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WANL-TME-561
Addendum IV

WANL Fuel Material Irradiation Program,

Capsule Series T-T

(Phase I),

Addendum IV, Thermal Stress Analysis

David C. Jacobs

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I. Introduction

A thermal stress analysis was omitted from the original safeguards study (WANL-TME-561). This addendum contains the required thermal stress calculations.

II. Thermal Stress Calculations

The following expressions for the tangential and radial stresses for a hollow thin wall cylinder are given by Timoshenko*:

$$(\sigma_{\Theta})_a = (\sigma_z)_a = - \frac{\alpha E (T_a - T_b)}{2 (1 - \nu)} \left(1 + \frac{m}{3}\right)$$

$$(\sigma_{\Theta})_b = (\sigma_z)_b = \frac{\alpha E (T_a - T_b)}{2 (1 - \nu)} \left(1 - \frac{m}{3}\right)$$

where: σ_{Θ} = tangential stress (tensile if positive)

σ_z = axial stress (tensile if positive)

α = coefficient of linear thermal expansion

E = modulus of elasticity

T = temperature

ν = Poisson's ratio

a = inner radius

b = outer radius

and m is defined by the equation:

$$(b/a) = 1 + m$$

* S. Timoshenko, "Theory of Elasticity;" McGraw-Hill, (1934).

For the T-T series capsules:

$$E = 2.8 \times 10^7$$

$$\alpha = 9.5 \times 10^{-6} (^\circ\text{F})^{-1}$$

$$\nu = 0.270$$

$$a = 0.969 \text{ inch}$$

$$b = 1.00 \text{ inch}$$

$$T_a = 299^\circ\text{F}$$

$$T_b = 203^\circ\text{F}$$

and

$$m = (1.00/0.969) - 1 = 0.03.$$

Therefore:

$$\begin{aligned} (\sigma_\Theta)_a &= (\sigma_z)_a = - (9.5 \times 10^6) (2.8 \times 10^7) (96) (1.01)/(2) (0.730) \\ &= -17,000 \text{ psi.} \end{aligned}$$

and

$$\begin{aligned} (\sigma_\Theta)_b &= (\sigma_z)_b = (9.5 \times 10^6) (2.8 \times 10^7) (96) (0.99)/(2) (0.730) \\ &= 17,300 \text{ psi.} \end{aligned}$$

III. Conclusions

The yield strength of Type 316 stainless steel at 250°F is 20,000 psi. Consequently, there is no danger of rupturing the capsule by induced thermal stresses during normal operation.