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FROM: Indiana & Michigan Power Co.
New York, N. Y. 10004
John Tillinghast

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DESCRIPTION

2p

ENCLOSURE

Consists of detailed information on the steam generator and reactor coolant pump support materials and evaluation of the fracture toughness and potential for lamellar tearing of the support materials...w/att mill certifications and support drawings

43p + 1-1/4"

see drawings

PLANT NAME: COOK UNITS 1 & 2
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FOR ACTION/INFORMATION

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November 23, 1977

Donald C. Cook Nuclear Plant Unit Nos. 1 & 2
Docket Nos. 50-315 & 50-316
DPR No. 58 and CPPR No. 61

Mr. Edson G. Case, Acting Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Case:

Mr. Don K. Davis, Acting Chief of Operating Reactors Branch #2, in his September 14, 1977 letter to us, requested that we supply detailed information on the steam generator and reactor coolant pump support materials and our own evaluation of the fracture toughness and potential for lamellar tearing of the support materials. Attachment I is our response to the above request. Specifications for detailing, fabrication and delivery of equipment supports are given in Attachment II. Attachment III and Attachment IV present mill certifications and support drawings respectively.

Please note that ASTM-A572-70a material was not used in the fabrication of the steam generator and reactor coolant pump supports. The materials used were ASTM-A36, and A588. We required the use of A-588 material for more critical members. A-588 requires fine grain practices for improved toughness. Impact tests of both A-36 and A-588 were specified to assure that good toughness was obtained.

773570136

Based on the through thickness mechanical tests that were required by our specification, the material would have a low propensity to lamellar tearing. If any cracks developed due to welding stress during fabrication, these materials with their good toughness would have a low probability that cracks would propagate. As can be seen from the Attachments, we have adequately designed and used material that will not be subject to lamellar tearing.

Very truly yours,

John Tillinghast

JT:mg

Sworn and subscribed to before
me on this day of November
1977 in New York County, New York

____
Notary Public

cc: R. C. Callen
G. Charnoff
P. W. Steketee
R. J. Vollen
R. Walsh
R. W. Jurgensen
D. V. Shaller - Bridgman

ATTACHMENT – I

Table of Contents

Question 1:

Provide engineering drawings of the steam generator and the reactor coolant pump supports sufficient to show the geometry of all principal elements. Provide a listing of materials of construction.

Answer:

Attachment IV is a set of engineering drawings of the D.C. Cook NSSS. The materials used in construction are shown with numbers on these drawings. These numbers are identified as per the ASTM specification number, yield point, material thickness group, and the testing required and are summarized in Table M9-1 of attachment II.

QUESTION 2:

Specify the detailed design loads used in the analysis and design of the supports. For each loading condition (normal, upset, emergency and faulted), provide the calculated maximum stress in each principal elements of the support system and the corresponding allowable stresses.

ANSWER:

The detailed design loads as provided by Westinghouse for the steam generator in report SD104 are given in the first 13 tables. Member stress levels expressed as a percentage of the allowable stress for the upper and lower supports are provided in tables 14 and 15. Figures 1 and 2 are provided to identify the elements of the steam generator supports. The loads for the Reactor Coolant pump supports are provided in tables 16 through 26. Tables 18 through 26 include both the loads and the margin of safety under the faulted condition for the R.C. Pump supports. Figure 3 is provided to identify the members. Stress levels for the R.C. Pump supports for the load cases normal, upset and emergency are provided in Table 27. Figure 3 identifies the elements for Table 27. The allowable stresses for each load condition and a description of the loading conditions themselves are provided in the following paragraphs.

Normal Condition

Thermal, weight, and pressure forces obtained from the RCL analysis acting on the support structures are combined algebraically. The combined load component vector is multiplied by member influence coefficient matrices to obtain all force components at each end of each member. The interaction equations of AISC-69 are used with allowable specified limits.

Upset Condition

OBE support forces are assigned all possible sign combinations and, in each case, are added algebraically to normal condition forces. The interaction and stress equations of AISC-69 are used with allowable specified limits.

Emergency Condition

DBE loads are assigned all possible sign combinations, combined with normal loads, and are used in the above stress and interaction equations. For this loading condition, limiting values of 1.5 times allowables are used. This limit represents a stress of about 0.9 yield and provides a margin against buckling from 10 percent for short stocky members whose buckling mode is highly inelastic to a margin of 30 percent for members that buckle elastically.

Faulted Condition - Elastic

LOCA support structure loads are obtained in time-history form and are combined with emergency condition loads. Stress and interaction equations are solved for each time step within the time-history.

The interaction equations of AISC-69 are adjusted such that stresses in the support are limited to yield with the exception of the reactor coolant pump supports. Pump support members subjected to both compressive and tensile loads are controlled by deflection criteria associated with member failure.

The LOCA (loss of coolant accident) breaks referenced in the following tables are defined as follows:

a. UH - Unbroken loop time-history dynamic analysis due to DEC LOCA in the hot leg.

b. HL - DEC LOCA at the center of the straight run of the hot leg.

c. SI - DEC LOCA at the steam-generator inlet nozzle.

d. SGO - DEC LOCA at the steam-generator outlet nozzle.

e. XLHR - DEC LOCA at the center of the horizontal straight run of the crossover leg.

f. PIB - DEC LOCA at the reactor-coolant-pump suction.

g. CL - DEC LOCA at the center of the straight run of the cold leg.

h. S1 - SEL LOCA at center of steam-generator outlet elbow (forces toward RV)

i. S2 - Same as h, except force away from RV.

j. UC - Unbroken loop time-history dynamic analysis due to DEC LOCA in cold leg.

k. SL - Steam-line break DE. Note that the steam-line break is not truly a LOCA; however, it was run to determine its effect on the RCL and because it is the controlling load for the SG upper support.

Where a double ended circumferential break is abbreviated DEC and a single ended longitudinal is abbreviated SEL.

In all cases the faulted condition controls the design. The maximum stress level found for the faulted condition for the steam generator lower lateral support was 84% of the maximum

permissible. The steam generator upper lateral support is stressed to 85.1% of the maximum permissible under the faulted condition. The reactor coolant pump supports were modeled as nonlinear elastic-plastic elements and thus the failure criterion is deflection. The maximum allowable deflection is determined from deflection criteria associated with failure and to maintain the RCL piping system within its faulted limits. The margin of safety for these supports is defined as:

$$\text{margin of safety} = 1 - \frac{\text{maximum deflection}}{\text{maximum allowable deflection}}$$

The minimum margin of safety obtained in the analysis was 0.5.

TABLE 1

PRIMARY EQUIPMENT SUPPORT STRUCTURE LOADS
(THERMAL, PRESSURE, DEADWEIGHT, SEISMIC)

Equipment and Position	F_x (kips)	F_y (kips)	F_z (kips)	M_x (in.-kips)	M_y (in.-kips)	M_z (in.-kips)
Thermal						
*Steam Generator (Lower)	0	11.66	0	2019.7	0	32811.5
Steam Generator (Upper)	0	0	0	0	0	0
Reactor Coolant Pump	0	-20.98	0	422.9	0	7812.0
Pressure						
*Steam Generator (Lower)	0	24.57	0	990.2	0	-5478.0
Steam Generator (Upper)	0	0	0	0	0	0
Reactor Coolant Pump	0	-17.28	0	3242.9	0	4884.6
Deadweight						
*Steam Generator (Lower)	0	-657.9	0	-1061.8	0	-632.8
Steam Generator (Upper)	0	0	0	0	0	0
Reactor Coolant Pump	0	-210.8	0	438.3	0	-371.7

TABLE 1 (Continued)

PRIMARY EQUIPMENT SUPPORT STRUCTURE LOADS
(THERMAL, PRESSURE, DEADWEIGHT, SEISMIC)

Operational Basis Earthquake (OBE) Equipment and Position	F_x (kips)	F_y (kips)	F_z (kips)	M_x (in.-kips)	M_y (in.-kips)	M_z (in.-kips)
*Steam Generator (Lower)	56.65	205.53	140.19	1050.1	2351.3	2016.1
+Steam Generator (Upper)	236.13	0	194.09	0	0	0
RCP (See Table 16)						
Design Basis Earthquake						
*Steam Generator (Lower)	95.39	286.69	236.05	1797.8	3574.5	3480.7
+Steam Generator (Upper)	409.60	0	342.63	0	0	0
RCP (See Table 16)						

These OBE and DBE loads act in both positive and negative directions.

+These forces are applied to the steam generator upper lateral support model according to the shell-band interface cases defined in Figure 2.

*These loads are applied to node 13 of the model shown in Figure 1.

TABLE 2

STEAM GENERATOR
BLOWDOWN UNBROKEN (HLB)** (UH)*
LOWER GLOBAL FORCES+

Force (kips)	Sec after Transient
f(x) max = 33.2199	.424500
f(x) min = -50.6857	.453500
f(y) max = 645.898	.136500
f(y) min = -606.747	.109500
f(z) max = 125.449	.453500
f(z) min = - 82.2049	.424500
Moment (in-k)	
m(x) max = 3284.21	.490000
m(x) min = -2601.65	.457500
m(y) max = 4317.14	.449500
m(y) min = -3161.66	.364500
m(z) max = 1257.57	.350000
m(z) min - -6366.94	.492500

*For notation, see page 4.

+These loads are applied to node 13 of the model shown in Figure 1.

**Defines break in opposite loop hot leg.

TABLE 3

STEAM GENERATOR
BLOWDOWN HOT LEG BREAK (HL)
LOWER GLOBAL FORCES+

Force (kips)	Sec after Transient
f(x) max = -1.777105E-05*	0.
f(x) min = -1630.48	.103500
f(y) max = 728.984	2.450000E-02
f(y) min = -1177.12	4.850000E-02
f(z) max = 3.737491E-03	5.000000E-04
f(z) min = -857.633	8.550000E-02
Moment (in-k)	
m(x) max = 15391.6	.229500
m(x) min = -7337.14	.413500
m(y) max = 5083.47	.466000
m(y) min = -20132.3	5.550000E-02
m(z) max = -5427.96	0.
m(z) min = -27208.5	3.800000E-02

*Computer notation, E ± xx, used in this and following tables, means the number preceding the E, times 10 to the power of the xx number following the E (exponent).

+These loads are applied to node 13 of the model shown in Figure 1.

TABLE 4

STEAM GENERATOR
BLOWDOWN STEAM GEN INLET (SI)
LOWER GLOBAL FORCES+

Force (kips)	Sec after Transient
f(x) max = -1.777107E-05	0.
f(x) min = -837.034	.367000
f(y) max = 2232.01	.491500
f(y) min = -877.222	4.550000E-02
f(z) max = 165.774	6.650000E-02
f(z) min = -539.380	.300500
Moment (in-k)	
m(x) max = 10800.6	.228500
m(x) min = -6183.59	.197500
m(y) max = 18284.5	.178000
m(y) min = -23408.1	.160500
m(z) max = 4276.82	.200500
m(z) min = -15688.8	.233000

*These loads are applied to node 13 of the model shown in Figure 1.

TABLE 5

STEAM GENERATOR
BLOWDOWN STEAM GEN OUTLET BREAK*
LOWER GLOBAL FORCES+

Force (kips)	Sec after Transient
f(x) max = 73.0130	4.650000E-02
f(x) min = -347.176	2.100000E-02
f(y) max = 2822.90	7.850000E-02
f(y) min = -1864.35	5.000000E-02
f(z) max = 859.139	2.100000E-02
f(z) min = -180.680	4.650000E-02
Moment (in-k)	
m(x) max = 8309.46	3.350000E-02
m(x) min = -1492.11	6.600000E-02
m(y) max = 7564.15	7.050000E-02
m(y) min = -4530.87	4.750000E-02
m(z) max = -310.483	.177000
m(z) min = -13225.8	.208000

*Supports Seismically Compensated. The "seismically compensated" notation accounts for the seismic load on the support by shifting the axis of the load-deflection curve. The zero point on the load axis is redefined as the seismic load, and zero point on the deflection axis is redefined as the equivalent elastic deflection of the seismic load.

+These loads are applied to node 13 of the model shown in Figure 1.

TABLE 6

STEAM GENERATOR
BLOWDOWN PUMP INLET BREAK
LOWER GLOBAL FORCES*

Force (kips)	Sec after Transient
f(x) max = 106.492	5.700000E-02
f(x) min = -239.636	3.550000E-02
f(y) max = 2245.81	2.950000E-02
f(y) min = -1855.47	5.750000E-02
f(z) max = 593.022	3.550000E-02
f(z) min = -263.518	5.700000E-02
m(x) max = 4311.32	2.300000E-02
m(x) min = -2203.27	.168500
m(y) max = 28419.8	.133500
m(y) min = -18722.0	.114500
m(z) max = 3615.46	.126000
m(z) min = -16481.7	3.600000E-02

*These loads are applied to node 13 of the model shown in Figure 1.

TABLE 7

STEAM GENERATOR
BLOWDOWN COLD LEG BREAK (CL)
LOWER GLOBAL FORCES*

Force (kips)	Sec after Transient
f(x) max = 33.2430	.402000
f(x) min = -41.3760	.307000
f(y) max = 790.901	3.150000E-02
f(y) min = -675.064	5.550000E-02
f(z) max = 102.241	.307000
f(z) min = -82.2925	.402000
Moment (in-k)	
m(x) max = 5600.41	3.800000E-02
m(x) min = -3265.61	7.100000E-02
m(y) max = 24784.6	.358500
m(y) min = -17885.5	.340500
m(z) max = 1053.12	.245000
m(z) min - -10041.0	.219000

*These loads are applied to node 13 of the model shown in Figure 1.

TABLE 8

STEAM GENERATOR
BLOWDOWN (XLHR)
LOWER GLOBAL FORCES*

Force (kips)	Sec after Transient
f(x) max = 3.18927	4.500000E-03
f(x) min = -230.700	.132500
f(y) max = 2871.19	7.200000E-02
f(y) min - -1456.62	4.350000E-02
f(z) max = 570.911	.182500
f(z) min = -7.89392	4.500000E-03
Moment (in-k)	
m(x) max = 4426.78	2.900000E-02
m(x) min = -1463.19	5.750000E-02
m(y) max = 26862.2	8.050000E-02
m(y) min = -5742.71	9.750000E-02
m(z) max = -2295.56	.173000
m(z) min = -17477.8	.203000

*These loads are applied to node 13 of the model shown in Figure 1.

TABLE 9

STEAM GENERATOR
BLOWDOWN UNBROKEN (CLB)** (UC)
LOWER GLOBAL FORCES*

Force (kips)	Sec after Transient
f(x) max = 41.8566	.409500
f(x) min = -50.3932	.239500
f(y) max = 360.556	.156000
f(y) min = -334.495	.198000
f(z) max = 124.725	.239500
f(z) min = -103.580	.409500
Moment (in-k)	
m(x) max = 4626.59	.112000
m(x) min = -3708.69	.250000
m(y) max = 3463.28	.364500
m(y) min = -3291.89	.411000
m(z) max = -589.657	.261000
m(z) min = -7249.29	.398500

*These loads are applied to node 13 of the model shown in Figure 1.

**Defines break in opposite loop cold leg.

TABLE 10

STEAM GENERATOR
BLOWDOWN SPLIT 1 SGOE (S1)
LOWER GLOBAL FORCES*

Force (kips)	Sec after Transient
f(x) max = 188.406	.000000E-02
f(x) min = -.217394	.500000E-03
f(y) max = 2429.24	.202500
f(y) min = -2243.43	.173500
f(z) max = .538015	.500000E-03
f(z) min = -466.394	.000000E-02
Moment (in-k)	
m(x) max = 13003.0	.500000E-02
m(x) min = -3365.22	.600000E-02
m(y) max = -2.118177E-07	
m(y) min = -72224.7	.800000E-02
m(z) max = 12450.8	.475000
m(z) min = -16189.0	.386500

*These loads are applied to node 13 of the model shown in Figure 1.

TABLE 11

STEAM GENERATOR
BLOWDOWN SPLIT 2 SGOE (S2)
LOWER GLOBAL FORCES*

Force (kips)	Sec after Transient
f(x) max = 499.650	.260000
f(x) min = -1.777105E-05	0.
f(y) max = 2415.47	.202500
f(y) min = -2234.61	.173500
f(z) max = 147.706	1.250000E-02
f(z) min = -587.085	3.250000E-02
Moment (in-k)	
m(x) max = 13055.4	3.450000E-02
m(x) min = -3302.59	.354000
m(y) max = -2.119923E-07	0.
m(y) min = -95727.2	.156500
m(z) max = 12743.3	.472500
m(z) min = -13560.9	.386500

*These loads are applied to node 13 of the model shown in Figure 1.

TABLE 12

STEAM GENERATOR
BLOWDOWN STEAM LINE BREAK (SL)
LOWER GLOBAL FORCES*

Force (kips)	Sec after Transient
f(x) max = 130.228	.148500
f(x) min = -605.631	.178000
f(y) max = 376.230	.477500
f(y) min = -319.381	.448000
f(z) max = 870.824	.178000
f(z) min = -298.343	.148500
Moment (in-k)	
m(x) max = 29915.0	.142000
m(x) min = -25678.5	.174000
m(y) max = 15962.0	.124500
m(y) min = -14346.0	.141500
m(z) max = 16852.2	.450000E-02
m(z) min = -28070.8	.396000

*These loads are applied to node 13 of the model shown in Figure 1.

TABLE 13

STEAM GENERATOR
BLOWDOWN STEAM LINE BREAK (SL)
UPPER GLOBAL FORCES*

Force (kips)	Sec after Transient
f(x) max = 2025.27	4.100000E-02
f(x) min = -6.366463E-11	0.
f(y) max = 0.	0.
f(y) min = 0.	0.
f(z) max = 415.060	.217500
f(z) min = -2302.78	.252000
Moment (in-k)	
m(x) max = 0.	0.
m(x) min = 0.	0.
m(y) max = 0.	0.
m(y) min = 0.	0.
m(z) max = 0.	0.
m(z) min = 0.	0.

*These forces are applied to the Steam Generator upper lateral support model according to the shell-band interface cases defined in Figure 2.

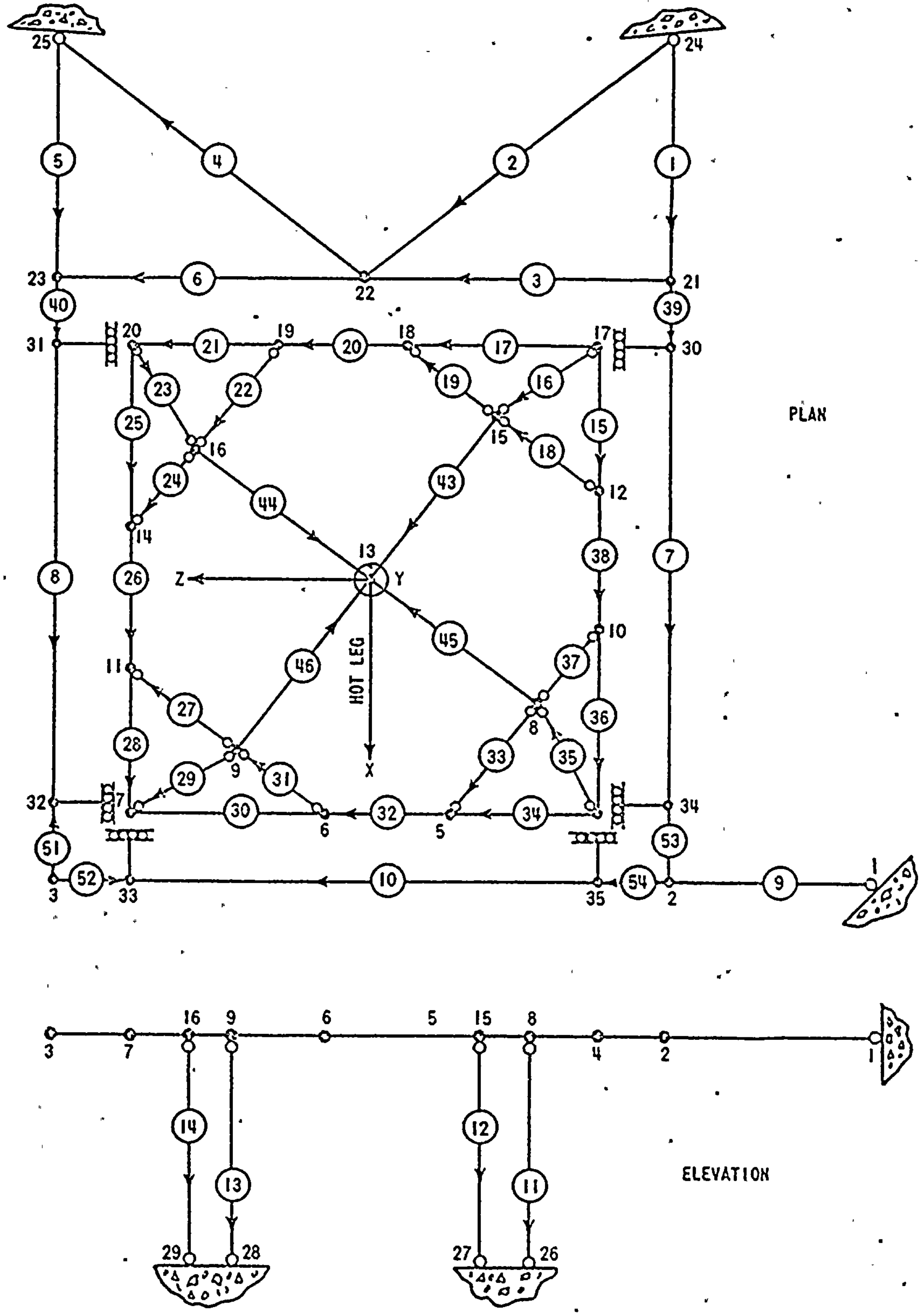


Figure 1 Steam Generator Lower Support Model

TABLE 14

STEAM GENERATOR LOWER SUPPORT STRESS
MAXIMUM MEMBER STRESS % MAXIMUM PERMISSIBLE

+Member	Normal	Loading Condition Upset	Emergency	Faulted
1	-	3.2	3.7	34.2
2	-	5.3	5.9	14.8
3	-	7.7	8.9	30.7
4	-	4.6	5.1	13.6
5	-	3.4	3.8	36.4
6	-	12.1	13.4	35.8
7	-	3.5	3.8	49.6
8	-	3.4	3.7	53.8
9	-	11.8	13.0	4.5
10	-	8.7	9.9	64.9
11	51.4	57.9	40.0	68.1
12	9.4	19.5	16.1	65.9
13	38.2	43.7	30.1	68.4
14	2.3	7.7	6.8	69.7
15	-	3.3	3.5	24.6
16	-	5.3	6.1	22.3
17	-	13.4	14.7	43.3
18	-	.6	.6	6.2
19	-	3.3	3.6	15.5
20	-	7.6	8.4	22.9
21	-	23.3	25.7	84.0
22	-	2.9	3.2	13.3

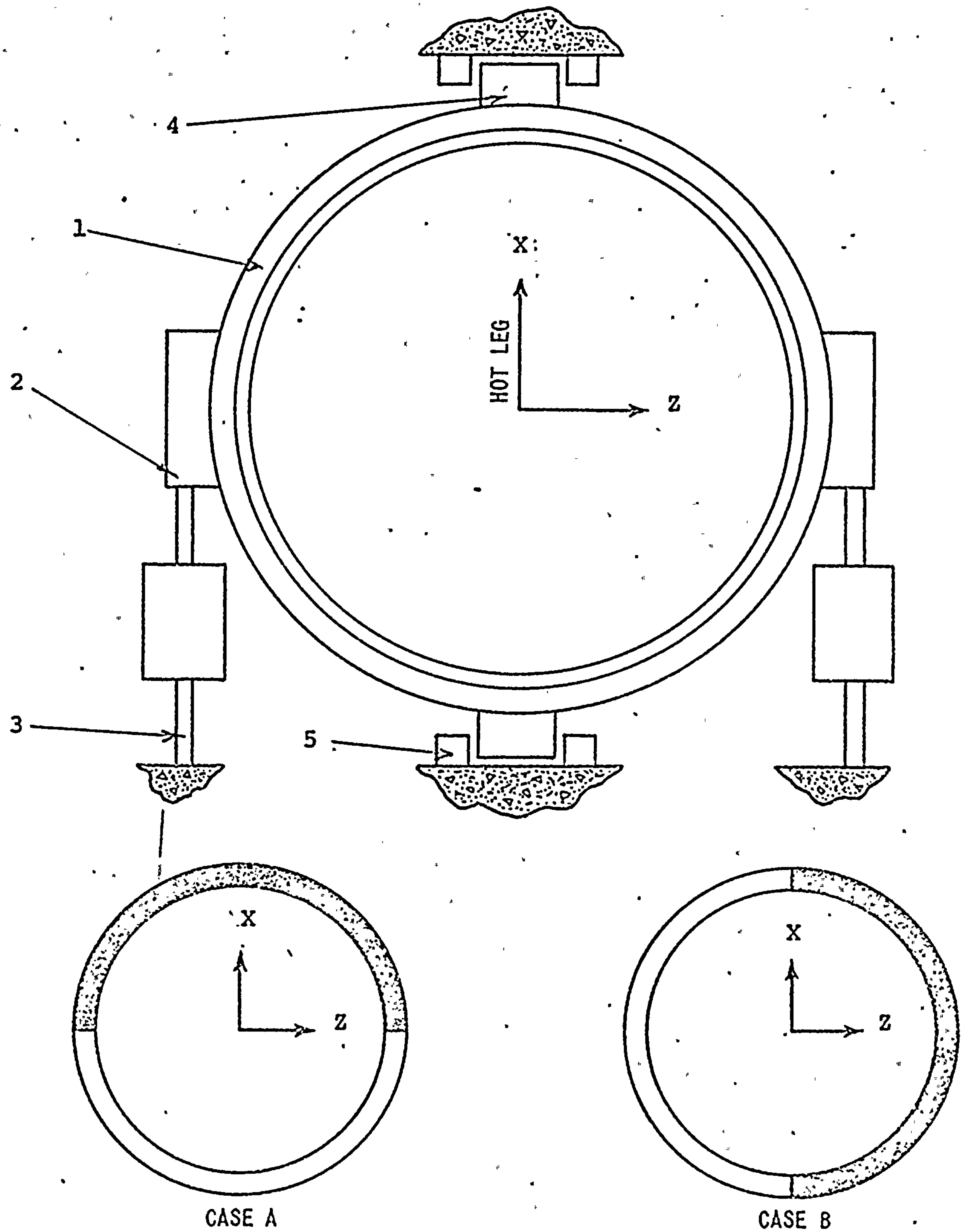
TABLE 14 (Continued)

STEAM GENERATOR LOWER SUPPORT STRESS
MAXIMUM MEMBER STRESS % MAXIMUM PERMISSIBLE

+Member	Normal	Loading Condition Upset	Emergency	Faulted
23	-	6.5	7.2	19.0
24	-	.8	.9	14.4
25	-	10.2	11.1	61.8
26	-	4.0	4.5	30.2
27	-	.9	.9	8.6
28	-	9.0	10.3	80.5
29	-	5.7	6.5	40.9
30	-	13.1	14.3	54.4
31	-	3.2	3.5	12.5
32	-	7.6	8.8	18.7
33	-	3.0	3.3	11.3
34	-	23.2	25.5	68.2
35	-	6.1	6.7	44.3
36	-	10.8	11.9	35.6
37	-	1.0	1.1	6.4
38	-	4.0	4.4	11.5
*39	-	11.4	12.6	33.8
*40	-	4.8	5.3	51.1
*51	-	4.3	4.7	67.5
*52	-	4.3	4.7	67.5
*53	-	5.4	5.8	75.8
*54	-	5.4	5.8	75.8

*The stress levels for these elements were determined by S&L. The levels determined will envelope the actual level from the W analysis.

+See Figure 1 for member locations.



NOTE: SHADED AREAS INDICATE S.G. SHELL AND BAND INTERFACE.

Figure 2 Support Case Definition – Upper Steam Generator Support

Load components are combined through the principle of superposition of case A and case B.

TABLE 15

TABLE 15a

STEAM GENERATOR UPPER SUPPORT STRESSES (RING)*

OPERATING CONDITION	MAXIMUM STRESS (psi)	PERCENT OF PERMISSIBLE STRESS
NORMAL	Not applicable	-
UPSET (OBE)	4,948	16.5
EMERGENCY (DBE)	8,633	19.2
FAULTED	42,578	85.1

TABLE 15b

*COMPONENTS	FAULTED CONDITION % OF PERMISSIBLE STRESS+
2	80.0
3	63.0
4	79.1
5	80.0

+All stress levels determined by S&L to envelope actual stress levels.

*See Figure 2 for location of components.

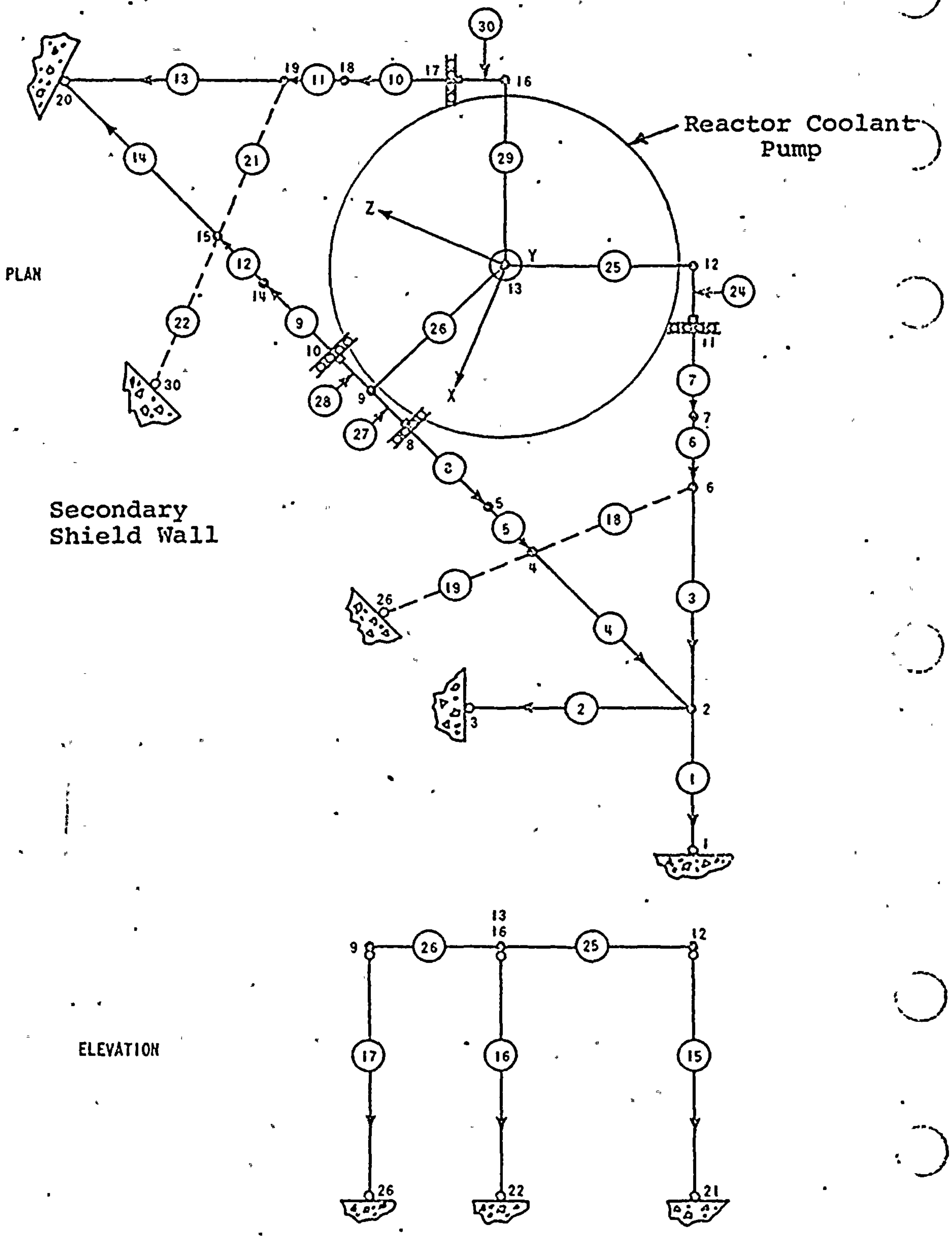


Figure 3 Reactor Coolant Pump Support Model

TABLE 16

PRIMARY EQUIPMENT SUPPORT STRUCTURE LOADS
(REACTOR-COOLANT PUMP SEISMIC LOADS, kips)

Operating Basis Earthquake (OBE)	Tension	Compression
*Member 7	0.0	53.9
Member 8	0.0	80.0
Member 9	0.0	80.0
Member 10	0.0	57.4
Member 15	101.6	101.6
Member 16	147.3	147.3
Member 17	134.5	134.5

*See Figure 3 for member locations.

TABLE 17

PRIMARY EQUIPMENT SUPPORT STRUCTURE LOADS
(REACTOR COOLANT PUMP SEISMIC LOADS, kips)

Design Basis Earthquake (DBE)	Tension	Compression
*Member 7	0.0	80.3
Member 8	0.0	118.8
Member 9	0.0	118.8
Member 10	0.0	85.5
Member 15	150.6	150.6
Member 16	216.7	216.7
Member 17	217.2	217.2

*See Figure 3 for member locations

TABLE 18

LOADS AND DEFLECTIONS

REACTOR COOLANT PUMP COLUMN 16 - TENSION (a)

Identification	Without Seismic Compensation	With Seismic Compensation (f)
Maximum Load (kips)	933	1048 (d)
Maximum Deflection (inches)	0.193	0.257 (e)
Permanent Plastic Deflection (inches)	0.010	0.058
Maximum Allowable Deflection (inches) (b)	3.3	3.3
Margin of Safety (c)	+0.94	+0.92

a. The loads and deflections presented in this table are for the most-severely loaded member, attached to point 16. They are based upon the most-severe postulated break considered, steam-generator-outlet nozzle (SG)). See Figure 3.

b. This value is based on load deflection relationship for R.C.P. column.

c. Margin of Safety = $1 - \frac{\text{maximum deflection}}{\text{maximum allowable deflection}}$

d. This number includes seismic load of 217 (kips).

e. This number includes seismic deflection of 0.041 (inches).

f. The "seismically compensated" notation accounts for the seismic load on the support by shifting the axis of the load-deflection curve. The zero point on the load axis is redefined as the seismic load, and zero point on the deflection axis is redefined as the equivalent elastic deflection of the seismic load.

TABLE 19

LOADS AND DEFLECTIONS
REACTOR COOLANT PUMP COLUMN 17 - TENSION (a)

Identification	Without Seismic Compensation	With Seismic Compensation (f)
Maximum Load (kips)	667	884 (d)
Maximum Deflection (inches)	.127	.168 (e)
Permanent Plastic Deflection (inches)	none	none
Maximum Allowable Deflection (inches) (b)	3.3	3.3
Margin of Safety (c)	+0.96	+0.95

a. The loads and deflections presented in this table are for the most-severely loaded member, attached to point 9. They are based upon the most-severe postulated break considered, Crossover-Leg Break (XLHR). See Figure 3.

b. This value is based on load deflection relationship for R.C.P. column.

c. $\text{Margin of Safety} = 1 - \frac{\text{maximum deflection}}{\text{maximum allowable deflection}}$

d. This number includes seismic load of 217 (kips).

e. This number includes seismic deflection of 0.041 (inches).

f. The "seismically compensated" notation accounts for the seismic load on the support by shifting the axis of the load-deflection curve. The zero point on the load axis is redefined as the seismic load, and zero point on the deflection axis is redefined as the equivalent elastic deflection of the seismic load.

TABLE 20

LOADS AND DEFLECTIONS

REACTOR COOLANT PUMP COLUMN 15 - TENSION (a)

Identification	Without Seismic Compensation	With Seismic Compensation (f)
Maximum Load (kips)	118	357 (d)
Maximum Deflection (inches)	0.011	0.067 (e)
Permanent Plastic Deflection (inches)	none	none
Maximum Allowable Deflection (inches) (b)	3.3	3.3
Margin of Safety (c)	+0.99	+0.98

a. The loads and deflections presented in this table are for the most-severely loaded member, attached to point 12. They are based upon the most-severe postulated break considered, steam-generator-outlet nozzle. See Figure 3.

b. This value is based on load deflection relationship for R.C.P. column.

c. Margin of Safety = $1 - \frac{\text{maximum deflection}}{\text{maximum allowable deflection}}$

d. This number includes seismic load of 217 (kips).

e. This number includes seismic deflection of 0.041 (inches).

f. The "seismically compensated" notation accounts for the seismic load on the support by shifting the axis of the load-deflection curve. The zero point on the load axis is redefined as the seismic load, and zero point on the deflection axis is redefined as the equivalent elastic deflection of the seismic load.

TABLE 21

LOADS AND DEFLECTIONS
REACTOR COOLANT PUMP COLUMN 16 - COMPRESSION (a)

Identification	Without Seismic Compensation	With Seismic Compensation (f)
Maximum Load (kips)	200	423 (d)
Maximum Deflection (inches)	0.022	0.047 (e)
Permanent Plastic Deflection (inches)	none	none
Maximum Allowable Deflection (inches) (b)	1.390	1.390
Margin of Safety (c)	+0.98	+0.97

a. The loads and deflections presented in this table are for the most-severely loaded member, attached to point 16. They are based upon the most-severe postulated break considered, steam-generator-outlet nozzle. See Figure 2.

b. This value is based on load deflection relationship for R.C.P. lateral support.

c. $\text{Margin of Safety} = 1 - \frac{\text{maximum deflection}}{\text{maximum allowable deflection}}$

d. This number includes seismic load of 217 (kips).

e. This number includes seismic deflection of 0.024 (inches).

f. The "seismically compensated" notation accounts for the seismic load on the support by shifting the axis of the load-deflection curve. The zero point on the load axis is redefined as the seismic load, and zero point on the deflection axis is redefined as the equivalent elastic deflection of the seismic load.

TABLE 22

LOADS AND DEFLECTIONS
REACTOR COOLANT PUMP COLUMN 17 - COMPRESSION (a)

Identification	Without Seismic Compensation	With Seismic Compensation (f)
Maximum Load (kips)	600	746 (d)
Maximum Deflection (inches)	0.067	0.084 (e)
Permanent Plastic Deflection (inches)	none	none
Maximum Allowable Deflection (inches) (b)	1.390	1.390
Margin of Safety (c)	+0.95	+0.94

a. The loads and deflections presented in this table are for the most-severely loaded member, attached to point 9. They are based upon the most-severe postulated break considered, steam-generator-outlet break (SGO). See Figure 3.

b. This value is based on load deflection relationship for R.C.P. lateral support.

c. $\text{Margin of Safety} = 1 - \frac{\text{maximum deflection}}{\text{maximum allowable deflection}}$

d. This number includes seismic load of 217 (kips).

e. This number includes seismic deflection of 0.024 (inches).

f. The "seismically compensated" notation accounts for the seismic load on the support by shifting the axis of the load-deflection curve. The zero point on the load axis is redefined as the seismic load, and zero point on the deflection axis is redefined as the equivalent elastic deflection of the seismic load.

TABLE 23

REACTOR COOLANT PUMP COLUMN 15 LOADS AND DEFLECTIONS (COMPRESSION) (a)

Identification	Without Seismic Compensation	With Seismic Compensation (f)
Maximum Load (kips)	1175	1292 (d)
Maximum Deflection (inches)	0.132	0.157 (e)
Permanent Plastic Deflection (inches)	-	0.001
Maximum Allowable Deflection (inches) (b)	1.390	1.390
Margin of Safety (c)	+0.91	+0.89

a. The loads and deflections presented in this table are for the most-severely loaded member, attached to point 12. They are based upon the most-severe postulated break considered, steam-generator-outlet nozzle (SGO). See Figure 3.

b. This value is based on load deflection relationship for R.C.P. lateral support.

c. Margin of Safety = $1 - \frac{\text{maximum deflection}}{\text{maximum allowable deflection}}$

d. This number includes seismic load of 217 (kips).

e. This number includes seismic deflection of 0.024 (inches).

f. The "seismically compensated" notation accounts for the seismic load on the support by shifting the axis of the load-deflection curve. The zero point on the load axis is redefined as the seismic load, and zero point on the deflection axis is redefined as the equivalent elastic deflection of the seismic load.

TABLE 24

LOADS AND DEFLECTIONS
REACTOR COOLANT PUMP LATERAL SUPPORT (a)

Identification	Without Seismic Compensation	With Seismic Compensation (f)
Maximum Load (kips)	722	770 (d)
Maximum Deflection (inches)	0.113	0.120 (e)
Permanent Plastic Deflection (inches)	none	none
Maximum Allowable Deflection (inches) (b)	0.99	0.99
Margin of Safety (c)	+0.89	+0.88

a. The loads and deflections presented in this table are for the most-severely loaded member, attached to point 16. They are based upon the most-severe postulated break considered, crossover-leg break (XLHR). See Figure 3.

b. This value is based on load deflection relationship for R.C.P. lateral support.

c. $\text{Margin of Safety} = 1 - \frac{\text{maximum deflection}}{\text{maximum allowable deflection}}$

d. This number includes seismic load of 86 (kips).

e. This number includes seismic deflection of 0.013 (inches).

f. The "seismically compensated" notation accounts for the seismic load on the support by shifting the axis of the load-deflection curve. The zero point on the load axis is redefined as the seismic load, and zero point on the deflection axis is redefined as the equivalent elastic deflection of the seismic load.

TABLE 25

REACTOR COOLANT PUMP LATERAL SUPPORT LOADS AND DEFLECTIONS (a)

Identification	Without Seismic Compensation	With Seismic Compensation (f)
Maximum Load (kips)	841	841 (d)
Maximum Deflection (inches)	0.279	0.354 (e)
Permanent Plastic Deflection (inches)	0.141	0.236
Maximum Allowable Deflection (inches) (b)	0.99	0.99
Margin of Safety (c)	+0.72	+0.50

a. The loads and deflections presented in this table are for the most-severely loaded member, attached to point 9. They are based upon the most-severe postulated break considered, steam-generator-outlet nozzle (SGO). See Figure 3.

b. This value is based on load deflection relationship for R.C.P. lateral support.

c. $\text{Margin of Safety} = 1 - \frac{\text{maximum deflection}}{\text{maximum allowable deflection}}$

d. This number includes seismic load of 119 (kips).

e. This number includes seismic deflection of 0.137 (inches).

f. The "seismically compensated" notation accounts for the seismic load on the support by shifting the axis of the load-deflection curve. The zero point on the load axis is redefined as the seismic load, and zero point on the deflection axis is redefined as the equivalent elastic deflection of the seismic load.

TABLE 26

LOADS AND DEFLECTIONS

REACTOR COOLANT PUMP LATERAL SUPPORT (a)

Identification	Without Seismic Compensation	With Seismic Compensation (f)
Maximum Load (kips)	366	472 (d)
Maximum Deflection (inches)	0.057	0.074 (e)
Permanent Plastic Deflection (inches)	none	none
Maximum Allowable Deflection (inches) (b)	0.99	0.99
Margin of Safety (c)	+0.94	+0.93

a. The loads and deflections presented in this table are for the most-severely loaded member, attached to point 12. They are based upon the most-severe postulated break considered, crossover-leg break (XLHR). See Figure 3.

b. This value is based on load deflection relationship for R.C.P. lateral support.

c. $\text{Margin of Safety} = 1 - \frac{\text{maximum deflection}}{\text{maximum allowable deflection}}$

d. This number includes seismic load of 86 (kips).

e. This number includes seismic deflection of 0.013 (inches).

f. The "seismically compensated" notation accounts for the seismic load on the support by shifting the axis of the load-deflection curve. The zero point on the load axis is redefined as the seismic load, and zero point on the deflection axis is redefined as the equivalent elastic deflection of the seismic load.

TABLE 27

REACTOR COOLANT PUMP SUPPORT STRESSES

Member*	Normal	Upset	Emergency
	Loading Condition		
	Maximum Member Stress, % Maximum Permissible		
1	-	11.0	10.9
2	-	6.8	6.7
3	-	4.7	4.7
4	-	6.9	6.9
5	-	6.7	6.6
6	-	4.5	4.5
7	-	4.4	4.4
8	-	6.6	6.5
9	-	6.6	6.5
10	-	4.7	4.7
11	-	4.8	4.8
12	-	6.7	6.6
13	-	4.9	4.8
14	-	6.8	6.7
15	22.8	33.1	25.4
16	13.8	27.1	22.3
17	18.6	32.2	27.1

*See Figure 3 for member locations.

Question 3

Describe how all heavy section intersecting weldments were designed to minimize restraint and lamellar tearing. Specify the actual section thickness in the structure and provide details of typical joint design. State the maximum design stress in the through thickness direction of plates and elements of rolled shapes.

Answer:

The D.C. Cook NSSS drawings provide both typical joint details and section thickness. The design of the heavy section intersecting weldments was made under the provisions of the 1969 AISC code. The joint details are therefore consistant with current practice in structural design. Plates were tested in the through gauge thickness. Reduction of area was generally above 20 percent indicating good resistance to lamellar tearing. Calculated stress leveliin the through thickness direction is 65% of yield. Materials that were subjected to transverse stress, classified as 3B in the drawings, were subjected to ultrasonic examination along all edges and on a specified grid in accordance with A-435. The area under all welds on through thickness extending to 3" on either side of the weld was 100% ultrasonically examined. Welding was required to be performed in accordance with AISC code and ASME (B&PV) Code Section VIII. The joints were stress relieved with post weld heat treatment in accordance with ASME code requirements. The above requirements on the heavy section intersecting weldments will minimize the possibility of lamellar tearing.

Question 4:

Specify the minimum operating temperature for the supports and describe the extent to which material temperatures have been measured at various points on the supports during the operation of the Plant.

Answer:

Technical specifications for Donald C. Cook Nuclear Plant require that the air temperature in the region where the supports are located should be maintained between 60° F and 120° F during operation. No actual temperature measurements of the supports have been taken during operation of the Plant. Both A-36 and A-588 materials were specified to pass a Charpy V-Notch test of 15 ft-lbs. at 30° F. Section 16.2 of the attached specification no DCC-CE-112 QCN (attachmentII) requires that the impact test be performed in conformance with paragraph SA-310 of ASME Section II Code. The test results indicate that all critical materials were Charpy tested and met the above requirement.

[illegible]

[illegible]

[illegible]

Question 5:

Specify all the materials used in the supports and the extent which mill certificate data are available. Describe any supplemental requirements such as melting practice, toughness tests and through thickness tests specified. Provide the results of all tests that may better define properties of the materials used.

Answer:

The materials used in the support are described in Table M9-1 of Attachment - II. Mill certification reports are available for all materials used in fabrication. Typical mill certifications are presented in attachment III. Charpy-V Notch test were performed to determine strain rate and temperatures. Ultrasonic examination was used to detect plate laminations. Section 15.5 of Attachment - II requires that the ultrasonic inspection be performed subject to the more restrictive requirements of the following two documents: (1) Appendix U of ASME Section VIII, Division I, and (2) ASTM 164.

[illegible]

[illegible]

[illegible]

[illegible]

Question 6

Describe the welding procedures and any special welding process requirements that were specified to minimize residual stress, weld and heat affected zone cracking and lamellar tearing of the base metal.

Answer

Details of welding procedures are presented in Section 13.0 through 13.9 of Attachment II. Table W 13-9 specifies the requirements for welding of A-558. All materials were welded based on approved welding procedures and all welders were qualified in accordance with ASME B & PV Code.

[illegible]

[illegible]

Question 7

Describe all inspections and non destructive tests that were performed on the supports during their fabrications and installation. (as well as any additional inspections that were performed during the life of the facility).

Answer

Section 15 of Attachment II describes requirements for non destructive testing of welds. All welds were examined volumetrically by radiographic or by ultrasonic methods where practical. If volumetric examination could not be performed welds were surface examined by either magnetic particle or penetrant methods. During erection, all fieldswelds were magnetic particle examined, in accordance with AWS D1.1-72 plus an intermediate root pass examination of welds over 3/8" thick.

8. Evaluation of the fracture toughness of the steam generator and reactor coolant pump support materials

The NSSS specification requires that A36 material be modified to fine grade practice. This is a steelmaking process which improves the notch toughness properties. The A588 material was purchased in the normalized condition. This guarantees ferritic fine grain size, lowers the ductile to brittle transition temperature and improves toughness. Both A36 and A588 materials were specified to pass a Charpy V-Notch test of 15 ft. lbs. at +30° F. The operating temperature of these supports is far in excess of the specified test temperatures. Therefore, these materials will be subject to temperatures above the transition temperature.

Question no. 6 of the NRC letter asks for a description of processes which were utilized to minimize residual stresses, weld and heat affected zone cracking and lamellar tearing of the base metal. The Cook NSSS specification specified the following welding requirements to eliminate these concerns.

1. Welding was performed in accordance with ASME B & PV Code to assure adequate preheat and postheat temperatures.

2. Low hydrogen electrodes and properly dried flux for submerged arc welds, were specified.

The NRC's concern regarding lamellar tearing was initiated by the North Anna Station cracking. Materials used for supports at the Donald C. Cook Nuclear Plant were ultrasonically examined and impact tested, and are, therefore, less susceptable to lamellar tearing.