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U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

South Texas Project
Unit 1
Docket No. STN 50-498
Supplement to Request for Relief from ASME Boiler and Pressure Vessel
Code Section XI Requirements (Relief Request RR-ENG-33)

References:
(1) Request for Relief, T. J. Jordan, South Texas Project, to NRC Document Control Desk, dated November 29, 1999 (NOC-AE-000694)
(2) Evaluation Analysis, T. J. Jordan, South Texas Project, to NRC Document Control Desk, dated December 16, 1999 (NOC-AE-000735)
(3) Addendum to Request for Relief, T. J. Jordan, South Texas Project, to NRC Document Control Desk, dated February 22, 2000 (NOC-AE-00000481)

The South Texas Project has requested relief (Reference 1) from IWA-5250(a) of ASME Section XI, 1983 Edition, for the disposition of a small, through-wall leak in the South Texas Project Unit 1 Refueling Water Storage Tank (RWST). The South Texas Project requested NRC approval to disposition the leak based on an analytical evaluation in accordance with IWB-3142.4 of the 1989 Edition of the ASME Section XI code. Pursuant to a verbal request from staff reviewers, the South Texas Project submits the following responses to the Nuclear Regulatory Commission to clarify the technical study (Reference 3) which documented the results of a finite element analysis, fracture mechanics analysis, and field inspection of the tank.

Question 1: Were seismic loads included in the Finite Element Analysis?

Response: The finite element analysis was performed to determine the specific stress state at the sidewall/baseplate connection. This analysis did not include the seismic loads. The original design report for the tank, which was performed at the time of installation, did include the seismic loads. However, the design report did not evaluate the stress state at the side wall/baseplate connection. The results of the finite element analysis showed that the hoop stress in the sidewall and baseplate at the connection is considerably less than the sidewall hoop stress determined in the original design calculation. For example, the baseplate hoop stress determined from the finite element analysis is only 1.75 ksi, whereas the originally calculated hoop stress in the sidewall is 19.74 ksi.

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The 19.74 ksi hoop stress (including seismic loads) was conservatively used to determine the critical flaw size in the sidewall of the tank. A crack in the sidewall rather than in the baseplate is considered to be much more of a concern because the stresses are so much greater. If the existing crack is going to propagate, it will grow in the direction of the greatest stress. Since the stress in the sidewall is an order of magnitude greater than that for the baseplate, the crack would preferentially grow up the sidewall.

The critical crack size calculated for the baseplate used the stresses determined from the finite element analysis that did not incorporate seismic loads. However, because the stress in the baseplate is so much lower than the sidewall, the resulting critical crack size is much larger than that for the sidewall. Therefore, sidewall cracking is the critical crack of concern.

The original design calculation showed that the contribution of seismic loads increased the sidewall hoop stress by 36%. If this factor is added to the baseplate hoop stress, the stress increases from 1.75 ksi to 2.37 ksi. The effect of this increase on baseplate critical crack size is discussed in the response to question 2 below.

Question 2: Equation (1) on page 4 of the report may not be appropriate.

Response: Equation (1) in the report (Reference 3) gives the stress intensity factor, K_I, for a through-edge crack in a semi-infinite plate as:

$$K_I = 1.12\sigma_H \sqrt{\pi a} \quad (1)$$

where σ_H is the applied hoop stress, a is the crack size, and $1.12\,\pi^{1/2}$ is a crack geometry term for a through-edge crack in a semi-infinite body. This relationship is accurate to within 5% for finite width plates for crack length up to 10% of the width. For this specific case, the base plate can be taken to be equal to the tank diameter of 648 inches, so that Equation (1) is valid for crack lengths up to 65 inches, considerably longer than the critical crack size (26 inches) determined for the sidewall.

The stress intensity factor for through-edge cracks in finite width plates with longer cracks is given by[1]:

$$K_I = Y\,\sigma_H \sqrt{a} \quad (2)$$

where

$$Y = 1.99 - 0.41\left(\frac{a}{w}\right) + 18.7\left(\frac{a}{w}\right)^2 - 38.48\left(\frac{a}{w}\right)^3 + 53.85\left(\frac{a}{w}\right)^4$$

where a is the crack length and w is the plate width. Calculations of the critical flaw size in the baseplate, assuming a fracture toughness of 200 ksi $\text{in}^{1/2}$ using Equation (2) and the applied

[1] "Elementary Engineering Fracture Mechanics, 4th edition" By David Broek, Martinum Nijhoff Publishers 1986.

baseplate hoop stress of 1.75 ksi, results in a critical flaw size of 359 inches. An increased baseplate hoop stress of 2.37 ksi to incorporate seismic loads results in a critical crack length of 314 inches. Both of these crack lengths are consistent with the "over 300 inches" critical crack length reported in the referenced report (Reference 3).

In addition, these are conservative because Equation (2) assumes that the stress on the crack is uniform whereas the finite element analysis shows that it decreases away from the sidewall. Equation (2) also assumes that the crack is free to open under the applied stress, but the constraint of the anchor bolts will restrain crack opening and thus decrease the crack driving force.

Finally, these values are about half the diameter of the tank and are more than an order of magnitude greater than the critical lengths for the sidewall. The critical baseplate crack length reported in the original report was "over 300 inches." Therefore, the crack length reported in the referenced report (Reference 3) is bounding.

Question 3: Based on the configuration of the base plate sections, justify why the crack would not go through a weld.

Response: The baseplate and sidewall crack size calculations are based on the assumption of uniform plate thickness. Should a crack grow and encounter a location where plates are welded together in lap joints, the growth would tend to arrest. Doubling plate thickness at these locations reduces the applied stress by a factor of two. Additionally, the applied stress intensity factor and crack driving force will decrease. This would have the effect of making the baseplate critical crack size predictions provided in the report (Reference 3) even more conservative.

The baseplate structural significance regarding catastrophic crack propagation (fishmouth) can be characterized as follows:

> The baseplate is constrained in the vertical direction by 30 plus feet of water (static head) upward and by the concrete floor in the downward direction; therefore, there will be no net vertical forcing functions to puncture or tear the baseplate. The baseplate is always in vertical compression.
>
> The baseplate is constrained in the horizontal direction by two factors:
> 1. Twenty-four gusset anchors bolted to the concrete, and
> 2. Static friction between the baseplate and concrete due to the static head of water.

The original design report for the RWST compared horizontal baseplate shear forces due to a seismic event with the frictional resistance between the baseplate and its concrete foundation. That comparison found that only 56% of the frictional resistance is utilized to completely offset horizontal forces due to an earthquake. Therefore, during a seismic event, the baseplate would not move and the crack would not widen or otherwise catastrophically fail.

Characterization of the crack inside the RWST would require a complete draindown of the tank and is not necessary. Draining down the tank requires a refueling outage and processing large quantities of Boric Acid as waste. The baseplate crack on the outside portion of the baseplate was not visible to the naked eye. The crack was characterized through the use of ultrasonic and dye penetrant tests. Crack characterization on the inside would require similar tests. Since these actions necessary to enable characterization would result in hardship and unusual difficulty without a compensating increase in the level of quality and safety, relief from performing such a characterization would be appropriate under 10CFR50.55a(a)(3)(ii).

SUMMARY:

The calculated critical crack sizes have been reanalyzed taking into account the above comments. The refined analysis does not alter any of the previous conclusions. The cracks are not expected to grow due to stress corrosion because of the ambient temperature conditions. Additionally, any crack growth will be preferentially in the direction of the sidewall because of the higher stresses, and sidewall cracking would be readily detectable.

If there are any questions, please contact either Mr. P. L. Walker at (361) 972-8392 or me at (361) 972- 7902. Representatives of the South Texas Project will be available to meet with you to resolve issues of concern.

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