TURKEY POINT NUCLEAR POWER STATION

UNITS 3 & 4

REPORT ON FRACTURE TOUGHNESS AND POTENTIAL FOR LAMELLAR TEARING OF STEAM GENERATOR AND REACTOR COOLANT PUMP SUPPORTS

(RESPONSE TO NRC QUESTIONS)

SEPTEMBER, 1978

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

RESPONSE

Figures 1 through 29 provide steam generator and reactor coolant pump support details including geometry of all principal elements.

Figures 11 through 29 provide listing of materials of construction.

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 element of the support system and the corresponding allowable stresses.

RESPONSE

The support systems for the steam gnerator and reactor coolant pump are designed to satisfy the load combinations and allowable stresses as per FSAR Section 5.1 and Subsection 5.1.9.1. The load combinations and corresponding allowable stresses are listed below:

$$S = (D + L + T)$$

$$1.33S = (D + L + T + E)$$

$$1.50S = (D + L + T + E')$$

$$Y = (D + L + T + R)$$

S = Allowable Stresses as per AISC Code

D = Dead Load Stresses

L = Live Load Stresses

T = Temperature Stresses where they apply

E = Operating Basis Earthquake Stresses (OBE)

E' = Design Basis Earthquake Stresses (DBE)

R = Stresses due to pipe rupture reactions

Y = Yield stresses of the materials used for the supports as allowed by the ASTM and the ASME Codes.

Design loads, calculated maximum stresses for the governing load combination and allowable stresses in elements of support system are given in Tables 1 through 3.

TABLE 1

DESIGN LOADS, ALLOWABLE STRESSES AND CALCULATED STRESSES FOR LOWER STEAM GENERATOR SUPPORTS AT EL. 30'-6"

MEMBER TYPE & REF. DRAWING	LOADS IN KIPS						DESIGN LOAD (KIPS)	MATERIAL TYPE	ALLOWABLE STRESSES (KSI)			CALCULATED STRESSES (KSI)			CONTROLLING LOAD COMBINATION
	D	L	T	E	E'	R			AXIAL	BENDING	SHEAR	AXIAL	BENDING	SHEAR	
(i) Column Base Plate (Fig. 27)	+240	-	-	-	-	±860	+1100	A516-55	-	30.0	-	-	13.40	-	D + L + T + R
(ii) Base Plate Anchors (Fig. 27)	+240	-	-	-	-	±860	- 620	A432	60.0	-	-	53.30	-	-	D + L + T + R
(iii) Columns W10X77 (Fig. 12, Mark No. 39 & 158)	+240	-	-	-	-	±860	+ 240 +1100	A588-GR. A*	20.75 50.0	- -	- -	10.57 24.30	- -	- -	D + L + T D + L + T + R
(iv) Pin (2.79" ø) (Fig. 11, Mark No. 58)	+240	-	-	-	-	±860	+1100	AISI-4340	-	-	90.0	-	-	90.0	D + L + T + R
(v) Bracket Connecting S.G. Lug & Column Cap Plate (Fig. 11, Assembly 43)	-	-	-	-	-	910	910	SA302-GR. B	-	-	30.0	-	-	17.33	D + L + T + R
a) Vertical Plate (3½" TH.)	+240					-860	- 620	SA302-GR. B	-	-	30.0	-	-	25.90	D + L + T + R
b) Horizontal Plate (4" TH.)	+240	-	-	-	-	-860	- 620	SA302-GR. B	-	-	30.0	-	-	26.31	D + L + T + R
(vi) Columns Cap Plate - 3½" TH. (Fig. 11)	+240	-	-	-	-	-860	- 620	SA302-GR. B	-	50.0	30.0	-	31.70	7.40	D + L + T + R
(vii) Bolt - Bet. Bracket & Col. Cap Plate - 2-3/4" ø	-	-	-	-	-	910	910	CARPENTER NI-MARK 300	-	-	156.0	-	-	153.2	D + L + T + R
(Fig. 11, Mark No. 56)	+240	-	-	-	-	-860	- 620		260	-	-	134.2	-	-	D + L + T + R
(viii) Bolts Connecting Bracket to Embed Plate @ El. 28'-0" (Fig.29)	-	-	-	-	-	910	910	A432	60	-	-	18.0	-	-	D + L + T + R
(ix) Vert.Plate.Bolted to Embed Plate (3" TH.) (Fig. 11)	-	-	-	-	-	910	910	SA302-GR. B	-	50	-	-	32.03	-	D + L + T + R
(x) Embedment WT. 10.5 x 56 (Fig. 12, Mark No. 41)	-	-	-	-	-	910	910	A588-GR. A*	-	-	30.0	-	-	9.20	D + L + T + R

NOTE: MAXIMUM ALLOWABLE SHEAR STRESS = 0.6X (MIN. YIELD OF MATERIAL)

* SEE RESPONSE TO QUESTION 5.

TABLE 2

DESIGN LOADS, ALLOWABLE STRESSES AND CALCULATED STRESSES FOR UPPER STEAM GENERATOR SUPPORTS AT EL. 58'-0"

MEMBER TYPE & REF. DRAWING	LOADS IN KIPS						DESIGN LOAD (KIPS)	MATERIAL TYPE	ALLOWABLE STRESSES (KSI)			CALCULATED STRESSES (KSI)			CONTROLLING LOAD COMBINATION
	D	L	T	E	E'	R			AXIAL	BENDING	SHEAR	AXIAL	BENDING	SHEAR	
(i) Stop Assembly No. 2 & No. 4 (Fig. 14, Mark No. 79)															
a) Compression on Embedded member	-	-	-	-	-	3686	3686	SA302-GR. B	50	-	-	50	-	-	D + L + T + R
b) Screws	-	-	-	-	-	368.6	368.6	CARPENTER Ni-MARK 300	-	-	156	-	-	139.6	D + L + T + R
(ii) Stop Assembly No. 3 (Fig. 14, Mark No. 85)															
a) Wedge Shape Stop Block	-	-	-	-	462	-	462	SA302-GR. B	-	-	30	-	-	19.25	D + L + T + E'
b) Bolts 2" ∅ Connecting Stop to Embed Plate	-	-	-	-	462	-	462	A354-GR. BC	-	-	65.40	-	-	36.76	D + L + T + E'
(iii) Thrust Beams W14 x 193 (Fig. 19 & 21)	-	-	-	-	-	1466	1466	A441	46	-	-	25.86	-	-	D + L + T + R
(iv) Ring Girder Around Steam Generator (WEB Compression) (Fig. 14, Mark Nos. 61, 62, 63 & 64)	-	-	-	-	-	1470	1470	SA302-GR. B	50	-	-	10.63	-	-	D + L + T + R

NOTE: MAXIMUM ALLOWABLE SHEAR STRESS = 0.6X (MIN. YIELD OF MATERIAL)

TABLE 3

DESIGN LOADS, ALLOWABLE STRESSES AND CALCULATED STRESSES FOR REACTOR COOLANT PUMP SUPPORTS

MEMBER TYPE & REF. DRAWING	LOADS IN KIPS					DESIGN LOAD (KIPS)	MATERIAL TYPE	ALLOWABLE STRESSES (KSI)			CALCULATED STRESS (KSI)			CONTROLLED LOAD COMBINATION
	D	T	E	E'	R			AXIAL	BENDING	SHEAR	AXIAL	BENDING	SHEAR	
(i) 3-3/4" Ø Hex. Bolt	+73	-	-	-	-2073	-2000	CARPENTER NI-MARK 300	260.0	-	-	181.08	-	-	D + L + T + R
(Fig. 23, Mark No. 21)	-	-	-	-	1350	1350	CARPENTER NI-MARK 300	-	-	156.0	-	-	122.28	D + L + T + R
(ii) Column Cap Plate 5¼" TH.	+73	-	-	-	+2073	2150	SA302-GR. B	-	50.0	30.0	-	29.65	14.83	D + L + T + R
(Fig. 23)	-	-	-	-	1350	1350	SA302-GR. B	50.0	-	30.0	7.5	-	18.62	D + L + T + R
(iii) W10 x 112 Column	+73	-	-	-	-2073	-2000	A588-GR. A*	50.0	-	-	30.4	-	-	D + L + T + R
(Fig. 24, Mark Nos. 8 & 164)	+73	-	-	-	+2073	2150	A588-GR. A*	50.0	-	-	32.6	-	-	D + L + T + R
(iv) Base Plate	+73	-	-	-	+2073	2150	A516-55	-	30.0	-	-	25.7	-	D + L + T + R
(Fig. 27)	+73	-	-	-	-2073	2000	A516-55	-	30.0	-	-	26.15	-	D + L + T + R
(v) Base Plate Anchors (Fig. 27)	+73	-	-	-	-2073	-2000	A432	60.0	-	-	47.16	-	-	D + L + T + R
(vi) Vertical Plate Bolted to Embedded Plate @ EL. 25'-6" (3" TH.)	-	-	-	-	1350	1350	SA302-GR. B	-	50.0	-	-	47.69	-	D + L + T + R
(FIG. 24, Mark No. 7	-	-	-	-	1350	1350	SA302-GR. B	-	50.0	-	-	49.74	-	D + L + T + R
(vii) Bolts Connecting Bracket to Embed Plate @ EL. 25'-6" (#18 Bar) (Fig. 29)	-	-	-	-	1350	1350	A432	60.0	-	-	25.94	-	-	D + L + T + R
(viii) Embedment @ EL. 25'-6" (W12 x 190) (Fig. 24, Mark No. 11)	-	-	-	-	1350	1350	A588-GR. A*	-	-	30.0	-	-	8.05	D + L + T + R

NOTE: MAXIMUM ALLOWABLE SHEAR STRESS = 0.6X (MIN. YIELD OF MATERIAL)

* SEE RESPONSE TO QUESTION 5.

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

RESPONSE

The weld joint designs used for the steam generator and reactor coolant pump supports were those shown for thick steel members in AWS D2.0-66, 'Standard Specification for Welded Highway and Railway Bridges', a nationally recognized code, considered suitable for the construction of heavy equipment supports. Preheats were used for shop welds.

The actual thickness of members used for steam generator and reactor coolant pump supports are shown in Figures 1 thru 29. The maximum design stresses in support components are given in Tables 1 thru 3.

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.

RESPONSE

There is no official designated operating temperature for the Turkey Point supports. The normal maximum operating temperature inside containment is 120°F. It is unlikely that the temperature of the supports would ever go below 60°F even during a startup on the coldest day in winter. The coast of South Florida has very mild winters and the reactor coolant system gives off a lot of heat even when it is shut down. This decay heat is from the fuel that is left in the reactor during refueling. In addition the containment and equipment are a large heat sink that helps stabilize the temperature.

The temperature of the supports has not been measured during operation. This was never considered critical and there was never any requirement to measure it.

5. Specify all the materials used in the supports and the extent to 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 the properties of the materials used.

RESPONSE

The principal materials used in the fabrication of steam generator and reactor coolant pump supports were ASTM A441, ASTM A588-GR. A and SA302-GR. B with a minimum yield point of 50 ksi. ASTM A588-GR. A material was used in lieu of MAYARI-R50 steel shown on Babcock & Wilcox Shop drawings. Both materials, ASTM A588-GR. A and MAYARI-R50, have minimum yield point of 50 ksi for structural shapes. All of the materials mentioned above have excellent fracture toughness properties. No additional requirements were invoked.

The mill certificates available in our files for these materials indicate that they met the ASTM requirements. No special tests were run on these materials.

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.

RESPONSE

Welding processes used in the fabrication of the supports were limited to the submerged arc and manual metal arc. These processes are standard methods used for heavy fabrications. All welding materials were of the low hydrogen type, to prevent heat affected zone cracking , and each lot of welding material was tested in accordance with the requirements of the appropriate welding material specification.

Welding procedures were in compliance with the requirements of AWS D2.0-66. Specification required welders and welding operators to be qualified by tests as prescribed by Section IX of the ASME Boiler Code.

Residual stresses were relieved by requiring postweld heat treatment on all weldments.

7. Describe all inspections and non-destructive tests that were performed on the supports during their fabrication and installation, as well as any additional inspections that were performed during the life of the facility.

RESPONSE

During fabrication all welds were dimensionally examined for the compliance with the design drawings. In addition, visual inspection for cracks in welds and base metal have been performed.

Additional inspections during the life of the facility have been performed. They are:

The steam generators and reactor coolant pumps support structures were inspected in compliance with DRO Bulletin 74-3 and Supplement 74-3A. The inspections were performed during the 1974 ISI, for Unit 3, as reported in the W report and during the 1975 ISI, for Unit 4, as reported in the SWRI report. However, in Unit 4 only the steam generators support structures were inspected as DRO-74-3 and 74-3A dictates.

In addition, the reactor coolant pump, Loop A, integrally welded supports were examined by liquid penetrant techniques and the support structures by visual methods. This is in compliance with the intent of the ASME Code Section XI, although volumetric examinations (techniques are not available at the time of this write up) are required by the Code. These examinations were performed by W during the 1974 ISI, for Unit 3, and by SWRI during the 1975 ISI, for Unit 4.

No reportable indications were observed during the inspections.

The reactor coolant pumps integrally welded supports for both units will be examined per Section XI during future ISI's. Also the reactor coolant pumps support structures will be examined per Section XI during future ISI's. However, there are no plans at this time to examine the steam generators supports during future ISI's per Section XI, because there are no integrally welded supports on the steam generators. If deemed desirable, a visual inspection of the support structures of the steam generators might be performed in the future.