditions. The bending that occurs will come from the dead load, live load and seismic load bending moments.

7.2 SHELL STRUCTURAL ANALYSIS

The shutdown condenser is supported by two saddles. During a seismic event forces and moments would be generated to the shell by the saddles. Gross failure of the shutdown condenser shell or internal tubes would result in breach of containment.

Static loads were used to evaluate the shutdown condenser shell and saddle supports. These loads were found using stiffness values, frequency and g-values from the analysis of the shutdown condenser platform (Reference 4). Therefore, the validity of the results of this report is contingent upon completion of the modifications recommended in Reference 4.

The areas around the saddle were investigated through the use of a finite element analysis using the ANSYS computer code (Reference 6). The area of concern is indicated on Figure 4 and 5. This area was broken down into a series of finite elements as shown in Figures 6 and 7. The nodes about which the elements were located are shown in Figures 8 and 9.

Static loads were placed on the computer model of the saddle and reaction forces and stresses found. These stresses were then added to dead load, live load and internal pressure, and seismic stresses in the shell.

7.3 CHANNEL OR SHELL INLET ANALYSIS

Calculations were done by hand except for nozzles. Evaluation of nozzle stresses was done using the computer program WERCO (Reference 5). This program uses formula developed by the welded research council and presented in WRC Bulletin 107 (Reference 13). These stresses were then added to the dead load, live load, pressure, and seismic stresses. Nozzle loads were derived from Reference 10 and 11.

7.4 SHUTDOWN CONDENSER SADDLES

The saddles were analyzed using the ANSYS model Described in Section 7.2 and is shown in Figures 6 thru 9. The stresses were compared to the allowables of the AISC Manual. The results are presented in Appendix A. The anchor bolts were also checked for their structural integrity. Their stresses are within the allowables in Reference 12.

7.5 SHUTDOWN CONDENSER NOZZLES

The nozzles of the shutdown condenser were evaluated using a computer program called "WERCO". The "WERCO" program was written to perform the stress calculations as presented in the Welding Research Council (WRC) Bulletin No. 107, entitled "Local Stresses in Spherical and Cylindrical Shells due to External Loadings" (Reference 13). The Bulletin contains a series of non-dimensional curves that are used to obtain the stresses at four locations in the shell around the shell to attachment juncture. The WERCO Program then selects appropriate factors from the non-dimensional curves presented in the Bulletin and calculates the stresses at four locations around the attachment and on the interior and exterior surfaces of the shell at those same locations. The typical model used with the WERCO program is shown in Figure 10.

The loadings for nozzle evaluations were taken from References 10 and 11.

7.6 SHUTDOWN CONDENSER INTERNALS

Some preliminary static, linear hand calculations were done to check the integrity of the U-tubes. After completing these calculations, stresses were found to be above the allowable for the material. It is felt at this time that the application of such analysis would not be applicable due to the complexity of the individual U-tube configuration, existing water in shell and U-tube bundle support configuration. Further studies would have to be done to assure the structural integrity of the shutdown condenser internals.

8. RESULTS OF ANALYSIS

The results of the seismic, structural and stress analysis on the shutdown condenser shell performed using the ANSYS computer code are contained in Reference 9.

Appendix A contains detailed calculations of dead, live, pressure and seismic loads for use as input for the ANSYS program. It also contains input and results for the 6" mainsteam inlet and condensate outlet nozzle analyses.

Saddle stresses and bolt load calculations are included in Appendix A.

A summary of the maximum stresses and the appropriate allowables and channel inlet are given in Table 1 of the report. Table 2 contains similar informaiton for the saddle and bolts.

9. CONCLUSIONS

The LACBWR shutdown condenser was evaluated for the SSE seismic loading in combination with pressure, dead + live load with respect to primary stresses. The results indicate that the shutdown condenser main structure will maintain its structural integrity during the SSE event. This conclusion assumes that recommend modifications are made to the platform (See Reference 4).

The U-tube bundle and internals could not be judged by the analysis done so far. The stresses appear to be above the allowables using simplistic approximations. Further studies or alterations may be required to make meaningful conclusions with regard to the internals.

The stresses placed on the shell due to the 14-inch vent line are being evaluated in a separate analysis. An acceptance criterion on the results of the vent line analysis will be that the line will not place excessive stress on the condenser shell.

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10. REFERENCES

1. Instruction Book for Reactor Shutdown Condenser, Struthers Wells Corp., Warren, Pennsylvania, January, 1965.

2. Letter (Reference No. P-5101-23) from NES to Dairyland Power Cooperative; Subject: "LACBWR Shutdown Condenser Thermal Cycles and Temperature Monitoring".

3. ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 and 2.

4. NES Report, Document 81A0045, Seismic and Structural Analysis for the LACBWR Shutdown Condenser Platform, Nuclear Energy Services, Danbury, Conn., November 1981.

5. "WERCO", Users Manual, AAA Technology and Specialities Co. Inc., Houston, Texas, May 1979.

6. Swanson Analysis, Inc., ANSYS - Engineering System, Revision 3, Update 67K, Swanson Analysis System, Houston, PA., June 1, 1979.

7. Pressure Vessel Handbook, 5th ed., Pressure Vessel Handbook Publishing, Inc., Tulsa, Oaklahoma, January, 1981.

8. Criteria of the ASME Boiler and Pressure Code for Design by Analysis in Sections II and VIII, Division 2, American Society of Mechanical Engineers, New York, New York, 1979.

9. NES Computer Binder S-46 for LACBWR shutdown condenser.

10. NES Report, Document 81A0088, Seismic and Stress Analysis of LACBWR Main Steam Piping System, Nucler Energy Services, Danbury, Conn., August 1975.

11. NES Report, Document 81A0087, Seismic and Stress Analysis of LACBWR Feedwater Piping System, Nuclear Energy Services, Danbury, Conn., June 1975.

12. Manual of Steel Construction 8th Edition, American Institute of Steel Construction. Chicago, Ill, 1980.

13. Welding Research Council Bulletin No. 107, "Local Stresses in Spherical and Cylindrical Shells due to External Loads" K. R. Wichman, A. G. Hopper and J. L. Mershon, New York, N. Y., Third Revised Printing - Spring, 1972.

14. Pressure Vessel Design Handbook, H.H. Bednar, Van Nostrand Reinhold Company, New York, N.Y., 1981.

TABLE 1
MAXIMUM STRESSES FOR THE SHUTDOWN CONDENSER
(psi)

	Shell		Channel Inlet	
	Circumferential	Longitudial	Circumferential	Longitudinal
Internal Pressure	2288	1124	15389	6987
Dead Load Bending + Seismic	N/A	200	N/A	200
Local Bending Due to Saddle	6230*	6230*	N/A	N/A
Nozzle Stresses 6" Mainsteam	N/A	N/A	7322*	7322*
6" Feedwater Condenser	N/A	N/A	5897	5897

* Use worst stress in both direction

Combined Maximum Stress

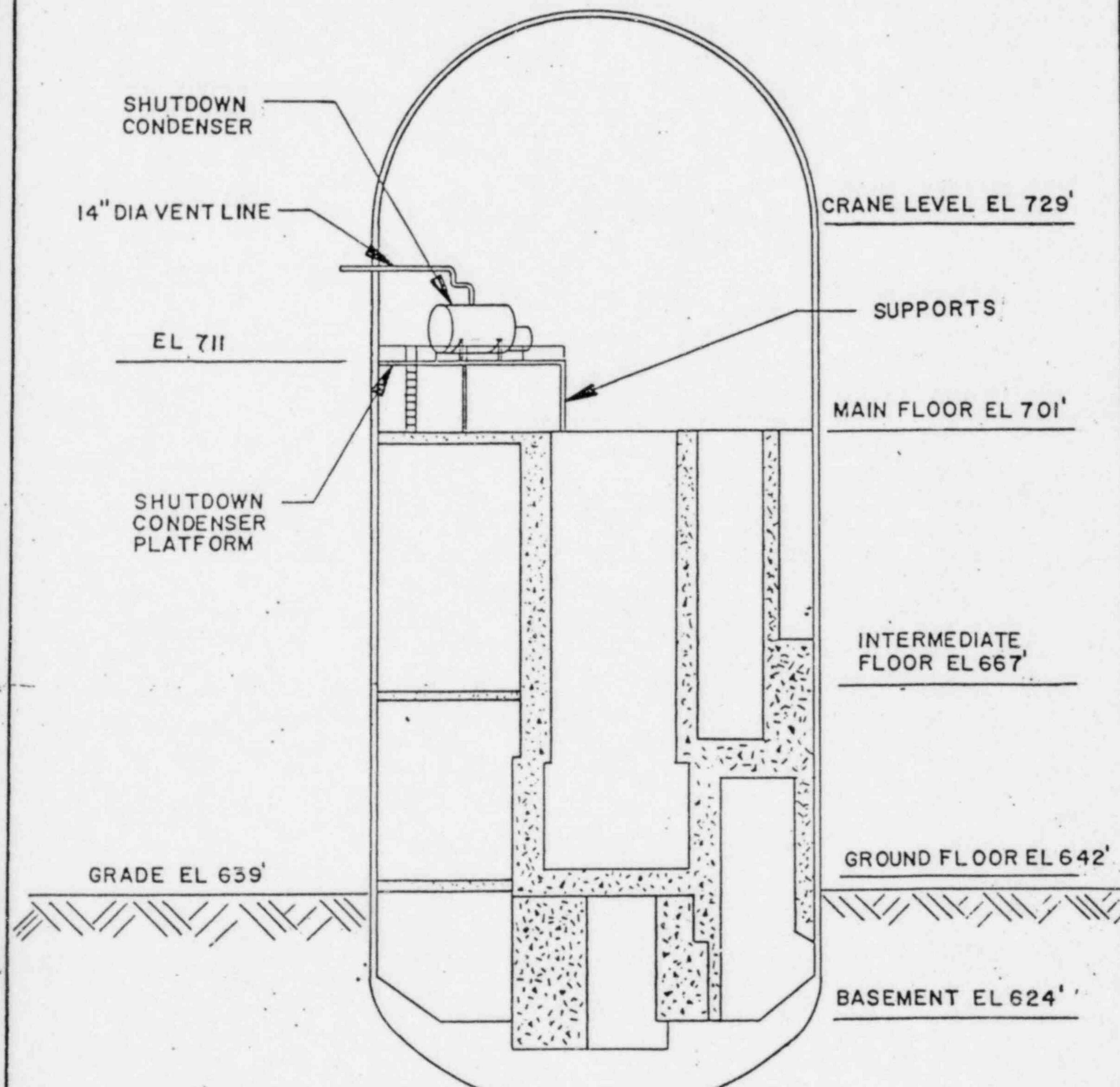
In Shell =
2288 + 6230 = 8,518 psi
Which is less the allowable of 32,130 psi

In Channel Inlet =
15389 + 7372 = 22,711 psi
Which is less the allowable of 31,320 psi

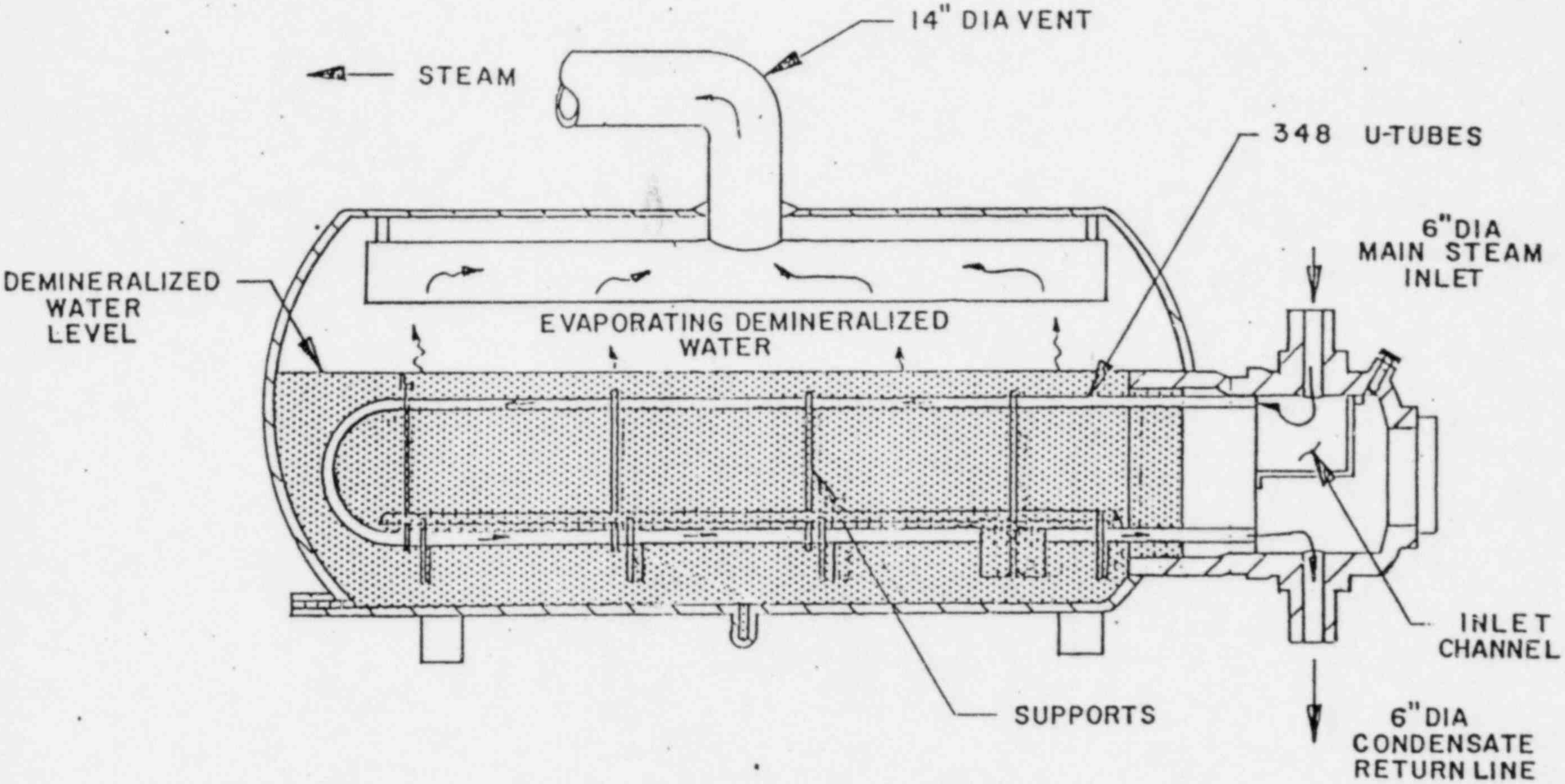
TABLE 2
SUMMARY OF RESULTS OF THE SADDLE AND BOLT ANALYSIS
(ksi)

	Axial Stress		Bending About Minor Axis		Bending About Major Axis		Combined Stress Ratio
	fa	1.6 Fa	f_{bz}	1.6 F_{bz}	f_{bx}	1.6 F_{bx}	
Saddle	0.372	33.15	8.44	34.56	0.497	34.56	0.248

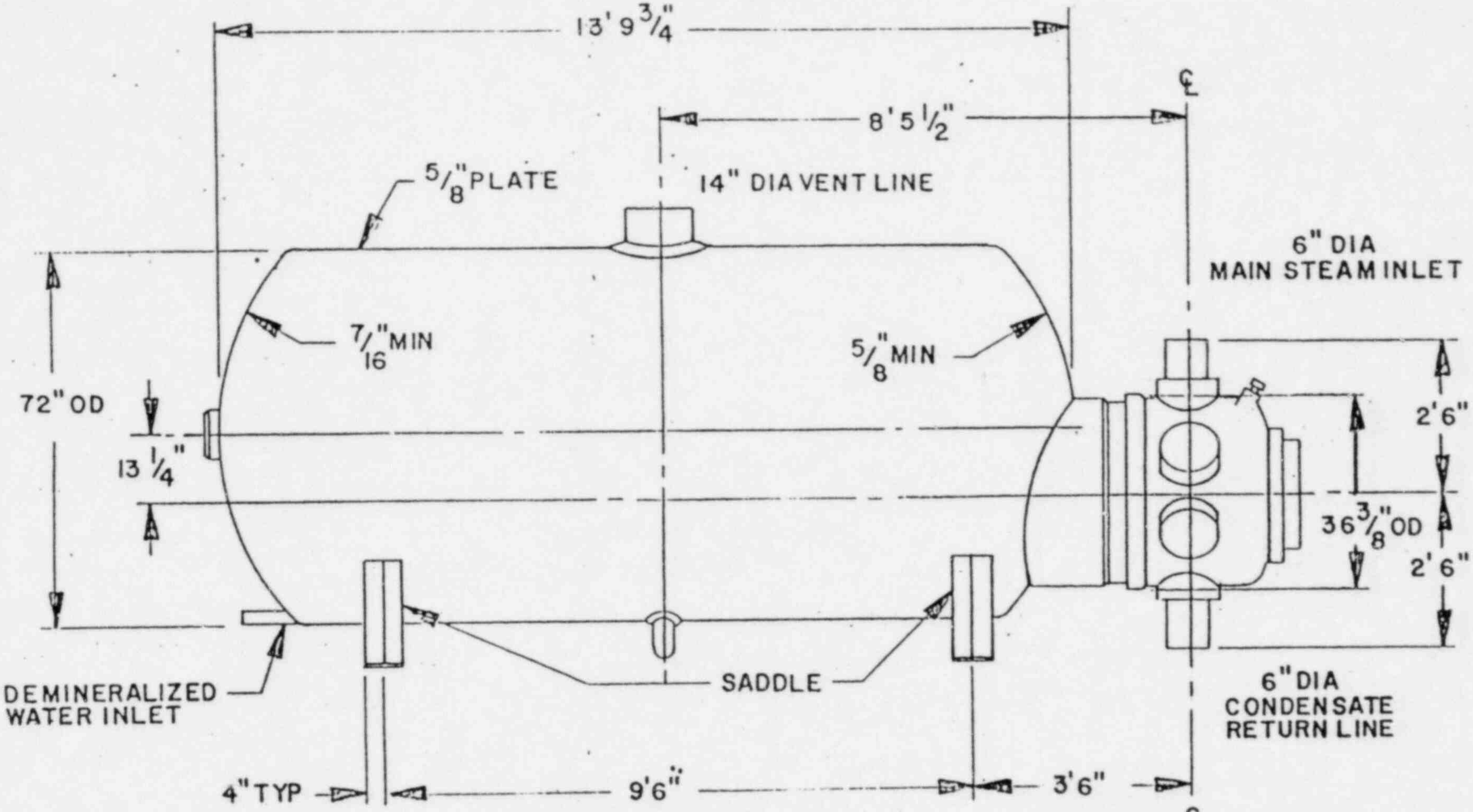
	Tension		Shear		Combined Stress Ratio
	f_t	F_t	f_v	F_v	
Bolts	3.15	16.7	5.16	10.0	0.705



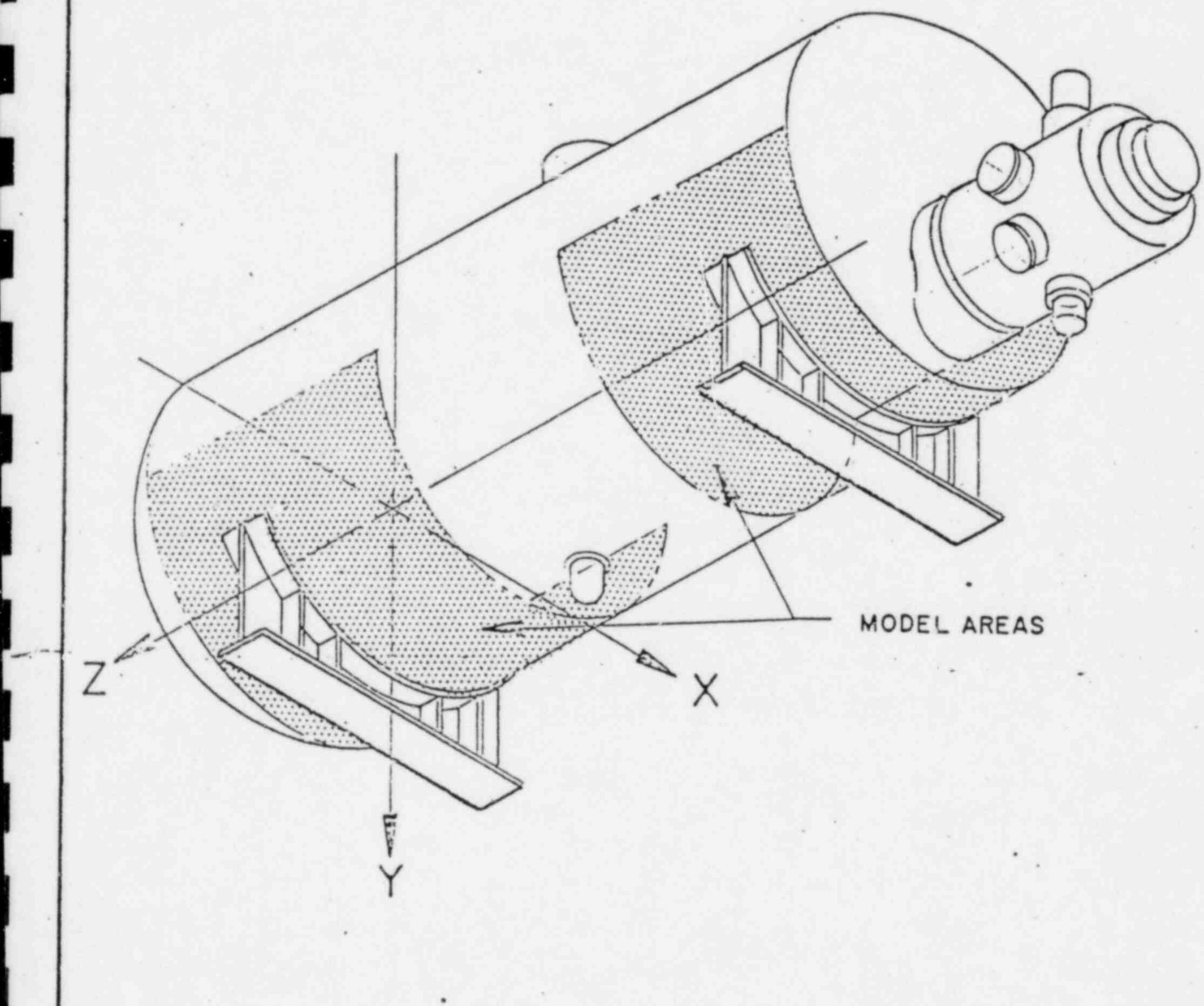
△ FIGURE 1. REACTOR CONTAINMENT BLDG.



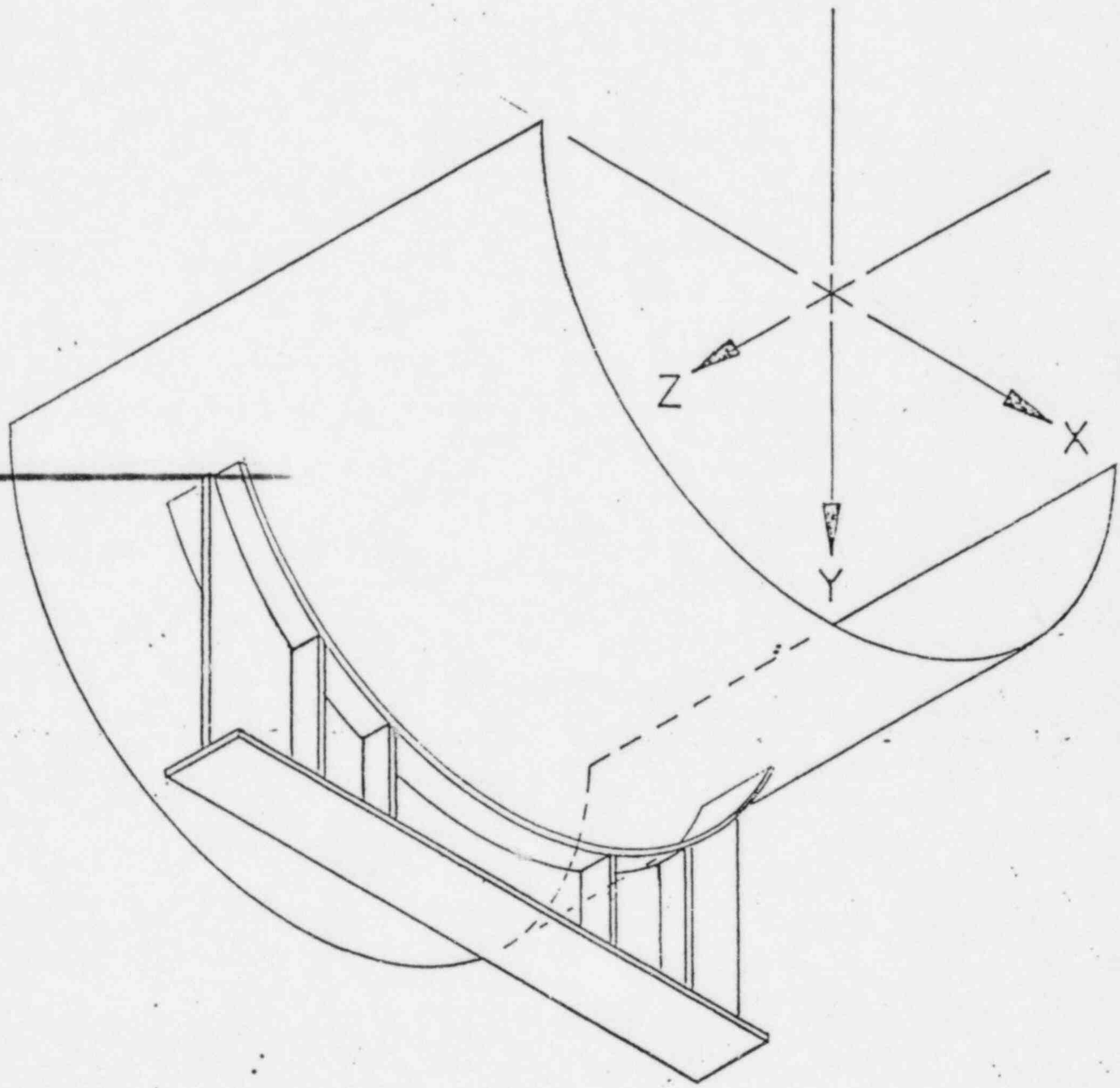
⚠ FIGURE 2. SHUTDOWN CONDENSER CROSS-SECTION



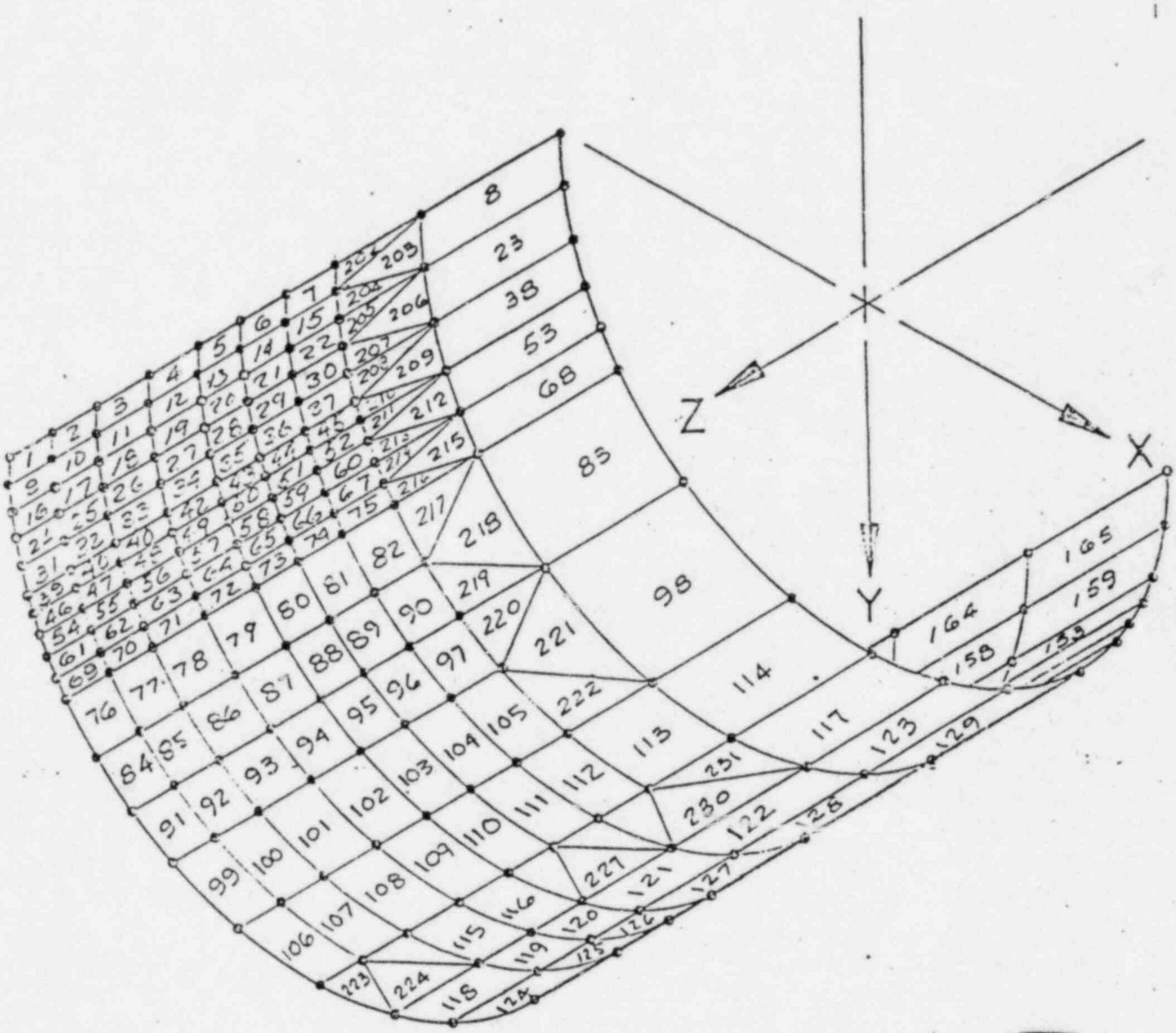
△ FIGURE 3. SHUTDOWN CONDENSER



△FIGURE 4. SHUTDOWN CONDENSER MODEL AREA



⚠ FIGURE 5. ANSYS MODEL:



△ FIGURE 6. SHUTDOWN CONDENSER SHELL ELEMENTS

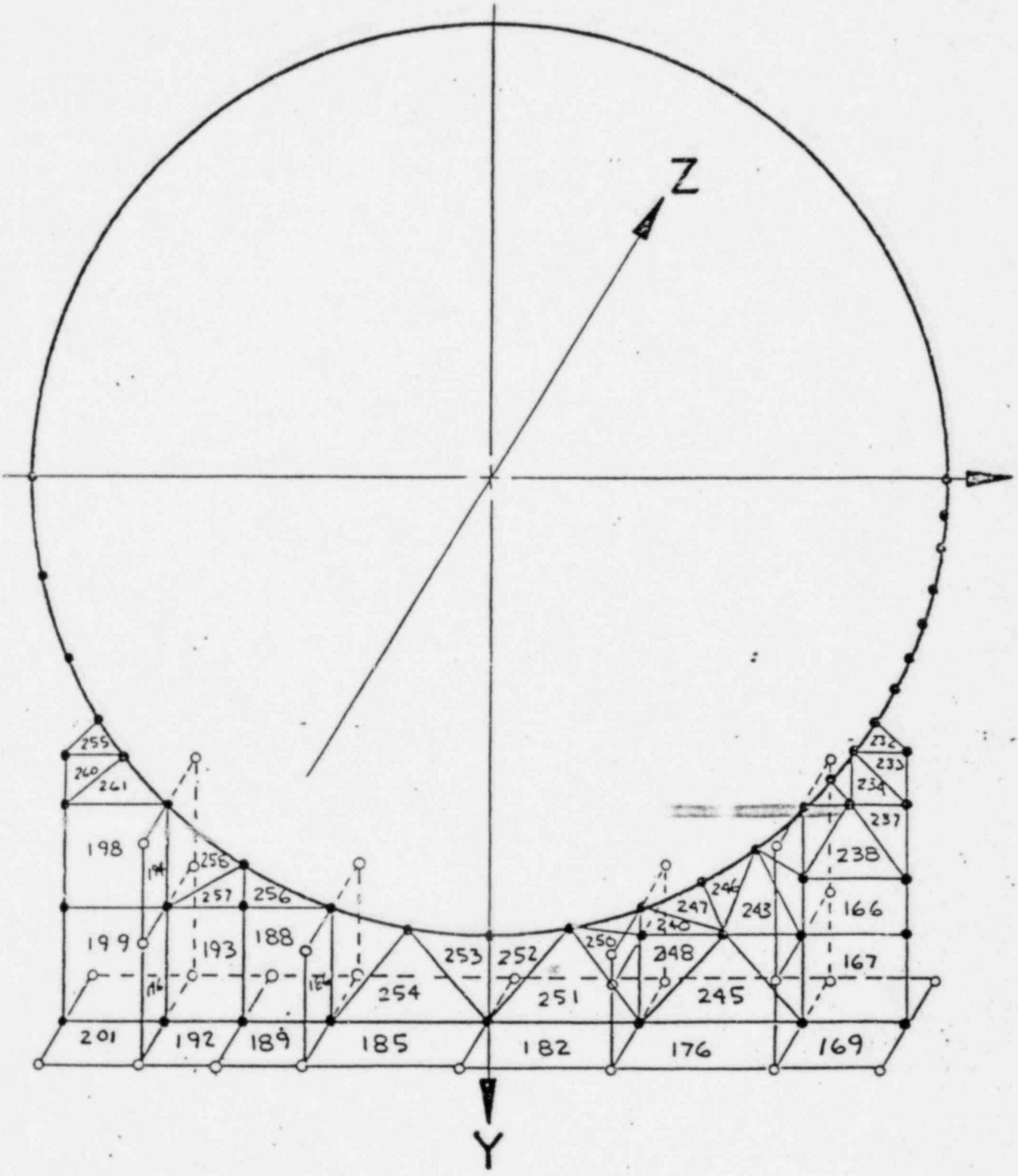
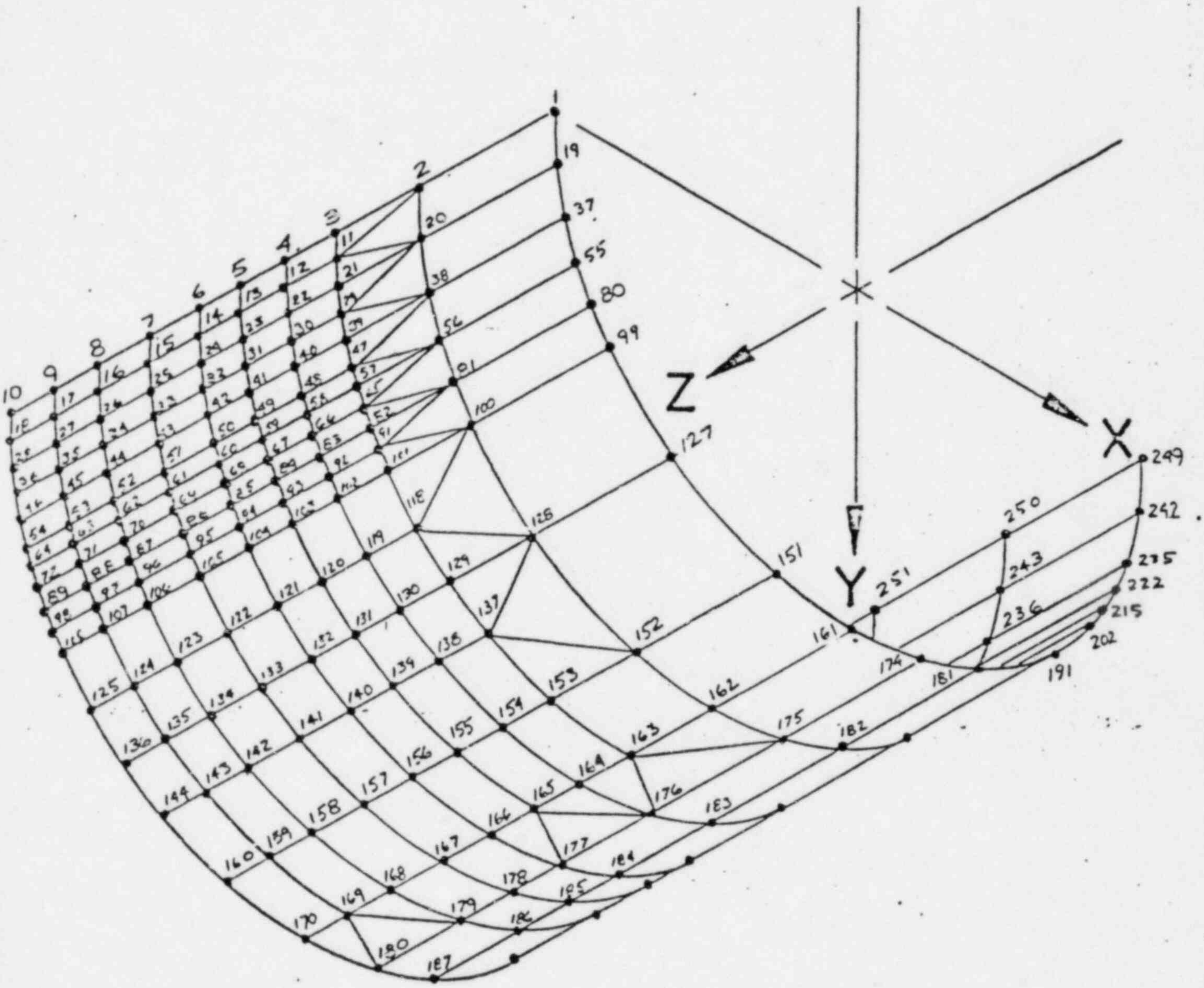


FIGURE 7. SHUTDOWN CONDENSER SADDLE ELEMENTS ⚠



△FIGURE 8. SHUTDOWN CONDENSER SHELL NODES

NUCLEAR ENERGY SERVICES, INC.

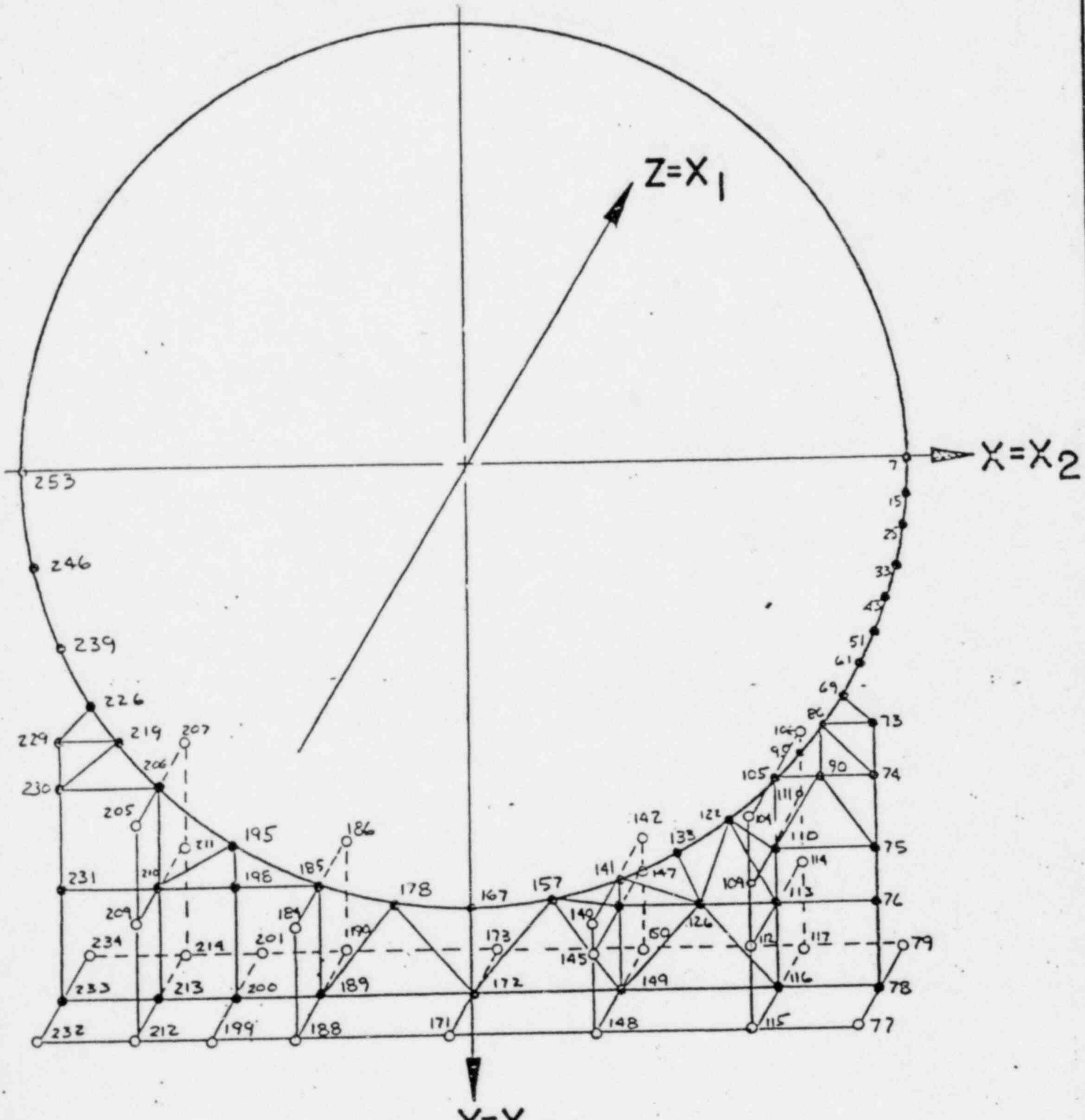
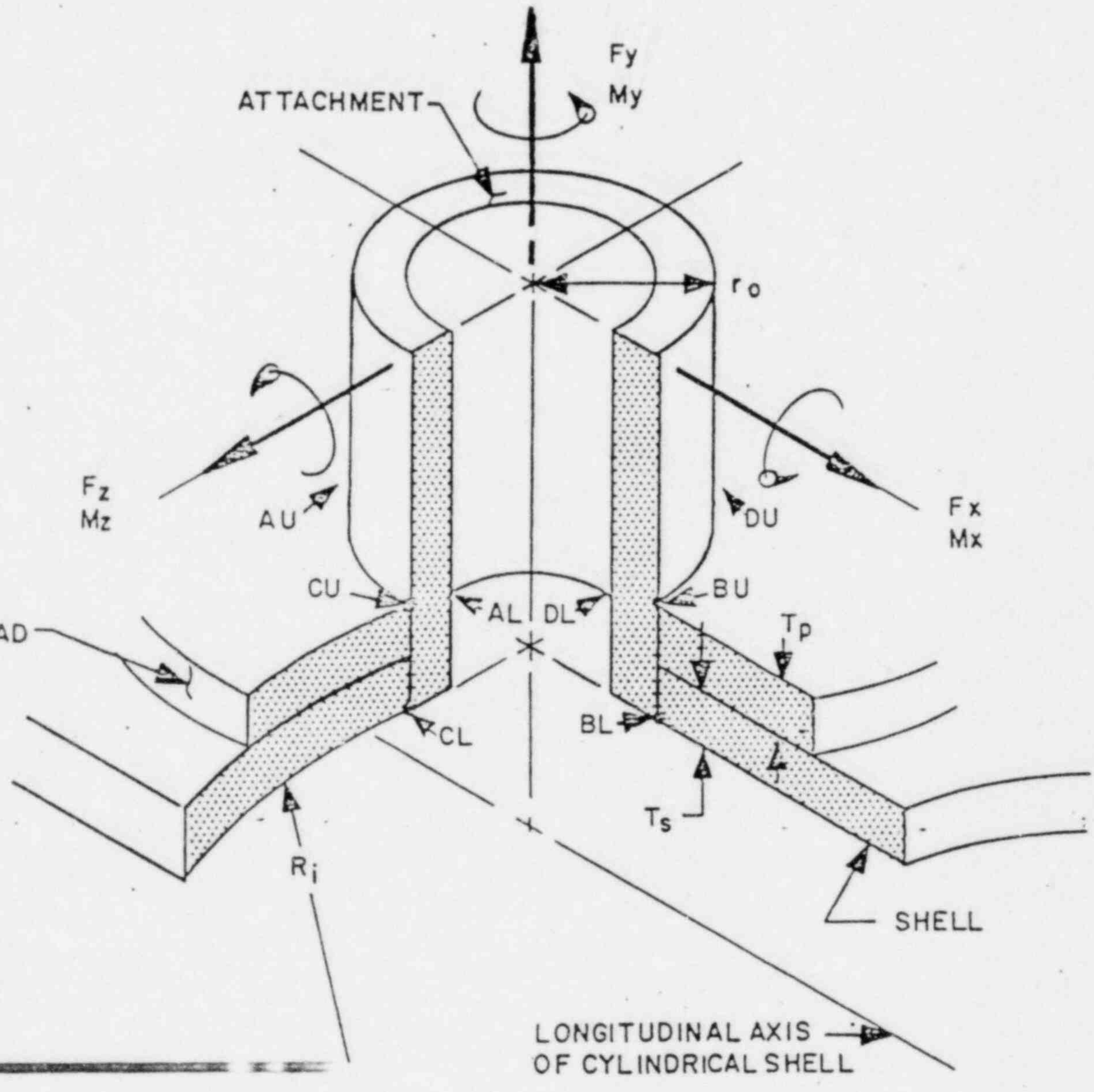


FIGURE 9. SHUTDOWN CONDENSER SADDLE NODES △



△ FIGURE 10. NOZZLE MODEL

APPENDIX A

DETAILED CALCULATIONS

	REF.

SPECIFIC ASSUMPTIONS & ANALYSIS PROCEDURES

1. STATIC ANALYSIS WAS USED.
2. THE STIFFNESS AND FREQUENCIES WERE CALCULATED AND CORRESPONDING G-VALUES WERE FOUND FROM FLOOR SPECTRA OF THE GULF UNITED REPORT (TWO DIMENSIONAL) MODEL OF CONTAINMENT BUILDING)
3. SINCE DIVISION 1 ASME CRITERIA IS NOT DEFINITIVE ON PROCEDURE OF HANDLING SEISMIC LOADS, DIVISION 2 METHODS WERE USED.
4. SECONDARY STRESSES WERE NOT LOOKED AT AND ARE COVERED UNDER ORIGINAL DESIGN.
5. FATIGUE CONSIDERATIONS WERE NOT LOOKED AT UNDER THIS REPORT.
6. THE 14"φ VENT LINE WILL BE COVERED UNDER A SEPARATE REPORT AND WILL BE DESIGNED TO MAINTAIN THE PROPER ALLOWABLE STRESSES ON THE SHELL OF THE SHUTDOWN CONDENSER

CALCULATION OF STIFFNESS.	REF.

REFERENCE — ALL VALUES FOR STRESS, LOADS AND DEFLECTIONS ARE TAKEN FROM COMPUTER PROGRAM S4400ZB STARDYNE MODEL — REF. 4

NOTE

FOR ADDITIONAL INFORMATION SEE THE DESIGN NOTEBOOK OF THE SHUTDOWN CONDENSER PLATFORM.

THE APPROXIMATE STRESSES FOR A 1.0g LOAD. ✓

DEFLECTION AT NODE 20 $\delta_{HORIZ\ X1} = 0.0051$ IN FOR THE 1K LATERAL LOAD AT NODES 18 & 22. ✓

$$\delta_{HORIZ\ X2} = \begin{matrix} 0.00062 \\ 0.00031 \end{matrix} \begin{matrix} @\ NODE\ 22 \\ @\ NODE\ 29 \end{matrix}$$

$$\frac{0.00093}{2} = 0.00047\,IN$$ AVERAGE FOR 1K LATERAL LOAD AT NODES 18, 22, 27 & 29 ✓

FLOOR STIFFNESS $K_{X1} = \frac{2^K}{0.0051\,IN} = 392.16$ K/IN ✓

FLOOR STIFFNESS $K_{X2} = \frac{4^K}{0.00047} = 8510.6$ K/IN ✓

FLOOR STIFFNESS $K_{VERT} = \frac{P}{\delta_{AVE}}$

$\delta_{18} = 0.0847$ ✓ $\delta_{29} = 0.0526$ ✓

$\delta_{21} = 0.0495$ ✓ $\delta_{27} = 0.01781$ ✓ $\delta_{V\,AVE} = 0.0511$ ✓ DUE TO 31K LOAD

$$K_{VERT} = \frac{31}{.0511} = 606.39\ K/in$$ ✓

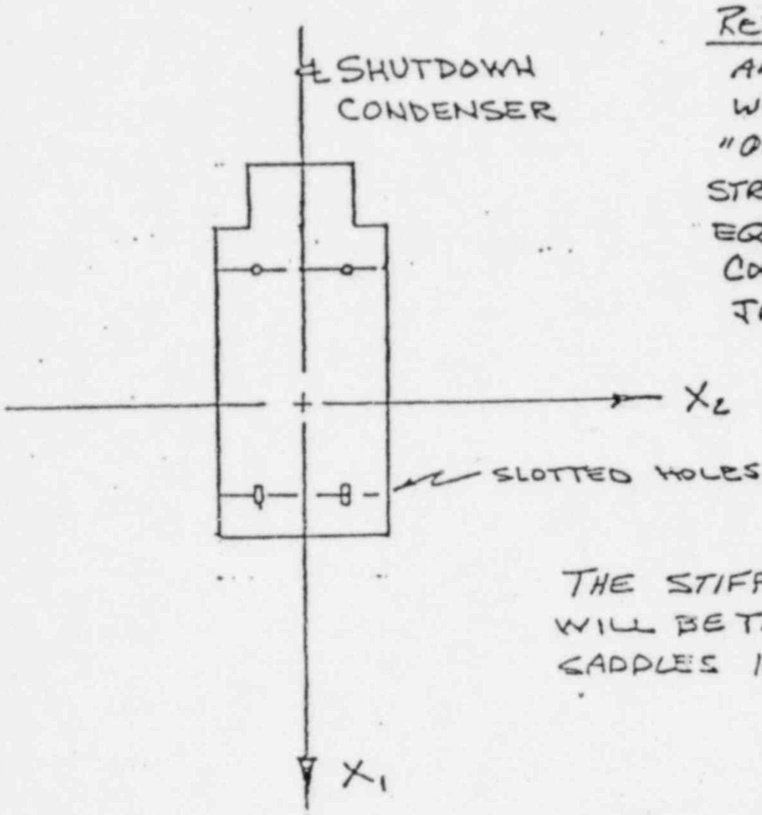
$$\text{VERTICAL FREQUENCY} = \frac{1}{2\pi}\sqrt{\frac{K}{M}} = \frac{1}{2\pi}\sqrt{\frac{606.4 \times 386.4}{31}}$$ ✓

$$f_{VERT} = 13.83\ CPS$$ ✓

CALCULATE APPROXIMATE STRESSES

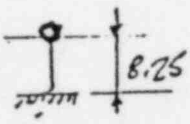
FIG.

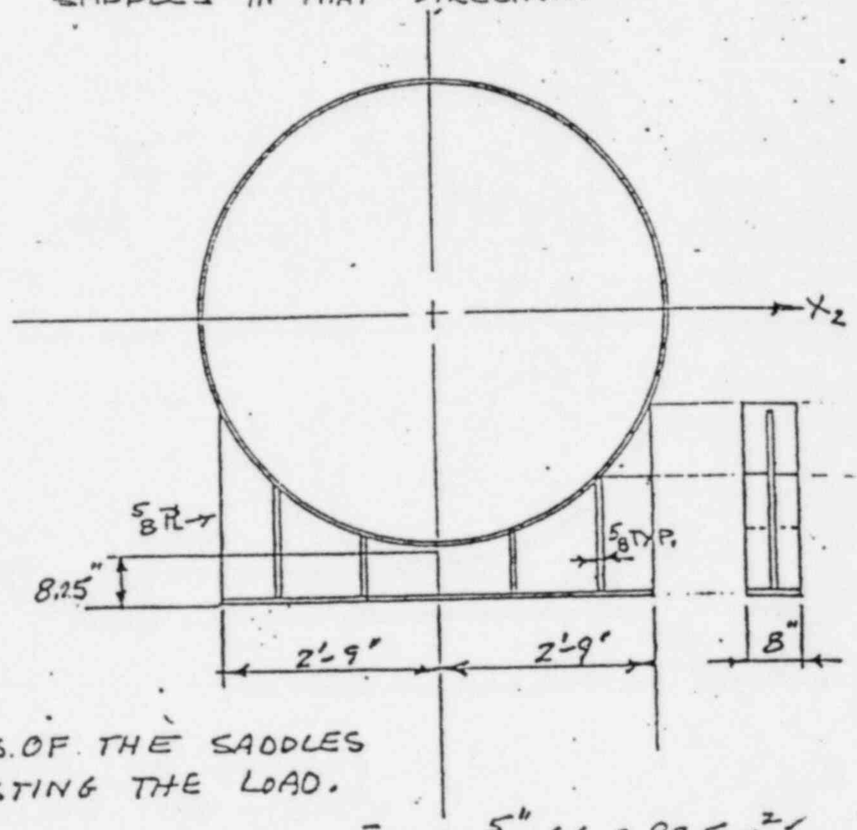
SHUTDOWN CONDENSER STIFFNESS



REFERENCE: ALL DIMENSIONS AND MATERIAL THICKNESSES WERE TAKEN FROM "OPERATION AND MAINTENANCE OF STRUTHERS WELLS HEAT TRANSFER EQUIPMENT", STRUTHERS WELLS CORP. WARREN, PENNSYLVANIA. JAN, 1965

THE STIFFNESS IN THE X_2 DIRECTION WILL BE THAT OF THE SUPPORT SADDLES IN THAT DIRECTION.





ASSUMING THE WEBS OF THE SADDLES ARE EFFECTIVE RESISTING THE LOAD.

$$K_{SHEAR} = \frac{\bar{A}G}{H}$$

$\bar{A} = 2 \times \frac{5}{8}" \times 66 = 82.5 \text{ in}^2$

$G = 12{,}000 \text{ ksi}$

$H = 8.25 \text{ in}$

$$K = \frac{82.5 \times 12{,}000}{8.25} = 120{,}000 \text{ K/in}$$

CALCULATE APPROXIMATE STRESSES

REF.

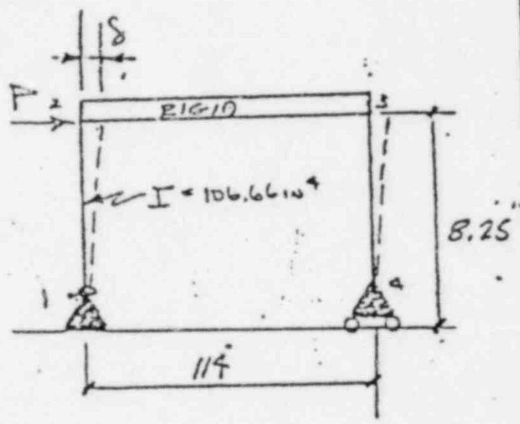
COMBINING THE STIFFNESSES OF THE FLOOR (EL 711) AND THE SHUT DOWN CONDENSER IN THE X_2 DIRECTION

$$K_{EQ\,X_2} = \frac{1}{\frac{1}{K_{X_2\,FLOOR}} + \frac{1}{K_{X_2\,SHUTDOWN}}} = \frac{1}{\frac{1}{8510.6} + \frac{1}{120,000}} = 7947\ ^{k}/_{IN}$$

$$f_{X_2} = \frac{1}{2\pi}\sqrt{\frac{K}{M}} = \frac{1}{2\pi}\sqrt{\frac{7947 \times 386.4}{31}} = \underline{50.1\ CPS}$$

CONDENSER STIFFNESS IN X_1 DIRECTION

ASSUME THAT THE SHUT DOWN CONDENSER IS RIGID AND THE SADDLE IS FLEXIBLE



THE I OF THE 8 STIFFNERS WILL BE EFFECTIVE

$$4\,I_{LEG} = 4 \times \frac{5}{8}\frac{(8)^3}{12} = 106.66\,IN^4$$

$$\bar{A} = 4 \times \frac{5}{8} \times 8 = 20\,IN^2$$

$$K = \frac{P}{\delta} = \frac{3EI}{\ell^3}$$

BENDING STIFFNESS $K_B = \frac{3 \times 30000 \times 106.66}{8.25^3}$

$K_B = 17,096.0\ ^{k}/_{IN}$

SHEAR STIFFNESS $= K_S = \frac{\bar{A}G}{H} = \frac{20 \times 12000}{8.25} = 29091\ ^{k}/_{IN}$

COMBINING THE SHEAR & BENDING STIFFNESSES

$$K_{EFF} = \frac{1}{\frac{1}{K_B} + \frac{1}{K_S}}$$

$$K_{EFF} = \frac{1}{\frac{1}{17,096} + \frac{1}{29091}} = 10768.0\ ^{k}/_{IN}$$

CALCULATE APPROXIMATE STRESSES

	REF.

USING THE FREQUENCIES CALCULATED AND THE APPROPRIATE SPECTRA FROM THE GULF UNITED REPORT "SEISMIC EVALUATION OF THE LACROSSE BOILING WATER REACTOR" JAN 11, 1979., THE ACCELERATION CANBE FOUND. ← A-1

COMBINING THE FLOOR STIFFNESS AND THE ~~HORIZONTAL SADDLE STIFFNESS IN THE X_1~~ DIRECTION

$$K_{eq} = \frac{1}{\frac{1}{392.16} + \frac{1}{10768}} = 378.40\ \text{k/in}$$

$$\text{HORIZONTAL FREQUENCY } X_1 = \frac{1}{2\pi}\sqrt{\frac{K}{M}}$$

$$= \frac{1}{2\pi}\sqrt{\frac{378.40 \times 386.4}{31}}$$

$$F_{H_1} = 10.93\ \text{CPS}$$

CRANE SUPPORT LEVEL

HORIZONTAL ACC VALUE FOR SSE (FIG G-14) — REF. A-1

HORIZ X_1 DIRECTION (10.93 CPS)		HORIZ X_2 DIRECTION (50.10 CPS)	VERTICAL X_3 (13.83 CPS)	

USING THE GREATER G-VALUE FOR 10% ±

	9.84 CPS	12.02 CPS	45.09 55.11	12.447	15.213
FLOOR	0.437	0.437	0.437	2/3 (0.38)	(0.38)
SUPPORT	0.786	0.629	0.437		
	0.612 >	0.533	0.437	0.25 G	

AVERAGE $\frac{0.612+0.533}{2} = 0.5735$

HORIZ X_1 ACC = 0.573 g

HORIZ X_2 ACC = 0.437 g

VERT X_3 ACC = 0.25 g

	REF.

CALCULATION FOR LATERAL & VERTICAL SEISMIC LOADS

$X_1 = 0.573g$ $X_2 = 0.437g$ $X_3 = 0.25g$

BEAM	LOADS X_3	X_1	X_2	X_3
1-4	-0.0013	0.00075	0.000568	0.000325
5	-0.0258	0.01478	0.011275	0.00645
6	-0.0328	0.01880	0.014334	0.00820
7	-0.0417	0.02389	0.018223	0.010425
8	-0.0250	0.01433	0.01093	0.00625
9-14	-0.0018	0.00103	0.00079	0.00045
16	-0.0018	0.00103	0.00077	0.00045
17	-0.0218	0.01250	0.00953	0.00545
→18	-0.0175	0.010028	0.00765	0.00438
19	-0.0081	0.00464	0.00354	0.00203
20	-0.0571	0.03272	0.02495	0.01428
21	-0.0268	0.015360	0.011712	0.00670
22-23	-0.0028	0.001604	0.001224	0.00070
24-27	-0.2688	0.154022	0.117466	0.06720
28-29	-0.0028	0.001604	0.001224	0.00070
30	-0.0010	0.000573	0.000437	0.00025
31	-0.0008	0.000458	0.00035	0.00020
32	-0.0244	0.0140	0.01066	0.0061
33	-0.0253	0.0145	0.011056	0.0063
34	-0.0196	0.01123	0.00857	0.0049
35	-0.0028	0.001604	0.001224	0.0007
36-37	-0.2688	0.15402	0.11747	0.0672
38-39	-0.0028	0.001604	0.001224	0.0007
41-42	-0.0028	0.001604	0.001224	0.0007
43	-0.0175	0.01003	0.00765	0.00438
44	-0.0258	0.01478	0.011275	0.00645
45	-0.0244	0.0140	0.01066	0.0061
46	-0.0314	0.0180	0.01372	0.00785
47-48	-0.0008	0.000458	0.00035	0.0002
49	-0.0258	0.01478	0.011275	0.00645
50	-0.0138	0.007907	0.00603	0.00345
51	-0.0179	0.01026	0.0078	0.0045
52	-0.0258	0.0148	0.01127	0.00645
53	-0.0328	0.01880	0.01433	0.0082
54	-0.0417	0.0239	0.01822	0.010425
55	-0.0175	0.01003	0.00765	0.0044
56	-0.0081	0.00464	0.00354	0.00203

REF.

BEAM LOADS

		X_1	X_2	X_3
57	-0.0571	0.03272	0.0250	0.0143
58	-0.0244	0.0140	0.0107	0.0061
59	-0.0244	0.0140	0.0107	0.0061

REF.

SUMMARY OF S.S.E. g-VALUES

X_1 = 0.573g ✓
X_2 - 0.437g ✓
VERT X_3 = 0.25g ✓

TAKEN FROM - REF 4
"SEISMIC AND STRUCTURAL ANALYSIS OF THE LACBWR SHUTDOWN CONDENSER PLATFORM"
NES. REPORT & NOTEBOOK

NUCLEAR ENERGY SERVICES

BY F.R. DATE 8/26/81 PROJ. TASK
CHKD. N.R DATE 8/26/81 PAGE A-9 OF 47
LACBWR SHUTDOWN CONDENSER

REF.

DESIGN CRITERIA

	SHELL	CHANNEL
MAX INT. PRESSURE	15 PSI ✓	1415 PSI ✓
MAX TEMP	275°F ✓	650°F ✓
MATERIAL	SA-285-C ✓	SA-105-2 ✓
T.S.	55,000 PSI ✓	70,000 PSI ✓
THICKNESS	5/8"	1.63
DIAMETER	6'-0" OD ✓	3'-0 3/8" OD
MAX EXT PRESSURE	52 PSI ✓	52 PSI ✓

REF.

INTERNAL PRESSURE STRESSES

FOR SHUTDOWN CONDENSER SHELL

CIRCUMFERENTIAL $t = \frac{PR}{SE - 0.6P}$ ✓

$$S = \left(\frac{PR}{t} + 0.6P\right)\frac{1}{E}$$ ✓

$$S = \left(\frac{40 \times 35.375}{0.625} + 0.6P\right)$$

CIRCUMFERENTIAL PRESSURE STRESS $S = 2288$ PSI

WHERE P = PRESSURE (PSI)
= 40 PSI
E = JOINT EFFICIENCY FROM UW-12
= 1.0 FOR ✓ BUTT WELDS FULLY RADIOGRAPHED
R = INSIDE RADIUS OF SHELL
= 35.375 IN
t = SHELL THICKNESS
= 0.625 IN
S = STRESS

LONGITUDINAL

$$t = \frac{PR}{2SE + 0.4P}$$

$$S = \left(\frac{PR}{t} - 0.4P\right)\frac{1}{2E}$$

$$S = \left(\frac{40 \times 35.375}{0.625} - 0.4 \times 40\right)\frac{1}{2}$$

LONGITUDINAL PRESSURE STRESS $S = 1124$ PSI

REF.

INTERNAL PRESSURE STRESSES

FOR SHUTDOWN CONDENSER CHANNEL OR INLET

CIRCUMFERENTIAL

$$S = \left(\frac{PR}{t} + 0.6P\right)\frac{1}{E}$$

P = 1415 psi

t = 1.63

D = 33½"

R = 16.75

$$S = \left(\frac{1415 \times 16.75}{1.63} + 0.6 \times 1415\right)$$

CIRCUMFERENTIAL PRESSURE STRESS $S = 15{,}389$ psi

LONGITUDINAL

$$S = \left(\frac{PR}{t} - 0.4P\right)\frac{1}{2E}$$

$$S = \left(\frac{1415 \times 16.75}{1.63} - 0.4 \times 1415\right)\frac{1}{2}$$

LONGITUDINAL PRESSURE STRESS $S = 6987$ psi

	REF.

EXTERNAL PRESSURE

LOCA PRESSURE = 52 PSI

FOR CYLINDRICAL SHELLS

USING ARTICLE D-3 ASME SECTION VIII DIV 2. — AD-310

$$\frac{D_o}{t} = \frac{72}{5/8} = 115.2 \geq 10$$

$$\frac{L}{D_o} = \frac{146.96}{72} = 2.04$$

WHERE L = THE DISTANCE BETWEEN HEAD TANGENT LINES PLUS 1/3 OF THE DEPTH OF EACH IF THERE ARE NO STIFFENING RINGS (REF. 63-2-7984-D1)

$$L = 11'\text{-}5\tfrac{5}{8} + 2 \times \tfrac{1}{3} \times 14''$$

$$L = 137.625 + 9.333$$

$$L = 146.96$$

ENTER FIG AGO-28.0 IN APPENDIX 2 SEE PAGE 377

$A = 0.0005$

TEMP = 275°F

FOR SA 285C

$f_y = 30$ ksi

FROM FIG ACS-28.2 PAGE 378

$B = 7200$ UP TO 300°F

$$P_a = \frac{4B}{3(D_o/t)} = \frac{4 \times 7200}{3 \times 115.2} = 83.3 \text{ PSI} \geq 52 \text{ PSI}$$

O.K.

IT IS EVIDENT THAT THE CHANNEL WILL NOT HAVE A PROBLEM DUE TO EXTERNAL PRESSURE.

- ORIGINAL DESIGN ALSO INCLUDED THE ABOVE ANALYSIS FOR BOTH PARTS.

	REF.

INTERNAL PRESSURE (CON'T)

FOR TORISPHERICAL HEADS
AT SHELL-HEAD JUNCTION

$$SE = \frac{PL_i M}{2t} + 0.1P$$

$t = 5/8$

$E = 1.0$

$r = 4\frac{3}{8}$

$OD = 72$

$OR = 36$

$$S = \frac{40 \times 72 \times 1.76}{2 \times 7/16} + 0.1 \times 40$$

$R_i = 36 - 5/8 = 35.375$

$L_i = 72''$

$S = 5797$ psi for $7/16''$

$$\sin\phi = \frac{(R-r)}{(L-r)} = \frac{(35.375 - 4.375)}{72 - 4.375}$$

$$\sin\phi = \frac{31}{67.625}$$

$S = 4059$ psi for $5/8''$

$\sin\phi = 0.458$

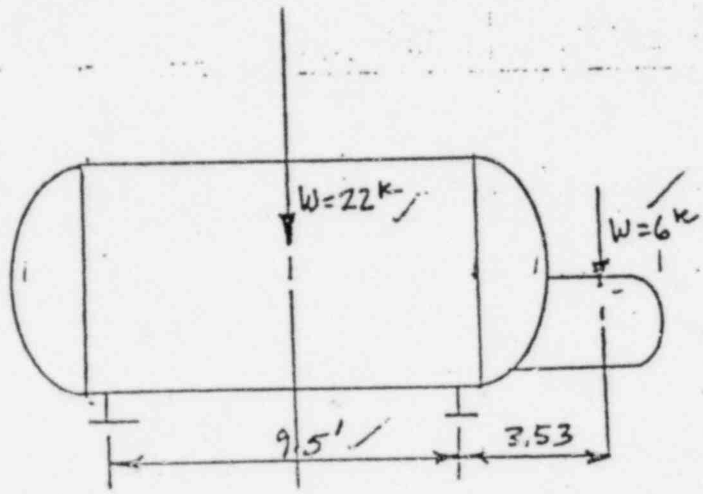
$\phi = 27.285°$

$$M = \frac{1}{4}\left[3 + \left(\frac{L_i}{r_i}\right)^{\frac{1}{2}}\right]$$

$M = 1.76$

REF.

DEAD LOAD BENDING STRESS



TOTAL WEIGHT = 28k

OD = 72"

ID = 70.75

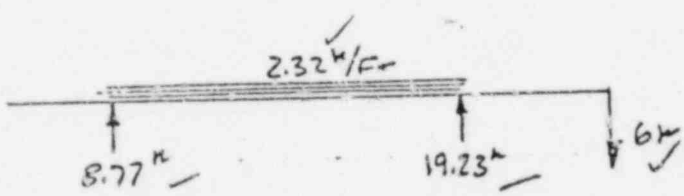
SHELL

$$S = \pi\left(\frac{d^4 - d_i^4}{32d}\right)$$

$$S = \frac{\pi(72^4 - 70.75^4)}{32 \times 72}$$

$$S = 2479.2 \text{ in}^3$$

$$\pi R^2 t = 2500 \text{ in}^3$$



MAX +MOMENT = 16.57 1-k

MAX − MOMENT = 21.18 1-k

MAX BENDING STRESS IN THE SHELL $= \frac{M}{S} = \frac{21.18 \times 12}{2479.2} = 0.103$ ksi

USE 200 PSI SMALL COMPARED TO PRESSURE STRESS

INLET

OD = 37

ID = 33.5

$$S = \frac{\pi(37^4 - 33.5^4)}{32 \times 37}$$

$$S = 1631 \text{ in}^3$$

MAX BENDING STRESS IN THE INLET CHANNEL $= \frac{21.18 \times 12}{1631}$

= 0.156 ksi

USE 200 PSI

SMALL COMPARED TO PRESSURE STRESS

	REF.

SEISMIC BENDING STRESSES

USING THE ACCELERATIONS CALCULATED FOR THE SHUTDOWN CONDENSER.

HORIZ $X_1 = 0.573g$
HORIZ. $X_2 = 0.437g$
VERT. $X_3 = 0.25g$

MAX DEAD LOAD BENDING STRESS = 0.103 FOR SHELL
0.156 FOR INLET

ONE CAN SEE THAT THESE FORCES ARE VERY SMALL AND WILL BE NEGLECTED

FOR SHELL $0.573 \times 0.103 = 0.06$ KSI

FOR INLET $0.573 \times 0.156 = 0.09$ KSI

REF.

LOADINGS ON THE SHUTDOWN CONDENSER

ASSUMPTIONS

DEAD LOAD IS TAKEN FROM "OPERATION AND MAINTENANCE OF STRUTHERS WELLS HEAT TRANSFER EQUIPMENT" INSTRUCTION BOOK FOR REACTOR SHUTDOWN CONDENSER TAG 62-01-001

DRY WEIGHT - 15000# ✓
FLOODED WEIGHT 40,000# ✓
OPERATING WEIGHT = 28,000# ✓

"SETTING PLAN REACTOR SHUTDOWN CONDENSER DWG 63-2-7984-B-1 ✓

USE 28,000#

X - SEISMIC LOAD (SSE) (X_2)

ONE-HALF THE SEISMIC LOAD IS DISTRIBUTED TO EACH SADDLE.

LATERAL LOAD FACTORS TAKEN FROM FRAMING ANALYSIS = 0.437g ✓

PIPE LOADS FROM MAIN STEAM LINE

Y - SEISMIC LOAD (SSE) (X_3)

ONE-HALF THE SEISMIC LOAD IS DISTRIBUTED TO EACH SADDLE.

FACTOR IS 0.25 g FROM FRAMING ANALYSIS

Z - SEISMIC LOAD (SSE) (X_1)

1. ASSUME NO SNUBBER ALL LOAD GOES TO ONE SADDLE.

ANSYS MODEL (PIPE REACTIONS) 6" MAIN STEAM LINE

REF.

FROM N.E.S. REPORT 81A0088
"SEISMIC AND STRESS ANALYSIS OF LACBWR MAIN STEAM PIPING SYSTEM"

THE REACTIONS AT NODE 48

	LOAD CASE	FORCES X	FORCES Y	FORCES Z	MOMENTS X	MOMENTS Y	MOMENTS Z
	DEAD + SUSTAINED MECHANICAL LOADS	24.35	1397.53	14.60	-6939.87	-89.01	5060.44
2.	NORMAL OPERATING INC THERMAL MOV	1324.60	-2317.40	-4.0	70344.5	15409.6	-32785.2
3.	SEISMIC ANCHOR MOV X DIR ½SSE	-27.58	-115.88	25.27	5275.20	1772.71	917.68
4.	SEISMIC ANCHOR MOV Z DIR ½SSE	-1.15	-61.51	23.01	2784.26	-83.30	676.13
5	SEISMIC ANCHOR MOV X-DIR SSE	44.61	-193.39	40.32	8850.81	2873.10	1503.23
6	SEISMIC ANCHOR MOV Z-DIR SSE	-3.06	-105.55	36.84	4857.96	-209.27	1109.55
7	X+Y EARTHQUAKE 1/2 SSE	267.0	781.0	475.0	15944.0	10259.0	26176.0
8	Z+Y EARTHQUAKE 1/2 SSE	216.	788.0	468.0	15598.0	11000.0	25559.0
9	X+Y EARTHQUAKE SSE	383.0	950.0	563.0	21336.0	17355.0	32390.0
10	Z+Y EARTHQUAKE SSE	284.0	940.0	540.0	20594.0	16736.0	30338.0

ANSYS MODEL (PIPE REACTIONS) 6" MAIN STEAM LINE

REF.

LOAD COMBINATION $\frac{1}{2}$SSE EARTHQUAKE.

DEAD + SUSTAINED + NORMAL OPERATING ∓ $\sqrt{\text{SEISMIC ANCHOR}(X^2+Z^2)}$

∓ $\sqrt{\text{SEISMIC } \tfrac{1}{2}\text{SSE}(x+y)^2+(z+y)^2}$

FORCES (#) X	Y	Z	MOMENTS (IN.#) X	Y	Z
24.35	1397.53	14.60	-6939.87	-89.01	5060.44
1324.60	-2317.40	-4.00	70344.50	15409.60	-32785.20
1348.95	-919.87	10.60	63404.63	15320.59	-27724.8
+27.60	+131.19	+34.18	+5964.88	+1774.67	+1139.86
+343.43	+1109.46	+666.82	+22304.9	+15045.90	+36584.7
1719.98	+366.32	711.6	91674.41	32141.18	9999.8
1.72^k	0.366^k	0.71K	7.64^{1-K}	2.68^{1-k}	0.8333^{1-Kip}

LOAD COMBINATION SSE EARTHQUAKE

FORCES (#) X	Y	Z	MOMENTS (IN-#) X	Y	Z
24.35	AS ABOVE	"	"		
1324.60					
1348.95	-919.87	10.60	63404.63	15320.59	-27724.8
+44.71	+220.32	+54.62	+10096.37	+2880.71	+1868.37
+476.81	+1336.45	+780.11	+29653.63	+24109.95	+44379.12
1870.47	636.9	845.33	103154.63	42311.25	18522.7
1.87^k	0.637^k	0.845^k	8.596^{1-k}	3.526^{1-k}	1.543^{1-k}

6" CONDENSATE RETURN LINE

REF.

FROM N.E.S. REPORT 81A0087
"SEISMIC AND STRESS ANALYSIS OF LACBWR
FEEDWATER PIPING SYSTEM"

THE REACTIONS AT NODE 104

D CASE	FORCES (lb) X	Y	Z	MOMENTS (IN-lb) X	Y	Z
D + SUSTAINED HANICAL LOADS	-.12	474.29	-11.28	-4918.95	3736.56	7825.63
MAL OPER. TEMP THERMAL ANCHOR MOVEMENTS	33.94	-209.33	-10.00	29095.74	7026.95	-51897.47
SMIC ANCHOR V. X DIR (1/2 SSE)	4.774	-9.703	-0.782	1436.647	1105.790	-849.011
EISMIC ANCHOR VE Z DIR (1/2 SSE)	-1.27	5.85	4.09	-2508.78	-1358.05	1316.13
SMIC ANCHOR V. X-DIR (SSE)	10.009	-19.339	-1.524	2850.191	2014.627	-1530.613
SMIC ANCHOR V Z-DIR (SSE)	-2.17	10.63	8.54	-5010.92	-2844.98	2458.70
Y EARTHQ. (1/2 SSE)	411.4	166.9	378.6	30760.0	16299.0	21012.0
+Y EARTHQ. (1/2 SSE)	421.2	120.6	458.9	29828.0	9483.0	23102.0
Y EARTHQ. (SSE)	609.8	227.2	505.7	37303.0	25025.0	27908.0
+Y EARTHQ (SSE)	545.0	180.0	571.0	37209.0	14711.0	28910.0

6" CONDENSATE RETURN LINE | REF.

LOAD COMBINATION 1/2 SSE EARTHQUAKE

DEAD + SUSTAINED + NORMAL OPERATING $\pm\sqrt{\text{SEISMIC ANCHOR } X^2 + Z^2}$

$\pm\sqrt{\text{SEISMIC 1/2 SSE}}$

	FORCES (#) X	Y	Z	MOMENTS (IN-#) X	Y	Z
1.	-0.12	474.29	-11.28	-4918.95	3736.56	7825.63
2.	33.94	-209.33	-10.00	29095.74	7026.95	-51897.47
	33.82	264.96	-21.28	24176.79	10763.51	-44071.84
	± 4.94	±11.33	±4.16	± 2891.01	±1751.31	±1566.21
	± 588.78	± 205.91	± 594.92	± 42847.3	± 18856.95	± 31228.30
	±627.54	482.2	-620.36	69915.1	31371.77	-76866.36

LOAD COMBINATION SSE EARTHQUAKE

FORCES X	Y VERT	Z	MOMENTS X	Y	Z
33.82	264.96	-21.28	24176.79	10763.51	-44071.84
±10.24	± 22.07	± 8.68	5764.80	3486.06	2896.20
± 817.85	± 289.86	± 767.74	52687.98	29028.69	40182.64
861.91	576.89	792.7	82,629.57	43278.25	87150.68
0.862^{k}	0.577^{k}	0.793^{k}	6.89^{1-k}	3.61^{1-k}	7.26^{1-k}

WEIGHT OF HEAD ESTIMATE	REF.

38" O.D.

LENGTH = $8\frac{5}{8} + 12\frac{3}{4} + 14\frac{7}{8} + 6\frac{7}{8}$

USE 44" LENGTH

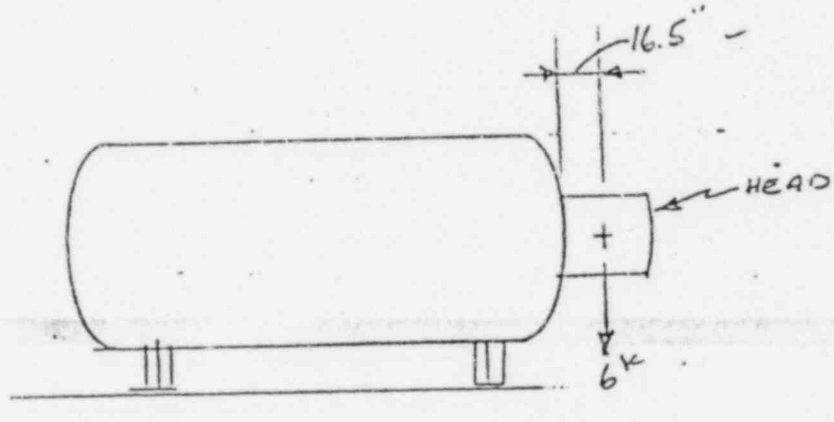
MATERIAL THICKNESS - $8\frac{5}{8}$" = 8.625

AREA: $\frac{\pi}{4}(d^2 - d_i^2)$

$= \frac{\pi}{4}(38^2 - 29.375^2) = 456.40\ IN^2$

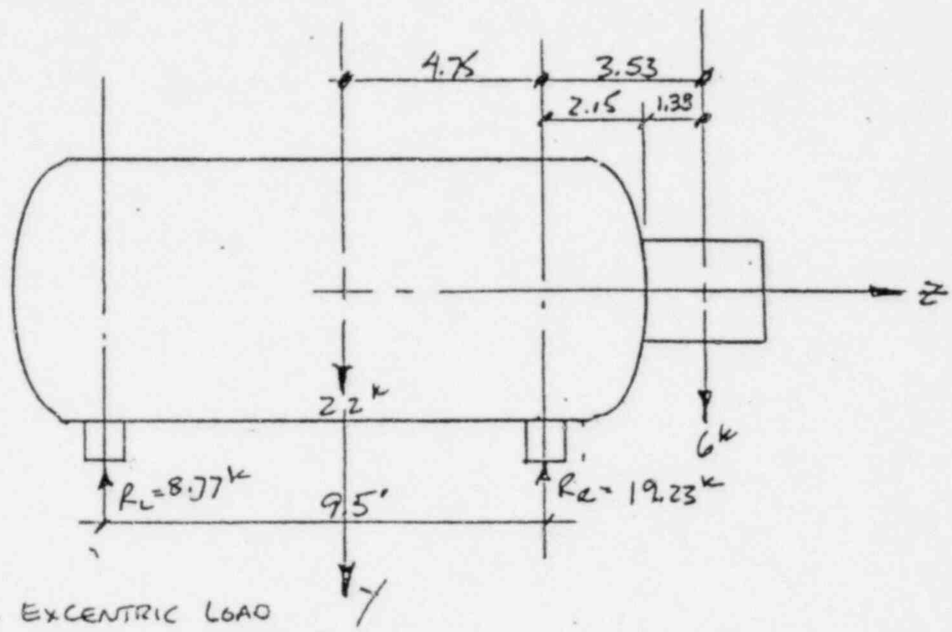
VOLUME = $\frac{\ \times 456.4}{1728} = 11.62\ FT^3$

WEIGHT = 11.62 × 490 #/FT³ = 5694 # USE 6K @ $\frac{37}{2}$ = 16.5"



LOADS ON SHUTDOWN CONDENSER	REF.

DEAD LOAD CASE (LOAD CASE 1)



ASSUME 6^k FOR EXCENTRIC LOAD IS DEDUCTED FROM TOTAL WT OF 28^k

$$\Sigma M_{RL}: 22 \times 4.75 + 6(9.5 + 3.53) = R_R \times 9.5$$

$$R_R = 19.23^k$$

$$R_L = 22 + 6 - 19.23$$

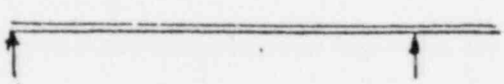
$$R_L = 8.77^k$$

13'-9 3/4
9-6"
4-3 1/4
1/2 : 2.15'

$$\text{DEAD LOAD (UNIFORM PRESS)} = \frac{19.32}{8 \times 2 \times 2.75 \times 12} = 0.0364 \ ^k/_{in^2}$$

DEAD LOAD BENDING ON SHELL

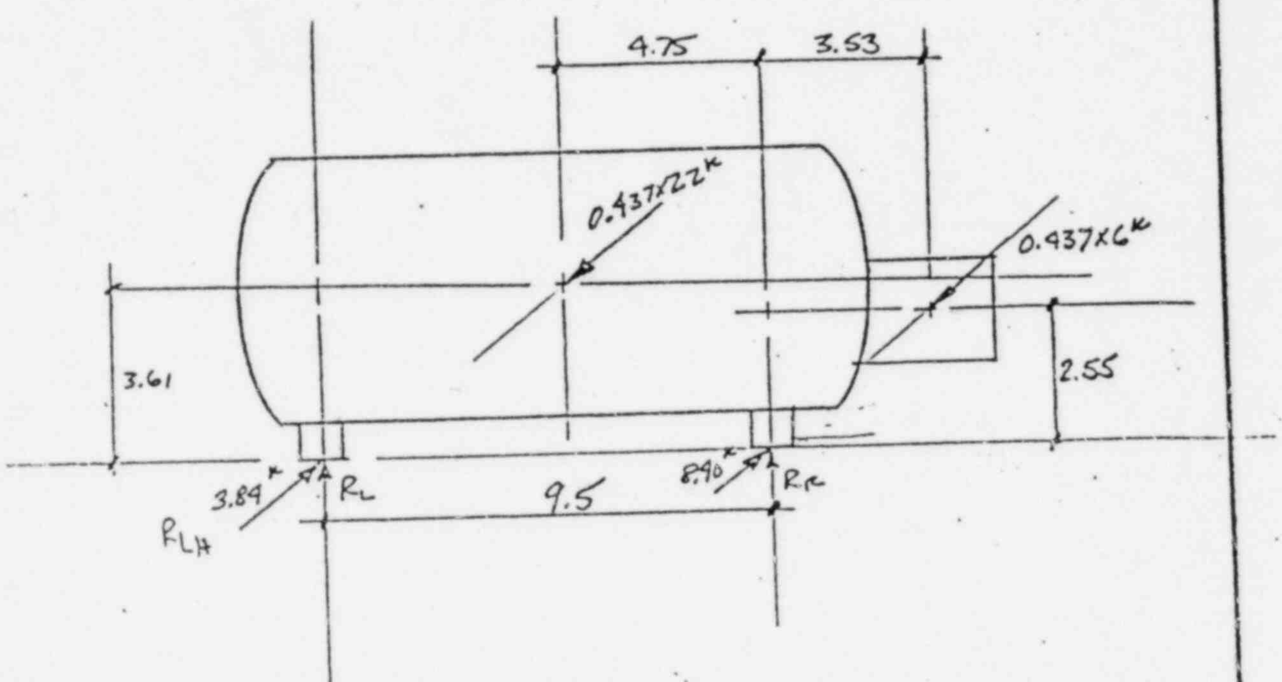
$$w = \frac{28-6}{9.5} = 2.32 \ ^k/_{ft}$$



REF.

LOADS ON SHUTDOWN CONDENSER

HORIZONTAL SEISMIC LOADS (X-EQ.) (LOAD CASE 2)



$$\Sigma M_{RLH} = 0.437\times22\times4.75 + 0.437\times6\times(9.5+3.53) = R_{RH}\times9.5$$

$$R_{RH} = 8.40^{k}$$

$$R_{LH} = 8.40 - 0.437(22+6) = -3.84^{k}$$

MOMENT INTRODUCED $= 0.437(22\times3.61 + 6\times2.55) = 41.39^{1\text{-}k}$

MOMENT IS SHARED BY 2 SADDLES

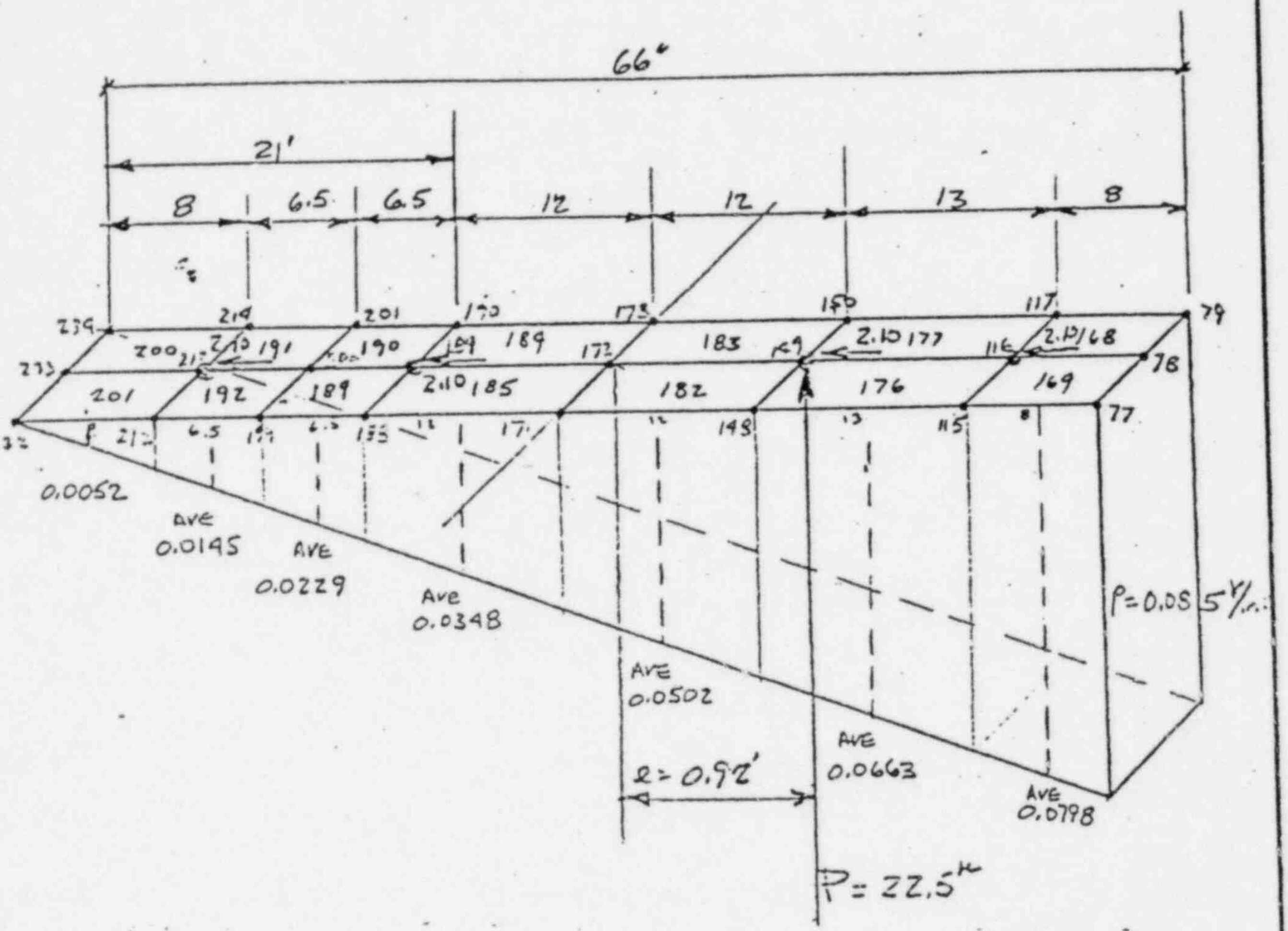
$\frac{1}{2} M = 20.70^{1\text{-}k}$ $\qquad e = \frac{2}{3}\times5.5 - \frac{5.5}{2}$

$P = \frac{M}{e} = \frac{20.70}{0.92} = 22.5^{k}$ $\qquad e = 0.92$ FT

MAX PRESSURE LOAD $= p = \frac{2P}{bW} = \frac{2\times22.5}{8\times5.5\times12} = 0.085^{k}/in^2$

REF.

LOADS ON SHUTDOWN CONDENSER



DIVIDE HORIZONTAL LOAD 1/4 AND PLACE AT NODES 116, 149, 189 213

MAX HORIZONTAL LOAD = 8.40k

HORIZONTAL LOAD / NODE = 2.10k

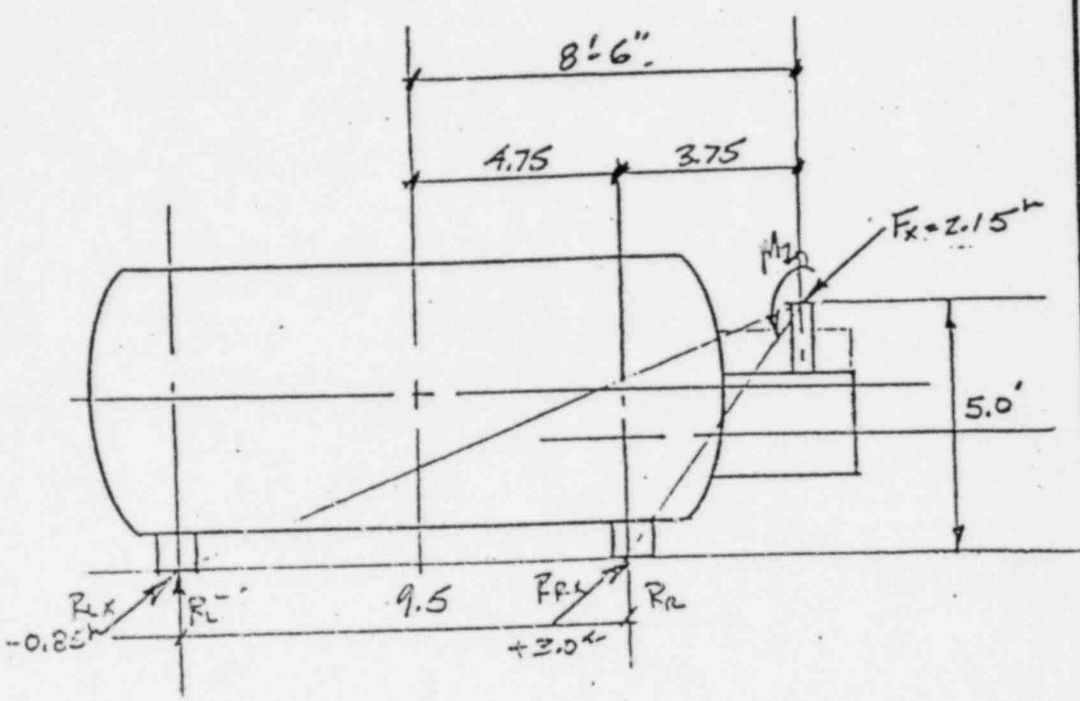
@ NODES 116, 149, 189 & 213

PRESSURE LOADINGS

ELEMENT	LOAD (ksi)	NODE	LOAD (ksi)
168	0.0798	189	0.0229
169	0.0798	190	0.0229
176	0.0663	191	0.0145
177	0.0663	192	0.0145
182	0.0502	200	0.0052
183	0.0502	201	0.0052
184	0.0348		
185	0.0348		

	REF.

PIPE LOADS (X-EQ)



$\Sigma M_{RL} = (9.5+3.75)(2.15) = R_{RX} \times 9.5$

$R_{RX} = 3.0^k$ ✓

$R_{LX} = 2.15 - 3.0^k = -0.85^K$ ✓

$M_z = 9.42^{1\text{-}k} + 2.15 \times 5 = 20.17^{1\text{-}K}$ $e = \frac{2}{3}\, 5.5 \frac{L}{2}\, 3.67' - \frac{5.5}{2} = 0.92$ ✓

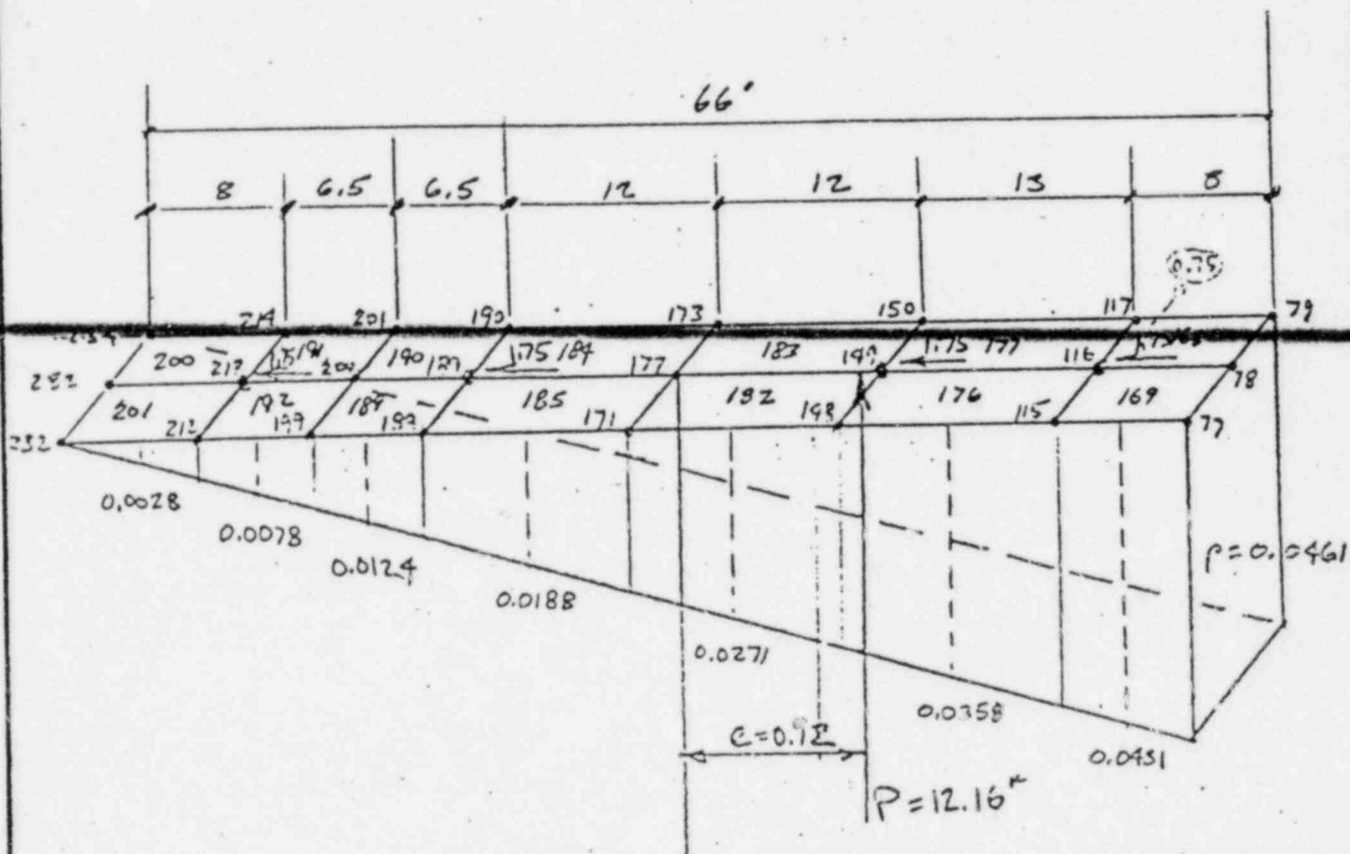
$M = Pe$ $\quad P = \frac{20.17}{0.92} = 21.92^K$ ✓ $\quad \frac{1}{2}P = 10.96^K$

THIS LOAD IS DIVIDED BETWEEN 2 SADDLES

$\text{PRESSURE LOAD} = p = \frac{2P}{bw} = \frac{2 \times 10.96}{8 \times 5.5 \times 12} = 0.042\, K/in^2$

PIPE LOADS (X-EQ)

REF.



DIVIDE HORIZONTAL LOAD 1/4 AND PLACE AT NODES 116, 149, 189, 213

MAX HORIZONTAL LOAD = 3.0k

HORIZONTAL LOAD/NODE = 0.75k

@ NODES 116, 149, 189, 213

PRESSURE LOADS

NODE	LOAD (KSI.)	NODE	LOAD
168	0.039	189	0.0116
169	0.039	190	0.0116
176	0.0337	191	0.0073
177	0.0337	192	0.0073
182	0.025	200	0.0026
183	0.025	201	0.0026
184	0.0175		
185	0.0175		

LOADS ON SHUTDOWN CONDENSER (X-EQ SUMMARY)	REF.

HORIZONTAL LOADS NODES

NODE No	Fx	
116	2.85^k = (2.1+0.75)	
149	2.85^k = "	NODE, FX, FORCE
189	2.85^k "	
213	2.85^k "	

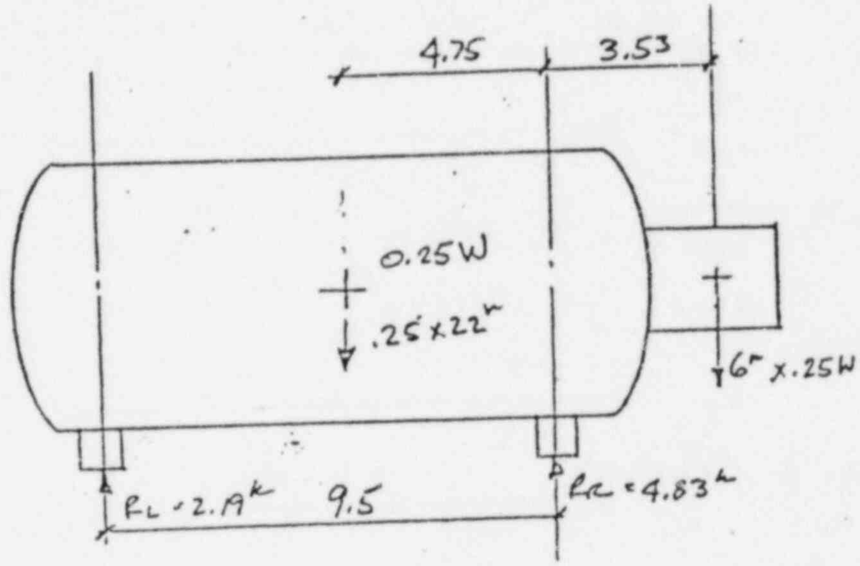
PRESSURE LOADS ON ELEMENTS

ELEMENT No	STRESS (KSI)	
168	0.119	
169	0.119	
176	0.1	ELEM No, 1, -( )
177	0.1	
182	0.075	
183	0.075	
184	0.052	
185	0.052	
189	0.0345	
190	0.0345	
191	0.0218	
192	0.0218	
200	0.0078	
201	0.0078.	

REF.

LOADS ON SHUTDOWN CONDENSER

VERTICAL EARTHQUAKE (Y-EQ) VERTICAL



ΣM_L : $R_L = .25 \times 8.77^k = 2.19^k$ ✓

$R_R : .25 \times 19.32^k = 4.83^k$ ✓

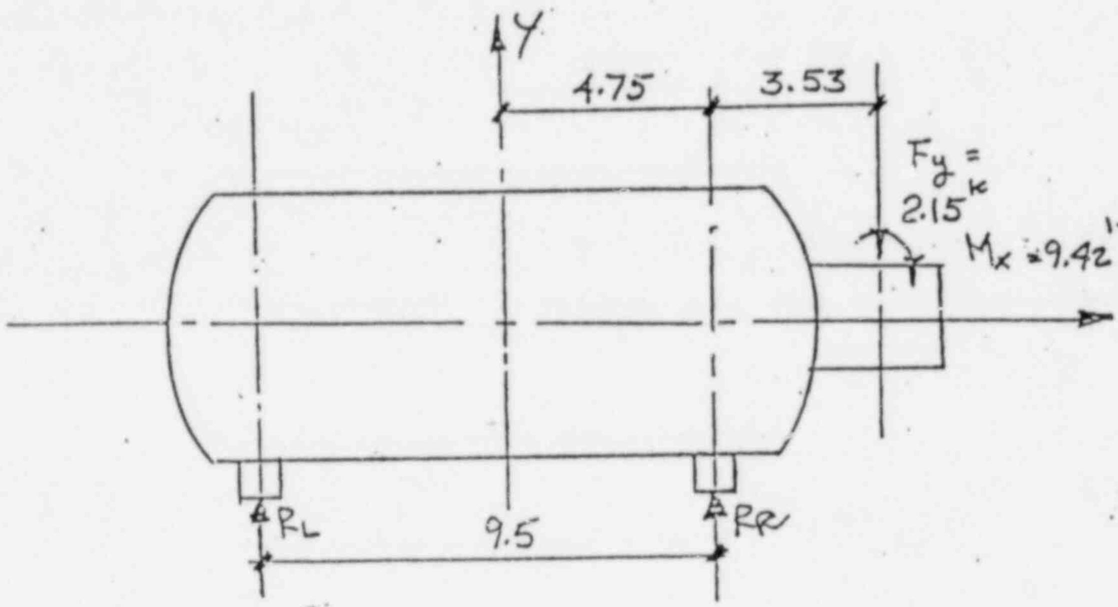
FROM PREVIOUS CALC.

VERTICAL UNIFORM SEISMIC PRESSURE $= \frac{4.83}{8 \times 2 \times 2.75 \times 12} = 0.0092^k/in^2$

REF.

PIPE LOADS ON THE SHUTDOWN CONDENSER

VERTICAL EARTHQUAKE (Y-EQ)



$$\Sigma R_{LO} = R_R \times 9.5 = 2.15 \times (9.5 + 3.53) + 9.42 \quad (M_x)$$

$$R_R = 3.94^k \checkmark$$

$$R_L = 2.15 - 3.94 = 1.79 \checkmark$$

PRESSURE LOAD = $p = \frac{P}{A} \quad \frac{3.94}{8 \times 5.5 \times 12} = 0.0075 \text{ ksi} \checkmark$

TOTAL PRESSURE LOAD $= (0.0075 + 0.0092)$ ksi

$= 0.0167$ ksi ✓

LOADS ON SHUTDOWN CONDENSER (Y-SUMMARY)	REF.

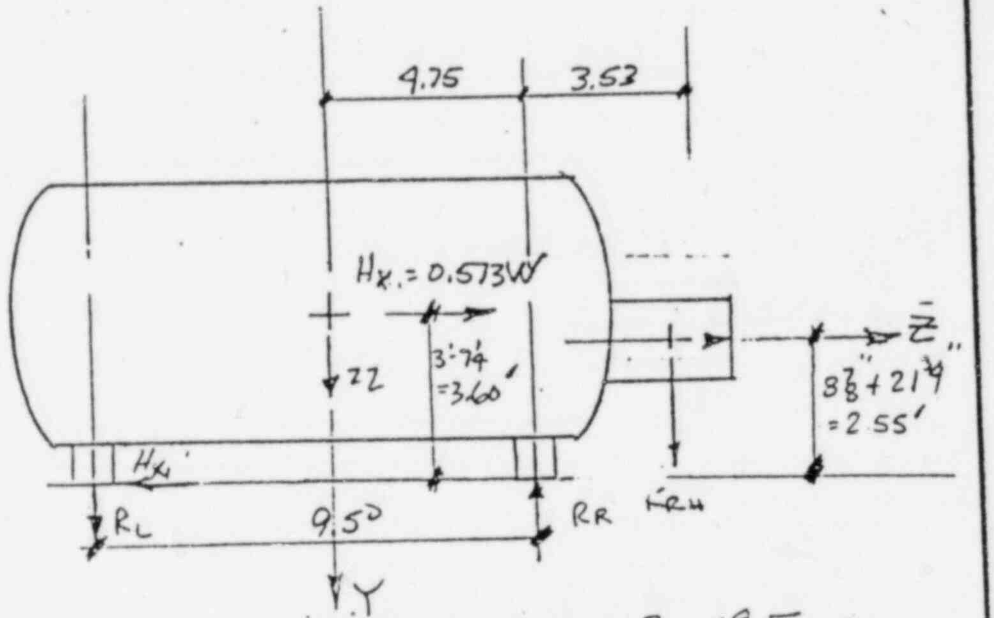
PRESSURE LOADS

ELEMENTS	PRESSURE
168	0.0167 KSI ✓
169	↓
176	↓
177	↓
182	↓
183	↓
184	↓
185	↓
189	↓
190	↓
191	↓
192	↓
200	↓
201	0.0167 KSI ✓

REF.

LOADS ON SHUTDOWN CONDENSER

HORIZONTAL SEISMIC LOAD (Z-EQ.)



$\Sigma M_{RL} = 0.573 \times 22 \times 3.60 + 0.573 \times 6 \times 2.55 = R_R \times 9.5$

$R_R = 5.70^k$

$R_L = 0.573 \times 28 - 5.70 = 10.34^k$

$H_{TOTAL} = .573(22+6) = 16.04^k$

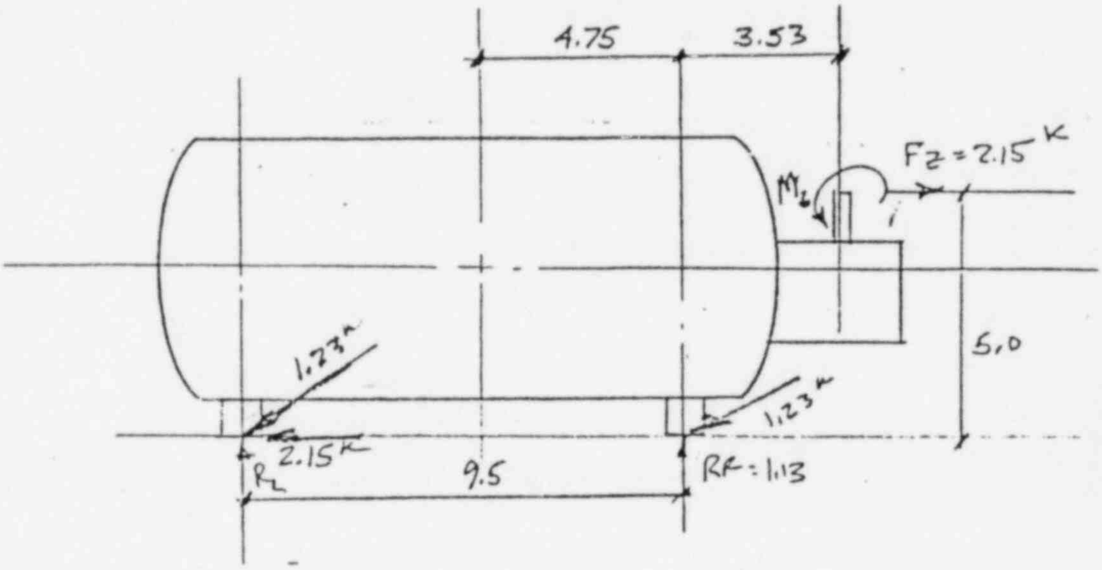
ASSUME ALL LOAD ON ONE SADDLE DUE TO SLOTTED HOLES.

VERTICAL UNIFORM PRESSURE FROM HORIZONTAL FORCE $= \frac{10.34}{8 \times 2 \times 2.75 \times 12} = 0.0196 \frac{KS}{IN}$

HORIZONTAL FORCE 16.04^k

NODES	Fz
116	4.02
149	4.02
189	4.02
213	4.02

PIPE LOADS ON SHUTDOWN CONDENSER (Z-EQ)	REF.



ΣF_{R_L} $R_R = \frac{F_Z \times 5.0}{9.5} = 1.13^k$

$R_L = -R_R = -1.13$

$R_{RH} = M_Z / 9.5 = \frac{9.42}{9.5} = 0.99^K$

$R_{LH} = -R_{RH} = 0.99^K$

$F_Z = \frac{2.15}{4} = 0.538^k$

PRESSURE LOAD $= \frac{1.13}{8 \times 5.5 \times 12} = 0.0021^{KSI}$

$F_Z = \frac{2.15}{2 \times 4} = 0.269^k$

HORIZONTAL LOADS $= \frac{0.99}{4} = 0.25^K$

NODE	F_X (K)	F_X
116	0.25^K	0.538
149	0.25^K	0.538
189	0.25^K	0.538
213	0.25^K	0.538

PIPE LOADS ON SHUTDOWN CONDENSER

REF.

HORIZONTAL SEISMIC SUMMARY (Z-EQ)

NODE LOADS

NODES	Fx	Fz (K)
116	0.25 ✓	4.56 ✓
149	0.25 ✓	4.56 ✓
189	0.25 ✓	4.56 ✓
213	0.25 .	4.56 ✓

PRESSURE LOADS

ELEMENTS	PRESSURE
168	0.0217 KSI ✓
169	↓
176	↓
177	↓
182	↓
183	↓
184	↓
185	↓
189	↓
190	↓
191	↓
192	↓
200	↓
201	0.0217 KSI ✓

RESULTS OF COMPUTER ANALYSIS ON SHUTDOWN CONDENSER	REF.

IN COMPUTER PRINTOUT S46007U, THE FOLLOWING CASES HAVE BEEN ANALYSED.

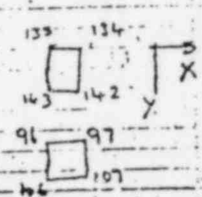
(1) D. LOAD
(2) X. EARTHQUAKE (SSE)
(3) Y. EARTHQUAKE (SSE)
(4) Z. EARTHQUAKE (SSE)

THE SUMMATION OF D. LOAD AND EARTHQUAKE

ie $|D.L| + \left|\left[X_{EQ}^2 + Y_{EQ}^2 + Z_{EQ}^2\right]^{1/2}\right|$

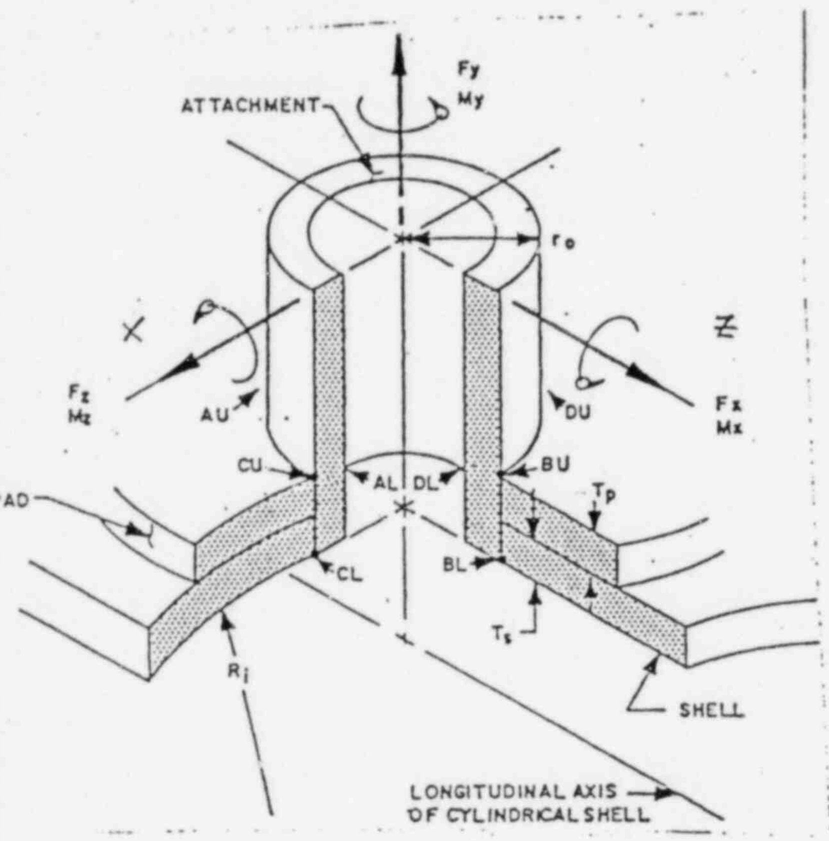
HAS BEEN PERFORMED IN S460058.

		S_x	S_y	Txy
EL	92	6.23 (MAX)	5.09	0.77
	70	6.21	5.73	1.63



92	6.23	5.1	0.77
179	0.88	4.43	1.54
70	6.21	5.73 (MAX)	1.63
179	1.32	5.19	1.38

NOZZLE LOADS FOR 6"ϕ MAIN STEAM LINE	REF.



INPUT DATA

INSIDE RADIUS OF VESSEL = 17.25 IN
WALL THICKNESS = 1.4875 IN
PAD THICKNESS = 0
OUTSIDE RADIUS = 4.625 INCHES
OF NOZZLE

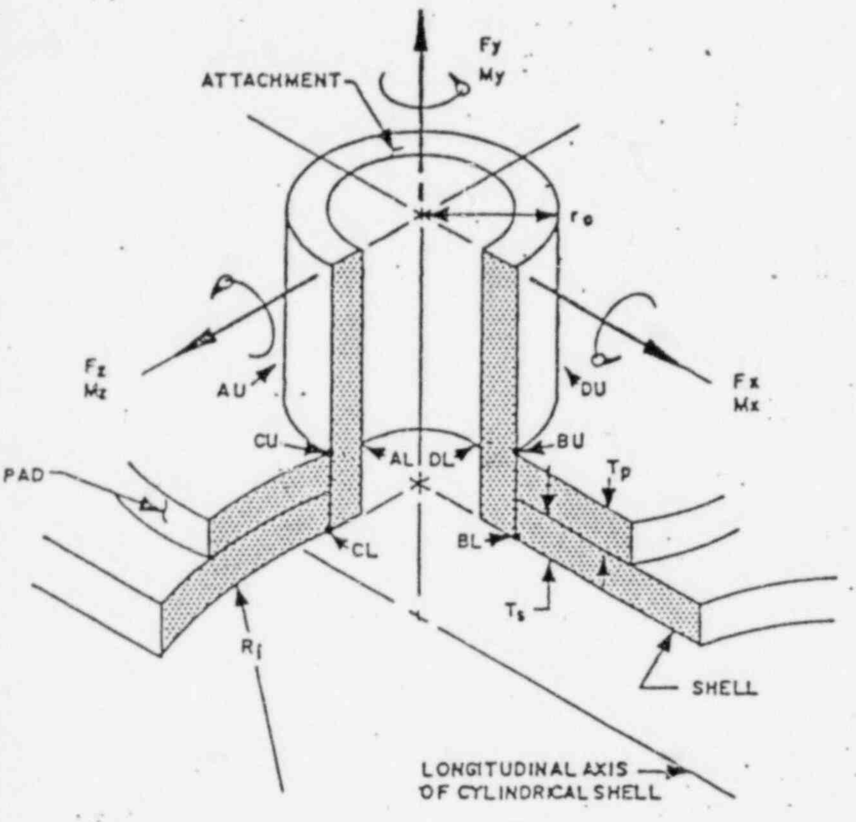
FORCES & MOMENTS (REF.: FROM INPUT LOADS DUE TO PIPING)

F_x = 1870 #
F_y = 637 #
F_z = 845 #
M_x = 8596 FT-#
M_y = 3526 FT-#
M_z = 1543 FT-#

MAXIMUM COMBINED
STRESS INTENSITY IN CHANNEL INLET
FROM WECCO PROGRAM = -7322 PSI

REF.

NOZZLE LOADS FOR 6"φ FEEDWATER LINE



INPUT DATA

INSIDE RADIUS OF VESSEL = 17.25 IN
WALL THICKNESS = 1.4875
PAD THICKNESS = 0
OUTSIDE RADIUS OF NOZZLE = 4.625

FORCES & MOMENTS

F_x = 862 #
F_y = 577 #
F_z = 793 #
M_x = 6890 Ft-#
M_y = 3610 Ft-#
M_z = 7260 Ft-#

MAXIMUM COMBINED
STRESS INTENSITY IN INLET
CHANNEL FROM WERCO PROGRAM = 5897 psi

TABLE 1

MAXIMUM STRESSES FOR THE SHUTDOWN CONDENSER (PSI)

	SHELL		CHANNEL INLET	
	CIRCUMFERENTIAL	LONGITUDINAL	CIRCUMFERENTIAL	LONGITUDINAL
INTERNAL PRESSURE	2288	1124	15389	6987
DEAD LOAD BENDING + SEISMIC	N.A	209	N.A	200
LOCAL BENDING DUE TO SADDLE	6230*	6230*	N.A.	N.A.
NOZZLE STRESSES				
6" MAIN STEAM	N.A.	N.A.	17322	7322
6" FEEDWATER CONDENSATE	N.A.	N.A.	15897	5897

* USE WORST STRESS IN BOTH DIRECTIONS.

COMBINED MAXIMUM STRESS IN SHELL = 2288+6230
= 8,518 PSI
WHICH IS LESS THAN THE ALLOWABLE OF 32,130 PSI

COMBINED MAXIMUM STRESS IN CHANNEL INLET = 15389+7322
= 22,711 PSI
WHICH IS LESS THAN THE ALLOWABLE OF 31,320 PSI

REF.

NUCLEAR ENERGY SERVICES

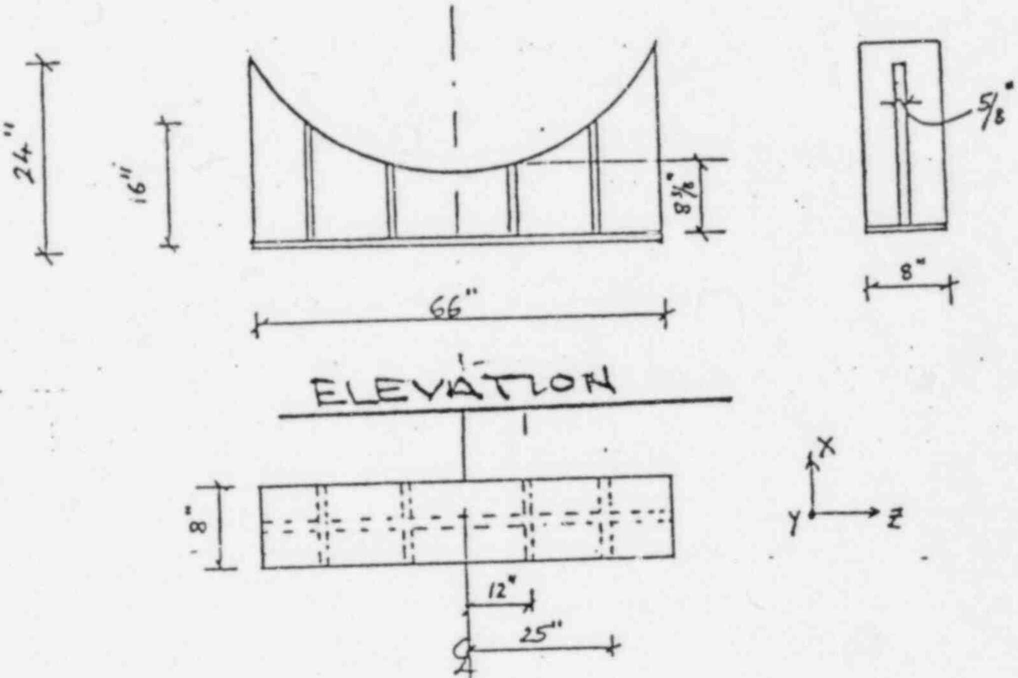
BY K.K. DATE 11/7/81 PROJ.
CHKD. N.R. DATE 11/11/81 PAGE A-37 OF 47

LACBWR SHUTDOWN CONDENSER

SADDLE STRESSES

REF.

SADDLE ANALYSIS



SADDLE DETAILS

REF.

SADDLE STRESSES

FORCES ACTING ON THE SHUTDOWN CONDENSER SADDLE

D. LOAD = 14 KIPS. (REF. "SETTING PLAN, REACTOR) SHUTDOWN CONDENSER" DWG. 63-2-7984-B1

HORIZONTAL FORCE DUE TO X - EARTHQUAKE = 11.4 KIPS
(FORCES DUE TO EARTHQUAKE AND PIPE LOADS ARE ADDED) (PAGE 23 → 25)

HORIZONTAL FORCE DUE TO Z - EARTHQUAKE = 17.08 KIPS
(FORCES DUE TO EARTHQUAKE AND PIPE LOADS ARE ADDED). (PAGE 31 → 33)

IT IS ASSUMED THAT SNUBBERS ARE NOT PRESENT.

IT IS ASSUMED THAT THE HORIZONTAL FORCES DUE TO EARTHQUAKE ACT AT A HEIGHT OF 20" ABOVE THE FLOOR LEVEL.

MAX. VERTICAL FORCE DUE TO Y (VERTICAL) EARTHQUAKE

$$= 4.83 + 3.94K = 8.8K$$

TOTAL VERTICAL FORCE ON EACH SADDLE = 14 + 8.8

= 22.8 KIPS.

REF.

SADDLE STRESSES

$$I_{ZZ} = 4 \times \frac{5}{8} \times \frac{8^3}{12} + 66 \times \left(\frac{5}{8}\right)^3 \times \frac{1}{12}$$ ✓

(WEAK AXIS)

$$= 106.66 + 1.34$$ ✓

$I_{ZZ} = 108.00\ in^4$ ✓ $A = 4 \times 8 \times \frac{5}{8} + 66 \times \frac{5}{8} = 61.25\ in^2$ $r_{zz} = 1.33''$

$S_{ZZ} = 27.00\ in^3$ ✓

$$I_{XX} = 0.625 \times \frac{(66)^3}{12} + 4 \times \frac{8}{12} \times (0.625)^3 + 2 \times 0.625 \times 8\ (12^2 + 25^2)$$

7690

(STRONG AXIS).

$I_{XX} = 22664.4$ ✓ in^4. $A = 61.25\ in^2$ $r = 19.24''$.

$S_{XX} = 686.8\ in^3$. ✓

W/t RATIO OF THE SECTION WITH THE LARGEST UNSUPPORTED LENGTH $= \frac{24}{0.625} = 38.4$ ✓

MAX. ALLOWABLE W/t RATIO $= \frac{253}{\sqrt{F_Y}}$ (AISC SPEC. 1.9.2.2)

$$= \frac{253}{\sqrt{36}} = 42.17.$$ ✓

AS W/t RATIO IS LESS THAN THE $(W/t)_{All}$, THE ENTIRE LENGTH OF THE PLATE IS CONSIDERED EFFECTIVE. ✓

Bending Stress $f_{bZ} = \frac{11.4^{k} \times 20''}{27.00\ in^3} = 8.44\ KSI$ ✓

Bending Stress $f_{bX} = \frac{17.08^{k} \times 20''}{686.8\ in^3} = 0.497\ KSI.$ ✓

	REF.

Saddle Stresses

Axial Stress $f_a = \frac{22.8}{66\times\frac{5}{8} + 4\times8\times5/8} = 0.3722$ KSI. ✓

MAX. DEPTH OF THE SADDLE PLATE = 24".

MAX: $\frac{Kl}{r} = \frac{24}{1.33} = 18.04 < C_c$. ✓

F_a = 20.72 KSI (TABLE 3-36 A.I.S.C. Spec). ✓

as $f_a < 0.15 F_a$, ✓

$$\frac{f_a}{F_a} + \frac{\sqrt{f_{bz}^2 + f_{bx}^2}}{F_b} = \frac{0.3722}{1.6\times20.72} + \frac{\sqrt{8.44^2 + .497^2}}{1.6\times0.6\times36} = 0.248 < 1$$ ✓

THE SADDLE IS SAFE UNDER THE COMBINED EFFECTS OF D. LOAD . AND EARTHQUAKE.

BEARING.

BEARING AREA = ARC LENGTH x THICKNESS

$= 36\times 2\times\frac{57.65}{180}\times 5/8$ ✓

(ANGLE SUBTENDED BY THE SADDLE AT THE CENTER OF THE VESSEL = 2x57.65° = 115.3° PAGE NO)

B. AREA = 14.41 in^2.

BEARING STRESS = $\frac{14}{14.41}$ = 0.97 KSI ✓

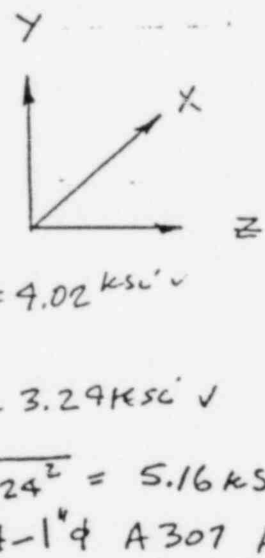
MUCH LESS THAN THE ALLOWABLE VALUE. ✓

ANCHOR BOLT STRESSES | REF.

ANCHOR BOLT EVALUATION

	VERTICAL	MAX	MIN	
DEAD LOAD	COMP	19.23ᵏ ✓	8.77ᵏ ✓	P7/18
Y - SEISMIC (VERTICAL)	TEN/COMP	± 4.83ᵏ ✓	± 2.19ᵏ ✓	P13/18
X - SEISMIC	SHEAR	8.4ᵏ ✓	3.84ᵏ ✓	P8/18
PIPE LOADS	SHEAR	3.0ᵏ ✓	.85ᵏ ✓	P10/18
	TEN/COMP	± 3.94ᵏ ✓	± 1.79ᵏ ✓	P14/18
	SHEAR	1.23ᵏ ✓	1.23ᵏ ✓	P17/18
Z - SEISMIC	SHEAR		8.02ᵏ	
PIPE	TEN OR COMP	1.13 ✓	1.13 ✓	P17/18
	SHEAR		2.15ᵏ	

USING WORST CASE



X-DIRECTION 8.4ᵏ ✓
3.0ᵏ ✓
1.23ᵏ ✓
$f_x = 12.63^k$

Z DIRECTION 8.02ᵏ ✓
2.15ᵏ ✓
$f_z = 10.17^k$

Y UPLIFT

4.83	2.19
3.94	1.79
1.13	1.13
$f_y = 9.90^k$ ✓	5.11ᵏ

$f_{v_x} = \frac{12.63}{4 \times \pi \frac{1^2}{4}} = 4.02\ ksi$ ✓

$f_{v_z} = \frac{10.17}{4 \times \pi \frac{1^2}{4}} = 3.24\ ksi$ ✓

$f_v = \sqrt{4.02^2 + 3.24^2} = 5.16\ ksi$ ✓

ASSUME 4-1"φ A307 ANCHOR BOLTS ✓

$F_t = 26 - 1.8 F_v \leq 20$ ✓ ALLOW $F_v = 10.0\ ksi$ ✓ | AISC Pg 5-29 5-28

$F_t = 26 - 1.8 \sqrt{4.02^2 + 3.24^2} \leq 20\ ksi$ ✓ ALLOW $F_t = 20.0\ ksi$ ✓

$F_t = 16.7\ ksi$ ✓

$f_t = \frac{9.90}{4 \times \frac{\pi}{4}} = 3.15\ ksi \leq 16.7\ ksi$ OK ✓

REF.

ANCHOR BOLT STRESSES

ALLOWABLE STRESS IN SHEAR FOR A307 BOLTS 1"ϕ

$$F_V = 10.0 \text{ ksi}$$

ALLOWABLE IN TENSION $F_T = 26 - 1.8 f_v \leq 20$

$$F_T = 16.7 \text{ ksi}$$

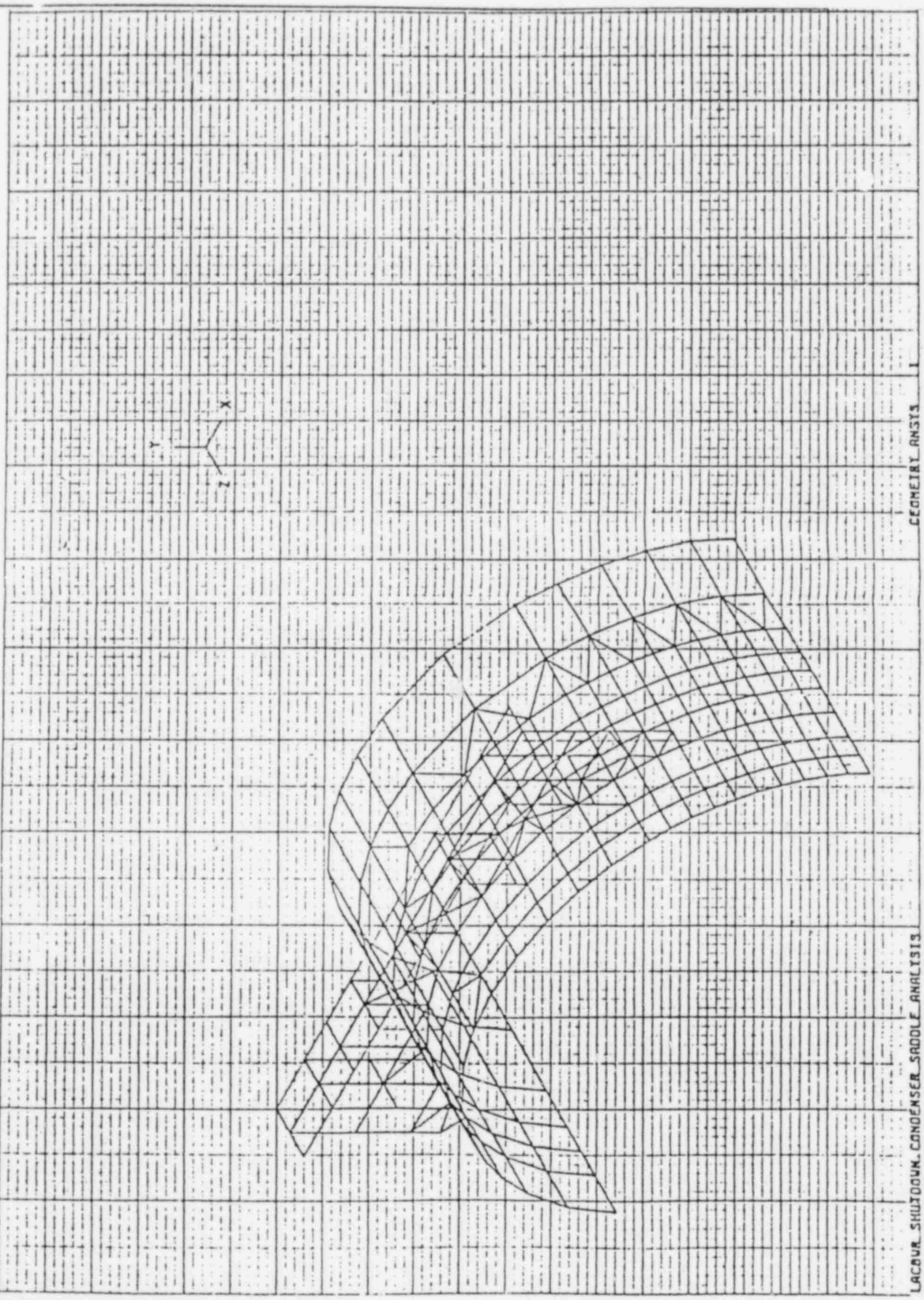
COMBINED STRESS RATIO IGNORING 1.6 FACTOR, FOR SSE EVENT

$$\frac{f_T}{F_T} + \frac{f_V}{F_V} \leq 1$$

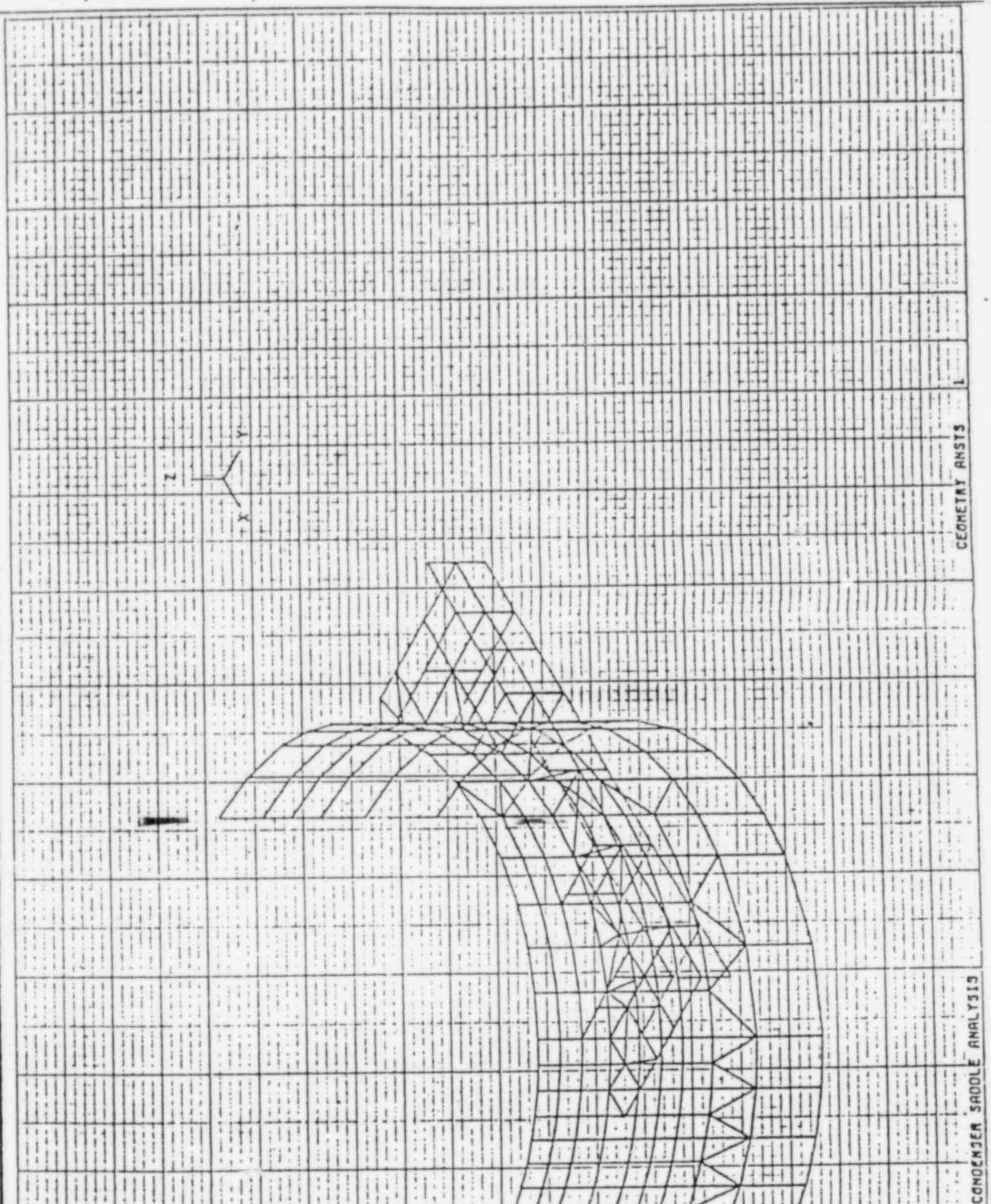
$$\frac{3.15}{16.7} + \frac{5.16}{10.0} = 0.705 \leq 1 \quad \text{O.K.}$$

GEOMETRY VERIFICATION OF ANSYS MODEL

REF.

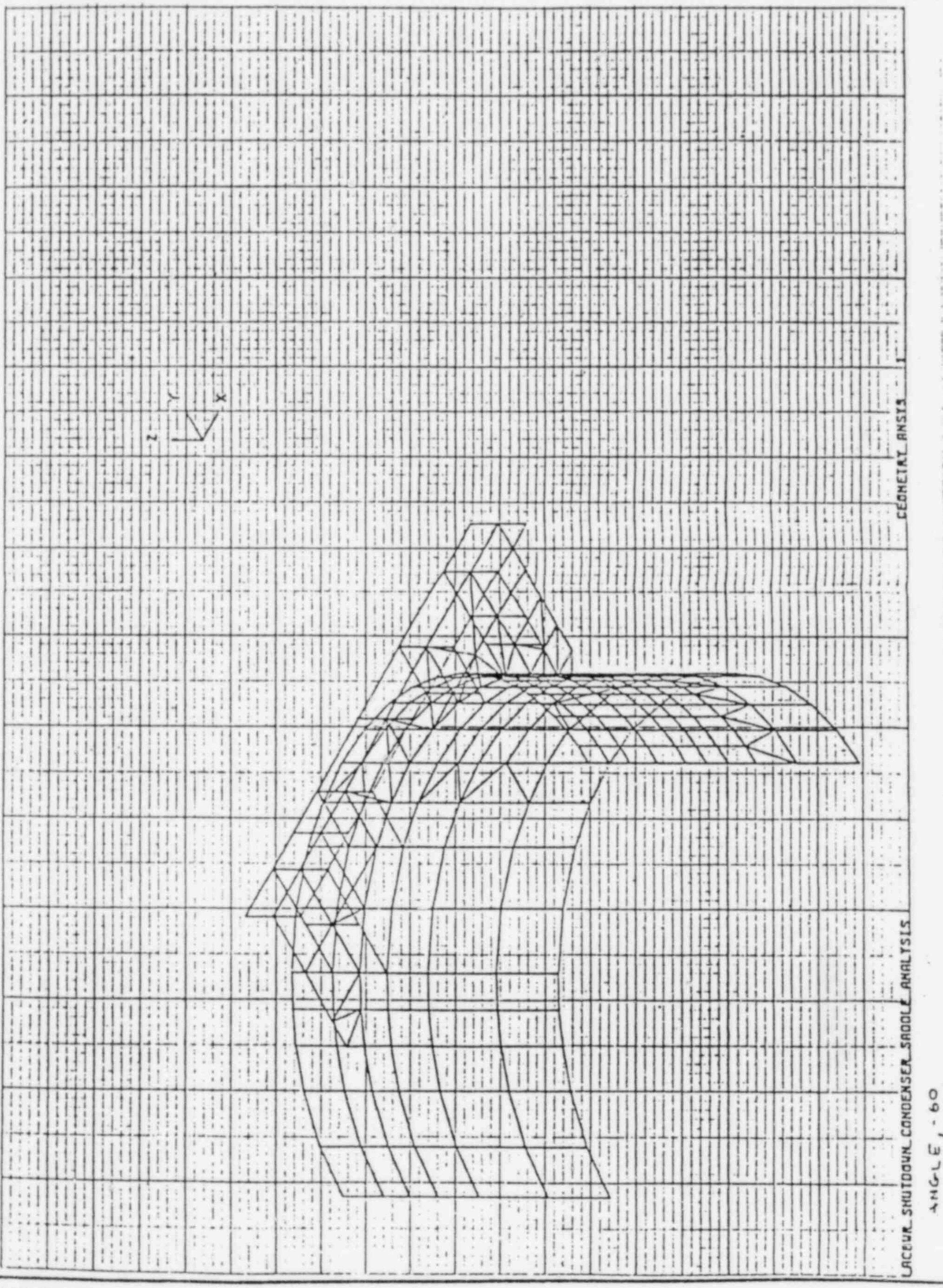


GEOMETRY VERIFICATION OF ANSYS MODEL	REF.



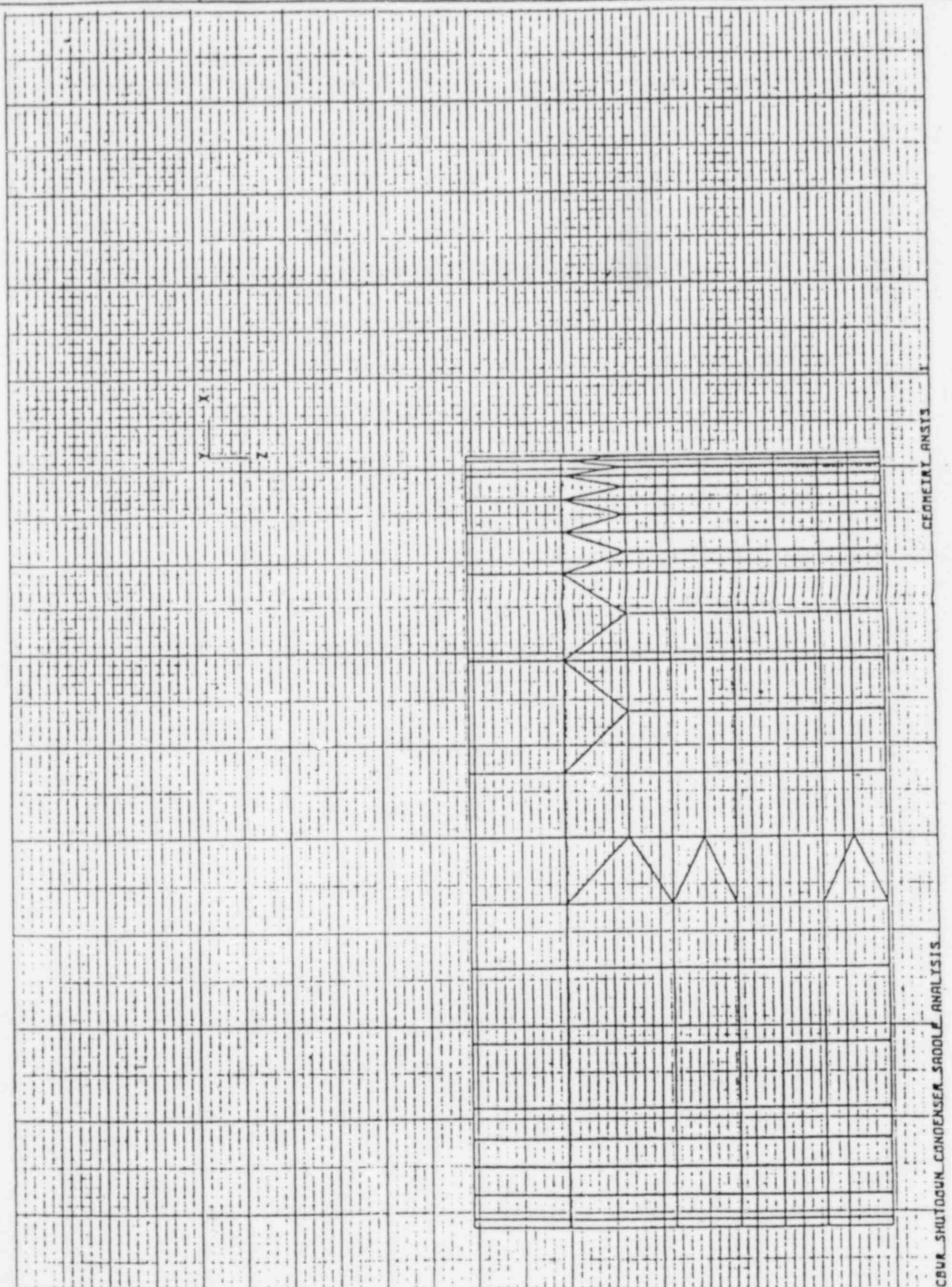
GEOMETRY VERIFICATION OF ANSYS MODEL

REF.



GEOMETRY VERIFICATION OF ANSYS MODEL

REF.



APPENDIX B

WERCO COMPUTER PROGRAM OUTPUT FOR FEEDWATER LINE NOZZLE

24
24-ENTER FORCE LOAD FZ (LBS)
? 793
ENTER QUESTION NUMBER (RETURN IF NO MORE CHANGES)
25

25-ENTER MOMENT LOAD M-X (FT-LBS)
6890
ENTER QUESTION NUMBER (RETURN IF NO MORE CHANGES)
26

26-ENTER MOMENT LOAD M-Y (FT-LBS)
3610
ENTER QUESTION NUMBER (RETURN IF NO MORE CHANGES)
? 27

27-ENTER MOMENT LOAD M-Z (FT-LBS)
? 7260
ENTER QUESTION NUMBER (RETURN IF NO MORE CHANGES)

Prepared by Mark W. Hostetler 10/30/81 B- 1/4

Checked By Robert Rungg 11/6/81

OUTPUT WITH 80 OR 132 CHARACTERS PER LINE?
? 80

AAA TECHNOLOGY AND SPECIALTIES CO., INC.
WERCO PROGRAM RELEASE 6.0.6 JUNE 1 1981

*** NOTICE ***

ALL INFORMATION PRESENTED BY THE WERCO PROGRAM
IS FOR REVIEW, INTERPRETATION, APPROVAL AND APPLICATION
BY A REGISTERED PROFESSIONAL ENGINEER.

** W E R C O **
LOCAL STRESSES IN SHELLS DUE TO EXTERNAL LOADINGS
BASED ON WELDING RESEARCH COUNCIL BULLETIN NO. 107 (MARCH 1979)

FEED WATER LINE AT THE SHUT DOWN CONDENSER
RUN DATE 29 OCT 81

** MAXIMUM STRESS INTENSITY OPTION SELECTED **

INPUT DATA
GEOMETRY
SHELL

TYPE CYLINDRICAL
INSIDE RADIUS 17.2500(INCHES)

TYPE ROUND
OUTSIDE RADIUS 4.6250(INCHES)

B- 2/4

PPLIED LOADS GIVEN IN X-Y-Z AXIS SYSTEM
** CYLINDRICAL AXIS DIRECTION IS X
** ATTACHMENT DIRECTION IS +Y

RADIAL LOAD (FY)	-577.0(LBS)
SHEAR LOAD (FX)	-862.0(LBS)
SHEAR LOAD (FZ)	-793.0(LBS)
OVERTURNING MOMENT (MX)	-6890.0(FT-LBS)
OVERTURNING MOMENT (MZ)	-7260.0(FT-LBS)
TORSIONAL MOMENT (MY)	·3610.0(FT-LBS)

STRESS CONCENTRATION FACTORS

DUE TO MEMBRANE LOADING (KN)	1.50
DUE TO BENDING LOAD (KB)	1.00

INTERNAL PRESSURE	1415.0(PSIG)
JOINT EFFICIENCY	1.00

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** W E R C O **

LOCAL STRESSES IN SHELLS DUE TO EXTERNAL LOADINGS
BASED ON WELDING RESEARCH COUNCIL BULLETIN NO. 107 (MARCH 1979)

FEED WATER LINE AT THE SHUT DOWN CONDENSER
UN DATE 29 OCT 81

TENSION = +
COMPRESSION = -

** MAXIMUM STRESS INTENSITY OPTION SELECTED **

OUTPUT DATA (ALL STRESSES ARE GIVEN IN (PSI))

CIRCUMFERENTIAL STRESSES- TYPE	DUE TO	AU	AL	BU	BL
		LOCATION			
MEMBRANE	(FY)	-65.	-65.	-65.	-65.
BENDING	(FY)	-109.	109.	-109.	109.
MEMBRANE	(MX)	0.	0.	0.	0.
BENDING	(MX)	0.	0.	0.	0.
MEMBRANE	(MZ)	-1656.	-1656.	1656.	1656.
BENDING	(MZ)	-2417.	2417.	2417.	-2417.
MEMBRANE STRESSES		-1720.	-1720.	1591.	1591.
BENDING STRESSES		-2526.	2526.	2308.	-2308.
[illegible]		-4246.	806.	3899.	-717.

BENDING (FY)	-152.	152.	-152.	152.	
MEMBRANE (MX)	0.	0.	0.	0.	
BENDING (MX)	0.	0.	0.	0.	
MEMBRANE (MZ)	-517.	-517.	517.	517.	
BENDING (MZ)	-3872.	3872.	3872.	-3872.	
MEMBRANE STRESSES	-570.	-570.	463.	463.	
BENDING STRESSES	-4024.	4024.	3721.	-3721.	
TOTAL LONGITUDINAL STRESSES	-4595.	3454.	4184.	-3257.	

B-3/4

SHEAR STRESSES DUE TO

TORSIONAL MOMENT (MY)	217.	217.	217.	217.
SHEAR LOAD (FZ)	37.	37.	-37.	-37.
SHEAR LOAD (FX)	0.	0.	0.	0.
TOTAL SHEAR STRESSES	253.	253.	180.	180.
COMBINED STRESS INTENSITY	4728.	3478.	4271.	3270.

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** W E R C O **

LOCAL STRESSES IN SHELLS DUE TO EXTERNAL LOADINGS
BASED ON WELDING RESEARCH COUNCIL BULLETIN NO. 107 (MARCH 1979)

FEED WATER LINE AT THE SHUT DOWN CONDENSER
RUN DATE 29 OCT 81

TENSION = +
COMPRESSION = -

** MAXIMUM STRESS INTENSITY OPTION SELECTED **

OUTPUT DATA -- (ALL STRESSES ARE GIVEN IN (PSI))

CIRCUMFERENTIAL STRESSES	TYPE	DUE TO	CU	CL	DU	DL
			LOCATION			
	MEMBRANE	(FY)	-54.	-54.	-54.	-54.
	BENDING	(FY)	-151.	151.	-151.	151.
	MEMBRANE	(MX)	-497.	-497.	497.	497.
	BENDING	(MX)	-5163.	5163.	5163.	-5163.
	MEMBRANE	(MZ)	0.	0.	0.	0.
	BENDING	(MZ)	0.	0.	0.	0.
MEMBRANE STRESSES			-550.	-550.	443.	443.
BENDING STRESSES			-5314.	5314.	5012.	-5012.
TOTAL CIRCUMFERENTIAL STRESSES			-5864.	4764.	5455.	-4569.

LONGITUDINAL STRESSES- TYPE DUE TO

	MEMBRANE	(FY)	-65.	-65.	-65.	-65.
	BENDING	(FY)	-108.	108.	-108.	108.
	MEMBRANE	(MX)	-831.	-831.	831.	831.
	BENDING	(MX)	-2868.	2868.	2868.	-2868.
	MEMBRANE	(MZ)	0.	0.	0.	0.
	BENDING	(MZ)	0.	0.	0.	0.
MEMBRANE STRESSES			-896.	-896.	767.	767.
BENDING STRESSES			-2976.	2976.	2761.	-2761.
TOTAL LONGITUDINAL STRESSES			-3872.	2080.	3528.	-1994.

SHEAR STRESSES DUE TO

MAX COMBINED STRESS INTENSITY 5897. 4788. 5471. 4581. B-4/4

INT. PRESS. STRESS(NOT INCLUDED IN COMBINED STRESS INTENSITY)

LONGITUDINAL 7922. CIRCUMFERENTIAL 17258.

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** W E R C O **

LOCAL STRESSES IN SHELLS DUE TO EXTERNAL LOADINGS

ED ON WELDING RESEARCH COUNCIL BULLETIN NO. 107 (MARCH 1979)

ED WATER LINE AT THE SHUT DOWN CONDENSER

N DATE 29 OCT 81

MAXIMUM STRESS INTENSITY OPTION SELECTED **

RAMETERS AND FACTORS USED BY THE PROGRAM

THE SOLUTION OF THE PROBLEM

SHELL TYPE: CYLINDRICAL

ATTACHMENT TYPE: ROUND

SHELL PARAMETER GAMMA = 12.097

ATTACHMENT PARAMETER BETA = .225

FACTORS FROM CURVES		FIGURE
(F 1)L =	1.9947	4C
(F 1)T =	1.6564	3C
(F 2)L =	.0699	2C-1
(F 2)T =	.0965	1C
(F 3) =	.4339	3A
(F 4) =	.0932	1A
(F 5) =	1.3722	3B
(F 6) =	.0414	1B-1
(F 7)L =	1.6564	3C
(F 7)T =	1.9947	4C
(F 8)L =	.0970	1C-1
(F 8)T =	.0688	2C
(F 9) =	.7261	4A
(F10) =	.0518	2A
(F11) =	.4285	4B
(F12) =	.0663	2B-1

+ INDICATES THAT THIS FACTOR HAS BEEN OBTAINED BY EXTENDING WRC 107 CURVES.

DOCUMENT NO. 81A0044

NUCLEAR ENERGY SERVICES, INC.

APPENDIX C

WERCO COMPUTER PROGRAM OUTPUT
FOR STEAM LINE NOZZLE

2-DO YOU WANT ... (YES OR NO).
n
ANY CHANGES? (YES OR NO)
n
OUTPUT WITH 80 OR 132 CHARACTERS PER LINE?
80

C- 1/4

Prepared by
Mark W. Hostetler
10/30/81

Checked By
Robert Rumpf
11/6/81

PAA TECHNOLOGY AND SPECIALTIES CO., INC.
WERCO PROGRAM RELEASE 6.0.6 JUNE 1 1981

*** NOTICE ***

ALL INFORMATION PRESENTED BY THE WERCO PROGRAM
IS FOR REVIEW, INTERPRETATION, APPROVAL AND APPLICATION
BY A REGISTERED PROFESSIONAL ENGINEER.

* * W E R C O * *
LOCAL STRESSES IN SHELLS DUE TO EXTERNAL LOADINGS
BASED ON WELDING RESEARCH COUNCIL BULLETIN NO. 107 (MARCH 1979)

SIX INCH MAIN STEAM LINE AT THE SHUTDOWN CONDENSER ✓
RUN DATE 29 OCT 81

** MAXIMUM STRESS INTENSITY OPTION SELECTED **

INPUT DATA
GEOMETRY
SHELL

TYPE	CYLINDRICAL
INSIDE RADIUS	17.2500(INCHES)
WALL THICKNESS	1.4875(INCHES)
PAD THICKNESS	0.0000(INCHES)

ATTACHMENT

TYPE	ROUND
OUTSIDE RADIUS	4.6250(INCHES) ✓

APPLIED LOADS GIVEN IN X-Y-Z AXIS SYSTEM
** CYLINDRICAL AXIS DIRECTION IS X
** ATTACHMENT DIRECTION IS +Y

RADIAL LOAD (FY)	-637.0(LBS)
[illegible] LOAD (FX)	-1870.0(LBS)

OVERTURNING MOMENT (MZ) 1543 (FT-LBS)

TORSIONAL MOMENT (MY) 3526.0(FT-LBS)

C=2/4

STRESS CONCENTRATION FACTORS

DUE TO MEMBRANE LOADING (KN) 1.50
DUE TO BENDING LOAD (KB) 1.00

INTERNAL PRESSURE 1415.0(PSIG)

JOINT EFFICIENCY 1.00

* * W E R C O * *
LOCAL STRESSES IN SHELLS DUE TO EXTERNAL LOADINGS
BASED ON WELDING RESEARCH COUNCIL BULLETIN NO. 107 (MARCH 1979)

SIX INCH MAIN STEAM LINE AT THE SHUTDOWN CONDENSER
RUN DATE 29 OCT 81
TENSION = +
COMPRESSION = -

** MAXIMUM STRESS INTENSITY OPTION SELECTED **

OUTPUT DATA (ALL STRESSES ARE GIVEN IN (PSI))

CIRCUMFERENTIAL STRESSES- TYPE	DUE TO	AU	AL	BU	BL
MEMBRANE	(FY)	-71.	-71.	-71.	-71.
BENDING	(FY)	-121.	121.	-121.	121.
MEMBRANE	(MX)	0.	0.	0.	0.
BENDING	(MX)	0.	0.	0.	0.
MEMBRANE	(MZ)	-352.	-352.	352.	352.
BENDING	(MZ)	-514.	514.	514.	-514.
MEMBRANE STRESSES		-423.	-423.	281.	281.
BENDING STRESSES		-634.	-234.	393.	-393.
TOTAL CIRCUMFERENTIAL STRESSES		-1057.	211.	674.	-112.

LONGITUDINAL STRESSES- TYPE	DUE TO	AU	AL	BU	BL
MEMBRANE	(FY)	-59.	-59.	-59.	-59.
BENDING	(FY)	-167.	167.	-167.	167.
MEMBRANE	(MX)	0.	0.	0.	0.
BENDING	(MX)	0.	0.	0.	0.
MEMBRANE	(MZ)	-110.	-110.	110.	110.
BENDING	(MZ)	-823.	823.	823.	-823.
MEMBRANE STRESSES		-169.	-169.	51.	51.
BENDING STRESSES		-991.	991.	656.	-656.
TOTAL LONGITUDINAL STRESSES		-1160.	822.	706.	-605.

SHEAR STRESSES	DUE TO	AU	AL	BU	BL
TORSIONAL MOMENT	(MY)	212.	212.	212.	212.
SHEAR LOAD	(FZ)	39.	39.	-39.	-39.

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C-3/4

** W E R C O **

LOCAL STRESSES IN SHELLS DUE TO EXTERNAL LOADINGS
BASED ON WELDING RESEARCH COUNCIL BULLETIN NO. 107 (MARCH 1979)

SIX INCH MAIN STEAM LINE AT THE SHUTDOWN CONDENSER
RUN DATE 29 OCT 81 TENSION = +
COMPRESSION = -

** MAXIMUM STRESS INTENSITY OPTION SELECTED **

OUTPUT DATA (ALL STRESSES ARE GIVEN IN (PSI))

CIRCUMFERENTIAL STRESSES	TYPE	DUE TO	CU	CL	DU	DL
	MEMBRANE	(FY)	-59.	-59.	-59.	-59.
	BENDING	(FY)	-167.	-167.	-167.	-167.
	MEMBRANE	(MX)	-620.	-620.	620.	620.
	BENDING	(MX)	-6441.	6441.	6441.	-6441.
	MEMBRANE	(MZ)	0.	0.	0.	0.
	BENDING	(MZ)	0.	0.	0.	0.
MEMBRANE STRESSES			-679.	-679.	561.	561.
BENDING STRESSES			-6608.	6608.	6275.	-6275.
TOTAL CIRCUMFERENTIAL STRESSES			-7287.	5929.	6835.	-5714.

LONGITUDINAL STRESSES	TYPE	DUE TO	CU	CL	DU	DL
	MEMBRANE	(FY)	-71.	-71.	-71.	-71.
	BENDING	(FY)	-119.	-119.	-119.	-119.
	MEMBRANE	(MY)	-1037.	-1037.	1037.	1037.
	BENDING	(MX)	-3579.	3579.	3579.	-3579.
	MEMBRANE	(MZ)	0.	0.	0.	0.
	BENDING	(MZ)	0.	0.	0.	0.
MEMBRANE STRESSES			-1108.	-1108.	966.	966.
BENDING STRESSES			-3697.	3697.	3460.	-3460.
TOTAL LONGITUDINAL STRESSES			-4806.	2589.	4426.	-2494.

SHEAR STRESSES	DUE TO	CU	CL	DU	DL
TORSIONAL MOMENT	(MY)	212.	212.	212.	212.
SHEAR LOAD	(FZ)	0.	0.	0.	0.
SHEAR LOAD	(FX)	87.	87.	-87.	-87.
TOTAL SHEAR STRESSES		298.	298.	125.	125.
MAX COMBINED STRESS INTENSITY		7322.	5956.	6842.	5719.

INT. PRESS. STRESS (NOT INCLUDED IN COMBINED STRESS INTENSITY)

LONGITUDINAL 7922. CIRCUMFERENTIAL 17258.

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** W E R C O **

LOCAL STRESSES IN SHELLS DUE TO EXTERNAL LOADINGS

SIX INCH MAIN STEAM LINE AT THE ...
RUN DATE - 29 OCT 81

** MAXIMUM STRESS INTENSITY OPTION SELECTED **

C-4/4

PARAMETERS AND FACTORS USED BY THE PROGRAM
IN THE SOLUTION OF THE PROBLEM

SHELL TYPE: CYLINDRICAL

ATTACHMENT TYPE: ROUND

SHELL PARAMETER GAMMA = 12.097

ATTACHMENT PARAMETER BETA = .225

FACTORS FROM CURVES FIGURE

(F 1)L =	1.9947	4C
(F 1)T =	1.6564	3C
(F 2)L =	.0699	2C-1
(F 2)T =	.0965	1C
(F 3) =	.4339	3A
(F 4) =	.0932	1A
(F 5) =	1.3722	3B
(F 6) =	.0414	1B-1
(F 7)L =	1.6564	3C
(F 7)T =	1.9947	4C
(F 8)L =	.0970	1C-1
(F 8)T =	.0688	2C
(F 9) =	.7261	4A
(F10) =	.0518	2A
(F11) =	.4285	4B
(F12) =	.0663	2B-1

++ INDICATES THAT THIS FACTOR HAS BEEN OBTAINED
BY EXTENDING WRC 107 CURVES.

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DO YOU WISH TO MAKE CHANGES AND RERUN THE PROBLEM (Y/N)
? y
ENTER QUESTION NUMBER (RETURN IF NO MORE CHANGES)
? 2

2-ENTER WERCO RUN TITLE:
? feed water line at the shut down condenser
ENTER QUESTION NUMBER (RETURN IF NO MORE CHANGES)
? 22

22-ENTER FORCE LOAD FX (LBS)
? 862
ENTER QUESTION NUMBER (RETURN IF NO MORE CHANGES)