Consumers Power
POWERING MICHIGAN'S PROGRESS

PALISADES NUCLEAR PLANT
ENGINEERING ANALYSIS WORK SHEET

EA - FES-93-277-01
Sheet 1 of 4
W ATTACHMENT & CHECKLIST

Title Structural Evaluation for the machined thermowell for TE-0101

INITIATION AND REVIEW

Rev #	Description	Initiated By	Initiated Date	Initiator Appd By	Review Method Check (✓) Alt Calc	Det Rvw	Qual Test	Technically Reviewed By	Technically Reviewed Date	Reviewer Appd By
0	Original Issue	J.C. Wong	10-25-93	BAL per telecon 10/25/93 DTV		✓		R.B.	10/25/93	BAL per telecon 10/25/93 DTV

Reference/Comment

1.0 Objective

The objective of this analysis is to demonstrate the structural integrity of the machined thermowell for TE-0101. Refer to the FES-93277 Rev. 0, a section of the external surface of the thermowell is machined which reduces the original diameter of 0.75 inches to 0.685 inches. Ref. 1

2.0 References

1 FES-93-277 Rev. 0, Machine Thermowell for TE-0101

2. ASME III, 1992 Ed., Appendix I Table I-14.1

3 ASME II, 1992 Ed., Fig. HA-2

4. "Strength of Materials" by S. Timoshenko 3rd Ed Page 209.

5. CE Analytical Report CENC-1114 for Palisades PZR

3.0 Analysis Inputs

a. The material is Stainless Steel TP 316

b. The wall thickness of the machined section is 0.2175 inches. Other dimensions are shown in the attached sketch — Ref. 1

4.0 Assumptions

Major = none

minor : ① listed in the analysis.
② thermowell cylinder is axisymmetric

5.0 Analysis

The thermowell is subject to an external pressure loading of Primary Coolant pressure. Therefore, the ASME III external pressure design is applicable. For TP 316 stainless steel, Ref. 2 REFER to the design chart — Ref. 2, Ref. 3
Fig HA-2 of Ref. 3. To determine the allowable thermowell thickness, the following parameters need to be calculated.

Pressure stresses in the cylindrical shell

$$\sigma_p = - \frac{P_o b^2}{b^2 - a^2}\left(1 + \frac{a^2}{r^2}\right)$$ — Ref. 4

where b = outside radius $= \frac{.685}{2} = .3425$

a = inside radius $= .3425 - .2175 = .125$

5.0 Analysis (cont'd)

Reference/Comment

Ref. 5

r = radius = a for maximum stress

P = 2500 psi

$$\sigma_p = \frac{(2500)\cdot .3425^2}{.3425^2 - .125^2}(1+1) = 5768 \text{ psi}$$

Conservatively assume that the entire length of the thermowell cylinder is under 6 ksi pressure stress.

Refer to the attached sketch, let L = 15"

$$L/D_o = \frac{15}{.685} = 21.9$$

$$D_o/t = \frac{.685}{.2175} = 3.15$$

From Fig. 6 of Ref. 3. the FACTOR A is beyond the analytical range. Therefore, for the purpose of this analysis, a conservative $D_o/t = 4$ is used which gives a FACTOR A value of 0.07

From Ref. 3 FIG HA-2, the corresponding B FACTOR for A = .07 Temperature = 700°F is 13,000 psi. which is well above the thermowell design ~~pressure~~ stress of ~~2500~~ 5768 psi

Reference/Comment

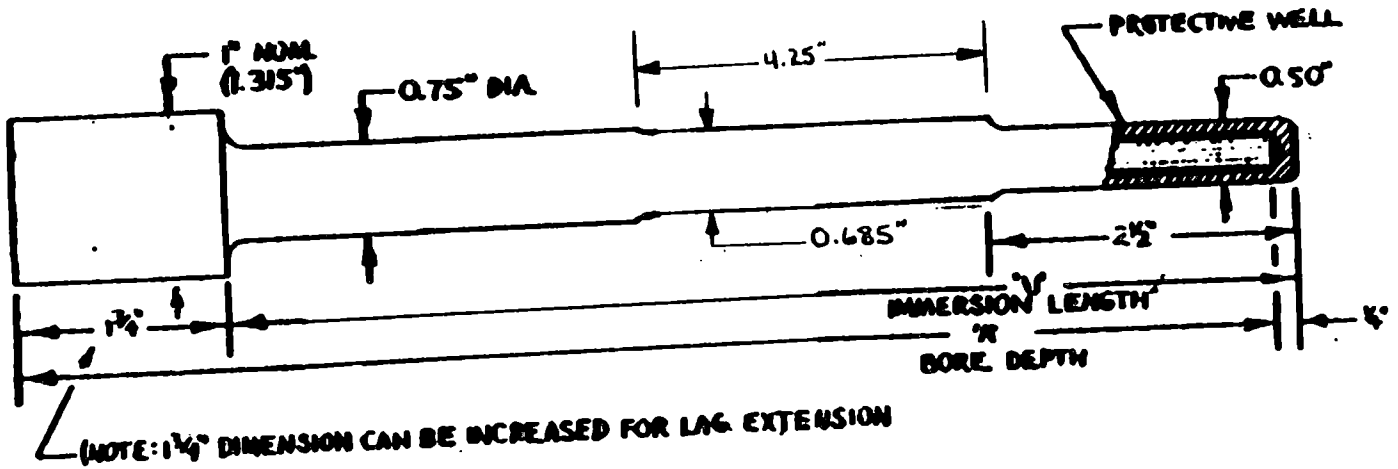
6.0 Conclusions

This analysis demonstrated that the primary stresses in the machined thermowell are within the Code allowable. The maximum stress intensity in the machined section is 6 + 2.5 = 8.5 ksi which is well below the material strength for the SS. 316 Stainless Steel at the design temperature. The buckling strength of the machined cylinder exceeds the Ref. 3 stipulated value. Ref. 2

Because of there is essentially no structural restraint for the thermowell, the secondary stresses are insignificant.

It is concluded that the machined thermowell is adequate for at least one fuel cycle.

Machined TE-0101 Thermowell Dimensions



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NUCLEAR OPERATIONS DEPARTMENT
Document Review Sheet

Document Title	Document Number	Revision Number	Page
STRUCTURAL EVALUATION FOR MACHINED THERMOWELL - TE-0101	EA-FES-93-277-01	0	1 of

Item Number	Page and/or Section Number	Comments	Response or Resolution
1	PAGE 3	IT MAY BE WORTHWHILE TO COMPARE 5768 PSI TO Sm TO SHOW THAT THE THICK THERMOWELL YIELDS BEFORE IT BUCKLES.	page 4, the SI = 8.5 Ksi is a conservative estimation of the pressure stress less than Sm
2	PAGE 2	IT SEEMS THAT AN ASSUMPTION IS MADE THAT THE CYLINDER (THERMOWELL) IS AXISYMMETRIC	incorporated
3	PAGE 3	IT IS NOT CLEAR WHETHER "B" IS EXTERNAL PRESSURE OR EXTERNAL PRESSURE STRESS	incorporated
4	PAGE 4	THE THERMOWELL WAS INSERTED INTO THE NOZZLE MANUALLY WITH SOME (BUT NOT MUCH) FORCE, THEREFORE, ANY THERMAL EXPANSION STRESSES FOR A SINGLE FUEL CYCLE FOR THIS DUCTILE MATERIAL SHOULD BE TOLERABLE.	no response required.

Reviewer	Organization	Date	Review Coordinator	Date	Document Sponsor REVIEWER	Date
[signature]	NECO M&C/S	10/25/93	J. C. [illegible]	10-25-93		10/25/93

Form 3110 10-91

TECHNICAL REVIEW CHECKLIST

EA - FES-93-200-01 REV. D

This checklist provides guidance for the review of engineering analyses. Answer questions Yes or No, or N/A if they do not apply. Document all comments on a 3110 Form. Satisfactory resolution of comments and completion of this checklist is noted by the Technically Reviewed signature on the Initiation and Review record block of Form 3619.

		(Y, N, N/A)
1.	Have the proper input codes, standards and design principles been specified?	Y
2.	Have the input codes, standards and design principles been properly applied?	Y
3.	Are all inputs and assumptions valid and the basis for their use documented?	Y
4.	Is Vendor information used as input addressed correctly in the analysis?	Y
5.	If the analysis argument departs from Vendor Information/Recommendations, is the departure justification documented?	Y
6.	Are assumptions accurately described and reasonable?	Y
7.	Has the use of engineering judgement been documented and justified?	Y
8.	Are all constants, variables and formulas correct and properly applied?	Y
9.	Have any minor (insignificant) errors been identified? If yes; Identify on the 3110 Form and justify their insignificance.	Y
10.	Does analysis involve welding? If Yes; verify the following information is accurately represented on the analysis drawing (Output document).	N

- Type of Weld
- Size of Weld
- Material Being Joined
- Thickness of Material Being Joined
- Location of Weld(s)
- Appropriate Weld Symbology

11.	Has the objective of the analysis been met?	Y
12.	Have administrative requirements such as numbering and format been satisfied?	Y

RBS 10/23/-3