Table 6.5.1

RACK MATERIAL DATA (200°F)

Material	Young's Modulus E (psi)	Yield Strength S_y (psi)	Ultimate Strength S_u (psi)
SA-240,304L (modified)*	27.6×10^6	25,000	71,000
Section III Reference	Table I-6.0	Table I-2.2	Table I-3.2

SUPPORT MATERIAL DATA (200°F)

	Material	Young's Modulus E (psi)	Yield Strength S_y (psi)	Ultimate Strength S_u (psi)
1	SA-240, Type 304L (modified)* (upper part of support feet)	27.6×10^6	25,000	71,000
2	SA-564-630 (lower part of support feet; age hardened at 1100°F)	27.6×10^6	106,300	140,000

* Dual certified to have chemical composition of 304L material and physical properties of 304 material.

7.3 Local Buckling of Fuel Cell Walls

This subsection and subsection 7.5 present details on the secondary stresses produced by buckling and by temperature effects.

The allowable local buckling stresses in the fuel cell walls are obtained by using classical plate buckling analysis. The following formula for the critical stress has been used based on a width of cell "b" [7.3.1]:

$$\sigma_{cr} = \frac{\beta \pi^2 E t^2}{12 b^2 (1 - \mu^2)}$$

σ_{cr} is the limiting vertical compressive stress in the tube, $E = 27.6 \times 10^6$ psi, $\mu = 0.3$, (Poison's ratio), t = .060" (away from a pedestal), b = 8.75". The factor β is suggested in (Ref. 7.3.1) to be 4.0 for a long panel. Near a pedestal, additional cell wall strength is provided by added strip material which increases the effective thickness of the region prone to buckling to .1045" in the highly loaded region.

For the given data,

$$\sigma_{cr} = 14232 \text{ psi}$$

It should be noted that this stability calculation is based on the applied stress being uniform along the entire length of the cell wall. In the actual fuel rack, the compressive stress comes from consideration of overall bending of the rack structures during a seismic event and as such is negligible at the rack top and maximum at the rack bottom. It is conservative to apply the above equation to the rack cell wall if we compare σ_{cr} with the maximum compressive stress anywhere in the cell wall. As shown in Section 6, the local buckling stress limit is not violated anywhere in the body of the rack modules. The maximum compressive stress in the outermost cell is obtained by multiplying the limiting value of the stress factor R_6 (for the cell cross-section just above the baseplate) by the allowable stress. Thus, from Table 6.7.2, σ = R_6 x allowable stress = .333 x 25000 = 8325 psi under faulted conditions.

7.4 Analysis of the Impact Shield for Cask Pit

To maximize the storage capacity of the spent fuel pool, a spent fuel storage rack containing 225 cells (15x15 cells) is proposed to be installed in the 12'x12' cask loading area of the cask pit of the Sequoyah spent fuel storage pool. After installation of the rack in the cask pit, the pit will be equipped with a removable impact shield (SA-36 material) to prevent accidental dropping of any object on the fuel rack. The proposed impact shield is shown in Figure 2.4.16. It consists of panel coverplates attached to a frame made of wide flange beams. This shield is designed to withstand a total load of 288,000 lbs. uniformly applied on the whole shield, or a total load of 70,000 lbs. uniformly applied on one of the panel plates. The panel plate thickness is determined by a limit load analysis, and the dimensions of the wide flange beams are chosen so that the maximum stresses in the frame for the postulated load cases are within the corresponding allowables. The ANSYS finite element program is used to perform the frame stress analysis. The results are summarized below:

(1) Panel plate can resist a uniform load of 70,000 lbs. on one panel or a concentrated load of 7952 lbs. applied at any point without sustaining a plastic collapse.

(2) Maximum direct plus bending stress in the frame beams is 51961 psi, which is below 90% of the ultimate material strength. Maximum average shear stress is 2850 psi, which is less than the postulated allowable (36,000 psi).

(3) Maximum average compression stress on concrete wall at the bearing locations is 329 psi, which is considerably lower than the allowable (2975 psi).

Therefore, we obtain an estimate of maximum weld shear stress in an isolated hot cell as

$$\tau_{max} = 15515 \text{ psi}$$

Since this is a secondary thermal stress, it is appropriate to compare this to the allowable weld shear stress for a faulted event $\tau < .42S_u = 29820$ psi. In the fuel rack, this maximum stress occurs near the top of the rack and does not interact with any other critical stress.

7.6 References for Section 7

[7.1.1] TVA Specification 3.54-3QNP-90, Revision 1, p. 42.

[7.2.1] TVA Sequoyah Nuclear Plant Updated Final Safety Analysis Report", April, 1991 Section 9.1.

[7.3.1] "Strength of Materials", S.P. Timoshenko, 3rd Edition, Part II, pp 194-197 (1956).

[7.5.1] "Seismic Analysis of High Density Fuel Racks, Part III-Structural Design Calculations - Theory", HI-89330, Revision 1, 1989.