50-338/339

From: <Tom_Shaub@vapower.com>
To: OWFN_DO.owf4_po(GEE)
Date: Mon, Aug 23, 1999 9:41 AM
Subject: Re: Sang Kim's questions - NAPS USI A-46

Attached is our draft response to question 1. Pleae provide it to the appropriate reviewer.

Thanks

Tom

(See attached file: tanks-naps-rai.doc)

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NORTH ANNA POWER STATION – USI A-46 Submittal

Response to additional NRC request dated August 9, 1999

August 19, 1999

NRC Request:

Data (preferably physical) to support two tank earthquake demand and capacity calculations (RAI 8) particularly with regard to inclusion of water hold-down force, sloshing and resulting stresses in tanks stability and anchor bolt adequacy of the tanks.

Response:

In our response to RAI # 8 on April 1, 1999, the USI A-46 calculations for the two tanks, i.e., the Emergency Condensate Storage Tank (CST) and the Refueling Water Storage Tank (RWST) were provided to the NRC Staff. Both of these tanks were initially classified as outliers. In addition, CST is unanchored and no guidelines for the base overturning moment of unanchored tanks are provided in the Generic Implementation Procedure, Revision 2 (GIP-2). Therefore, other guidelines and criteria were used in specific portions of the analyses of these tanks. The details of the analyses, data and the references to support the criteria are contained in the calculations provided to the NRC Staff earlier. A summary of the methodology used in the various aspects of the analysis is provided below for these two tanks. The analyses of both tanks are based on sound technical guidelines and are systematically presented in the tank calculations. Criteria other than GIP-2 were used from well-known references and only where required and/or not provided in GIP-2. The use of these additional criteria does not conflict with those portions of the tank calculations where the GIP-2 methodology is used. The main references from which data and criteria were obtained for use in these calculations are also listed below.

Condensate Storage Tank:

For the various aspects of the analysis of this tank, the methodology is as follows:

Sliding shear capacity: The calculation is based on GIP-2.

Freeboard clearance: The calculation uses the GIP-2 method.

Convective (sloshing) mode response of the tank: This is calculated using the GIP-2 method.

Impulsive mode response (base shear and overturning moment): The calculation uses the GIP-2 method.

Overturning Moment Capacity: Uplifting of the tank and the fluid hold-down forces were used to calculate the moment capacity of the tank. For unanchored tanks, the small displacement theory is excessively conservative, and an upper bound theory is considered appropriate, in accordance with Reference 2. The equations in reference 2 are based primarily on Flugge (ref. 3) and also on references 4 and 5. Reference 2 recommends limiting uplift height to 0.1L, where L is the uplift length of the base. The uplift length was estimated as 16" (less than 5% of the diameter), therefore, 0.1L worked out as 1.6". However, for additional conservatism, the uplift height was limited to 0.8" which is 50% of the value recommended in reference 2.

Tank Stability: The criteria used for the tank buckling are primarily based on GIP-2. Elephant-foot buckling follows the GIP-2 method, and the axial stress capacity is calculated from the equation provided in GIP-2, page 7-21, which is the same as EPRI NP-6041 (ref. 6). The diamond shaped buckling capacity is based on NASA SP-8007 (ref. 7) and guidance from GIP-2.

Refueling Water Storage Tank:

Tank responses, i.e., base shear and overturning moment, including impulsive mode and convective (sloshing) mode: These calculations are primarily based on the GIP-2 methodology. Although in Attachment A of the

calculation several equations, e.g. to calculate convective mode frequency, base shear and moment responses, are listed as being taken from Reference 6, they will essentially provide the same result as the GIP-2 methodology.

Top plate stress, tank shell stress, vertical stiffner plates and chair-to-tank wall weld: The calculation uses GIP-2 equations.

Sloshing height and freeboard clearance: These calculations are based on GIP-2.

Anchor bolt tensile capacity, overturning capacity, and permissible uplift: The initial anchor bolt tensile capacity was based on GIP-2 and ACI 349. Subsequently, the capacity was revised by studying the failure mechanism for overturning as follows. The calculation of the overturning moment capacity, initially based on the GIP-2 criterion, showed that the moment capacity was lower than the demand. A further evaluation was performed based on a yield line analysis of the top plate that utilized ref. 8. This analysis showed that the permissible load capacity of the anchorage was substantially higher than the initially calculated value. Based on this, the overturning moment capacity was reevaluated, as shown in Attachment D of the calculation. Note that the fluid hold-down forces were neglected, consistent with GIP-2. The permissible uplift was based on Ref. 2 (smaller than that permitted by GIP-2).

Tank Stability: The criteria used for the tank buckling are primarily based on GIP-2. Elephant-foot buckling follows the GIP-2 method, and the axial stress capacity is calculated from the equation provided in GIP-2, page 7-21, which is the same as EPRI NP-6041 (ref. 6). The diamond shaped buckling capacity is based on NASA SP-8007 (ref. 7) and guidance from GIP-2.

References:

Winston and Strawn et al., "Generic Implementation Procedure, Revision 2, (GIP-2)", Seismic Qualification Utilities Group, February 14, 1992.

Bandyopadhyay, K., et al., "Seismic Design and Evaluation Guidelines for the Department of Energy High Level Waste Storage Tanks and Appurtenances", Brookhaven National Laboratory, October 1995.

W. Flugge, Stresses in Shells, Springer-Verlag, 1960.

G. C. Manos, "Earthquake Tank Wall Stability of Unanchored Tanks", Journal of Structural Engineering, Vol. 112, No. 8, ASCE, August 1986, pp 1863-1880.

M. A. Haroun and H. S. Badawi, "Nonlinear Axisymmetric Uplift of Circular Plates", Dynamics of Structures, ASCE, August 1987, pp77-89.

Jack R. Benjamin Associates, et al., "A Methodology for Assessment of Nuclear Power Plant Seismic Margin (Revision 1)", EPRI NP-6041-SL, August 1991.

"Buckling of Thin-Walled Circular Cylinders", National Aeronautics and Space Administration, NASA SP-8007, August 1986.

R. P. Kennedy, Notes on yield line analysis", Structural Mechanics Consulting, July 29, 1986.