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NUCLEAR SAFETY-RELATED

STRUCTURAL DESIGN ASSESSMENT FOR SAFE - END BREAK ENRICO FERMI POWER PLANT - UNIT 2

REPORT PREPARED FOR

DETROIT EDISON COMPANY

REPORT SL-3647

MAY 26, 1978
MARCH 14, 1980 (REV. 2)

POOR ORIGINAL

SARGENT & LUNDY
ENGINEERS

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March 14, 1980

Detroit Edison Company
Enrico Fermi 2 Project
Document Control Office - 110 S.B.
2000 Second Avenue
Detroit, Michigan 48226
Attention: Mr. M. L. Batch
Room No. 318 ECT

Dear Mr. Batch:

We are enclosing herewith fifteen copies of the following revised report in response to your letter EF2-47110, dated November 13, 1979:

Report SL-3647
Structural Design Assessment for Safe-End Break
Enrico Fermi Atomic Plant - Unit 2
Revision 2, March 14, 1980

This report has been revised to incorporate the revised results of the Annulus Pressurization (AP) analysis performed by General Electric Company.

If you have any questions or comments, or feel that any further points should be reviewed, kindly advise.

Yours very truly,

J. M. McLaughlin, Manager
Structural Department

JMM/mgg
Enclosures

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March 22, 1979

Mr. W. F. Colbert, Project Engineer
Detroit Edison Company
2000 Second Avenue, Room 333 ECT
Detroit, Michigan 48226

Dear Mr. Colbert:

We are enclosing herewith fifteen copies of the Revision 1, change-out pages for:

Report SL-3647
Structural Design Assessment for Safe-End Break
Enrico Fermi Atomic Power Plant - Unit 2
Revision 1, March 22, 1979

This report has been revised to expand the description of the methods employed to transform the data received from NUS to be compatible with our analysis technique, and also to include changes in the RPV anchor bolt stresses due to vessel skirt loads received from General Electric Company.

The following pages have been revised or added. Please insert these pages in the appropriate place in the report and void the superseded pages of the previous issue:

Table of Contents page ii
Text pages 6, 6A, 7, 7A, 8, and 9
Table 15
Exhibits 8, 9, and 10.

If you have any questions or comments, or feel that any further points should be reviewed, kindly advise.

Yours very truly,

J. M. McLaughlin
Assistant Manager,
Structural Department

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May 26, 1978

Mr. W. F. Colbert, Project Engineer
Detroit Edison Company
2000 Second Avenue, Main Lobby
Detroit, Michigan 48226

Dear Mr. Colbert:

We are enclosing herewith fifteen copies of the following report:

Report SL-3647
Structural Design Assessment for Safe-End Break
Enrico Fermi Atomic Power Plant - Unit 2
Dated May 26, 1978

This report presents the results of our analysis of the effect of annulus pressurization between the reactor vessel and the sacrificial shield to assess the design adequacy of the affected structures. We have concluded that the sacrificial shield, reactor pedestal, stabilizer truss, RPV and shield anchor bolts can safely accommodate the effects of annulus pressurization resulting from a postulated safe-end break.

If you have any questions or comments, or feel that any further points should be reviewed, kindly advise.

Yours very truly,

J. M. McLaughlin
Assistant Manager,
Structural Department

JMM/ens
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NUCLEAR SAFETY-RELATED

STRUCTURAL DESIGN ASSESSMENT

FOR SAFE - END BREAK

ENRICO FERMI POWER PLANT - UNIT 2

REPORT PREPARED FOR

DETROIT EDISON COMPANY

REPORT SL-3647

MAY 26, 1978
MARCH 14, 1980 (REV. 2)

SARGENT & LUNDY
ENGINEERS

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STRUCTURAL DESIGN ASSESSMENT FOR SAFE-END BREAK ENRICO FERMI ATOMIC POWER PLANT – UNIT 2

DETROIT EDISON COMPANY

I SUMMARY

The purpose of this study is to analyze for the effect of annulus pressurization between the reactor vessel and the sacrificial shield and to assess the design adequacy of the affected structural components. The study considered three independent postulated safe-end breaks: recirculation inlet, recirculation outlet, and feedwater pipe break.

A thin shell finite element model is used to analyze for forces and moments on the structure. The structural components assessed in this report are:

1) sacrificial shield,
2) reactor pedestal,
3) stabilizer truss,
4) reactor anchor bolts, and
5) sacrificial shield anchor bolts.

The various components are shown in Exhibit 1. The model used in the analysis is shown in Exhibit 2. The resulting forces and moments are combined with other appropriate loads as defined in the design criteria to obtain the final design forces and moments. The resulting stresses are found to be within the allowables.

II STRUCTURAL COMPONENTS

A. Sacrificial Shield

The sacrificial shield is a cylindrical shell with 14 feet-6-1/2 inches average radius, 48 feet-9 inches high and 1 foot-9 inches thick. It has 3/8 inch thick steel exterior and interior plates meridionally stiffened by 12 vertical steel columns. The steel plates are welded to the flanges of columns. The annular space between the plates is filled with concrete which functions as the primary

radiation shield and also transmits shear forces between the exterior and the interior plates. Buckling of the plates is prevented by studs welded to the plates and embedded in the concrete. Cross-sectional views of the sacrificial shield along the meridian and the circumference are shown in Exhibit 3.

The bottom of the shield is rigidly attached to the reactor support pedestal; the top is free to displace in all directions, except tangential, which is restrained by a stabilizer truss system.

B. Reactor Pedestal

The reactor pedestal provides a support for the reactor pressure vessel, the sacrificial shield wall and the pipe break support truss system.

The reactor pedestal is a reinforced concrete cylindrical shell with an average radius of 12 feet-6-1/2 inches and a height of approximately 26 feet as shown in Exhibit 4. The thickness of the shell varies from 4 feet at its base to 5 feet-6 inches at its top. The shell is reinforced on the inside and outside faces in the hoop as well as meridional directions. *

C. Stabilizer Truss

The stabilizer truss system (Exhibit 5) is a horizontal structural steel truss connecting the top of the sacrificial shield to the primary steel containment. The function of this system is to stabilize the RPV and the sacrificial shield under dynamic excitation. The RPV is connected to the sacrificial shield by the RPV stabilizer and the sacrificial shield, in turn, is connected to the primary steel containment by the stabilizer truss. A special "shear lug" connection attaches the truss gusset plates to the containment wall. The shear lug connection permits radial and vertical movements but restrains tangential movement of the shield. *

D. RPV Anchor Bolts

The function of the RPV anchor bolts is to transmit the forces from the RPV skirt to the reactor pedestal. The RPV anchoring consists of two 3-1/4 inch Ø bolts every 12 degrees around the circumference of the pedestal. The anchor bolts and their locations are shown in Exhibits 6 and 7. *

E. Sacrificial Shield Anchor Bolts

The function of the sacrificial shield anchor bolts is to transmit the forces from the sacrificial shield to the reactor pedestal. The sacrificial shield anchoring consists of three sizes of bolts: 2-3/4 inch Ø, 2-1/2 inch Ø, and 2 inch Ø bolts which are spaced approximately every 6°. The anchor bolts and their locations are shown in Exhibits 6 and 7.

III MATERIAL AND MATERIAL PROPERTIES

A. Sacrificial Shield

Steel Plates	A588 Grade A Material Fy = 50 ksi
Concrete Fill	f'_c = 6000 psi
Weld	E70 Electrode

B. Reactor Pedestal

Concrete	f'_c = 4000 psi
Reinforcing Steel	A615 Grade 60 Material Fy = 60 ksi

C. Stabilizer Truss

Steel Pipes	A53 Grade B Material Fy = 35 ksi
Weld	E70 Electrode

D. Bolting Material

Anchor Bolts	A193 Grade B7 Material
	Fy = 105 ksi for Ø $\leq$ 2-1/2"
	f_u = 125 ksi for Ø $\leq$ 2-1/2"
	Fy = 95 ksi for 2-1/2" < Ø $\leq$ 4"
	F_u = 115 ksi for 2-1/2" < Ø $\leq$ 4"

Nuts A194 Grade 2H Material

where F_y = specified minimum yield stress of steel.

f_y = specified yield strength of nonprestressed reinforcement.

f'_c = specified compressive strength of concrete.

f_u = tensile strength of steel.

IV DESIGN CRITERIA

A. Loads and Load Combinations

This study is mainly concerned with the effect of a postulated safe-end break of the feedwater and the recirculation lines. The three major loads that are associated with a safe-end break are:

1) annulus pressurization load,
2) jet impingement load, and
3) pipe whip reaction load.

The first two loads are described in NUS Report NUS-3129 (Ref. 4). The pipe whip reaction loads are described in Sargent & Lundy Report SL-2880 (Ref. 3).

Other loads that are considered in the structural assessment are:

1) dead load,
2) thermal effect due to accident temperature = 281°F, and
3) seismic effect due to OBE and SSE excitations.

The accident transient temperature is given in EF-2-FSAR (Ref. 1). The seismic forces and moments are obtained from Sargent & Lundy Report SL-2682 (Ref. 2).

Load combinations considered in this study are presented in Tables 1 and 2. Table 1 gives the load combinations for the sacrificial shield, stabilizer truss and the anchor bolts. Table 2 gives the load combinations for the reactor

pedestal. The only two load combination categories that are considered in this assessment are the Abnormal/Severe Environmental and the Abnormal/Extreme Environmental, since they are the only ones associated with a safe-end break.

The combined forces and moments derived by the General Electric Co. for the concrete RPV pedestal, RPV anchor bolts and stabilizer truss as provided in Reference 5 are also included in this study. Thus the larger of the stresses computed from the S&L and GE analyses are presented in this report. *

B. Allowable Stresses

The yield limit criteria are used in defining the allowable stresses for the sacrificial shield, stabilizer truss, anchor bolts and the reactor pedestal. Tables 3, 4 and 5 specify the allowable stresses used in the assessment.

V ANALYSIS AND RESULTS

The structure was analyzed using a Sargent & Lundy thin shell of revolution program, DYNAX (see Appendix A). The various components included in the model are:

1) sacrificial shield,
2) reactor pedestal,
3) reactor pressure vessel,
4) stabilizer truss, and
5) refueling bellows.

Exhibit 2 presents the model used in the analysis, and Tables 6 and 7 give the geometric properties of the elements.

The boundary conditions at the base of the pedestal and the points where the stabilizer truss and refueling bellows are attached to the containment wall were considered to be fixed. Since the stabilizer truss, the refueling bellows and the RPV stabilizer can resist only tangential loads, they were modeled as thin annular steel plates accounting for the tangential stiffness only.

The sacrificial shield is modeled as an orthotropic material to simulate the difference in stiffness between the meridional and the hoop direction. The reactor pedestal is modeled as an isotropic material axisymmetrical shell. Small openings are assumed to have little effect on the overall behavior of the structure. The reactor pressure vessel (RPV) is modeled also as an isotropic material. The masses and member properties were chosen to simulate the natural frequency of the RPV. The RPV and the sacrificial shield are attached to the reactor pedestal through rigid horizontal members to account for the rigid connection between three components.

A finer finite element mesh is provided in the sacrificial shield and the shell of the RPV in order to more accurately model the pressure distribution that acts on these two components in the meridional direction.

The annulus pressurization load is due to any of the three postulated pipe ruptures:

1) feedwater line,

2) recirculation inlet, and

3) recirculation outlet.

The pressure time histories and spatial distributions for these three pipe ruptures are provided in NUS Report NUS-3129 (Ref. 4). The differential pressure due to a postulated feedwater pipe rupture was found to be the governing load. Therefore, all analyses are performed using the feedwater pressure time histories.

The annulus pressurization loads on the sacrificial shield were defined, both temporally and spatially, with 42 individual pressure time-histories distributed over a 180° segment of the shield. Since the pressure loads are symmetric about the ruptured pipe, it was only necessary to define the load distributions over a semicylindrical portion of the shield. Exhibit 8 shows the arrangement of the node points on the inside surfaces of the annulus for which time-histories of differential pressures were computed. It should be noted that the azimuth locations mentioned here and in Exhibits 8, 9, and 10 are relative to the postulated feedwater line rupture. *

The node/time-history points on the inside surfaces were then divided into seven circumferential strips as shown on Exhibit 6. The strip configurations were used to arrange the individual time-histories into a format that could be readily converted

into a set of Fourier harmonics. Since the analysis was to be performed on an axisymmetric shell model, the loads have to be in terms of circumferential strips so as to coincide with the model elements.

By using Sargent & Lundy's computer applications program, FORANL (see Appendix A), the six pressure time-histories per strip were converted into 13 symmetric Fourier harmonics and their corresponding time-histories, cosine (0) through cosine (12). Since the load is symmetric about the pipe break, the sine terms for the Fourier series are all zero. The time-histories produced by FORANL are, in essence, a set of Fourier coefficients that were computed for each time step of the loading. The Fourier harmonic time-histories were normalized to produce a single representative coefficient for each harmonic, and to show the contribution of each harmonic to the idealized load. Based upon the normalized Fourier coefficients, it could be seen that only the first four harmonics need be used. Exhibit 9 shows the pressures in strip 1 as a histogram, at the time of occurrence of the peak pressure at the feedwater pipe rupture location. Superimposed onto Exhibit 9 is the pressure load distribution as represented by the four Fourier harmonics at the same instant of time. Exhibit 10 illustrates the distribution of the pressures across the seven strips between azimuths ± 30 at the time of occurrence of the peak pressure in strip 1.

The pressures were applied to the RPV and sacrificial shield in the mathematical model as nodal forces by identifying which strip coincides with each node, and then applying a factor which relates to the surface area, per foot of the circumference, that contributes to the total nodal load. The analysis, as performed by DYNAX, consisted of solving the equations of motion for each time step of the harmonic time-history, for each harmonic individually.

To insure that the maximum probable responses would be used in the assessment herein, discrete responses were obtained with the solutions of the equations of motion for several azimuths between 0° and 180°, and then summing for all four of the harmonics considered. The results from the individual azimuths were then enveloped. Presented in Table 8 is a listing of the enveloped maximum positive and negative membrane forces, moments and shears.

VI STRUCTURAL ASSESSMENT

A. Sacrificial Shield

The assessment of the sacrificial shield is made by choosing four critical sections at different elevations of the shield as shown in Exhibit 3. Each section is designed for the load combinations given in Table 1. Final stresses are obtained for the concrete fill, the steel plates, the column stiffeners and the welds. They are presented in Tables 9 through 12.

It is found that the Abnormal/Extreme Environmental load combination category governs the design.

B. Reactor Pedestal

In the assessment of the reactor pedestal, five design sections are selected as shown in Exhibit 4. Each section is designed for the load combinations given in Table 2. The final stresses in reinforcement and concrete are obtained by using the TEMCO program. The maximum stresses in reinforcing steel and concrete and maximum shear forces are presented in Tables 13 and 14 for meridional and hoop sections, respectively.

It is found that the Abnormal/Extreme Environmental load combination governs the design.

C. Stabilizer Truss

The stabilizer truss is assessed for the governing Abnormal/Extreme Environmental load combination category as presented in Table 1. Each 10-inch-diameter double extra strong pipe of the stabilizer truss is designed for an axial load of 450 kips. The computed compressive stress is 13.1 ksi, which is less than * the allowable axial compressive stress of 33.4 ksi. The high-strength bolts and fillet welds at the end connections are also checked and found to be satisfactory, with a minimum margin factor of 2.01. *

D. Anchor Bolts

The anchor bolts are also assessed for the governing Abnormal/Extreme Environmental load combination category as presented in Table 1. The maximum

stresses in the shear lugs and the maximum tensile forces in bolts are given in Table 15. The RPV anchor bolts' assessment is based on the skirt loads given in the FSAR section 3.9.1.5 (Ref. 5).

VII CONCLUSION

The existing design of the sacrificial shield, reactor pedestal, stabilizer truss, RPV and shield anchor bolts can safely accommodate the effects of annulus pressurization resulting from a postulated safe-end break.

SARGENT & LUNDY,

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VIII REFERENCES

1. Enrico Fermi Atomic Power Plant Unit Final Safety Analysis Report, Vol. 2.

2. Seismic Analysis of the Reactor Auxiliary Building Complex, Enrico Fermi Atomic Power Plant Unit 2, Sargent & Lundy Report SL-2682, revised September 27, 1974.

3. Pipe Whip Restraint Support System Design Criteria, Enrico Fermi Atomic Power Plant Unit 2, Sargent & Lundy Report SL-2880, January 10, 1973.

4. Reactor Vessel - Sacrificial Shield Annulus Pressurization Analysis, Enrico Fermi Unit 2, NUS Report NUS-3129, April 1978.

5. Enrico Fermi Atomic Power Plant Unit 2, Final Safety Analysis Report Section 3.9.1.5. *

TABLES

TABLE 1 LOAD COMBINATIONS FOR SACRIFICIAL SHIELD, STABILIZER TRUSS AND ANCHOR BOLTS

LOAD COMBINATION NUMBER	LOAD COMBINATION CATEGORY	D	T_a	A_p	Y_r	Y_j	E_o	E_s
1	ABNORMAL/SEVERE ENVIRONMENTAL	1.0	1.0	1.0	1.0	1.0	1.0	
2	ABNORMAL/EXTREME ENVIRONMENTAL	1.0	1.0	1.0	1.0	1.0		1.0

D = Dead load of structure plus any other permanent loads.

T_a = Thermal effects which occur during a postulated accident.

A_p = Annulus Pressurization load which occurs during a postulated safe-end breaks.

Y_r = Forces Associated with a Whipping Pipe.

Y_j = Jet Impingement Forces.

E_o = Operating basis earthquake (OBE) effects.

E_s = Safe shutdown earthquake (SSE) effects.

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TABLE 1
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TABLE 2 LOAD COMBINATIONS FOR REACTOR PEDESTAL

LOAD COMBINATION NUMBER	LOAD COMBINATION CATEGORY	D	T_a	A_p	Y_r	Y_j	E_o	E_s
1	ABNORMAL/SEVERE ENVIRONMENTAL	1.0	1.0	1.0	1.0	1.0	1.25	
2	ABNORMAL/EXTREME ENVIRONMENTAL	1.0	1.0	1.0	1.0	1.0		1.0

D = Dead load of structure plus any other permanent loads.

T_a = Thermal effects which occur during a postulated accident.

A_p = Annulus Pressurization load which occurs during a postulated safe-end breaks.

Y_r = Forces Associated with a Whipping Pipe.

Y_j = Jet Impingement Forces.

E_o = Operating basis earthquake (OBE) effects.

E_s = Safe shutdown earthquake (SSE) effects.

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TABLE 2
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TABLE 3 ALLOWABLE STRESSES FOR SACRIFICIAL SHIELD

LOAD COMB. NO.	ALLOWABLE STRESSES				
	STEEL		CONCRETE	WELD	
	COMPRESSION TENSION	SHEAR	SHEAR	COMPRESSION TENSION	SHEAR
1&2	1.6 AISC ALLOWABLE $\leq .95\ F_y$	1.6 AISC ALLOWABLE $\leq \frac{.95}{\sqrt{3}} F_y$	$2\sqrt{f'_c}$	1.6 AISC ALLOWABLE $\leq 0.95\ F_y$ of Base Metal	1.6 AISC ALLOWABLE $\leq \frac{.95}{\sqrt{3}} F_y$ of Base Metal

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CHICAGO

TABLE 3
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TABLE 4 ALLOWABLE STRESSES FOR REACTOR PEDESTAL

CONCRETE			REINFORCING STEEL
MEMBRANE PLUS FLEXURAL COMPRESSION	TENSION	RADIAL SHEAR**	TENSION AND COMPRESSION
*0.85 f'_c	None	ACI 318-71 Chapter 11	0.9 f_y

*Due to primary plus secondary forces.
**The meridional reinforcing steel is designed to carry the entire tangential shear.

TABLE 5 ALLOWABLE STRESSES FOR BOLTING MATERIAL AND SHEAR LUGS

LOAD COMB. NO.	BOLTS*			SHEAR LUGS CONCRETE BEARING
	TENSION Ft	COMBINED TENSION AND SHEAR Ft'	SHEAR Fu	
1&2	1.6 x 0.33 Fu	1.6 x 0.43 Fu - 1.4 f_v	1.6 x 0.22 Fu	ACI 318-71 Sect. 10.14

*1978 AISC Table 1.6.3 Page 23, with 1.6 factor.

Fu = ultimate strength of steel, ksi

f_v = computed shear stress, ksi

TABLE 6 GEOMETRY OF NODAL POINTS

Nodal Point Number	Radius R (ft)	Elevation Z (ft)	Nodal Point Number	Radius R (ft)	Elevation Z (ft)
1	12.54	.00	43	10.73	47.71
2	12.54	3.78	44	10.73	48.47
3	12.54	7.56	45	10.73	50.26
4	12.54	11.34	46	6.00	58.17
5	12.54	15.12	47	13.66	57.87
6	12.54	18.90	48	10.73	52.04
7	12.54	22.68	49	10.73	53.82
8	12.54	26.46	50	10.73	55.61
9	13.66	26.46	51	6.00	61.65
10	10.73	26.46	52	13.66	59.87
11	13.66	28.11	53	10.73	57.39
12	13.66	29.75	54	10.73	59.18
13	13.66	31.40	55	4.00	64.85
14	10.73	28.10	56	13.66	61.87
15	10.73	29.73	57	10.73	60.96
16	10.73	31.37	58	13.66	63.87
17	5.09	26.46	59	10.73	62.74
18	13.66	33.04	60	13.66	66.87
19	13.66	35.62	61	10.73	64.53
20	13.66	37.78	62	13.66	69.90
21	13.66	39.93	63	10.73	66.08
22	10.73	33.87	64	10.73	67.64
23	10.73	35.55	65	10.73	69.19
24	10.73	37.23	66	10.73	70.75
25	10.73	38.91	67	13.66	71.90
26	6.00	38.91	68	13.66	73.87
27	13.66	42.08	69	10.73	72.30
28	13.66	44.08	70	10.73	73.86
29	13.66	46.08	71	13.66	75.41
30	13.66	48.29	72	19.50	75.41
31	6.00	42.07	73	10.73	75.41
32	10.73	41.02	74	13.66	77.44
33	10.73	42.07	75	13.66	79.22
34	10.73	43.14	76	10.73	80.09
35	10.73	44.20	77	10.73	88.79
36	13.66	50.51	78	10.73	90.41
37	6.00	48.47	79	16.46	90.41
38	13.66	52.72	80	10.73	93.04
39	10.73	45.27	81	8.65	97.33
40	6.00	51.70	82	3.98	101.62
41	13.66	54.94	83	10.73	39.96
42	10.73	46.34			

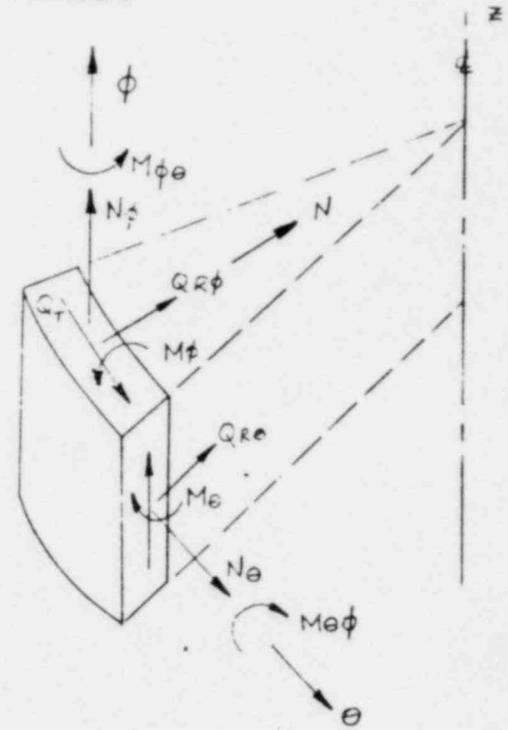
TABLE 7 ELEMENT INDICES

Element Numbers	Start Joint	End Joint	Element Numbers	Start Joint	End Joint
1	1	2	43	23	24
2	2	3	44	24	25
3	3	4	45	25	83
4	4	5	46	83	32
5	5	6	47	32	33
6	6	7	48	33	34
7	7	8	49	34	35
8	8	9	50	35	39
9	9	11	51	39	42
10	11	12	52	42	43
11	12	13	53	43	44
12	13	18	54	44	45
13	18	19	55	45	48
14	19	20	56	48	49
15	20	21	57	49	50
16	21	27	58	50	53
17	27	28	59	53	54
18	28	29	60	54	57
19	29	30	61	57	59
20	30	36	62	59	61
21	36	38	63	61	63
22	38	41	64	63	64
23	41	47	65	64	65
24	47	52	66	65	66
25	52	56	67	66	69
26	56	58	68	69	70
27	58	60	69	70	73
28	60	62	70	73	76
29	62	67	71	76	77
30	67	68	72	77	78
31	68	71	73	78	79
32	71	72	74	78	80
33	71	73	75	80	81
34	71	74	76	81	82
35	74	75	77	25	26
36	8	10	78	26	31
37	10	14	79	31	37
38	14	15	80	37	40
39	15	16	81	40	46
40	16	17	82	46	51
41	16	22	83	51	55
42	22	23			

TABLE 8 MAXIMUM POSITIVE SHELL MEMBRANE FORCES

ELEM	TIME (SEC.)	MERIDIONAL (K/FT)	TIME (SEC.)	CIRCUMFERENTIAL (K/FT)	TIME (SEC.)	SHEAR (K/FT)
1	.42+00	.1456+02	.20+00	.3933+01	.20+00	.7766+01
2	.42+00	.1281+02	.85-01	.3019+01	.20+00	.8808+01
3	.42+00	.1089+02	.77-01	.1788+01	.20+00	.9230+01
4	.24+00	.9229+01	..71-01	.2274+01	.20+00	.9063+01
5	.24+00	.7737+01	.72-01	.2161+01	.20+00	.8459+01
6	.33+00	.7294+01	.12+00	.7498+01	.20+00	.7641+01
7	.33+00	.8406+01	.12+00	.2420+02	.19+00	.6852+01
9	.13+00	.1894+02	.12+00	.1078+02	.37+00	.5126+01
10	.13+00	.1814+02	.12+00	.1552+02	.23+00	.6077+01
11	.13+00	.1731+02	.11+00	.1701+02	.23+00	.6663+01
13	.13+00	.1742+02	.11+00	.5884+02	.23+00	.7946+01
15	.12+00	.2542+02	.11+00	.6833+02	.17+00	.9061+01
17	.12+00	.3077+02	.29+00	.7585-01	.29+00	.2410+00
19	.12+00	.3099+02	.93-01	.3215+02	.17+00	.1470+01
21	.12+00	.3366+02	.92-01	.3900+02	.17+00	.6019+01
23	.17+00	.4145+02	.83-01	.8468+02	.13+00	.8066+01
25	.17+00	.5100+02	.51-01	.4733+02	.13+00	.1153+02
26	.17+00	.5381+02	.69-01	.7051+02	.53-01	.1470+02
27	.17+00	.5388+02	.69-01	.1072+03	.54-01	.1947+02
28	.17+00	.4715+02	.69-01	.1264+03	.52-01	.3322+02
29	.17+00	.3447+02	.69-01	.1005+03	.52-01	.4593+02
30	.10+00	.2159+02	.13+00	.5769+02	.51-01	.5242+02
31	.13+00	.1302+02	.20+00	.3669+02	.13+00	.5588+02
32	.33+00	.9742+01	.33+00	.2493+01	.70-01	.4020+01
33	.21+00	.6634+02	.20+00	.2553+02	.13+00	.4105+02
34	.22+00	.5049+01	.13+00	.2899+02	.22+00	.1909+02
35	.49-01	.1130+01	.59-01	.3157+02	.22+00	.7676+01
37	.44+00	.2045+02	.13+00	.1641+01	.11+00	.2381+02
38	.44+00	.1881+02	.78-01	.3799+01	.11+00	.2382+02
39	.61-01	.1799+02	.46-01	.2783+01	.11+00	.2376+02
42	.57-01	.1996+02	.25-01	.1605+00	.12+00	.1927+02
45	.57-01	.2459+02	.28+00	.1423+02	.11+00	.1624+02
48	.54-01	.2066+02	.26-01	.1916+01	.28+00	.2100+02
57	.16+00	.2093+02	.18-01	.2811+01	.11+00	.1381+02
63	.27+00	.2834+02	.26-01	.1416+01	.16+00	.9171+01
65	.22+00	.2164+02	.26-01	.2292+01	.16+00	.1200+02
67	.24+00	.8272+01	.23-01	.1224+01	.16+00	.1580+02
69	.17+00	.3187+02	.22+00	.8441+02	.16+00	.6560+01
71	.93-01	.1555+02	.25+00	.1452+01	.88-01	.7166+01
74	.93-01	.6327+01	.15+00	.3956+01	.93-01	.4750+01

*For element location see Exhibit 2.



POSITIVE SIGN CONVENTION

N_ϕ - Meridional Shell Membrane Force

N_θ - Circumferential Shell Membrane Force

M_ϕ - Meridional Shell Bending Moment

M_θ - Circumferential Shell Bending Moment

$M_{\phi\theta}$ - Cross Shell Bending Moment

$M_{\theta\phi}$ - Cross Shell Bending Moment

Q_t - Shear Membrane Force

$Q_{R\phi}$ - Meridional Transverse Shear Force

$Q_{R\theta}$ - Circumferential Transverse Shear Force

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TABLE 8 MAXIMUM NEGATIVE SHELL MEMBRANE FORCES (CONT.)

ELEM	TIME (SEC.)	MERIDIONAL (K/FT)	TIME (SEC.)	CIRCUMFERENTIAL (K/FT)	TIME (SEC.)	SHEAR (K/FT)
1	.15+00	-.2329+02	.16+00	-.5470+01	.89-01	-.7952+01
2	.15+00	-.2105+02	.16+00	-.4015+01	.89-01	-.9091+01
3	.15+00	-.1874+02	.96-01	-.2702+01	.88-01	-.9530+01
4	.15+00	-.1655+02	.10+00	-.2141+01	.87-01	-.9558+01
5	.15+00	-.1442+02	.10+00	-.2033+01	.86-01	-.9449+01
6	.15+00	-.1236+02	.44-01	-.2088+01	.86-01	-.8980+01
7	.25+00	-.1162+02	.71-01	-.9978+01	.87-01	-.8277+01
9	.22+00	-.1549+02	.71-01	-.3854+01	.11+00	-.2025+02
10	.22+00	-.1388+02	.71-01	-.4462+01	.11+00	-.2160+02
11	.22+00	-.1196+02	.61-01	-.4759+01	.11+00	-.2239+02
13	.13+00	-.1176+02	.41-01	-.1516+02	.11+00	-.2356+02
15	.13+00	-.1279+02	.40-01	-.3772+01	.60-01	-.1751+02
17	.13+00	-.1255+02	.48+00	-.3488-01	.32+00	-.4258+00
19	.13+00	-.1201+02	.38-01	-.6751+01	.17+00	-.2888+01
21	.22+00	-.1192+02	.29-01	-.4958+01	.17+00	-.1123+02
23	.17+00	-.1939+02	.20-01	-.8745+01	.17+00	-.1349+02
25	.17+00	-.2437+02	.15-01	-.1576+00	.15+00	-.1428+02
26	.17+00	-.2525+02	.15-01	-.1310+00	.15+00	-.1255+02
27	.17+00	-.2420+02	.14-01	-.1082+00	.15+00	-.4839+01
28	.17+00	-.1965+02	.14-01	-.1700+00	.17+00	-.5083+01
29	.16+00	-.1276+02	.80-02	-.5335-01	.16+00	-.5241+01
30	.83-01	-.6746+01	.30-02	-.2622-01	.16+00	-.5150+01
31	.51-01	-.4394+01	.30-02	-.2699-01	.16+00	-.4595+01
32	.25+00	-.1264+02	.25+00	-.3168+01	.50-02	-.4008-03
33	.27+00	-.1329+02	.14-01	-.8089-01	.24+00	-.4322+01
34	.16+00	-.3406+01	.50-01	-.5270+02	.16+00	-.5723+01
35	.16+00	-.7432+00	.59-01	-.1045+03	.16+00	-.2356+01
37	.11+00	-.2417+02	.11+00	-.9495+01	.23+00	-.6192+01
38	.13+00	-.2326+02	.98-01	-.4240+02	.23+00	-.6023+01
39	.13+00	-.2202+02	.11+00	-.2139+02	.23+00	-.6326+01
42	.13+00	-.2009+02	.11+00	-.3817+02	.93-01	-.5562+01
45	.58-01	-.2268+02	.97-01	-.3970+02	.16+00	-.1181+02
48	.64-01	-.2771+02	.91-01	-.3433+02	.16+00	-.1647+02
57	.21+00	-.4483+02	.67-01	-.3019+02	.53-01	-.1072+02
63	.16+00	-.6822+02	.11+00	-.8551+02	.50-01	-.2146+02
65	.15+00	-.6254+02	.98-01	-.1338+03	.53-01	-.3601+02
67	.15+00	-.3597+02	.82-01	-.1122+03	.22+00	-.6158+02
69	.17+00	-.2237+02	.27+00	-.4428+02	.22+00	-.5864+02
71	.15+00	-.1127+02	.94-01	-.3174+01	.15+00	-.5825+01
74	.14+00	-.4421+01	.86-01	-.7905+01	.15+00	-.3845+01

*For element location see Exhibit 2.

TABLE 8 MAXIMUM POSITIVE SHELL MEMBRANE FORCES (CONT.)

ELEMENT	MOMENTS TIME (SEC.)	MERIDIONAL (K-FT/FT)	TIME (SEC.)	CIRCUMFERENTIAL (K-FT/FT)	TIME (SEC.)	CROSS (K-FT/FT)	TRANSVERSE SHEAR FORCES TIME (SEC.)	MERIDIONAL (K/FT)	TIME (SEC.)	CIRCUMFERENTIAL (K/FT)
1	.15+00	.1193+02	.16+00	.2023+01	.22+00	.1260+01	.17+00	.2590+01	.19+00	.8742+00
2	.16+00	.4427+01	.11+00	.1283+01	.11+00	.2586+01	.17+00	.1393+01	.19+00	.2556+00
3	.67-01	.3254+01	.11+00	.3798+01	.11+00	.3325+01	.11+00	.1040+01	.68-01	.3543+00
4	.12+00	.3842+01	.11+00	.6871+01	.11+00	.3991+01	.11+00	.1523+01	.11+00	.7501+00
5	.11+00	.5302+01	.11+00	.1054+02	.11+00	.4416+01	.11+00	.2016+01	.11+00	.1307+01
6	.11+00	.1005+02	.11+00	.1432+02	.11+00	.4042+01	.12+00	.1875+01	.11+00	.2030+01
7	.12+00	.1061+02	.11+00	.1634+02	.11+00	.1735+01	.61-01	.6042+00	.12+00	.3215+01
9	.11+00	.1772+02	.11+00	.3035+01	.11+00	.6399+00	.70-01	.1628+01	.11+00	.9180+00
10	.71-01	.3082+01	.62-01	.5013+00	.11+00	.1431+01	.70-01	.1232+01	.12+00	.2953+00
11	.61-01	.2235+01	.70-01	.7845+00	.23+00	.1542+01	.12+00	.2818+01	.11+00	.3663+00
13	.13+00	.1226+02	.11+00	.9866+01	.12+00	.3603+01	.13+00	.6011+01	.29+00	.2096+01
15	.13+00	.3676+02	.13+00	.1085+02	.17+00	.2949+01	.55-01	.4705+01	.24+00	.1442+01
17	.13+00	.1027+02	.13+00	.8302-02	.32+00	.8851-02	.48-01	.2841+01	.17+00	.1035-02
19	.17+00	.1200+02	.17+00	.1715+01	.17+00	.3006+01	.13+00	.4871+01	.17+00	.2724+01
21	.17+00	.1801+02	.25+00	.3821+01	.17+00	.4508+01	.13+00	.4649+01	.17+00	.2646+01
23	.97-01	.1907+02	.25+00	.2408+02	.19+00	.1955+01	.58-01	.4699+01	.25+00	.4793+01
25	.15+00	.7832+01	.24+00	.9180+01	.22+00	.1279+01	.43-01	.8024+00	.17+00	.1904+01
26	.17+00	.4867+01	.24+00	.8981+01	.22+00	.9060+00	.65-01	.4634+00	.17+00	.2428+01
27	.17+00	.4196+01	.24+00	.8798+01	.40-01	.7119+00	.17+00	.1713+01	.17+00	.3598+01
28	.84-01	.4662+01	.24+00	.7487+01	.17+00	.4720+01	.18+00	.8866+00	.17+00	.4024+01
29	.82-01	.2641+01	.24+00	.4845+01	.17+00	.8790+01	.17+00	.9524+01	.24+00	.3272+01
30	.13+00	.3051+01	.24+00	.2662+01	.17+00	.1013+02	.17+00	.2227+02	.13+00	.5774+00
31	.87-01	.4524+02	.15+00	.9663+01	.17+00	.1861+02	.87-01	.3686+02	.27+00	.1024+01
32	.17+00	.3783+00	.17+00	.2054+00	.16+00	.4351-01	.17+00	.2219+00	.16+00	.1580-01
33	.17+00	.1805+02	.59-01	.7187+01	.17+00	.2948+01	.51-01	.1450+02	.16+00	.7488+00
34	.67-01	.3936+02	.22+00	.1218+02	.17+00	.1268+02	.13+00	.6757+01	.16+00	.1298+01
35	.17+00	.7303+01	.10+00	.9270+01	.17+00	.1029+02	.13+00	.2330+01	.29+00	.7787+00
37	.72-01	.7300-01	.73-01	.2147-01	.10+00	.3420-01	.10+00	.1765+01	.11+00	.2653-01
38	.98-01	.5692+00	.97-01	.1484+00	.11+00	.1627-01	.11+00	.2982+00	.12+00	.2957-01
39	.71-01	.1007+00	.71-01	.2459-01	.12+00	.2603-01	.73-01	.5181+00	.11+00	.1973-01
42	.10+00	.1138+01	.10+00	.5454+00	.12+00	.3096+00	.28+00	.3939+00	.13+00	.1330+00
45	.28+00	.3858+01	.16+00	.6270+00	.98-01	.4353+00	.99-01	.6233+01	.98-01	.9378+00
48	.10+00	.1293+01	.99-01	.1369+01	.99-01	.8412+00	.17+00	.4795+00	.21+00	.2915+00
57	.16+00	.1400+01	.21+00	.3799+01	.16+00	.6890+00	.83-01	.5074+00	.25+00	.6243+00
63	.16+00	.2758+01	.16+00	.5691+01	.19+00	.7378+00	.85-01	.2188+01	.21+00	.9908+00
65	.16+00	.5151+01	.16+00	.6174+01	.25+00	.5043+00	.45-01	.5890+00	.21+00	.1066+01
67	.22+00	.8418+01	.16+00	.5624+01	.16+00	.9640+00	.16+00	.1374+01	.15+00	.7861+00
69	.16+00	.8832+01	.17+00	.1877+01	.26+00	.9494+00	.16+00	.7981+01	.17+00	.2696+01
71	.25+00	.3764+00	.33+00	.1024+01	.28+00	.2743+00	.15+00	.6517-01	.25+00	.2815+00
74	.14+00	.6902+00	.25+00	.2951+01	.28+00	.1452+01	.13+00	.7739+00	.25+00	.7043+00

*For element location see Exhibit 2.

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TABLE 8 MAXIMUM NEGATIVE SHELL MEMBRANE FORCES (CONT.)

ELEMENT	TIME (SEC.)	MERIDIONAL (K-FT/FT)	TIME (SEC.)	MOMENTS CIRCUMFERENTIAL (K-FT/FT)	TIME (SEC.)	CROSS (K-FT/FT)	TIME (SEC.)	TRANSVERSE SHEAR FORCES MERIDIONAL (K/FT)	TIME (SEC.)	CIRCUMFERENTIAL (K/FT)
1	.17+00	-.9921+01	.20+00	-.1817+01	.11+00	-.1318+01	.15+00	-.3142+01	.15+00	-.1090+01
2	.20+00	-.3647+01	.22+00	-.1555+01	.11+00	-.2423+01	.22+00	-.1614+01	.16+00	-.3104+00
3	.12+00	-.2015+01	.11+00	-.4188+01	.11+00	-.3021+01	.22+00	-.8421+00	.11+00	-.4138+00
4	.67-01	-.1293+01	.11+00	-.7139+01	.11+00	-.3477+01	.75-01	-.6754+00	.11+00	-.9440+00
5	.61-01	-.2377+01	.11+00	-.1042+02	.12+00	-.3884+01	.75-01	-.1355+01	.11+00	-.1610+01
6	.75-01	-.6343+01	.11+00	-.1436+02	.12+00	-.3745+01	.76-01	-.2150+01	.11+00	-.2551+01
7	.76-01	-.1400+02	.11+00	-.1875+02	.29+00	-.1737+01	.11+00	-.5153+01	.11+00	-.3664+01
9	.49-01	-.2835+01	.48-01	-.3992+00	.29+00	-.7181+00	.11+00	-.1327+02	.12+00	-.1248+01
10	.12+00	-.5359+01	.11+00	-.7654+00	.29+00	-.1676+01	.11+00	-.8642+01	.11+00	-.4120+00
11	.11+00	-.8133+01	.11+00	-.2391+01	.12+00	-.1833+01	.12+00	-.2374+01	.61-01	-.2061+00
13	.44+00	-.2701+01	.29+00	-.1002+02	.11+00	-.4951+01	.49-01	-.7318+00	.23+00	-.1665+01
15	.47-01	-.6184+01	.44+00	-.6173+01	.16+00	-.5021+01	.46-01	-.1240+01	.13+00	-.2115+01
17	.17+00	-.5620+01	.13+00	-.4223-02	.29+00	-.9423-02	.13+00	-.1771+02	.13+00	-.2337-02
19	.13+00	-.3865+02	.24+00	-.2861+01	.13+00	-.6935+01	.54-01	-.7947+01	.17+00	-.1528+01
21	.55-01	-.2990+02	.24+00	-.5074+01	.13+00	-.2010+02	.45-01	-.4102+00	.17+00	-.1687+01
23	.43-01	-.5370+01	.24+00	-.2754+02	.13+00	-.4746+01	.13+00	-.3167+01	.29+00	-.2[illegible]
25	.17+00	-.2249+01	.17+00	-.1052+02	.14+00	-.3008+01	.86-01	-.3247+01	.29+00	-.1615+01
26	.17+00	-.4912+01	.17+00	-.1256+02	.14+00	-.3329+01	.19+00	-.7321+01	.29+00	-.1098+01
27	.17+00	-.1884+02	.17+00	-.1586+02	.17+00	-.2558+01	.15+00	-.8785+01	.29+00	-.1752+01
28	.69-01	-.2964+02	.24+00	-.1691+02	.17+00	-.3293+01	.17+00	-.1424+01	.29+00	-.1552+01
29	.69-01	-.2756+02	.24+00	-.1344+02	.17+00	-.3953+01	.17+00	-.2247+01	.17+00	-.9700+00
30	.60-01	-.2963+01	.24+00	-.4813+01	.17+00	-.3944+01	.49+00	-.3081+01	.23+00	-.2071+00
31	.50+00	-.5680+01	.27+00	-.1576+01	.16+00	-.7026+01	.50+00	-.3976+01	.86-01	-.3739+01
32	.17+00	-.1154+00	.17+00	-.8398-01	.17+00	-.9376-01	.17+00	-.5601+00	.17+00	-.3836-01
33	.16+00	-.3465+01	.16+00	-.2269+01	.16+00	-.1402+01	.13+00	-.1644+02	.17+00	-.2098+01
34	.13+00	-.1095+02	.27+00	-.4806+01	.16+00	-.5137+01	.53-01	-.2078+02	.17+00	-.3987+01
35	.17+00	-.2216+01	.10+00	-.5064+01	.16+00	-.4482+01	.53-01	-.8944+01	.10+00	-.1681+01
37	.11+00	-.4613+00	.11+00	-.1185+00	.12+00	-.2474-01	.71-01	-.4910+00	.10+00	-.1062-01
38	.72-01	-.1656+00	.72-01	-.5029-01	.11+00	-.1935-01	.83-01	-.1352+00	.11+00	-.4055-01
39	.11+00	-.2510+00	.12+00	-.6228-01	.11+00	-.4012-01	.97-01	-.1685+01	.12+00	-.1625-01
42	.50-01	-.2797+00	.28+00	-.3199+00	.22+00	-.2850+00	.28+00	-.4064+00	.96-01	-.1111+00
45	.10+00	-.6149+01	.10+00	-.1251+01	.28+00	-.2937+00	.28+00	-.3714+01	.16+00	-.5977+00
48	.28+00	-.6735+00	.28+00	-.1034+01	.16+00	-.5625+00	.98-01	-.4963+00	.98-01	-.3596+00
57	.91-01	-.1252+01	.21+00	-.2745+01	.16+00	-.4801+00	.54-01	-.3832+00	.21+00	-.8765+00
63	.16+00	-.1892+01	.16+00	-.4285+01	.63-01	-.2618+00	.17+00	-.8362+00	.16+00	-.1482+01
65	.16+00	-.2253+01	.16+00	-.4261+01	.16+00	-.7657+00	.13+00	-.2276+00	.16+00	-.1788+01
67	.27+00	-.1885+01	.16+00	-.2980+01	.16+00	-.2245+01	.47+00	-.1598+00	.15+00	-.1745+01
69	.22+00	-.2241+02	.13+00	-.5657+01	.16+00	-.2349+01	.22+00	-.3093+02	.16+00	-.1149+01
71	.13+00	-.4269+00	.25+00	-.1191+01	.15+00	-.3776+00	.15+00	-.2169+00	.94-01	-.1978+00
74	.27+00	-.4768+00	.25+00	-.4080+01	.15+00	-.1201+01	.13+00	-.8782+00	.94-01	-.4220+00

*For element location see Exhibit 2.

TABLE 9 MAXIMUM STRESSES IN PLATES

SECTION* NO.	MERIDIONAL** SHELL MEMBRANE (ksi)	CIRCUMFERENTIAL** SHELL MEMBRANE (ksi)	SHELL*** MEMBRANE SHEAR (ksi)
1	12.73	18.00	5.37
2	12.62	16.18	8.67
3	7.51	6.20	1.80
4	7.24	5.35	6.55

* For Section Number see Exhibit 3.

** Allowable Shell Membrane Force = 47.5 ksi

*** Allowable Shell Membrane Shear = 27.42 ksi

TABLE 10 MAXIMUM STRESSES IN WELDS

SECTION* NUMBER	ACTUAL VALUES			ALLOWABLE VALUES		
	TENSION (ksi)	COMPRESSION (ksi)	SHEAR (ksi)	ALLOWABLE TENSION (ksi)	ALLOWABLE COMPRESSION (ksi)	ALLOWABLE SHEAR (ksi)
1**	17.84	-27.00	8.06	33.6	-47.5	27.42
2	16.18	-8.77	8.67	47.5	-47.5	27.42
3	7.51	-6.62	1.80	47.5	-47.5	27.42
4**	10.86	-1.86	9.83	33.6	-41.5	27.42

* For Section Number See Exhibit 3.

**Partial Penetration Welds

TABLE 11 MAXIMUM STRESSES IN COLUMNS

SECTION NUMBER*	MAXIMUM STRESS** (ksi)
1	18.61
2	9.83
3	1.97
4	2.06

*For Section Number See Exhibit 3.
**Allowable Combined Axial and Bending Stress = 47.5 ksi

TABLE 12 MAXIMUM SHEAR STRESSES IN CONCRETE FILL IN SACRIFICIAL SHIELD

SECTION NUMBER*	MAXIMUM SHEAR STRESS** (PSI)
1	135.29
2	104.24
3	34.20

*For Section Number See Exhibit 3.
**Allowable Shear Stress = 154.9 psi

TABLE 13 SUMMARY OF MAXIMUM STRESSES AT DESIGN SECTIONS OF PEDESTAL (MERIDIONAL DIRECTION)

Section Number**	Elevation	ACTUAL VALUES*			ALLOWABLE VALUES		
		Reinforcing Steel (ksi)	Concrete (ksi)	Transverse Shear (k/ft)	Reinforcing Steel (ksi)	Concrete (ksi)	Transverse Shear (k/ft)
1	571'-5" (Base)	35.6	0.7	55.7	54.0	3.4	58.9
2	578'-5"	36.1	0.6	52.2	54.0	3.4	58.9
3	589'-5"	44.9	0.8	46.0	54.0	3.4	58.9
4	592'-5"	50.5	0.7	52.2	54.0	3.4	78.2
5	597'-3" (Top)	37.2	0.4	68.6	54.0	3.4	82.0

*Stresses in reinforcement are tensile stresses and stresses in concrete are compressive membrane plus flexural stresses.

**For Section Location See Exhibit 4.

TABLE 14 SUMMARY OF MAXIMUM STRESSES AT DESIGN SECTIONS OF PEDESTAL (HOOP DIRECTION)

Section Number**	Elevation	ACTUAL VALUES*			ALLOWABLE VALUES		
		Reinforcing Steel (KSI)	Concrete (KSI)	Transverse Shear (K/FT)	Reinforcing Steel (KSI)	Concrete (KSI)	Transverse Shear (K/FT)
1	571'-5" (Base)	32.0	0.2	1.1	54.0	3.4	57.0
2	578'-5"	34.0	0.3	0.3	54.0	3.4	57.0
3	589'-5"	33.4	0.4	1.6	54.0	3.4	57.0
4	592'-5"	42.2	0.3	2.6	54.0	3.4	76.4
5	597'-3" (Top)	28.4	0.5	3.7	54.0	3.4	80.2

*Stresses in reinforcement are tensile stresses and stresses in concrete are compressive membrane plus flexural stresses.

**For section location see Exhibit 4.

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TABLE 14
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TABLE 15 SUMMARY OF MAXIMUM FORCES IN ANCHOR BOLTS

	ACTUAL VALUES			ALLOWABLE VALUES		
	TENSION (ksi)	COMBINED TENSION & SHEAR (ksi)	SHEAR (ksi)	TENSION (ksi)	COMBINED TENSION & SHEAR (ksi)	SHEAR (ksi)
RPV	16.10	16.10	27.56	60.72	40.50	40.48
SACRIFICIAL SHIELD	34.5	34.5	24.97	60.72	44.16	40.48

(1) Maximum Value Occurs in 2-3/4" Ø Bolt.

(2) These values are based on the RPV skirt loads given in the FSAR Section 3.9.1.5 (Ref. 5).

EXHIBITS

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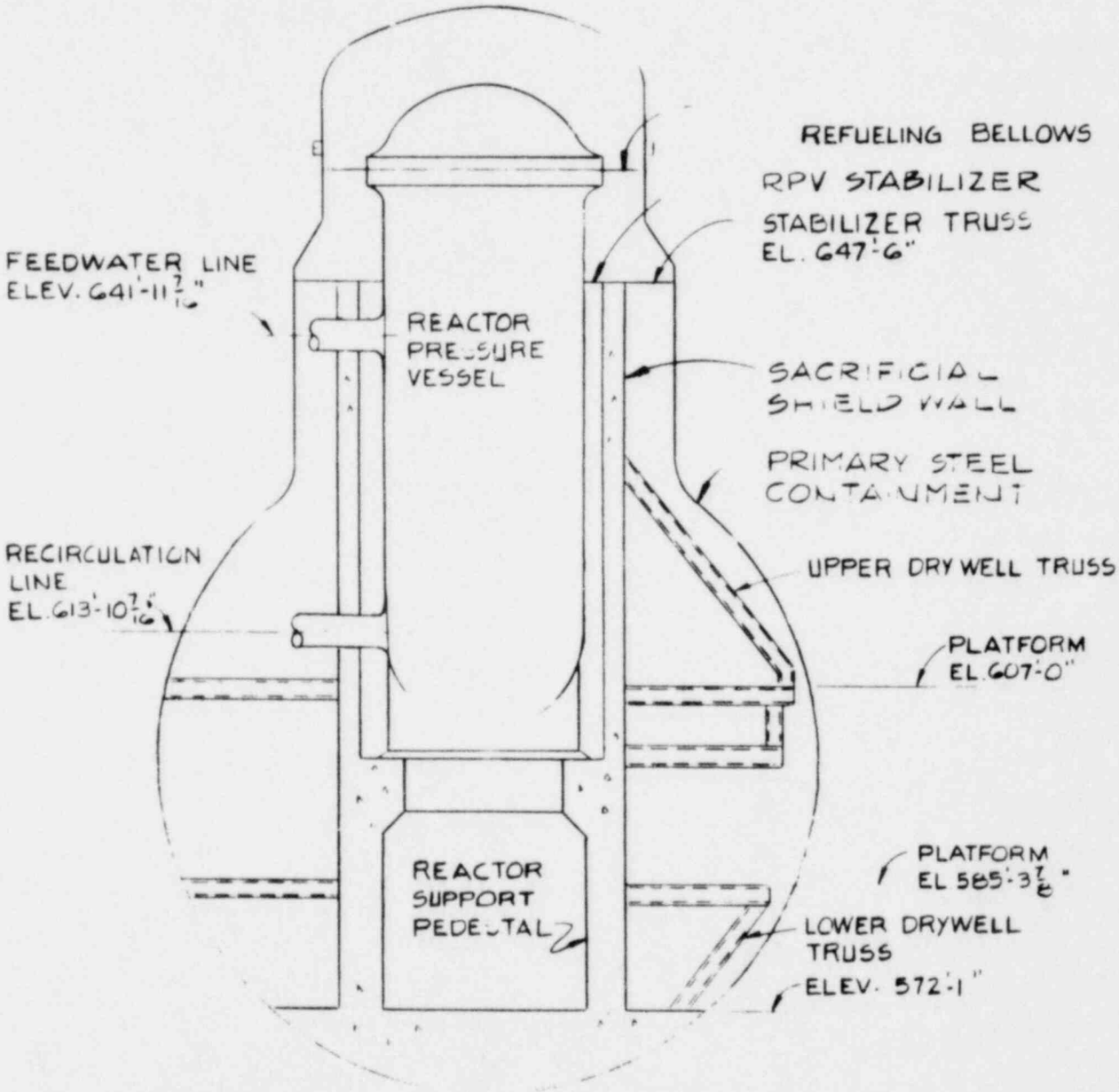
EXHIBIT 1
SL—3647
5—26—78



SECTION THROUGH CENTERLINE OF DRYWELL

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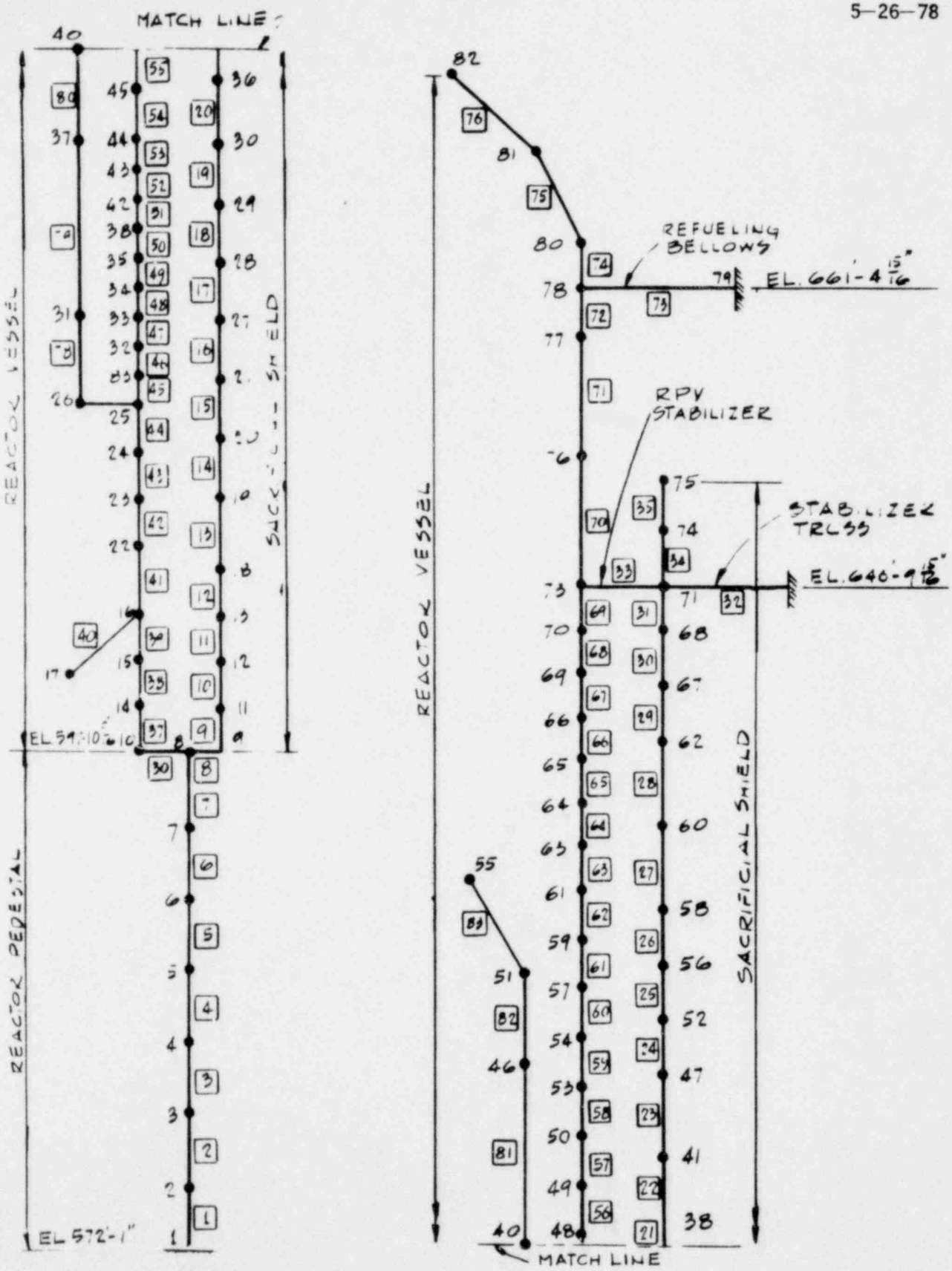
EXHIBIT 2
SL—3647
5—26—78



ANNULUS PRESSURIZATION MATHEMATICAL MODEL

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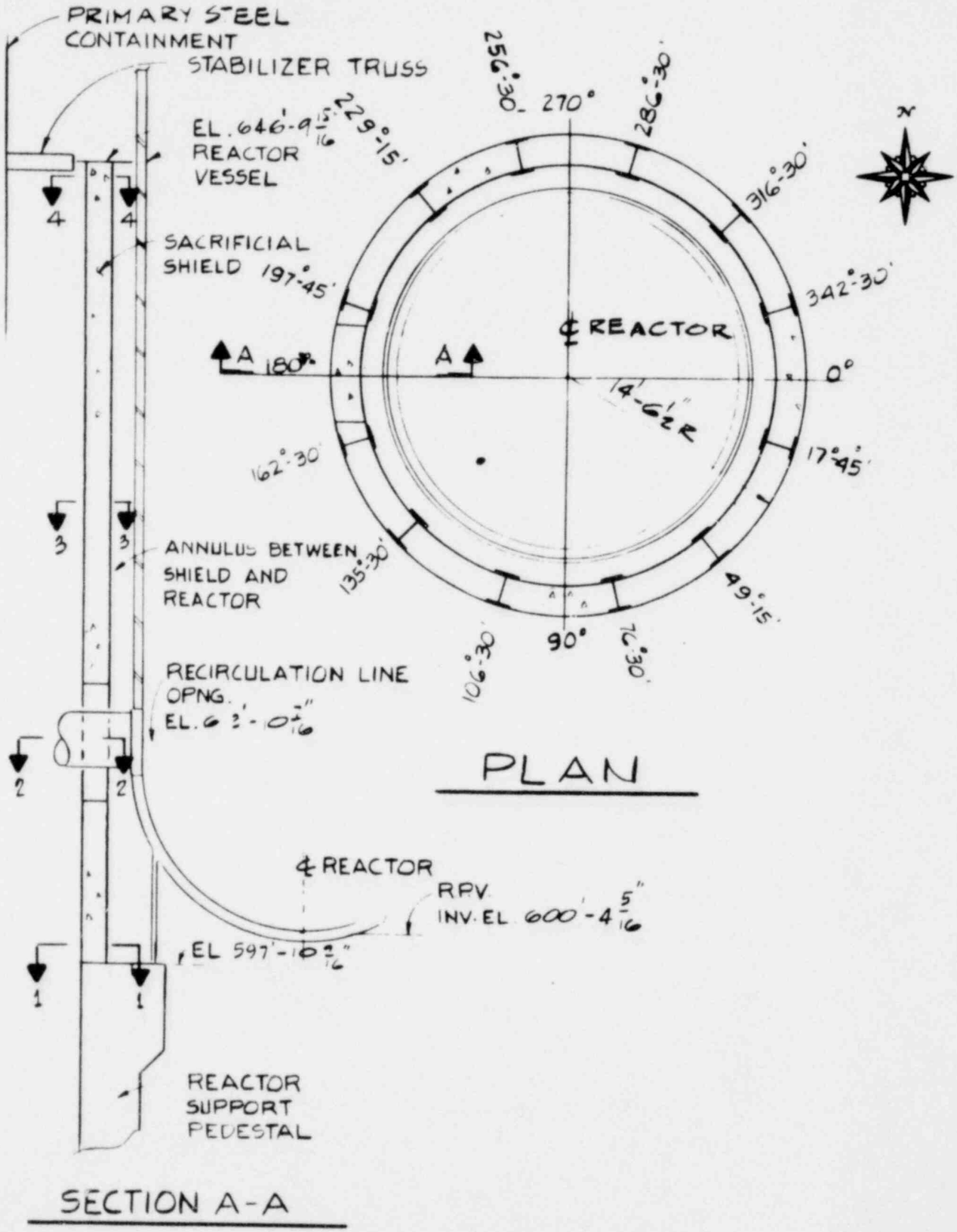
EXHIBIT 3
SL—3647
5—26—78



SACRIFICIAL SHIELD

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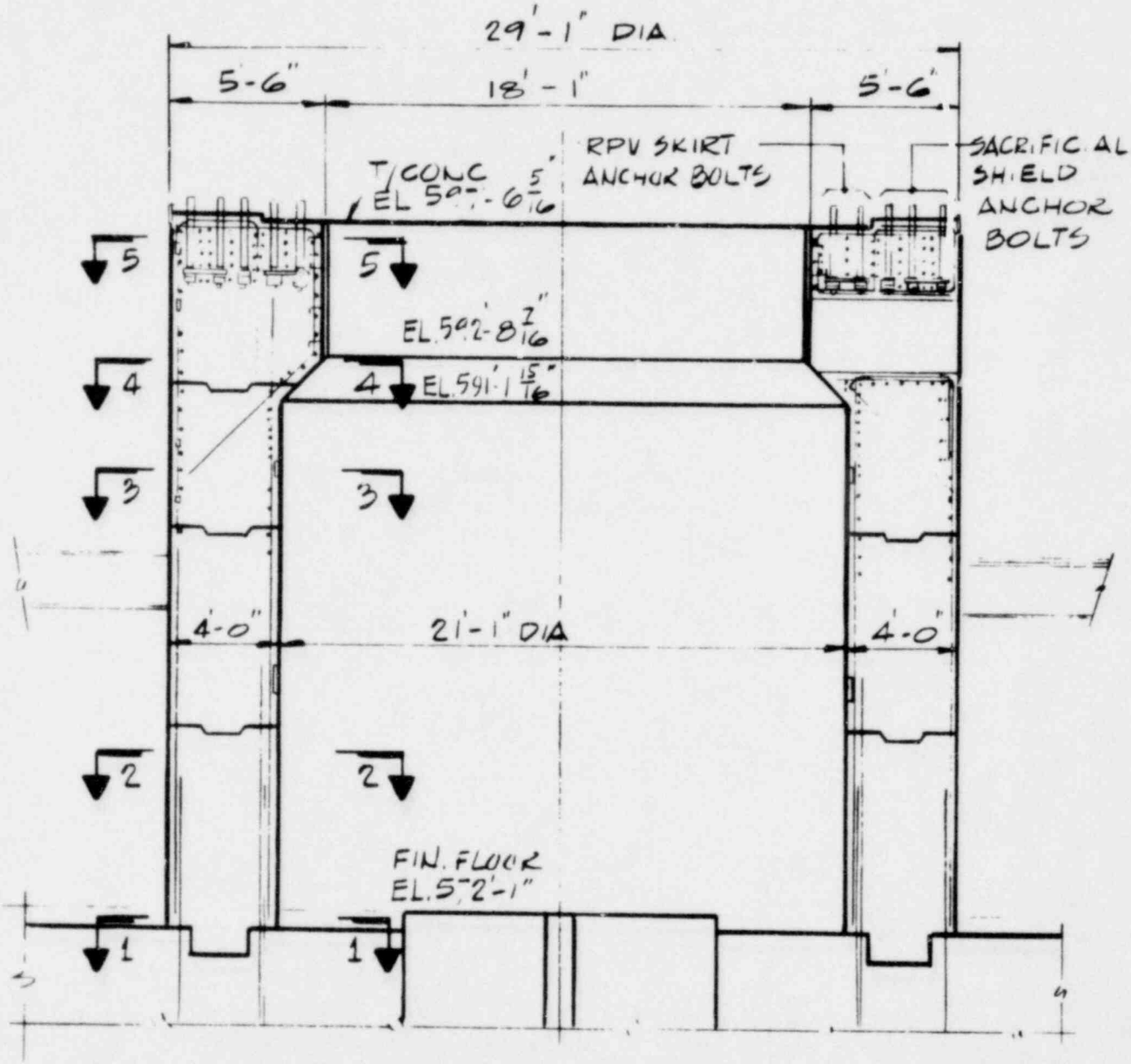
EXHIBIT 4
SL—3647
5—26—78



SECTION

REACTOR PEDESTAL

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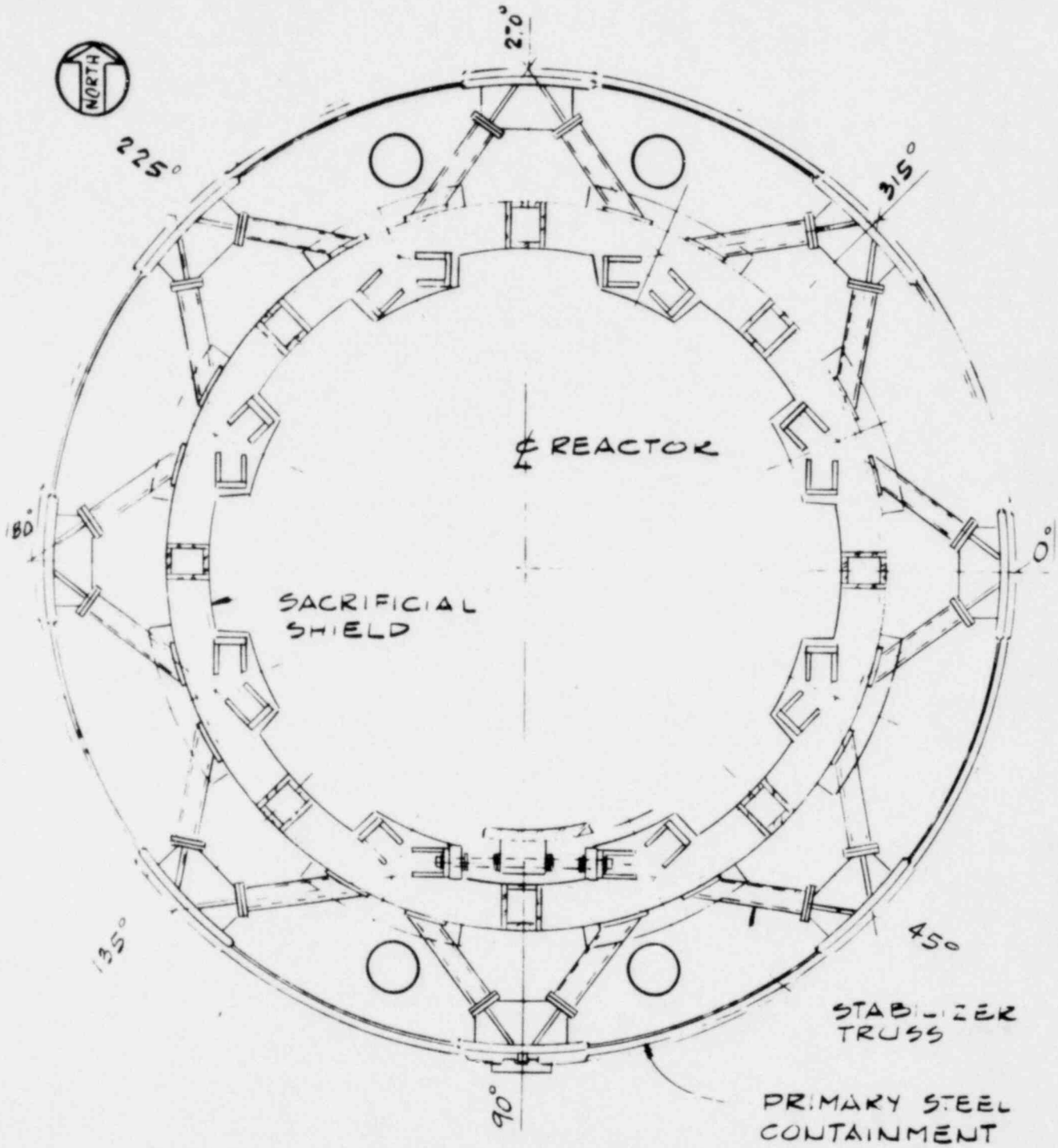
EXHIBIT 5
SL-3647
5-26-78



FRAMING PLAN

STABILIZER TRUSS

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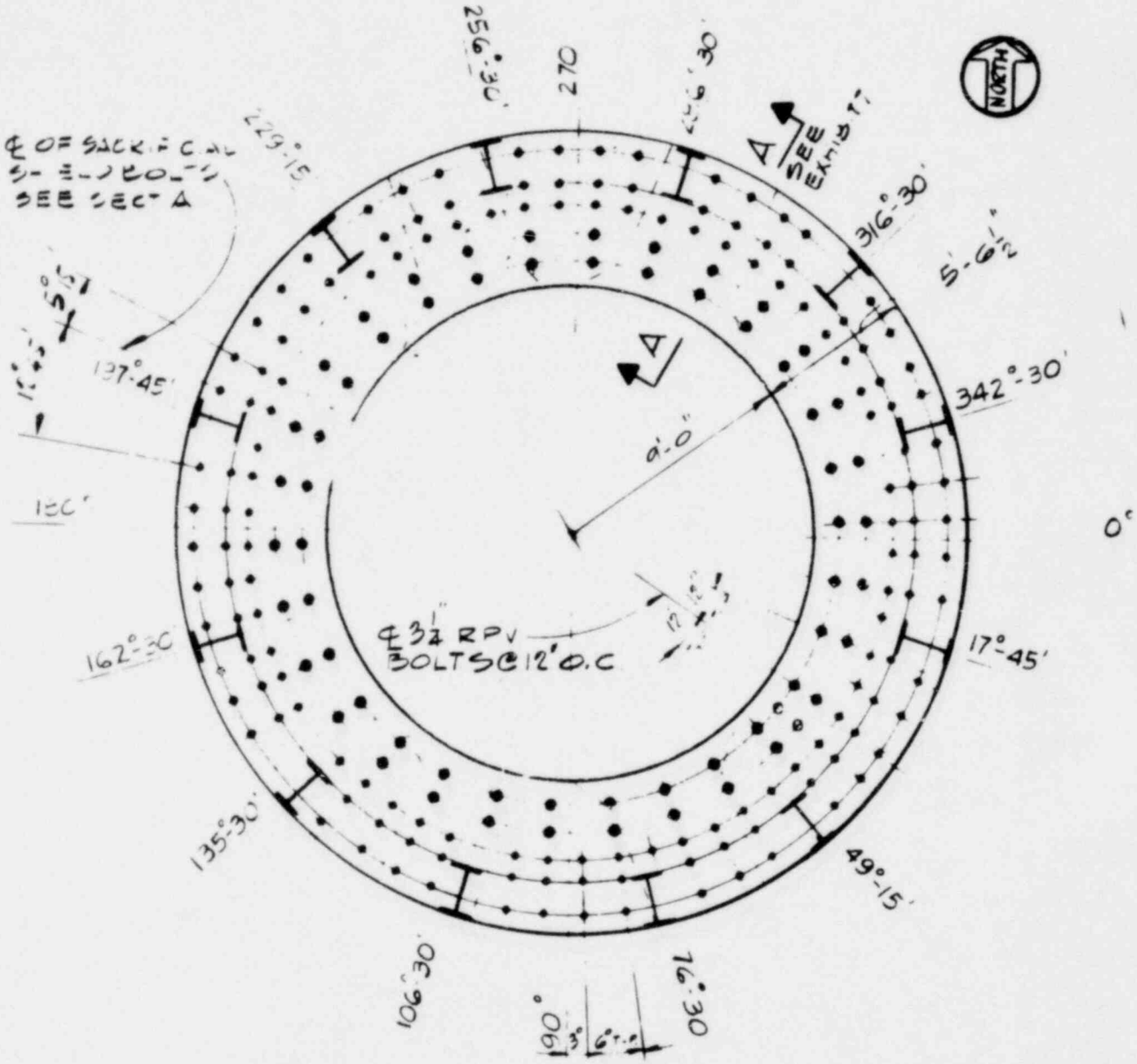
EXHIBIT 6
SL-3647
5-26-78



PLAN AT EL 597'-10 9/16"

ANCHOR BOLT LAYOUT

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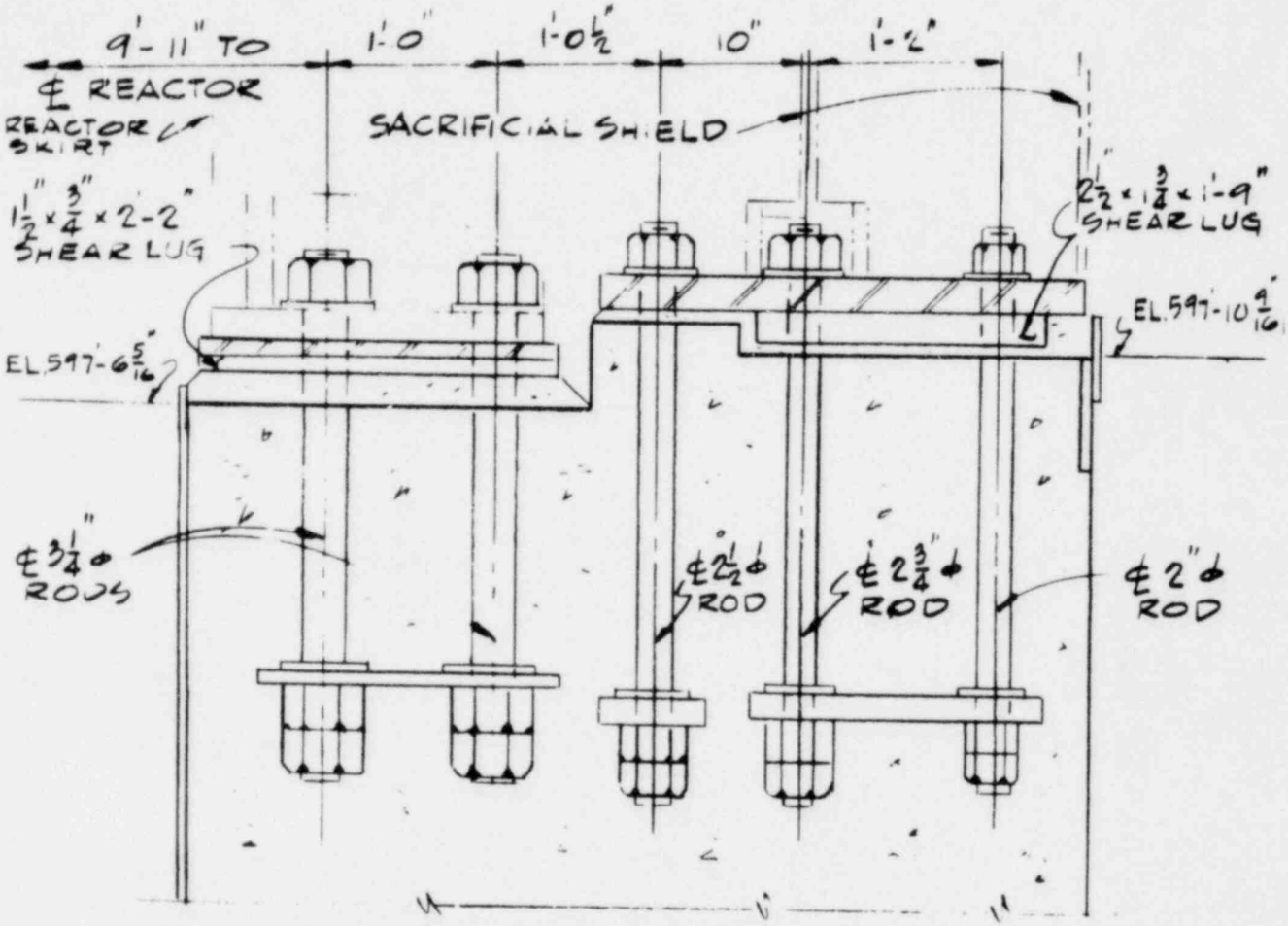
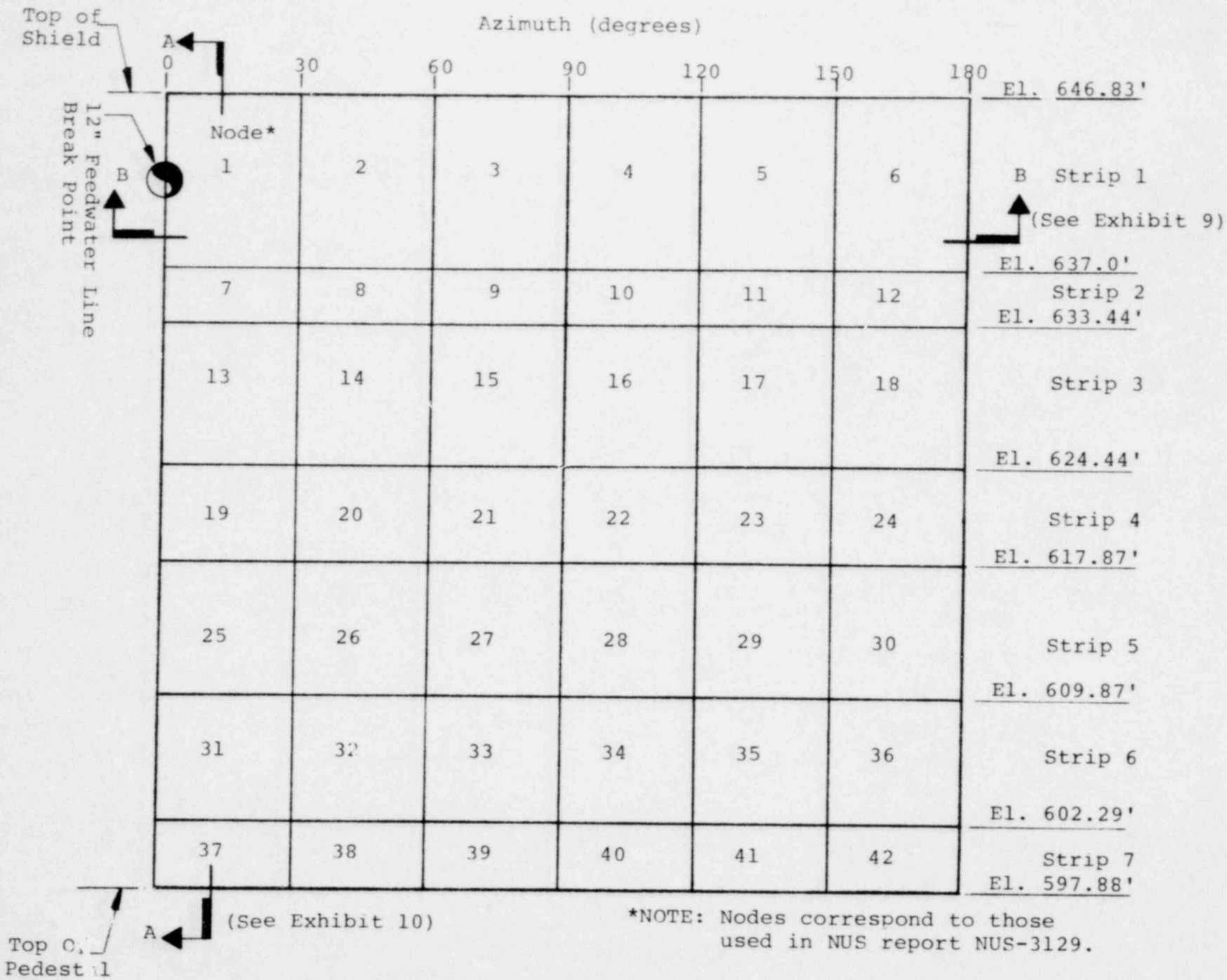
EXHIBIT 7
SL—3647
5--26—78



SECTION A-A

ANCHOR BOLT DETAIL



*NOTE: Nodes correspond to those used in NUS report NUS-3129.

LOAD NODE POINTS ON SACRIFICIAL SHIELD

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REV. 1, 3-22-79

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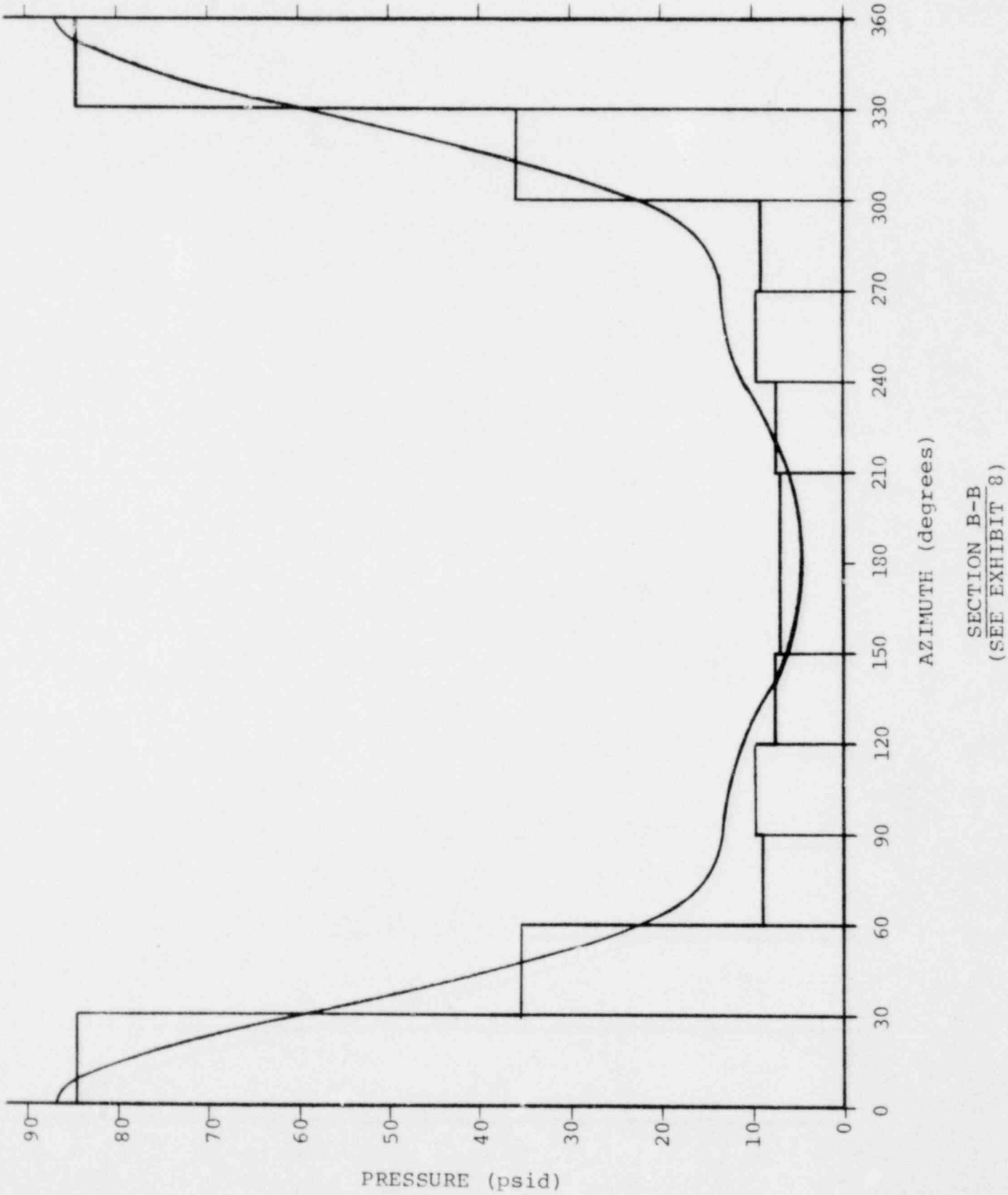
EXHIBIT 9
SL-3647
REV. 1, 3-22-79



PRESSURE DISTRIBUTION IN STRIP 1

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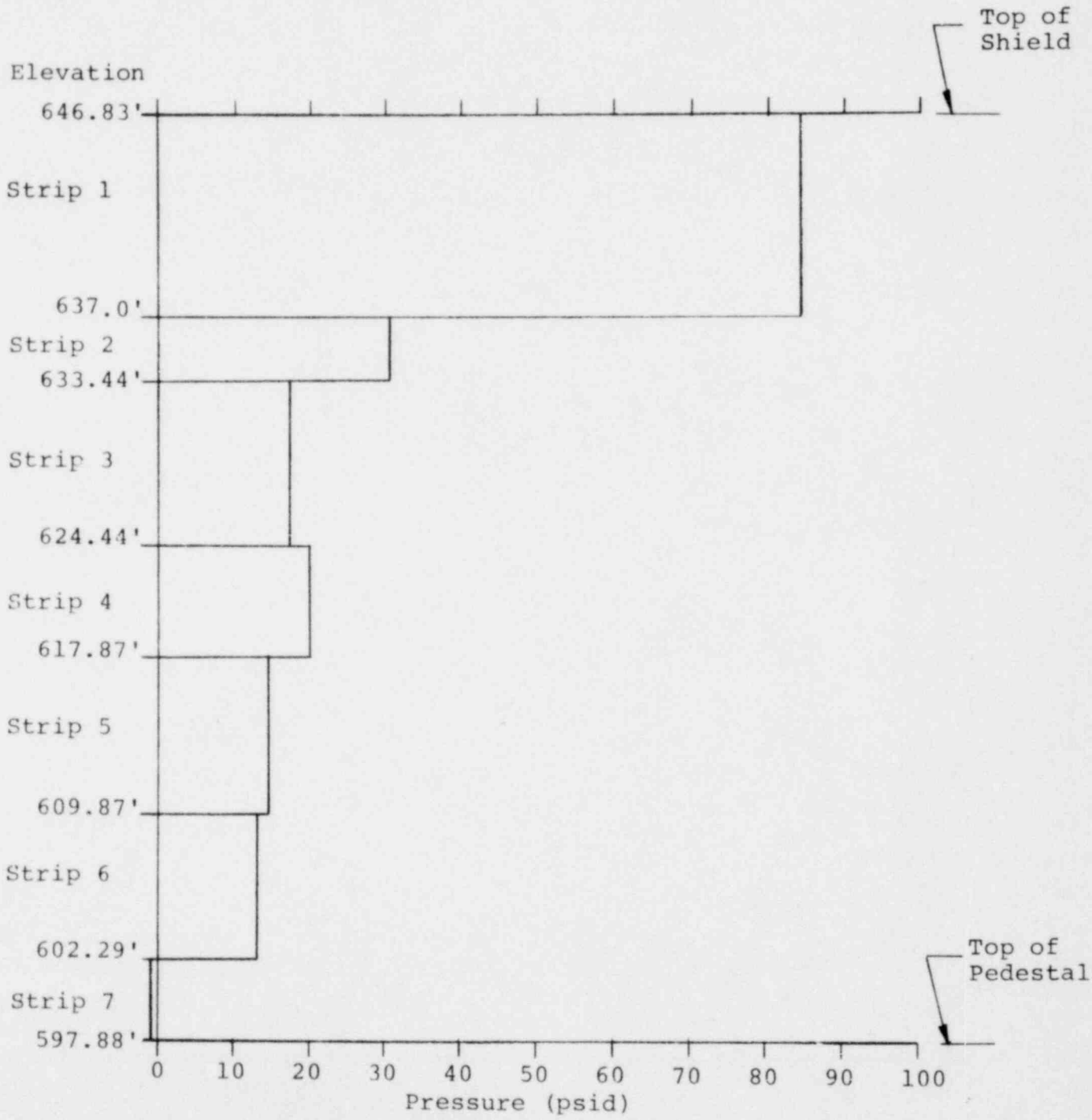
EXHIBIT 10
SL-3647
REV. 1, 3-22-79



SECTION A-A
(See Exhibit 8)

VERTICAL DISTRIBUTION OF PRESSURE ± 30°

APPENDIX A

COMPUTER PROGRAMS

DYNAX

DYNAX (Dynamic Analysis of Axisymmetric Structures) is a finite element program capable of performing both static and dynamic analyses of axisymmetric structures. Its formulation is based on a small displacement theory.

Three types of finite elements are available: quadrilateral, triangular, and shell. The geometry of the structure can be general as long as it is axisymmetric. Both the isotropic and orthotropic elastic material properties can be modeled. Discrete and distributed springs are available for modeling elastic foundations, etc.

For static analysis, input loads can be structure weight, nodal forces, nodal displacements, distributed loads, or temperatures. Loads can be axisymmetric or nonaxisymmetric. For the solids of revolution, the program outputs nodal displacements and element nodal point stresses in the global system (radial, circumferential, and axial). In the case of shells of revolution, the output consists of nodal displacements and element and nodal point shell forces in a shell coordinate system (meridional, circumferential, and normal).

For dynamic analysis, three methods are available: direct integration method, modal superposition method, and response spectrum method. In the case of dynamic analysis by direct integration method or modal superposition method, a forcing function can be input as: 1) nodal force components versus time for any number of nodes, or 2) vertical or horizontal ground acceleration versus time. For nonaxisymmetric loads the equivalent Fourier expansion is used. In the case of dynamic analysis by response spectrum method, spectral velocity versus natural frequency for up to four damping constants is input. The output of dynamic analysis is in terms of nodal displacements, element stresses, and resultant forces and moments at specified time steps. When the modal superposition method is used, and in the case of earthquake response analysis, the requested number of frequencies and mode shapes is computed and printed together with the cumulative response of all the specified modes, as computed by the root sum square (RSS) method and the absolute sum method.

DYNAX was originally developed under the acronym ASHAD by S. Ghosh and E. L. Wilson of the University of California, Berkeley in 1969. It was acquired by Sargent & Lundy in 1972 and is operating under EXEC 8 on a UNIVAC 1106.

TEMCO

TEMCO (Reinforced Concrete Sections Under Eccentric Loads and Thermal Gradients) analyzes reinforced concrete sections subject to separate or combined action of eccentric loads and thermal gradients. The effect of temperature is induced in the section by reactions created by the curvature restraint.

The analysis may be done assuming either a cracked or an uncracked section. Material properties can be assumed to be either linear or nonlinear. The program is capable of handling rectangular as well as nonrectangular sections.

The program input consists of section dimensions, areas and location of each layer of reinforcing steel, loads, load combinations and material properties.

The curvature and axial strain corresponding to the given eccentric loads (axial load and bending moments) are determined by an iterative procedure. Thermal gradient is applied on the section by inducing reactions created by the curvature restraints, i.e., there is no curvature change due to a thermal gradient on the section. The axial expansion is assumed to be free after thermal gradient is applied. An iterative procedure is completed again for finding the final strain distribution such that equilibrium of internal and external loads is satisfied.

The program output consists of the echo of input, combined loads, final location of neutral axis, final stresses in steel and concrete and final internal forces. Similar intermediate results (before thermal gradient is applied) can also be output if desired.

The program has applications to a wide variety of reinforced concrete beams and columns, slabs, and containment structures, subject to various combinations of external loads and thermal gradients.

The program was developed and is maintained by Sargent & Lundy. Since February 1972, the program has been used extensively at Sargent & Lundy on UNIVAC 1106 hardware operating under EXEC 8.

FORANL

FORANL (Fourier Analysis Postprocessor) provides methods of performing an approximate Fourier Analysis along each strip of spatial arrangement of the nodal pressure values.

The Fourier Analysis is performed by the histogram numerical method or by a linear interpolation of the pressure values between node centers.

The output consists of a data file for each strip analyzed as well as printer output which echoes the data and lists the computed values stored in the generated data files. Maximum and minimum Fourier coefficients and the time they occur are also listed.

The FORANL program was originally developed by Sargent & Lundy in 1976. The program is currently maintained on a UNIVAC 1106 operating under EXEC 8.

APPENDIX B

DEFINITIONS OF LOAD COMBINATION CATEGORIES

Abnormal/Severe Environmental Category

This category includes combinations that result from the postulated combined occurrence of abnormal and severe environmental effects when the occurrence of a specified Severe Environmental Category load condition at the plant site imposes effects that significantly increase the probability of the occurrence of Abnormal Category load conditions or when the specified Abnormal or Severe Environmental Category load condition is of such extended duration that a significant probability exists that loads in these two aforementioned categories will occur simultaneously.

Abnormal/Extreme Environmental Category

This category includes combinations that result from the postulated combined occurrence of abnormal and extreme environmental effects when the occurrence of a specific Extreme Environmental Category load condition at the plant site imposes effects that significantly increase the probability of the occurrence of Abnormal Category load conditions or when the specified Abnormal or Extreme Environmental Category load condition is of such extended duration that a significant probability exists that loads in these two aforementioned categories will occur simultaneously.

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