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STRESS ANALYSIS OF THE LOFT MODULAR DTT FLOWMETER

FOR LOCE TRANSIENTS (L1-5 AND L2-4)

(Supplement No. 1)

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IDAHO NATIONAL ENGINEERING LABORATORY

DEPARTMENT OF ENERGY

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STRESS ANALYSIS OF THE LOFT MODULAR DTT FLOWMETER FOR LOCE TRANSIENTS (L1-5 AND L2-4) (Supplement No. 1)

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<u>SUMMARY</u>					

Attachment A is an analysis of combined stresses in the LOFT Modular DTT for the revised temperature gradients given in Reference 2.

All combined stress intensities listed in Table I of Reference 1 are shown in the attachment to stay within applicable allowable stress intensities given in Reference 3.

The fatigue analysis of Reference 1 was also re-done and indicates that the LOFT Modular DTT will withstand 70,000 blowdown cycles. The LOFT Modular DTT is still shown to meet the Class 1 stress requirements of Reference 3.

Attachment B is a stress analysis of the tab region of the newly designed MDTT tab-type shroud.

This stress analysis shows that the Class 1 stress requirements of Reference 3 are met by the tab-type MDTT shroud design and that this design imposes no fatigue life limitation on the MDTT.

REFERENCES

1. W. R. Mosby, "Stress Analysis of the LOFT Modular DTT Flowmeter for LOCE Transients (L1-5 and L2-4)", EG&G Technical Report RE-A-77-118 (LTR 141-77), December 2, 1977.
2. C. M. Martin, "Thermal Analysis of LOFT Modular DTT for LOCE Transients", EG&G Technical Report RE-A-77-104 (LTR 141-76), September 30, 1977, Supplement No. 1.
3. American Society of Mechanical Engineers, ASME Boiler and Pressure Vessel Code, Section III, Division 1, "Nuclear Power Plant Components", 1977.

ATTACHMENT A

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1. Temperature Calculations

New values of ΔT_{RSA} are given in Reference 2 for PC-1, PC-2, PC-3, BL-1, and BL-2 locations in the LOFT cooling system. Assuming proportionality between ΔT_{RSA} , ΔT_{SSA} , and ΔT_{SBA} at a given MDTT location, the values of ΔT_{SSA} and ΔT_{SBA} for the abovementioned locations were calculated. The values of ΔT_{SBA} , ΔT_{SSA} , and ΔT_{RSA} were then calculated using the method used in Reference 1.

TABLE I

LOFT MDTT Hydraulic and Thermal Loads for
L2-4 Nuclear LOCE

Location	P_{SS}	P_{TS}	P_{TA}	ΔT_{SBA}	ΔT_{SSA}	ΔT_{RSA}
PC-1	6.47	1.4	.1455	282	101	63.2
PC-2	6.47	0	.1455	148	47	45.6
PC-3	6.47	1.4	.1455	137	47	39.7
BL-1	8.63	1.86	.1943	186	66	41.4
BL-2	8.63	1.86	.1943	148	45	45.6
1ST-1	1.62	0	.0364	139	50	43
2ST-1	1.62	0	.0364	139	50	43
1UP-1	24.05	0	0	149	53	46
3UP-1	24.05	0	0	149	53	46
5UP-1	24.05	0	0	149	53	46

For the PC-1 location, L1-5 LOCE,
assume proportionality between corresponding ΔT s
for both LOCE's at this location. Then

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$$\Delta T_{SBA} = \frac{240}{220} \times 282 = 308$$

$$\Delta T_{SSA} = 65 \times \frac{101}{59.115} = 111$$

$$\Delta T_{RSA} = 56 \times \frac{45.6}{33.6} = 76$$

2. Maximum Combined Stress Intensities

a. stressed point 1 (Table I, Reference 1)

The combined stress here is mostly due to the hydraulic loads, so

$$2T_{max} \leq \frac{186}{93} \times 13,860 = 27,720 \text{ psi}$$

the allowable here is $3S_m = 42,000 \text{ psi}$.

$\therefore$ the maximum stress intensity is well below the allowable.

b. stressed point 3 (Table I, Reference 1)

The combined stress here is mostly due to the hydraulic load, so

$$2T_{max} \leq \frac{186}{93} \times 237 = 474 \text{ psi}$$

this is well below the allowable stress intensity

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or $3S_m = 49,200 \text{ psi}$

c. Stressed point 6B (Table I, Reference 1),
front end cap fillet weld.

Using the maximum value of ΔT_{RSA} ,

$\Delta T_{RSA} = 76^\circ$ for LOCE L1-5, PC-1 location,

$2T_{max} = 42,439 \text{ psi}$.

The new end cap design eliminates the
fillet weld and consists of one piece. The
allowable stress intensity is then

$3S_m = 2 \times \frac{3}{2} S_m = 2 \times (25,050 \text{ psi})$

$3S_m = 50,100 \text{ psi}$.

Then $2T_{max}$ is still comfortably below
the allowable stress intensity.

d. Stressed point 8C (Table I, Reference 1),
rear end cap fillet weld.

As in c. above, $\Delta T_{RSA} = 76^\circ$

$2T_{max} = 30,191 \text{ psi} < 50,100 \text{ psi}$.

3. Fatigue Considerations

Again using the method of Reference 1

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$$\frac{S_a}{2E\alpha} \leq 76^\circ\text{F}$$

$$\text{or } S_a \leq 40,271 \text{ psi}$$

$$\text{or } S_a \leq 40,271 \left(\frac{26}{26.6} \right) = 39,362 \text{ psi on Fig. I.9-2}$$

of Appendices of Reference 3. Fig. I.9-2 then gives

$$N \leq 70,000$$

Thermal stress considerations limit the MDTT to 70,000 blowdown cycles.

4. Comments

It should be pointed out that the stress intensities calculated in 2c, 2d, and 3 above are quite conservative. The calculation assumes a section equivalent to a .05 inch fillet weld, when in fact the design has been changed to a full solid section at the junction between the end cap fairing and ring sections.

The actual stresses at these points are much lower than those calculated here.

ATTACHMENT B

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1. General

a. Material

$S_m = 14,000$ psi ; see part II, A. 2. of the Appendix of this LTR.

b. Geometry

The welded shroud slide has been replaced by the bent tab arrangement shown in Figure 1.

Figure 1: MDTT Tab Configuration

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2. Fluid dynamic pressure forces

a. General

The fluid and reaction force system is shown in figure 2. Only the transverse fluid flow exerts any force on the shroud, as explained in the Appendix of this LTR. Figure 2 shows the worst reaction force load case. In this case there are no thermally induced forces on the MDTT shroud.

Figure 2: Shroud Fluid and Reaction Force System

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b. Force Calculation

$$\sum F_x = 0$$

$$F_2 = F_f = 4.571 P C_D$$

$$\sum F_y = 0$$

$$F_1 = F_3$$

$$\sum M_o = 0$$

$$-F_2 (.745) + F_1 (.238) + F_3 (.238) = 0$$

$$F_1 = F_3 = 1.565 F_2$$

$$F_1 = 7.154 P C_D$$

$$F_2 = 4.571 P C_D$$

$$F_3 = 7.154 P C_D$$

with P = fluid dynamic pressure

C_D = drag coefficient
= 2

3. Tab stresses

a. "Straight" tabs

Figure 3 shows the force system in the straight tabs. The stresses will be calculated at the location of the .02 inch saw cuts, since the rest of the shroud has already been analyzed

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Figure 3: "straight" tab stress calculation

elsewhere in this LTR.

Summing forces,

$$\sum F_x = 0$$

$$-T \cos \theta + V \sin \theta = 0$$

$$\sum F_y = 0$$

$$T \sin \theta + V \cos \theta - F_1 = 0$$

$$\sum M_o = 0$$

$$M_1 - F_1 d_1 = 0$$

From which, with $\theta = 34.15^\circ$,

$$M = 1.209 P C_D$$

$$T = 4.016 P C_D$$

$$V = 5.920 P C_D$$

Bending stress:

$$(\sigma_b)_{\max} = \frac{M c}{I} = 1500 P C_D, \text{ with:}$$

$$c = \frac{.05}{2} = .025$$

$$I = \frac{b h^3}{12} = \frac{(.6-.01+2.4-1.6-.02+3.930-3.3-.063-.01)(.05)^3}{12}$$

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$$I = 2.0156 \times 10^{-5} \text{ in}^4$$

Tensile stress

$$\sigma_T = \frac{I}{A} = 41.5 \text{ PCO}, \text{ with } A = 9.675 \times 10^{-2} \text{ in}^2$$

Shear stress

$$\tau = \frac{V}{A} = 61.2 \text{ PCO}$$

The tensile and shear stresses are much smaller than the bending stress and will be neglected.

4. Maximum primary stress intensity

The maximum primary stress is that due to bending in the "straight" tab as calculated above. The maximum stress in the "bent" tabs is also due to bending and has been calculated to be 855 PCO.

The maximum side flow fluid dynamic

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pressure occurs at the BL-1 and BL-2 locations during LOCE L2-4. The steady component of this pressure is

$$P_{Ts} = 1.86 \text{ psi}$$

while the alternating component is

$$P_{Ta} = .1943 \text{ psi}$$

The maximum primary stress intensity in the tabs is then

$$2T_{max} = (1500)(1.86)(2) = 5580 \text{ psi}$$

the allowable (see Table I of this LTR, stressed point 1) is

$$S_m = 14000 \text{ psi}$$

so $2T_{max} < S_m$ here.

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5. Fatigue analysis

The alternating stress intensity in the tabs is calculated as explained in the Appendix of this LTR:

a. $2T_{max}$ with steady + alternating side pressure

$$2T_{max})_{S+A} = 6163 \text{ psi}$$

b. $2T_{max}$ with steady - alternating side pressure

$$2T_{max})_{S-A} = 4997 \text{ psi}$$

$$\Delta 2T_{max} = 6163 - 4997 \text{ psi} = 1165 \text{ psi.}$$

Using a factor of 2 for dynamic effects, a factor of 2 for impact effects, and a factor of 4 for stress intensification in the saw cuts,

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$$S_a = 2 \times 2 \times 4 \times 1165 = 18,640 \text{ psi}$$

Referring to page 66 of the Appendix of this LTR, the endurance limit of this material is 25,800 psi.

$$S_a = 18,640 < 25,800$$

and the shroud tabs do not impose a fatigue limit on the life of the MDTT.

G. Primary plus secondary stresses

The design change analyzed in this supplement does not affect this part of the analysis.