DRESDEN NUCLEAR GENERATING PLANT UNITS 2 & 3
MODIFICATIONS TO THE SUPPRESSION CHAMBER SUPPORT COLUMNS AND PIN CONNECTION

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DRESDEN NUCLEAR GENERATING PLANT UNITS 2 & 3 MODIFICATIONS TO THE SUPPRESSION CHAMBER SUPPORT COLUMNS AND PIN CONNECTION

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1.3	0			6.8	0		
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3.5	0			6.14	0		
3.6	0			6.15	0		
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PREFACE

Pool swell loads have recently been identified as possible loadings on GE Mark I Containments. The magnitudes and time characteristics of these loads are the subjects of many ongoing studies by GE and others. These loads, as presently identified, have been used in the structural evaluations of the critical components of the containments in the Short Term Program.

Evaluation of the results of the various structural analyses which have been conducted to date has resulted in the decision by Commonwealth Edison Co. to reinforce the inside columns and the pin connections at the base of the inside columns at Dresden Units 2 & 3.

This document describes these modifications and presents new values of Code allowable capacity that will exist as a result of the modification.

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1.0 INTRODUCTION

The first major generation of General Electric Boiling Water Reactors are housed in a containment structure designated as the GE Mark I containment. A total of 25 of these units are built or are being built in the United States. Included in this number are the Dresden Nuclear Generating Plant containment vessels. The original design of the containments for these plants considered all the loads normally associated with containment vessel design. These include for example: pressure and temperature loads associated with a loss-of-coolant accident, wind loads, seismic loads, dead loads, jet impingement loads, hydrostatic loads due to the water in the suppression chamber, overload pressure test loads and construction loads.

As described in Section 2.0 of this report, the original designs were analyzed for compliance with the appropriate design specification (Reference 1) and ASME Code (Reference 2) requirements. The results of those analyses are documented in the containment vessel ASME Section III Stress Reports (Reference 3). Since the time of the original design criteria, possible additional loading conditions have been revealed. These additional loading conditions result from suppression chamber pool swell which may be produced from clearing air from the vent system following a postulated loss of coolant accident.

The owners of Mark I containments have formed a Mark I Owners Group to address these new loadings. They have initiated a Short Range Program which is designed to make an assessment of the effects of these loads on the containments and to determine if the containment will remain intact if subjected to these new loads. The Owners Group is also making plans for a Long Range Program which entails a more detailed evaluation of the magnitudes of the loads themselves as well as their effects on the structures. Included in the Long Range Program will be various tests on scale models or prototype structures.

The purpose of the work reported herein is to describe structural modifications to the suppression chamber supports of the Dresden Nuclear Generating Plant deemed necessary as a results of the effort completed on the Short Range Program.

This report consists of a discussion of the general criteria being used for the modifications, a description of the components being evaluated, a description of the modifications, an identification of the various loads, a description of the analyses which was performed to arrive at new capacities and a summary of the results from these analyses.

The calculations have been done on the basis of linear elastic systems. The elastic analysis provides sufficient data for evaluating the actual behavior and, when combined with the generic analyses reported from the Short Range Program, provides another level of assurance that the integrity of the containment vessel for the Dresden plants will be maintained during a postulated loss of coolant accident.

2.0 CRITERIA

The containment vessels were designed, constructed, and stamped as Class B vessels in accordance with Section III of the ASME Boiler and Pressure Vessel Code (Reference 2). The suppression chamber supports were designed in accordance with the American Institute of Steel Construction Specification for the Design, Fabrication and Erection of Structural Steel for Buildings (Reference 4). Therefore, applicable code allowable stress and stress intensity limits were satisfied for all loads specified for the original design. Pool swell loads, however, were not included in the originally specified loads.

The criteria used in this report for evaluation of the modified column and pin connection is the 1974 Edition of the ASME Code, Section III, Subsection NF, "Component Supports".

3.0 GENERAL DESCRIPTION OF CONTAINMENT VESSEL

The containment vessel considered herein is a General Electric Company Mark I design with a drywell and toroidal suppression chamber as illustrated schematically in Figures 3.0-1 and 3.0-2. The basic dimensions and configurations are as established by the original Design Specifications (Reference 1) and are documented in the appropriate ASME Stress Reports (Reference 3). This section provides a general description of the suppression chamber shell and its support structure. Other structural components connected to the suppression chamber, such as the vent system, vent header support columns, penetrations, access hatches, internal piping supports, ladders, platforms, monorails, spray headers, weld pads and horizontal seismic supports are not included in the scope of this report.

The suppression chamber is in the general form of a torus but is actually constructed of 16 mitered cylindrical shell segments as shown in Figures 3.0-1 and 3.0-2. A reinforcing ring with two supporting columns is provided at each mitered joint. The reinforcing ring is located slightly off the mitered joint in a plane parallel to the mitered joint. As such, the intersection of the ring's web with the shell plate is an ellipse. For ease of fabrication, the inner flanges of the ring is rolled to a constant inside radius. Thus the web depth varies around the ring. The plate thickness of the suppression chamber shell, the ring web and flanges, and the details of the support columns are provided in Section 3.1.

The suppression chamber is connected to the drywell by eight vent lines. At the drywell end of the vent line, a transition is provided which increases the diameter at the penetration into the drywell. Within the suppression chamber, the vent lines are connected to a common header. Connected to the header are downcomers which terminate below the normal water level of the suppression pool. A bellows assembly at the suppression chamber end of the vent line allows for differential expansion between the drywell and the suppression chamber. In order to accommodate the downcomer thrust loads, column supports are provided which connect the vent header to the reinforcing ring at the suppression chamber mitered joint. The general arrangement of the vent system can be seen in Figure 3.0-1.

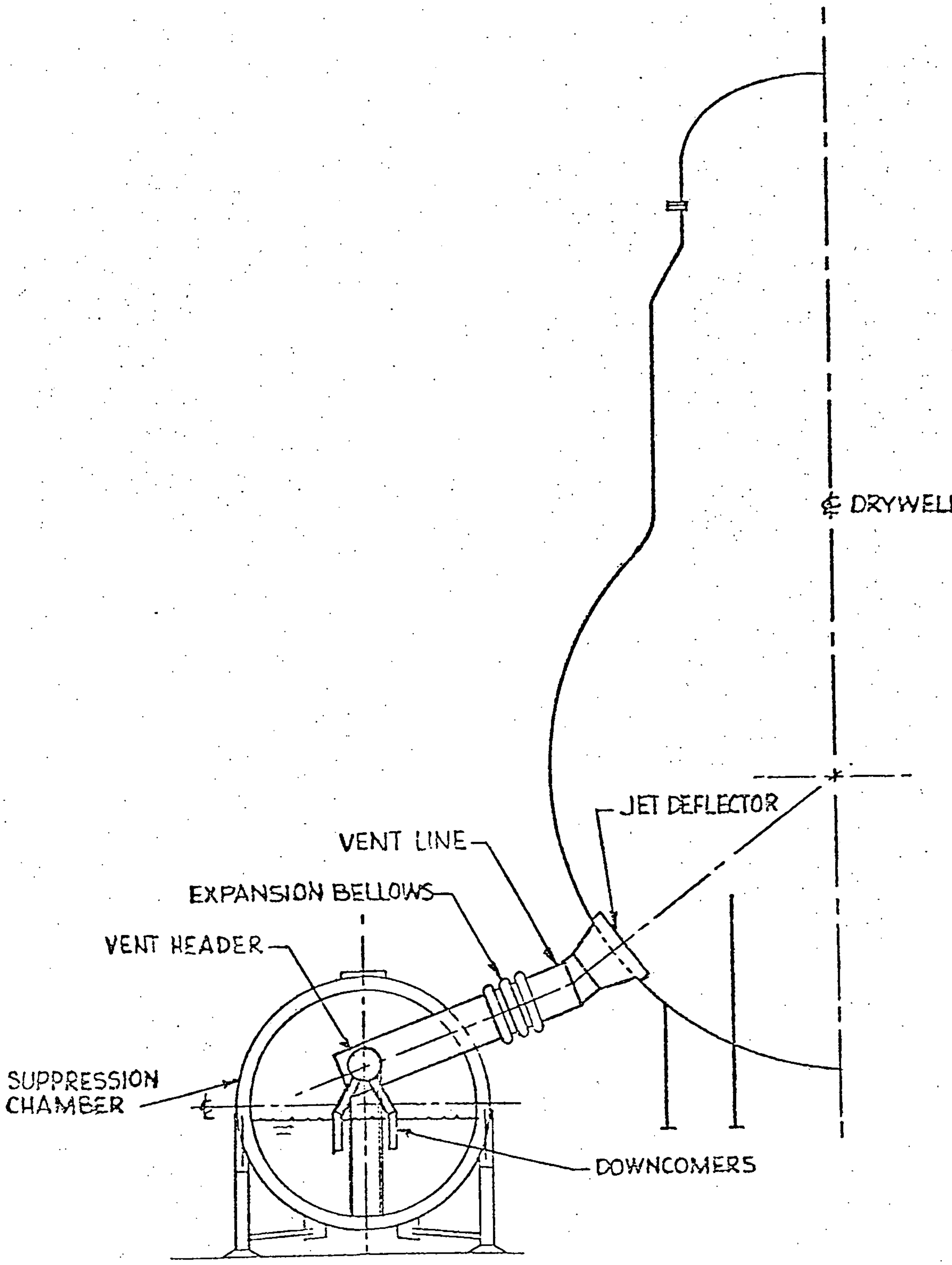

FIGURE 3.0-1 GENERAL ARRANGEMENT OF CONTAINMENT-SCHEMATIC

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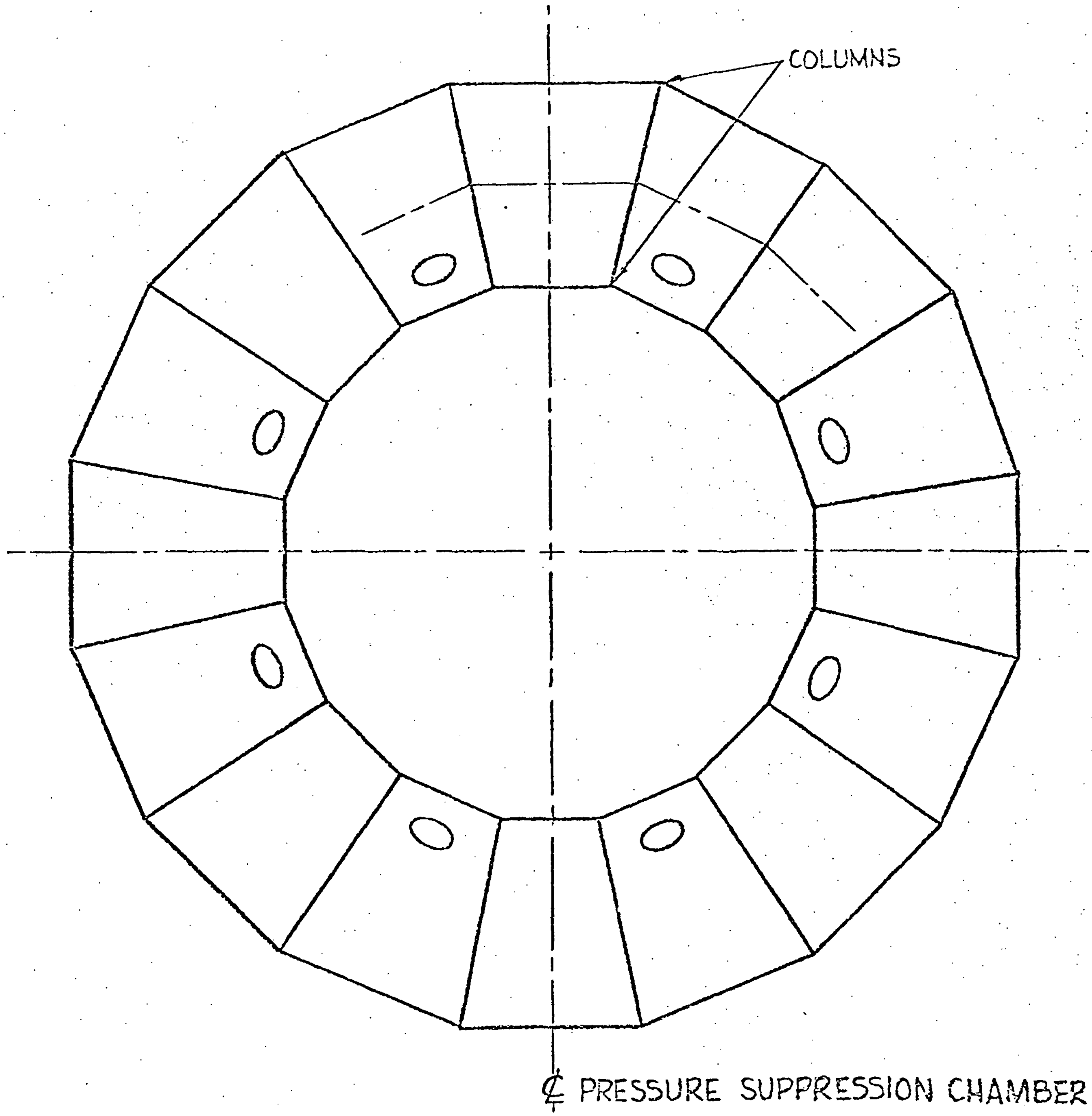

FIGURE 3.0-2 PLAN VIEW
OF SUPPRESSION CHAMBER - SCHEMATIC

3.1 Suppression Chamber

The dimensions and plate thicknesses of the Dresden Nuclear Generating Plant containment vessel are given in the ASME Section III Stress Report (Reference 3). The details which affect the analyses reported herein are discussed below.

As seen in Figure 3.1-1, the inside diameter of the cylindrical segments which make up the suppression chamber is 30'-0". The shell plate in the upper half of the torus is 0.585 inches thick and in the bottom half of the torus the thickness is 0.653 inches. The major diameter, measured at the midsection of the mitered cylinders, is 109'-0".

The reinforcing ring at the suppression chamber mitered joints is shown in Figure 3.1-2. The 15" wide inside flange is of 1-1/4" thick material. The inside flange is rolled to a constant radius of 12'-10 3/4". The intersection of the web with the suppression chamber is elliptical in form. As such, the depth of the 1" thick web varies from 24 to 27.5 inches.

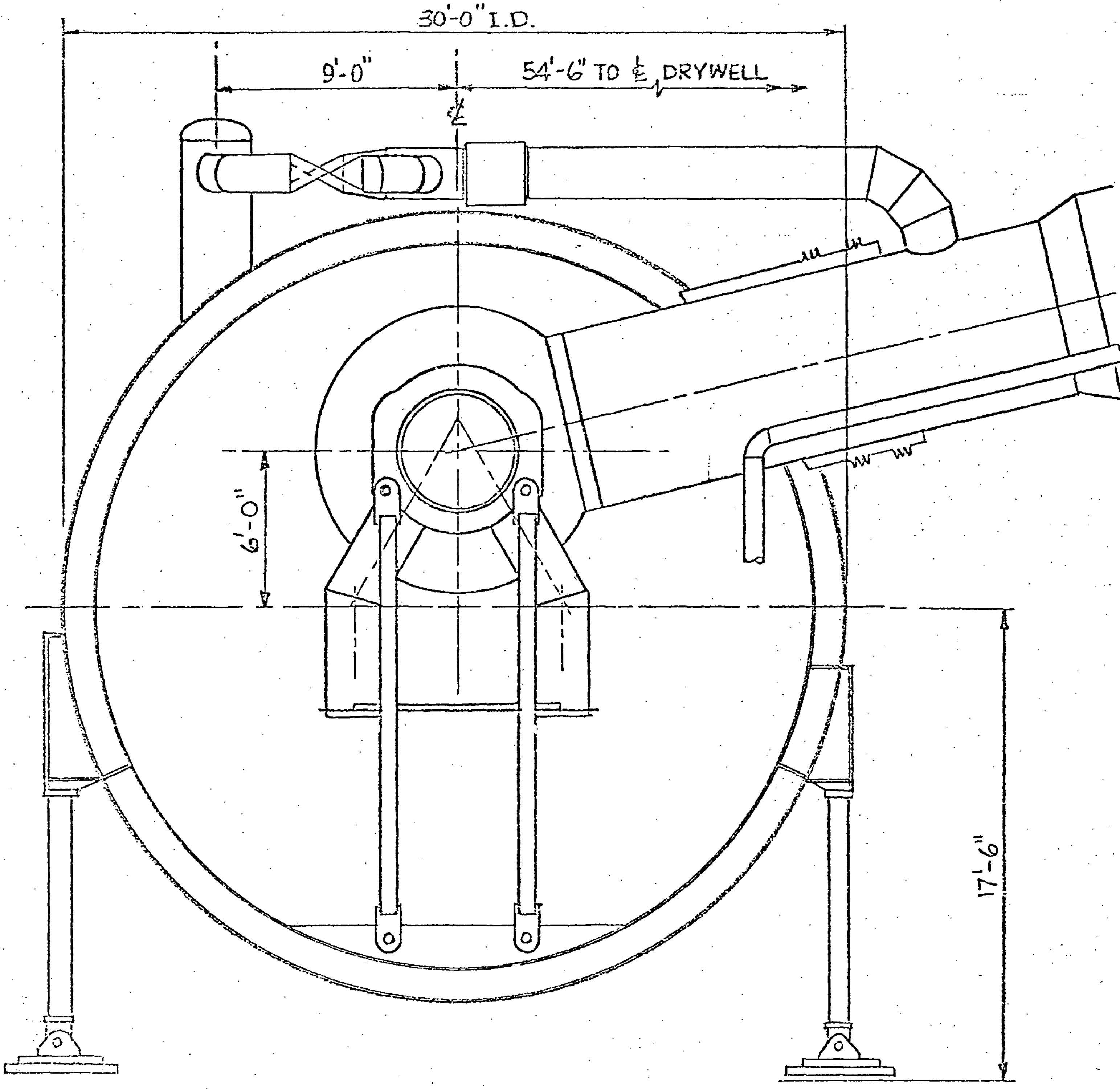

FIGURE 3.1-1 DRESDEN UNITS 2 & 3 COMPOSITE SECTION THROUGH SUPPRESSION CHAMBER

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REFERENCE:

CB&I DWG 202 REV 4 – UNIT 2
CB&I DWG 202 REV 0 – UNIT 3

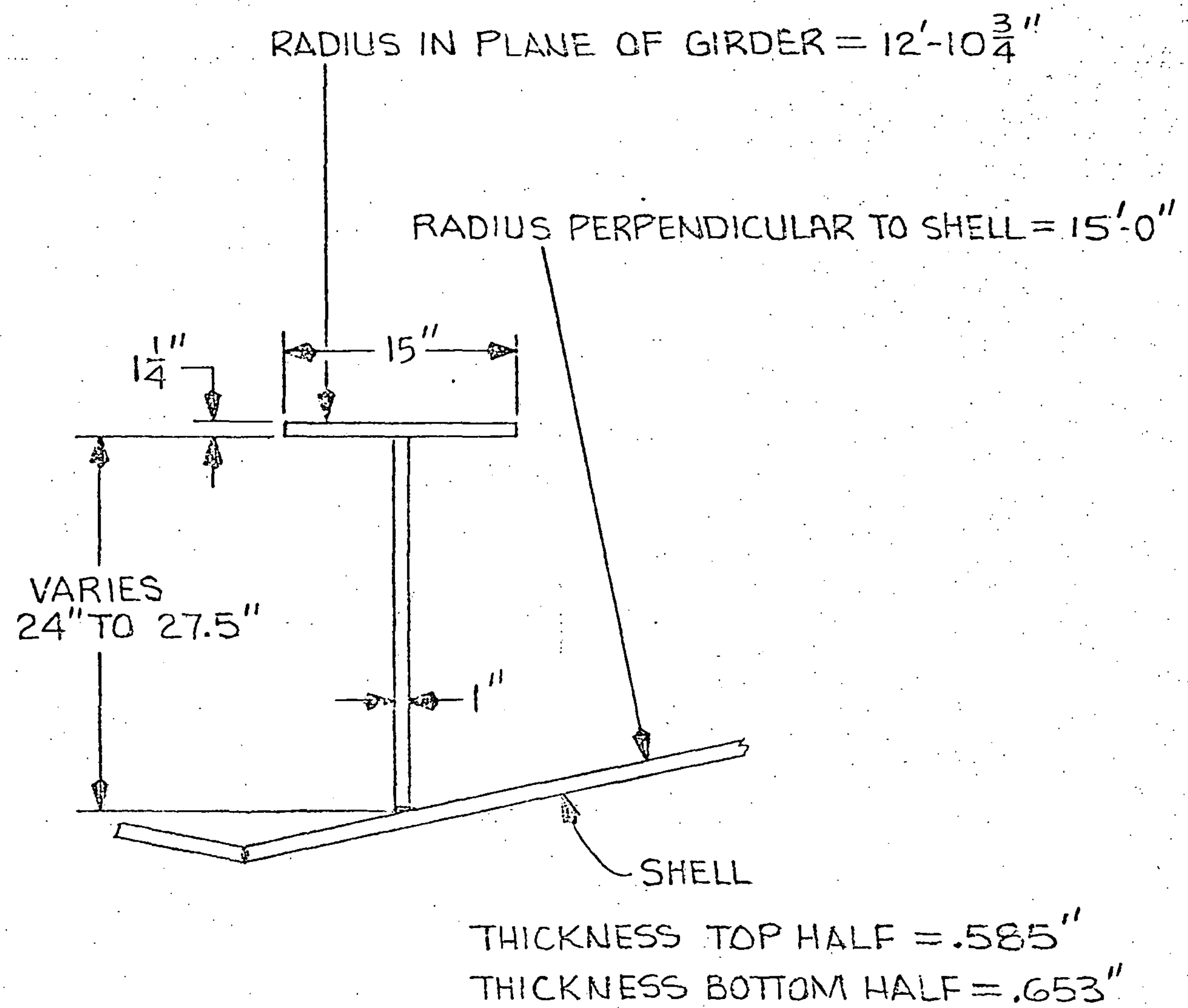


FIGURE 3.1-2 DRESDEN UNITS 2 & 3 MITER JOINT REINFORCING RING

3.2 Support Structure

The suppression chamber support columns and the details of the connection between the suppression chamber and the columns are shown in Figure 3.2-1. The outside columns are 10-3/4" outside diameter pipe with a wall thickness of 2-1/4". The original inside columns are 8-5/8" outside diameter pipe with a wall thickness of 1-1/4". The detail of the column connection at the suppression chamber corresponds to a fixed connection whereas the connection to the foundation is a pinned connection.

REFERENCE

CB&I DWG. 204 REV. 0 FOR UNIT 3 }
CB&I DWG. 205 REV. 1 FOR UNIT 3 } UNIT 2
CB&I DWG. 207 REV. 1 }

CB&I DWG. 204 REV. 0 }
CB&I DWG. 205 REV. 1 } UNIT 3
CB&I DWG. 207 REV. 0 }

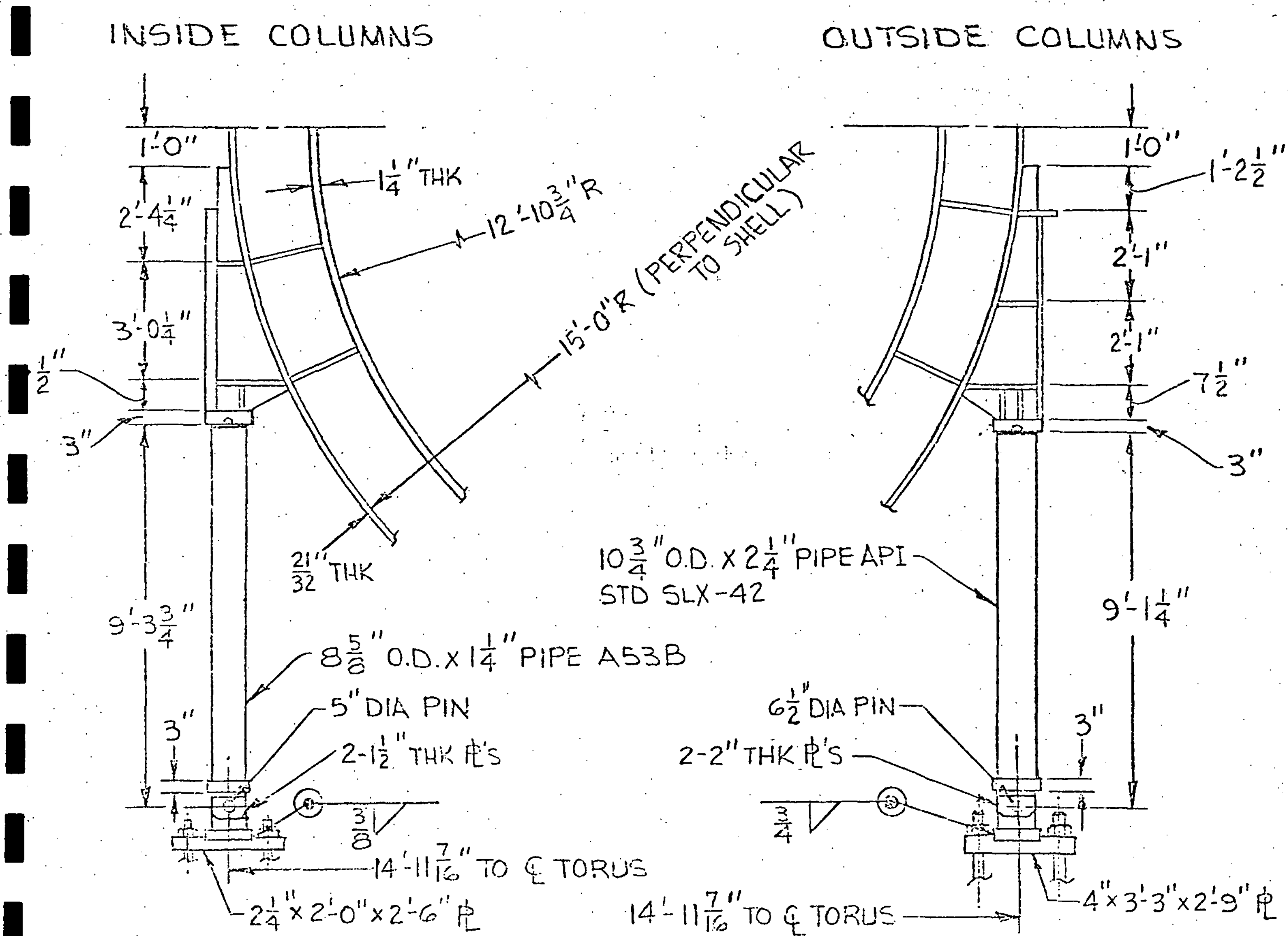


FIGURE 3.2-1

DRESDEN UNITS 2 AND 3 SUPPRESSION CHAMBER SUPPORT SYSTEM **nutech**

4.0 MODIFICATION DESCRIPTION

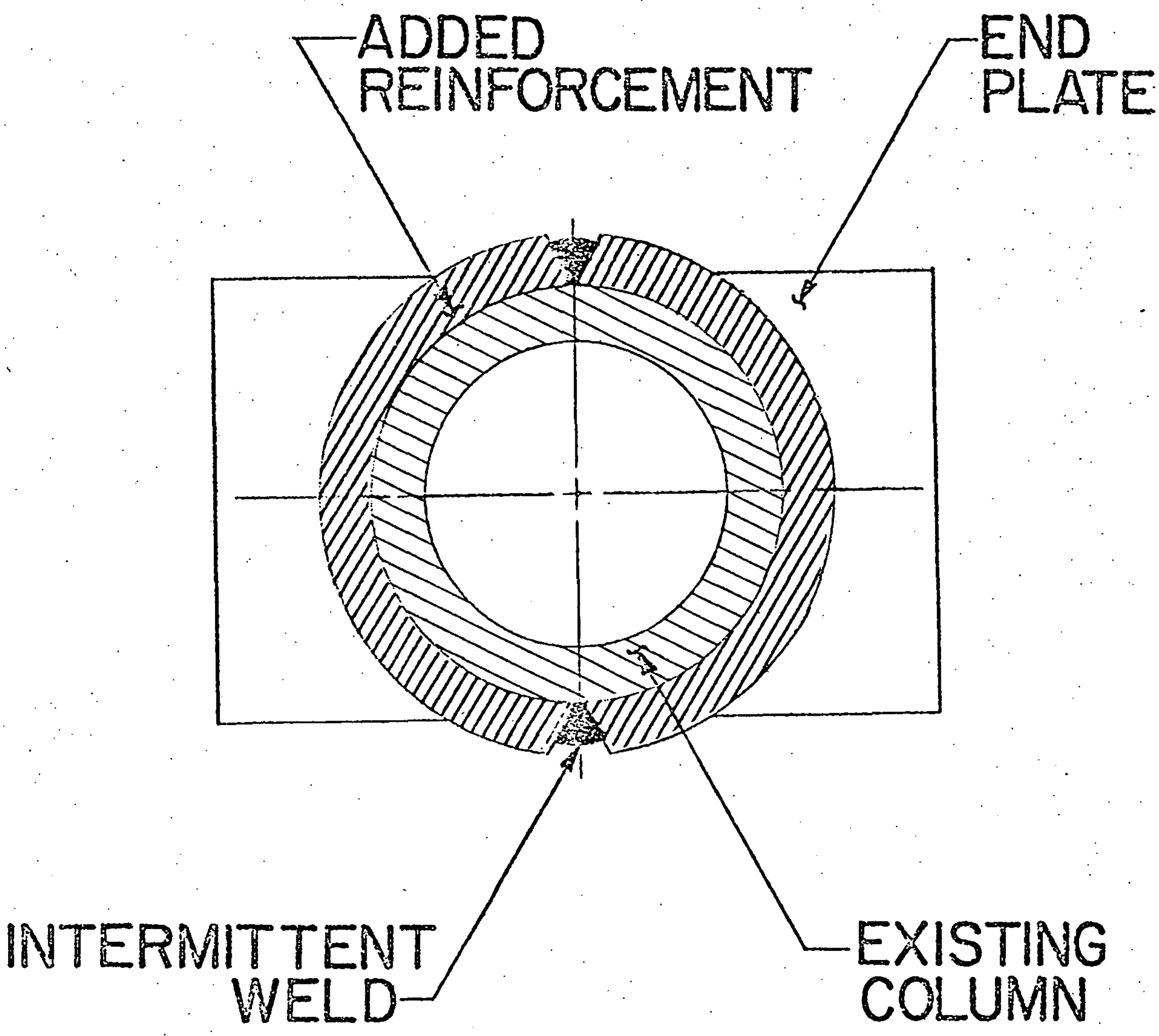
The modifications to the Dresden torus support structure which are currently being implemented consist of adding reinforcement to the inside columns and the pin connection at the base of the inside columns. These modifications are discussed in Sections 4.1 and 4.2 below.

4.1 Column Reinforcement

The existing inside columns consist of 8" pipe (8 5/8" outside diameter). The reinforcement is 10" pipe (10 3/4" OD, 8 3/4" ID) which is split longitudinally and then fit around the existing columns. The column reinforcement is shown schematically in Figure 4.1-1. Also refer to drawing No. 102 in Appendix A for more detailed information.

Full penetration welds are used at the top and bottom of the reinforcement pipe to transfer the load into the reinforcement. Intermittent welds are used along the edges of the 10" pipe to preclude reinforcement buckling.

The addition of the reinforcement results in the inside column cross sectional area being increased from 28.96 square inches to 56.19 square inches. The pipe material for the reinforcement is ASME SA-106 Grade B pipe, which has the same minimum spec. yield and ultimate as the existing column material, A-53 GR B.



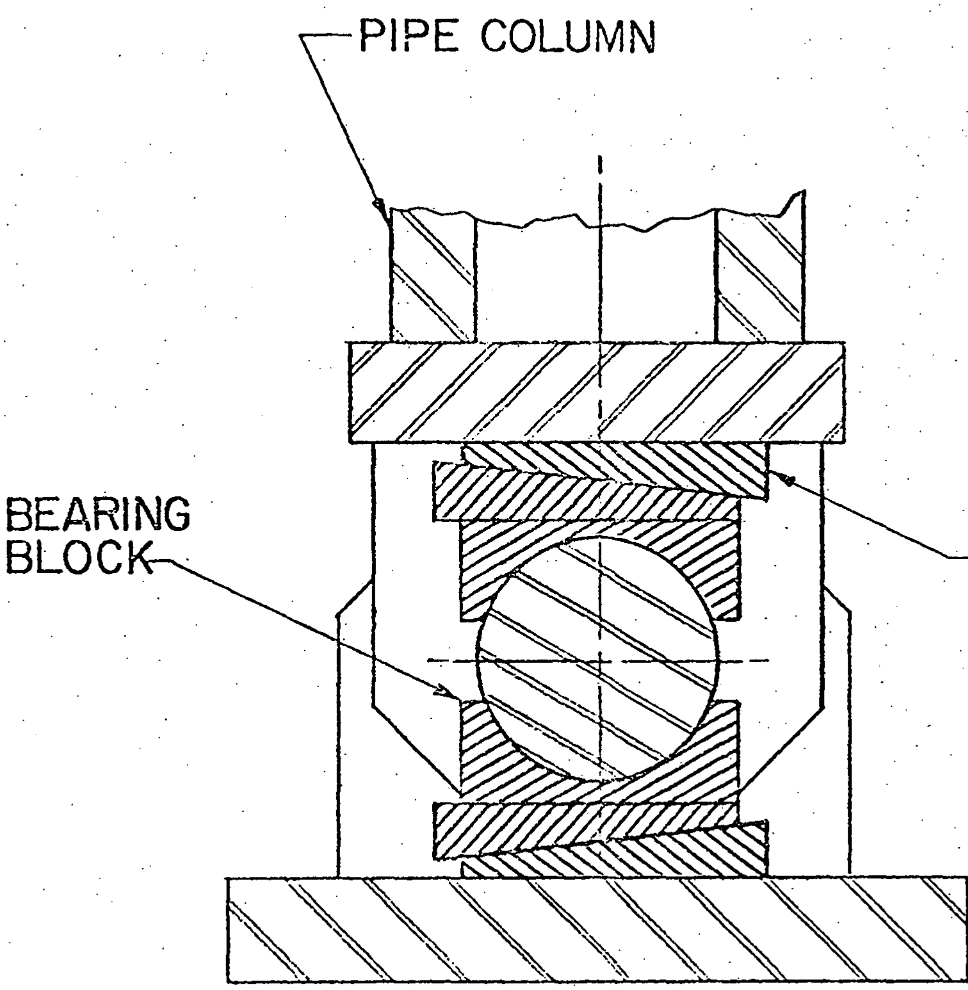
COLUMN REINFORCEMENT

Figure 4.1-1

4.2 Pin Reinforcement

The existing pin connection consists of a 5"ϕ pin and double 1 1/2" clevis plates. The reinforcement is a cradle both above and below the pin located between the inner clevis plates. Wedges allow installation of the cradle without pin removal and insure bearing contact between the pin and cradle. The pin reinforcement is shown schematically in Figure 4.2-1. Also refer to drawing no. 101 in Appendix A for more detailed information. The addition of the reinforcement results in the pin/clevis bearing area being increased from 15.0 square inches to 51.77 square inches.

The cradle and wedge material is ASME SA-515 Grade 70 plate.



COLUMN PIN CONNECTION REINFORCEMENT

Figure 4.2-1

5.0 LOADS AND LOAD COMBINATIONS

The loads which are employed from the analyses of the suppression chamber support are described in Section 5.1. As noted previously, many of the loads associated with the postulated loss of coolant accident are not, at present, firmly established. As discussed in the following sections, the loads utilized in the analyses have been obtained from GE and Bechtel documents which have been provided to the utilities at various meetings. The magnitudes, durations, etc. employed for the loads represent the latest information that is available at this time.

The plant unique analysis which is presently being conducted for Dresden Units 2 and 3 will provide better definition of the structural response to the pool swell loads. The plant unique analysis is scheduled for completion in August 1976.

5.1 Loads

The loads that are of interest in this report are those which can act on the torus support columns and pin connections at the time of pool swell. These loads are as follows:

a) Torus dead weight

b) Torus water weight

c) Vertical and horizontal seismic loads

d) Dynamic pool swell loads

The source of the numerical values for the above loads for the Dresden inside columns is the tables provided by Bechtel at the February 19 and 20, 1976 meeting with the NRC in Bechtel offices in San Francisco, California. (Reference 7). The downward loads are given in the table titled "Estimated Compression Loads Including Plant Factors and Seismic". For the upward load phase the column loads are given in the table titled "Estimated Column Tension Loads from 2-D Model-Table 2A". In arriving at these loads Bechtel used magnitudes, time characteristics, etc. associated with the initial bubble pressure and torus air space compression pressure portions of the dynamic pool swell loads as given in References 5 and 6. For the downward loads the values given in the above referenced table are multiplied by a correlation factor of 0.85. This factor is used in the ratio tables of Reference 7 and in this report to provide correlation between the Bechtel 2-D model of the "reference plant" and the NUTECH 3-D model of the same plant. The plant unique analysis which is currently being conducted will not utilize the 0.85 factor since a structural model of the specific Dresden torus will be used. Since the results of the plant unique analysis are not available at this time, the column loads from Reference 7 are considered appropriate.

Table 5.1-1 is a summary of the loads given in Reference 7. These loads have been computed assuming no pressure differential between the drywell and suppression chamber. (i.e. $\Delta P = 0$). Table 5.1-2 provides values for the column loads for the ΔP of 1.0 psi currently being maintained at Dresden Units 2 and 3.

TABLE 5.1-1

LOAD SUMMARY (ΔP = 0 psi)

	COLUMN	DEAD LOAD WATER & STEEL (KIPS)	SEISMIC LOAD - VERT. & HORIZ. SEISMIC (KIPS)	DYNAMIC POOL SWELL LOAD (ΔP= 0 psi) (KIPS)	TOTAL LOAD $.85 \times \sum (2)$, (3) & (4)
DOWNWARD LOAD PHASE	DRESDEN INSIDE COLUMN	-242	-55	-760	-898
	DRESDEN OUTSIDE COLUMN	-296	-67	-928	-1098
UPWARD LOAD PHASE	DRESDEN INSIDE COLUMN	-242	+55	+347	+160
	DRESDEN OUTSIDE COLUMN	-296	+67	+425	+196
	(1)	(2)	(3)	(4)	(5)

NOTES:

1) Values in columns (2), (3), and (4) above have been obtained from Reference 7.

2) The .85 factor (column (5)) is the correlation factor of reference plant 2-D results and 3-D results and is used for the downward load phase only.

3) (-) used for column compression load
(+) used for column tension load

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TABLE 5.1-2

LOAD SUMMARY (ΔP = 1.0 psi)

	COLUMN	DEAD LOAD WATER & STEEL (KIPS)	SEISMIC LOAD - VERT. & HORIZ. SEISMIC (KIPS)	DYNAMIC POOL SWELL LOAD (ΔP= 1 psi) (KIPS)	TOTAL LOAD .85×∑(2), (3) & (4)
DOWNWARD LOAD PHASE	DRESDEN INSIDE COLUMN	-242	-55	-540	-711
	DRESDEN OUTSIDE COLUMN	-296	-67	-659	-869
UPWARD LOAD PHASE	DRESDEN INSIDE COLUMN	-242	+55	+309	+122
	DRESDEN OUTSIDE COLUMN	-296	+67	+378	+149
	(1)	(2)	(3)	(4)	(5)

NOTES:

1) Values in columns (2) and (3) above have been obtained from Reference 7.

2) Values in column (4) above were derived by multiplying values from Reference 7 by the ΔP factor of 0.71 for downward loads and 0.89 for upward loads. The P factors are obtained from Reference 8.

3) The .85 factor (Column (5)) is the correlation factor of reference plant 2-D results and 3-D results and is used for the downward load phase only.

4) (-) used for column compression load
(+) used for column tension load

6.0 ANALYSIS

Analyses have been performed to determine the effect of the added reinforcement on the Code allowable capacities of the inside column and pin connection.

Sections 6.1 and 6.2 discuss the methods and results of the calculations. The results are summarized in Section 7 of this report in Table 7.0-1.

6.1 Code Allowable Column Load

The code allowable column loads are computed using the rules of Subsection NF of Section III of the ASME Code, 1974 edition. Paragraph NF-3300 "Design of Class 2 and Class MC Component Supports" refers to paragraph NF-3230 for linear type supports, such as the columns for the Dresden torus support. Paragraph NF-3230 makes a distinction between stresses resulting from the application of mechanical loads and the effects resulting from constraint of free end displacements (i.e. Subsection NF recognizes the difference between primary and secondary stresses as is done in the other subsections of Section III for pressure vessels).

It is clear from an inspection of the torus support structure that there are secondary stresses imposed in the columns as a result of constraint of free end displacements. The conclusion that the stresses resulting from the constraint of free end displacements are indeed secondary stresses is substantiated by the fact that the imposed displacements and rotations at the top of the columns are self-limiting in nature and that the stability of the structure (torus and torus support structure) is not dependent upon the bending stiffness of the columns. The sketches below serve to illustrate the above statements.

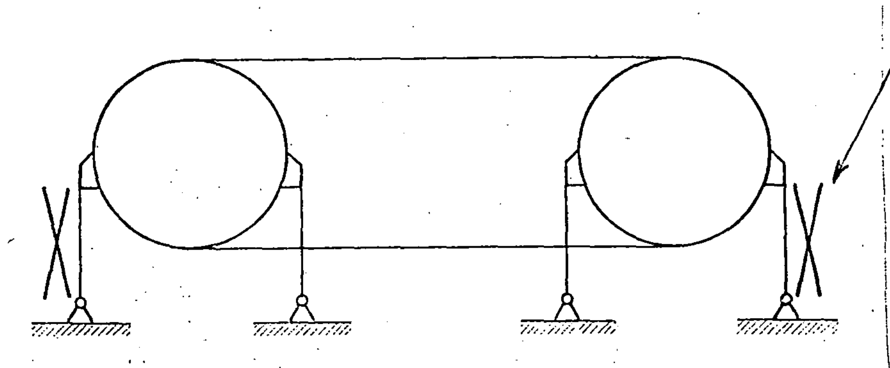

Figure 6.1-1 - Elevation section of torus and torus support columns. Moment transferring connection at top of columns and pin connection at base.

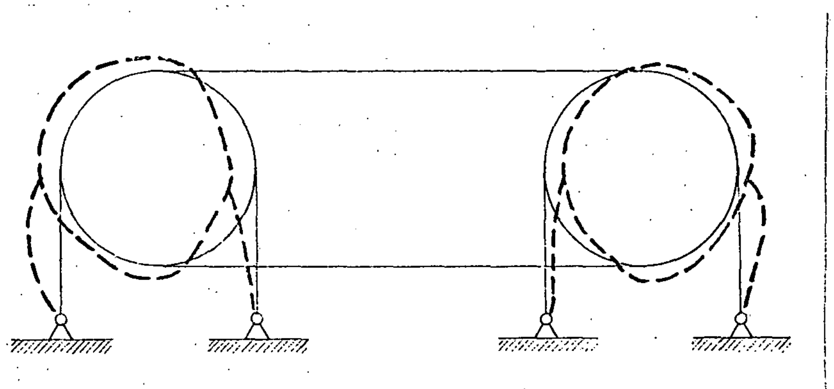

Figure 6.1-2 - Exaggerated Elastic Deformation of Torus Cross Section

The elastic deformation shown above in Figure 6.1-2 results in a displacement of the top of the columns relative to the base of the column and a rotation at the top of the column. These displacements and rotations at the top of the column are caused by the following conditions.

a) Initial preset of the base of the column at time of construction of the structure

b) Overall thermal growth of the torus shell due to changes in temperature of the shell

c) Elastic deformation of the ring and shell due to the imposition of mechanical loads on the structure.

Items a), b), and c) above are all self-limiting imposed displacements and rotations at the top of the columns. It is clear that the resulting bending stresses at the top of the column are secondary stress when consideration is given to the fact that the structure would be stable even if the columns were pinned at the top as well as the base. Stability of the structure for lateral loads is provided by the x-bracing in each bay between outside columns. No credit is taken for the bending resistance of the columns in resisting lateral loads.

The self-limiting displacements and rotations at the top of the column do, however, introduce primary bending moments along the length of the column. This is a result of the fact that curvature is introduced in the column. Refer to Fig. 6.1-3 below.

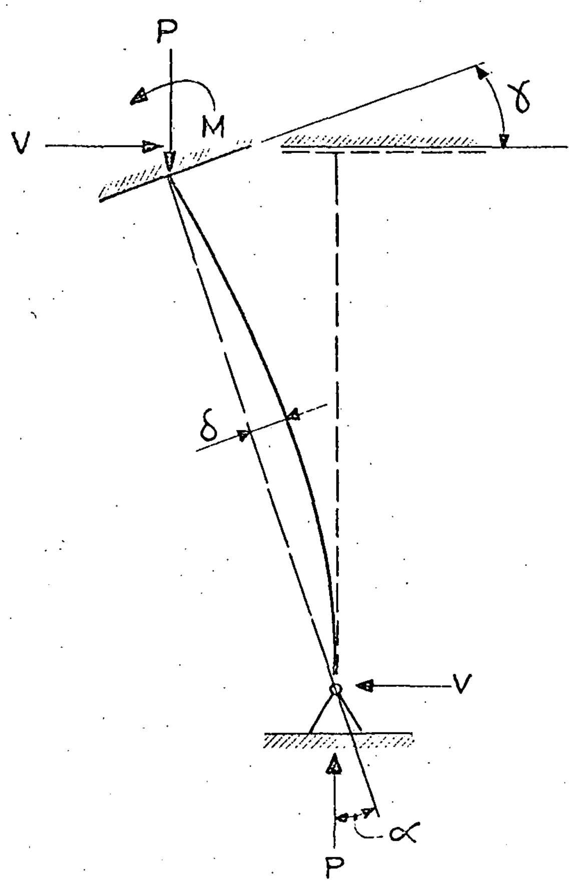

Figure 6.1-3

Exaggerated Column Deformation

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From Figure 6.1-3 above, the following categorization of stresses can be made:

STRESSES RESULTING FROM	CATEGORY
$\frac{P}{\cos \alpha}$ (Axial Load)	Primary
$\frac{P}{\cos \alpha} \times \delta$ (Bending along the column)	Primary
M (Bending Moment at Top of Column)	Secondary

Table 6.1-1

The code allowable column load is therefore a function of P, α, δ, and M. Since the magnitude of these parameters vary for the different design conditions (i.e. temperature of the torus, imposed mechanical loads, etc.) there is no unique value for the code allowable column load. In the calculations that follow, the code combined bending-compression interaction equations are evaluated for the currently defined "most probable loads" acting on the suppression chamber columns at the time of pool swell.

The value of P at the time of maximum pool swell downward load is provided in Tables 5.1-1 and 5.1-2. To arrive at a value for δ, consideration has been given to items a), b), and c) above and a column curvature of .30 inches has been calculated from a very conservative combination of all these effects combined in such a way as to result in maximum column curvature. After detailed plant specific analysis have been completed, a more accurate, less conservative value for δ, for each column, for all design conditions, will be available. For the magnitudes of displacements at the top of the columns for the subject structure, cos α can be assumed to be unity.

Table 6.1-2 gives the properties of the torus support columns. Table 6.1-3 and 6.1-4 are tabular calculations for evaluation of the code interaction equations for primary stresses using loads given in Table 5.1-1 ($\Delta P=0$). Tables 6.1-5 and 6.1-6 are tabular calculations for evaluation of the code interaction equations for secondary stresses using loads given in Table 5.1-1. Tables 6.1-7 through 6.1-10 are identical to Tables 6.1-3 through 6.1-6 except the loads from Table 5.1-2 ($\Delta P=1.0$) are use.

Preliminary plant unique ring analysis indicate that the bending moments at the top of the columns are considerably less than the 1000 in-kips used in Tables 6.1-5, 6.1-6, 6.1-9, and 6.1-10. Therefore it can be concluded that the column code allowable capacities will be controlled by primary stresses, not secondary stresses.

TABLE 6.1-2
COLUMN PROPERTIES

COLUMN	MAT'L AND F_Y (KSI)	AREA (IN^2)	S_{xx} (IN^3)	r (IN)		ℓ (IN)	$K\ell/r$		C_{mx}	F_a (KSI)	F'_{ex} (KSI)	F_{bx} (KSI)
				X-X AXIS	Y-Y AXIS		X-X AXIS	Y-Y AXIS				
DRESDEN INSIDE COLUMN	A53B SA-106B F_Y=35	56.19	105.44	3.18	2.95	111.70	35.14	37.88	0.60	18.80	116	23.10
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]

WHERE:

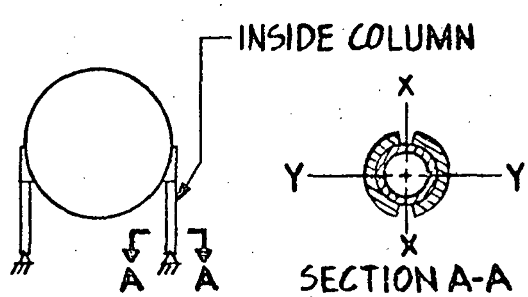
$$F_a = \frac{\left[1 - \frac{(K\ell/r)^2}{2C_c^2}\right] F_Y}{\frac{5}{3} + \frac{3(K\ell/r)}{8C_c} - \frac{(K\ell/r)^3}{8C_c^3}}$$

$$C_c = \left[\frac{2\pi^2 E}{F_Y}\right]^{1/2}$$

$$E = 27.9 \times 10^3 \text{ KSI}$$

$$F'_e = \frac{12\pi^2 E}{23(K\ell_b/r_b)^2}$$

$$F_{bx} = 0.66 F_Y$$



SECTION A-A

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TABLE 6.1-3 ($\Delta P = 0$)

EVALUATION OF EQUATION (19) OF APPENDIX XVII OF ASME SECTION III FOR PRIMARY STRESSES

$$\frac{f_a}{F_a} - \frac{C_{mx} f_{bx}}{\left(1 - \frac{f_a}{F'_{ex}}\right) F_{bx}} \leq 1.0$$

COLUMN	f_a (KSI)	f_{bx} (KSI)	f_a / F_a	$\frac{C_{mx} f_{bx}}{\left(1 - \frac{f_a}{F'_{ex}}\right) F_{bx}}$	$\frac{f_a}{F_a} + \frac{C_{mx} f_{bx}}{\left(1 - \frac{f_a}{F'_{ex}}\right) F_{bx}}$
	(5) / [3]	δ × (5) / [4]	② / [11]	[10] ③ / ((1 − ② / [12]) [13])	④ + ⑤
DRESDEN INSIDE COLUMN	15.98	2.56 (SEE NOTE 2)	0.85	0.08	0.93 < 1.0
①	②	③	④	⑤	⑥

NOTES:

1. ( ) - VALUES FROM CORRESPONDING COLUMN IN TABLE 5.1-1.
   [ ] - VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-2.
   ○ - VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-3.
2. $\delta = 0.30''$

TABLE 6.1-4 ($\Delta P = 0$)

EVALUATION OF EQUATION (20) OF APPENDIX XVII OF ASME SECTION III FOR PRIMARY STRESSES

COLUMN	$\frac{f_a}{0.6 S_Y} + \frac{f_b}{F_{bx}} \Big/ \frac{②}{0.6[2]} + \frac{③}{[13]}$
DRESDEN INSIDE COLUMN	0.87 < 1.0
1	2

NOTES:

○ – VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-3

[ ] – VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-2

TABLE 6.1-5 ($\Delta P = 0$)

EVALUATION OF EQUATION (19) OF APPENDIX XVII OF ASME SECTION III FOR SECONDARY STRESSES

$$\frac{f_a^p + f_a^s}{3F_a} + \frac{C_{mx}(f_{bx}^p + f_{bx}^s)}{\left(1 - \frac{f_a^p}{F'_{ex}}\right) 3F_{bx}} \leq 1.0$$

WHERE:

f_i^p DENOTES PRIMARY STRESSES

f_i^s DENOTES SECONARY STRESSES

COLUMN	f_{bx}^s M_{bx}^s/[4]	$\frac{②}{3\,[11]} + \frac{[10]\,(③ + \triangle 2)}{\left(1 - \frac{②}{[12]}\right) 3\,[13]}$
DRESDEN INSIDE COLUMN	9.48	0.28 + 0.12 = 0.40 < 1.0
△1	△2	△3

NOTE: FROM PRELIMINARY 2-D RING ANALYSES OF THE DRESDEN TORUS SUPPORT SYSTEM WITHOUT ΔP THE MOMENT AT THE TOP OF THE COLUMN M_{bx}^s IS SHOWN TO BE CONSIDERABLY LESS THAN 1000 IN-KIPS. THEREFORE, 1000 IN-KIPS WILL BE USED HERE FOR A CONSERVATIVE CHECK ON SECONDARY STRESSES.

○ – VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-3.
[ ] – VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-2.
△ – VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-5.

TABLE 6.1-6 (ΔP=0)

EVALUATION OF EQUATION (20) OF APPENDIX XVII OF ASME SECTION III FOR SECONDARY STRESSES

$$\frac{f_a^p + f_a^s}{3(0.6 S_Y)} + \frac{f_{bx}^p + f_{bx}^s}{3 F_{bx}} \le 1.0$$

WHERE:

f_i^p DENOTES PRIMARY STRESSES

f_i^s DENOTES SECONDARY STRESSES

COLUMN	(2) / (1.8 [2]) + ((3) + △2) / (3 [13])
DRESDEN INSIDE COLUMN	0.25 + 0.17 = .42 < 1.0
1	2

NOTES:

○ – VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-3.

[ ] – VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-2.

△ – VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-5.

TABLE 6.1-7 ($\Delta P = 1.0$ PSI)

EVALUATION OF EQUATION (19) OF APPENDIX XVII OF ASME SECTION III FOR PRIMARY STRESSES

$$\frac{f_a}{F_a} - \frac{C_{mx} f_{bx}}{\left(1-\frac{f_a}{F'_{ex}}\right) F_{bx}} \leq 1.0$$

COLUMN	f_a (KSI)	f_{bx} (KSI)	f_a/F_a	$\frac{C_{mx} f_{bx}}{\left(1-\frac{f_a}{F'_{ex}}\right) F_{bx}}$	$\frac{f_a}{F_a} + \frac{C_{mx} f_{bx}}{\left(1-\frac{f_a}{F'_{ex}}\right) F_{bx}}$
	(5)/[3]	δ × (5)/[4]	②/[11]	$\frac{[10]\ ③}{\left(1-\frac{②}{[12]}\right)[13]}$	④ + ⑤
DRESDEN INSIDE COLUMN	12.65	2.02 (SEE NOTE 2)	0.67	0.06	0.73 < 1.0
①	②	③	④	⑤	⑥

NOTES:

1. ( ) - VALUES FROM CORRESPONDING COLUMN IN TABLE 5.1-2.
   [ ] - VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-2.
   ○ - VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-7.
2. $\delta = 0.30''$

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TABLE 6.1-8 (ΔP=1.0 PSI)

EVALUATION OF EQUATION (20) OF APPENDIX XVII OF ASME SECTION III FOR PRIMARY STRESSES

COLUMN	$\frac{f_a}{0.6 S_Y} + \frac{f_b}{F_{bx}}$ / $\frac{②}{0.6[2]} + \frac{③}{[13]}$
DRESDEN INSIDE COLUMN	0.69 < 1.0
1	2

NOTES:

○ - VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-7.

[ ] - VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-2.

TABLE 6.1-9 (ΔP = 1.0 PSI)

EVALUATION OF EQUATION (19) OF APPENDIX XVII OF ASME SECTION III FOR SECONDARY STRESSES

$$\frac{f_a^P + f_a^S}{3F_a} + \frac{C_{mx}(f_{bx}^P + f_{bx}^S)}{\left(1 - \frac{f_a^P}{F'_{ex}}\right) 3F_{bx}} \leq 1.0$$

WHERE:

f_i^P DENOTES PRIMARY STRESSES

f_i^S DENOTES SECONARY STRESSES

COLUMN	f_{bx}^S $M_{bx}^S/[4]$	$\frac{②}{3\,[11]} + \frac{[10]\,(③ + △2)}{\left(1 - \frac{②}{[12]}\right) 3\,[13]}$
DRESDEN INSIDE COLUMN	9.48	0.22 + 0.11 = 0.33 < 1.0
△1	△2	△3

NOTE: FROM PRELIMINARY 2-D RING ANALYSES OF THE DRESDEN TORUS SUPPORT SYSTEM WITHOUT ΔP THE MOMENT AT THE TOP OF THE COLUMN M_{bx}^S IS SHOWN TO BE CONSIDERABLY LESS THAN 1000 IN-KIPS. THEREFORE, 1000 IN-KIPS WILL BE USED HERE FOR A CONSERVATIVE CHECK ON SECONDARY STRESSES.

○ – VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-7.

[ ] – VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-2.

△ – VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-9.

TABLE 6.1-10 ($\Delta P = 1.0$ PSI)

EVALUATION OF EQUATION (20) OF APPENDIX XVII OF ASME SECTION III FOR SECONDARY STRESSES

$$\frac{f_a^P + f_a^S}{3(0.6 S_Y)} + \frac{f_{bx}^P + f_{bx}^S}{3 F_{bx}} \leq 1.0$$

WHERE:

f_i^P DENOTES PRIMARY STRESSES

f_i^S DENOTES SECONDARY STRESSES

COLUMN	$\frac{\text{(2)}}{1.8\ [2]} + \frac{\text{(3)} + \triangle 2}{3\ [13]}$
DRESDEN INSIDE COLUMN	0.20 + 0.17 = 0.37 < 1.0
1	2

NOTES:

○ – VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-7.

[ ] – VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-2.

△ – VALUES FROM CORRESPONDING COLUMN IN TABLE 6.1-9.

6.2 Pin Connection Capacities

The code allowable load for the pin connections at the base of the inside columns is computed by checking bearing stresses on the pin clevis and reinforcing saddles, shear in the pin, and for the upward load capacities, tension and shear in the ligaments of the clevis. The results are summarized in Table 6.2-1.

Table 6.2-1

PIN/CLEVIS CODE ALLOWABLE LOADS

	ITEM	CODE ALLOWABLE LOAD (kips)	REMARKS
DOWNWARD LOAD PHASE	Pin	1321	Controlled by bearing
	Clevis	987	Controlled by bearing
UPWARD LOAD PHASE	Pin	N/A	
	Clevis	159	Controlled by shear

7.0 SUMMARY

Table 7.0-1 provides a summary of the net loads, upward and downward, acting on the inside column and pin connection. Also the percent of code allowable load which these loads represent is given. For the columns, the percent of code allowable load is taken as the maximum result for the various interaction education evaluations. The values of load and percent of code allowable are given for $\Delta P=0$ and $\Delta P=1.0$ psi.

Table 7.0-1

LOAD AND CODE CAPACITY SUMMARY

	ITEM	TOTAL LOAD (kips)		PERCENT OF CODE ALLOWABLE LOAD	
		ΔP=0	ΔP=1 psi	ΔP=0	ΔP=1
DOWNWARD LOAD PHASE	DRESDEN INSIDE COLUMN	-898	-711	93%	73%
	DRESDEN INSIDE PIN/LUG	-898	-711	91%	72%
UPWARD LOAD PHASE	DRESDEN INSIDE COLUMN	+160	+122	<50%	<50%
	DRESDEN INSIDE PIN/LUG	+160	+122	100%	77%

8.0 REFERENCES

1. Specification for Containment Vessels, Dresden Units 2 and 3, Sargent & Lundy Engineers, Chicago, Ill.

2. ASME Boiler and Pressure Vessel Code, Section III, Rules for Construction of Nuclear Vessels, 1965 Edition.

3. Primary Containment ASME Section III Stress Report for Dresden Units 2 & 3, Chicago Bridge & Iron Co., Oakbrook, III.

4. Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, American Institute of Steel Construction, 1965 Edition.

5. Letter, R. S. Vij (GE) to Bechtel Power Corporation, dated Jan. 14, 1976, subject: Torus Pressure Loads, Downward Phase LOCA.

6. Letter, R. S. Vij (GE) to Bechtel Power Corporation, dated Jan. 15, 1976, subject: Torus Pressure Loads, Upwards Phase.

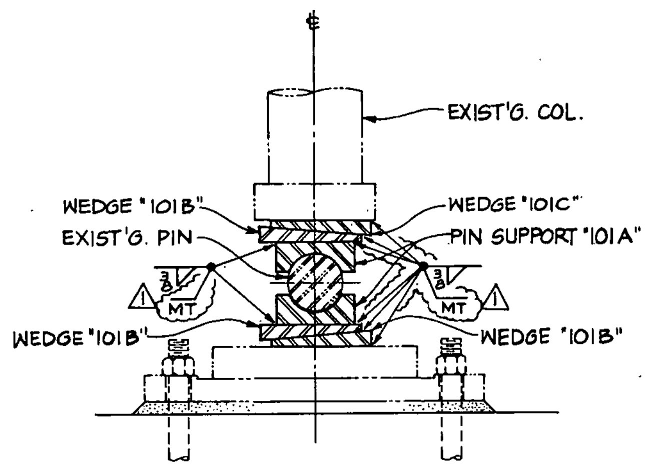
7. Bechtel tables provided to NRC at February 19 and 20, 1976, meeting in San Francisco, California.

8. Curves titled, "Sensitivity of Maximum Upward Pressure Load to Drywell Overpressure" and 'Sensitivity of Maximum Downward Pressure Load to Drywell Overpressure", provided as handouts at March 3, 1976 meeting of ACRS Subcommittee in Washington D.C.

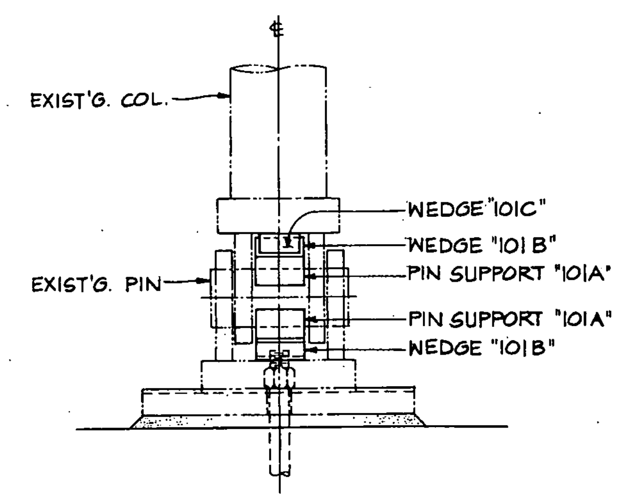
Appendix A

MODIFICATION DRAWINGS

QUANTITY	PIECE MARK	DESCRIPTION	LENGTH		MATERIAL
			FT.	IN.	
64 PCS.	101 A	ℙ 4¾"x 2⅝"	0	7	SEE NOTES
96 PCS.	101 B	ℙ 4¾"x 1⅜"	0	9	SEE NOTES
32 PCS.	101 C	ℙ 4"x 1⅜"	0	9	SEE NOTES

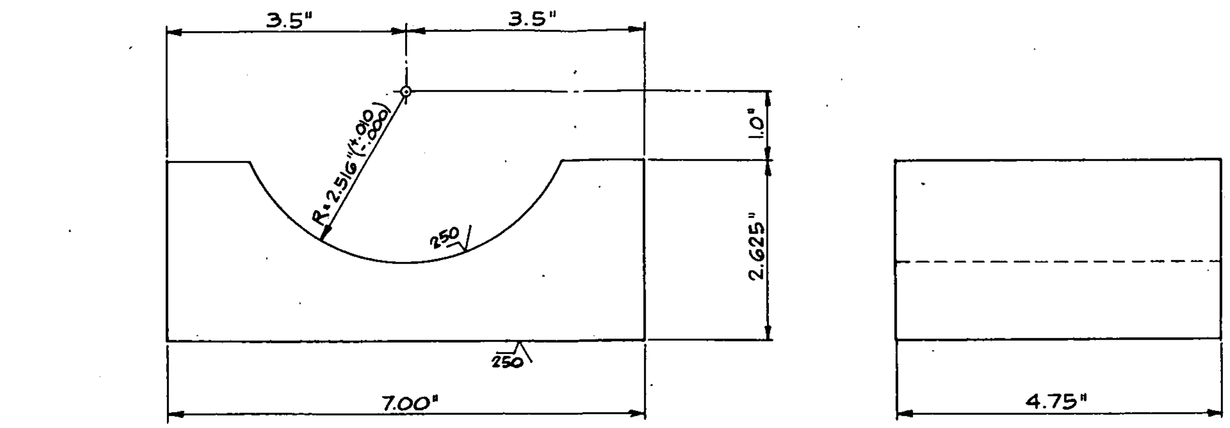


SECTION

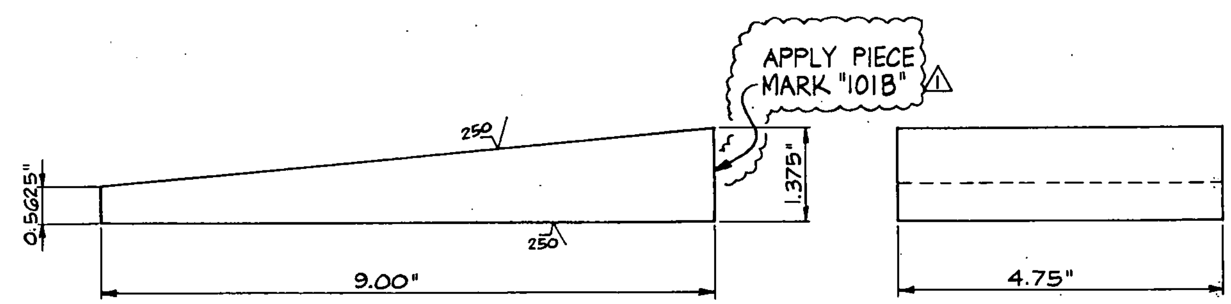


ELEVATION

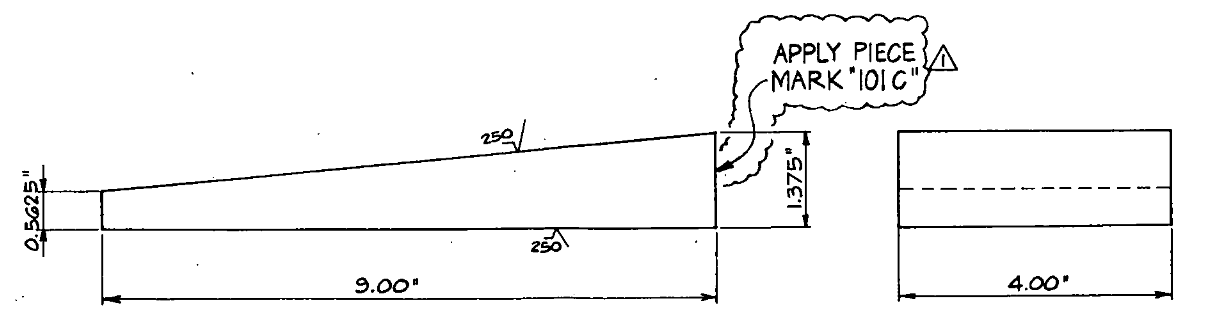
PIN SUPPORT ASSEMBLY
1½" = 1'-0



PIN SUPPORT - MARK 101A
¾" = 1"



WEDGE - MARK 101 B
¾" = 1"



WEDGE - MARK 101C
¾" = 1"

NOTES

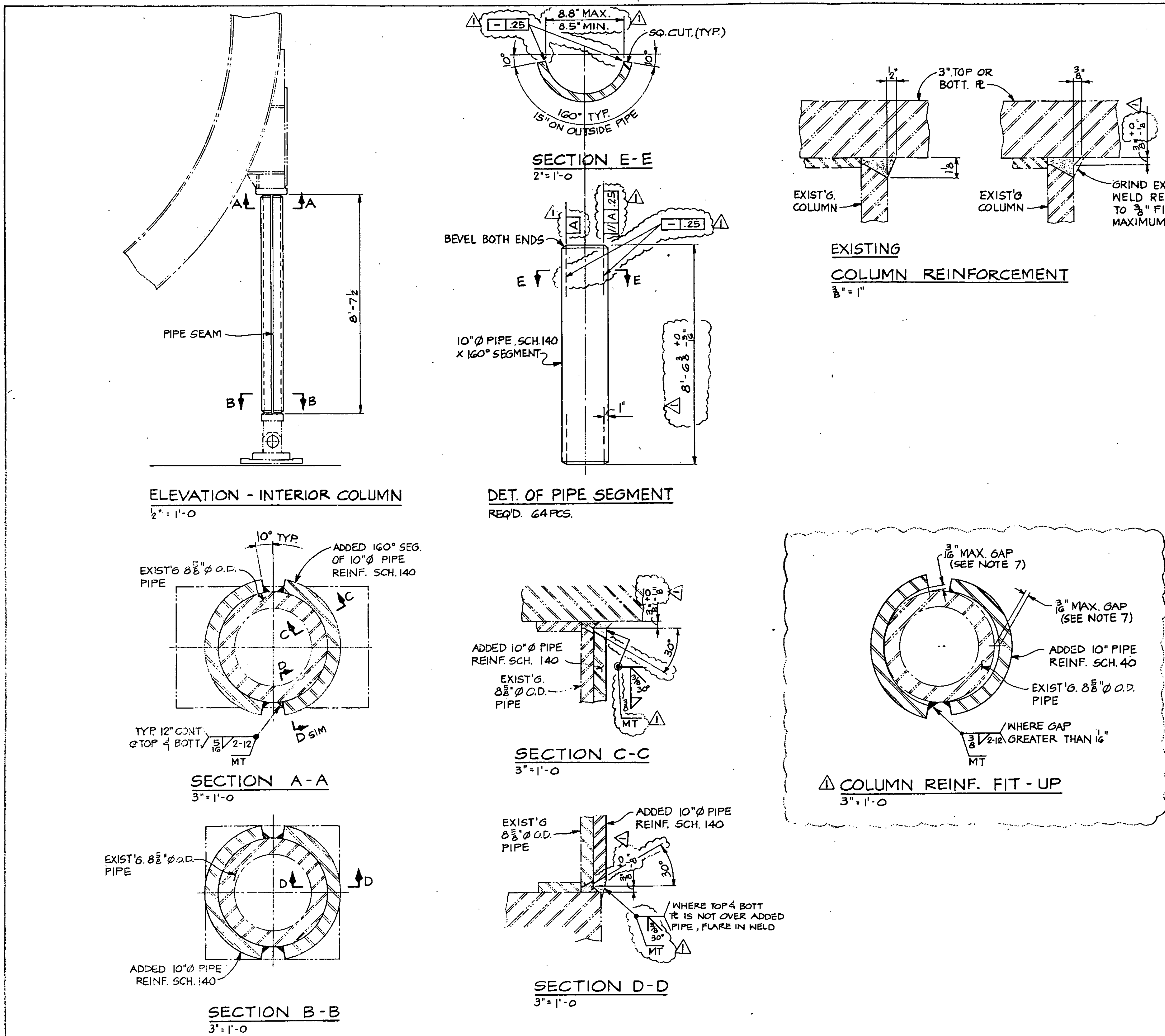
1. MATERIAL : SA-515 GRADE 70 PER NUTECH MATERIAL SPECIFICATION MS-SA-515-70 (COM-01-008).
2. MATERIAL CERTIFICATIONS REQUIRED.
3. UNLESS NOTED, TOLERANCE ON ALL DIMENSIONS SHALL BE ± 0.05".
4. UNLESS NOTED, ALL MACHINED SURFACES 250/ FINISH OR BETTER.
5. △ FOR CLEANING AND PAINTING REQUIREMENTS REFER TO NUTECH PAINT LETTER PL-P1 (COM-01-013).
6. △ PIECE MARK TO BE APPLIED TO ALL WEDGES AS SHOWN.

REVISION	DESCRIPTION		
△	ADDED PIECE MARK & WELDS; REVISED NOTES 5 & 6 AND DELETED NOTE 7.		
	CHANGED DD 2/19/76	CHECKED GRE 2/20/76	APPROVED [signature] 2/20/76

san jose **nutech** california

TITLE
DRESDEN UNITS 2 AND 3
TORUS SUPPORT MODIFICATIONS
PIN REINFORCEMENT

DRAWN DUQUE 2/11/76	JOB No. COM-0300	FILE No. 29.301
CHECKED G. R. Edwards 2/12/76	DWG. No. 101	REV. No. 1
APPROVED [signature] 2/12/76	SCALE AS NOTED	SHEET 1 OF 1



NOTES

1. MATERIAL MUST BE CERTIFIED AND COMPLY WITH REQUIREMENTS OF NUTECH MATERIAL SPECIFICATION MS-SA-106B. (COM-01-010).
2. UNLESS NOTED, TOLERANCE ON ALL DIMENSIONS SHALL BE ± 1/8", WELD BEVELS ± 2 1/2°.
3. PIPE DIMENSIONS SHALL COMPLY WITH ANSI B36.10-1970.
4. TOLERANCE SYMBOLS PER ANSI Y14.5-73.
5. FOR CLEANING AND PAINTING REQUIREMENTS REFER TO NUTECH PAINT LETTER PL-P1 (COM-01-013).
6. HEAT STRAIGHTENING IS NOT PERMITTED WITHOUT PRIOR NUTECH APPROVAL.
7. FOR TOP AND BOTTOM CIRCUMFERENCE WELDS LIMIT GAP TO 1/16".

REVISION	DESCRIPTION
1	ADDED COL. REINF. FIT-UP; NOTES 5,6,&7; PIPE SEGMENT DIM. 4 AS NOTED. REVISED NOTE 4. CHANGED DD 2/19/76 CHECKED GPE 2/20/76 APPROVED 2/20/76

san jose **nutech** california

DRESDEN UNITS 2 AND 3
TORUS SUPPORT MODIFICATIONS
COLUMN REINFORCEMENT

DRAWN DUQUE 2/12/76	JOB No. COM-0300	FILE No. 29.301
CHECKED Glen R. Edwards 2/12/76	DWG No. 102	REV. No. 1
APPROVED 2/12/76	SCALE AS NOTED	SHEET 1 of 1

Appendix B

MODIFICATION MATERIAL SPECIFICATIONS

CONTROLLED COPY NO. _____

February 1976

COM-01-008

MATERIAL SPECIFICATION

MS-SA-515-70

SPECIFICATION FOR CARBON STEEL PLATES FOR PRESSURE VESSELS FOR INTERMEDIATE AND HIGH-TEMPERATURE SERVICE

Prepared for:

Commonwealth Edison Co.

Prepared by: G. R. Edwards Date 2/12/76

G. R. Edwards

Approved by: [signature] for Date 2/12/76

N. W. Edwards

Issued by: [signature] Date 2/12/76

R. E. Keever

nutech

Specification: Material Specification MS-SA-515-70

Description: Specification for Carbon Steel Plate for Pressure Vessels for Intermediate and Higher Temperature Service

This page is a record of all revisions of the specification. Each time the specification is changed, only the new or revised pages are issued.

REVISION	DATE	BY	PAGES	REMARKS
0	2/12/76	GRE	1,2	Initial Issue

1.0 INFORMATION AND GENERAL REQUIREMENTS

1.1 SCOPE: This specification constitutes the requirements of NUTECH, for plate material to be used to reinforce existing Mark I Containment Suppression Chamber, Torus Support Column Pin Connections.

2.0 TECHNICAL REQUIREMENTS

2.1 Plate material shall conform to ASME SA 515 Grade 70 as given in the ASME Boiler and Pressure Vessel Code, Section II, "Material Specifications - Part A - Ferrous", 1974 Edition, with Addenda up to and including Summer 1975 Addenda (hereafter referred to as the Material Code).

2.2 All tests and inspections required by Material Code SA 515 and SA 20 shall be performed. Mechanical tests required by Material Code SA 515 and SA 20 shall be performed in accordance with SA 20.

2.3 Notch toughness testing is not required.

3.0 IDENTIFICATION AND CERTIFICATION

3.1 Material identification and marking shall be in accordance with Material Code SA 20. As a minimum, the following permanent markings are required and shall be legibly die stamped on each plate using blunt-nose-continuous or blunt-nose-interrupted-dot-die stamps having a minimum radius of 1/32 inch.

a. Manufacturer's Name or Brand
b. Specification Number and Grade
c. Heat Number
d. Any additional marking required to facilitate traceability of all tests and examination performed.

3.2 Material certification and reports shall be in accordance with Material Code SA 20 paragraph 19. The Materials Manufacturer's Certified Materials Test Report shall include certified reports of the actual results of all required chemical analyses, mechanical tests (tensiles, flattening and hydrostatic tests), examinations (including NDE operator's name and SNT-TC-1A rating and NDE procedures with acceptance standards) and any other tests as well as a statement listing any heat treatments (including times and temperatures) that have been performed.

3.3 When permitted by his Quality System Program, the Material Supplier shall provide a Certified Materials Tests Report for thoseoperations performed by him or by his subcontractor. (This paragraph not applicable to plate manufacturer).

3.4 Three (3) legible copies of the Certified Materials Test Report shall be sent at the time the materials are shipped. The Certified Materials Test Report shall be sent to:

Commonwealth Edison Co.
P. O. Box 767
Chicago, IL 60696

Attn: Cordell Reed

CONTROLLED COPY NO. ______

February 1976

COM-01-010

MATERIAL SPECIFICATION

MS-SA-106-B

SPECIFICATION FOR SEAMLESS CARBON STEEL PIPE

FOR HIGH-TEMPERATURE SERVICE

Prepared for:

Commonwealth Edison Co.

Prepared by: G. R. Edwards Date 2/12/76

G. R. Edwards

Approved by: [signature] for Date 2/12/76

N. W. Edwards

Issued by: [signature] Date 2/12/76

R. E. Keever

nutech

Specification: Material Specification MS-SA-106-B

Description: Seamless Carbon Steel Pipe for High Temperature Service

This page is a record of all revisions of the specification. Each time the specification is changed, only the new or revised pages are issued.

REVISION	DATE	BY	PAGE	REMARKS
0	2/12/76	GRE	1,2	Initial Issue

1.0 INFORMATION AND GENERAL REQUIREMENTS

1.1 SCOPE: This specification constitutes the requirements of NUTECH, for pipe material to be used to reinforce existing Mark I Containment, Suppression Chamber, Torus Support Columns.

2.0 TECHNICAL REQUIREMENTS

2.1 Pipe material shall conform to ASME SA 106 Grade B as given in the ASME Boiler and Pressure Vessel Code, Section II, "Material Specifications - Part A - Ferrous", 1974 Edition, with Addenda up to and including Summer 1975 Addenda (hereafter referred to as the Material Code).

2.2 All tests and inspections required by Material Code SA 106 and SA 530 shall be performed. Mechanical tests required by Material Code SA 106 and SA 530 shall be performed in accordance with SA 370.

2.3 Dimensions shall comply with ANSI B36.10-1970.

2.4 Pipe shall be hot finished and need not be heat treated.

2.5 Hydrostatic tests are not required.

2.6 Notch toughness testing is not required.

3.0 IDENTIFICATION AND CERTIFICATION

3.1 Material identification and marking shall be in accordance with Material Code SA-106 paragraph 21 and SA 530 paragraph 20. As a minimum, the following permanent markings are required and shall be legibly die stamped on each pipe using blunt-nose-continuous or blunt-nose-interrupted-dot-die stamps having a minimum radius of 1/32 inch.

a. Manufacturer's Name or Brand.
b. Specification Number and Grade
c. Heat Number
d. Hot Finished
e. Seamless
f. Schedule Number
g. Any additional marking required to facilitate traceability of all tests and examination performed.

3.2 Material certification and reports shall be in accordance with Material Code SA 530 paragraph 19. The Materials Manufacturer's Certified Materials Test Report shall include certified reports of the actual results of all required chemical analyses, mechanical tests (tensiles, flattening and hydrostatic tests), examinations (including NDE operator's name and SNT-TC-1A rating and NDE procedures with acceptance standards) and any other tests as well as a statement listing any heat treatments (including times and temperatures) that have been performed.

3.3 When permitted by his Quality System Program, the Material Supplier shall provide a Certified Materials Tests Report for those operations performed by him or by his subcontractor. (This paragraph not applicable to pipe manufacturer).

3.4 Three (3) legible copies of the Certified Materials Test Report shall be sent at the time the materials are shipped. The Certified Materials Test Report shall be shipped to:

Commonwealth Edison Co.
P. O. Box 767
Chicago, IL 60696

Attn: Cordell Reed

Appendix C

SAFETY EVALUATION

Per

10CFR50.59

10CFR50.59 FORMAT FOR SAFETY EVALUATION

STATION Dresden UNITS 2 and 3

SYSTEM Primary Containment MODIFICATION No. ______

EQUIPMENT NAME Torus Support Columns

EQUIPMENT No. ______

DESCRIPTION OF MODIFICATION:

Reinforcement of inside torus support (pipe) columns and pin connection at the base of the inside columns. See Nutech Report COM-01-022 for detailed description. Appendix A to that report contains design drawings for this modification.

SAFETY EVALUATION: Answer the following questions with a "yes" or "no", and provide specific reasons justifying the decision:

1. Is the probability of an occurrence or the consequence of an accident, or malfunction of equipment important to safety as previously evaluated in the Final Safety Analysis Report increased? ____ Yes __X__ No, Because:

   The modification provides a marked increase in the structural capacity of the torus support system and, therefore, additional margin for load associated with the design basis LOCA previously evaluated in the FSAR. Furthermore, as shown in Table 7.0-1 of report COM-1-022 the modified columns and pin connections accommodate pool shell dynamic loads (as currently defined by the Mark I Short Term Program) within Code allowables.

2. Is the possibility for an accident or malfunction of a different type than any previously evaluated in the Final Safety Analysis Report created? ____ Yes __X__ No, Because:

   This modification to strengthen a passive structural component has no potential for creation of a new accident. The behavior of the containment structure as effected by this modification has been investigated and no potential for malfunction of the containment as a result of the modification has been identified.

3. Is the margin of safety, as defined in the basis for any Technical Specification, reduced? ____ Yes __X__ No, Because:

   Torus supports are not the subject of a technical specification. No technical specification will change as a result of this modification.

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