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LOFLIN,L.I. Carolina Power & Light Co.
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SUBJECT: Forwards response to NRC 890601 request for info re vertical steel tanks.

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CP&L
Carolina Power & Light Company

OCT 3 1989

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United States Nuclear Regulatory Commission
ATTENTION: Document Control Desk
Washington, DC 20555

SHEARON HARRIS NUCLEAR POWER PLANT
DOCKET NO. 50-400/LICENSE NO. NPF-63
REQUEST FOR INFORMATION CONCERNING VERTICAL STEEL TANKS

Gentlemen:

By letter dated June 1, 1989, Carolina Power & Light Company (CP&L) was requested by NRC staff to submit information concerning the seismic design of two large safety-related vertical steel tanks at the Shearon Harris Nuclear Power Plant (SHNPP). The requested information regarding the Refueling Water Storage Tank (RWST) and the Condensate Storage Tank (CST) is attached.

The staff request indicated that as a result of "significant evolution in the seismic design practice for tanks ... a preliminary determination has been made that a potential safety issue exists with regard to the ability of certain safety-related above-ground vertical liquid storage tanks at your facility to maintain their structural integrity during postulated earthquake events". Specifically, the method used for tank analysis in the past[1] did not account for tank flexibility. If tank wall flexibility was considered in the seismic design of the subject tanks, CP&L should submit a summary of the analysis to show how the specific concerns listed in the attachment to the request letter were addressed.

Carolina Power & Light Company did account for flexibility in the tank design of the RWST and the CST. Therefore, information specific to each item requested is presented in the attachment to this letter. The referenced standard (footnote 1) was utilized in the design analysis to determine slosh height as endorsed by the staff in the requesting letter.

CP&L expects that the attached information will satisfactorily disposition any concern relative to the subject tanks.

A001 1/1

1 "Nuclear Reactors and Earthquakes" TID-7024

411 Fayetteville Street • P. O. Box 1551 • Raleigh, N. C. 27602

Please refer any questions regarding this submittal to Mr. Steven Chaplin at (919) 546-6623.

Yours very truly,

Leonard I. Loflin
Manager
Nuclear Licensing Section

LIL/SDC

cc: Mr. R. A. Becker
Mr. W. H. Bradford
Mr. S. D. Ebneter

VERTICAL STEEL TANKS

a. Staff Criteria

A minimum acceptable analysis should incorporate at least two horizontal modes of combined fluid-tank vibration and at least one vertical mode of fluid vibration. The horizontal response analysis should include at least one impulsive mode in which the response of the tank shell and roof are coupled together with the portion of the fluid contents that moves in unison with the shell. Furthermore, at least the fundamental sloshing (convective) mode of the fluid should be included in the horizontal analysis.

CP&L Response

The storage tanks analysis incorporated two horizontal modes of combined fluid tank vibration and one vertical mode of fluid vibration. The horizontal analysis consisted of the tank shell, fluid, and roof response (impulsive mode) combined with the sloshing (convective) mode.

Ebasco's in-house computer program "Dynamic 2037" was used to determine the dynamic response in the horizontal direction for the impulsive mode. The mathematical model adopted for the horizontal dynamic analyses of the tanks consists of a single cantilever lumped mass system. The lumped masses are connected by weightless elastic bars which represent the stiffness of the tanks' shell. Dead weight of the tank shell plus the fluid weight are included in the lumped mass at the corresponding level. The time histories of accelerations for the Operating Basis Earthquake (OBE) and Design Basis Earthquake (DBE) at the level of tank support were obtained from the Tank Building Dynamic Analysis. The program was utilized to determine the horizontal natural frequencies and associated mode shapes for the tank and fluid system. The maximum responses (displacements, acceleration, forces, shears, and moments) for each mass point was then calculated for the given earthquake record and damping factor. The combination of modal responses follows Regulatory Guide 1.92 "Combining Modal Responses and Spatial Components in Seismic Response Analysis."

A dynamic analysis was not performed to determine the responses in the vertical direction. Vertical fluid and tank vibration was accounted for by using accelerations of 0.075g for the OBE and 0.15g for the DBE.

The maximum horizontal responses obtained from the seismic analysis of the tanks were increased to include the sloshing (convective) effect of the fluid on the tank. The calculation methodology for the sloshing effects were based on "Dynamic Pressure on Fluid Containers" (Chapter 6), Nuclear Reactors and Earthquakes, TID 7024.

b. Staff Criteria

The frequency of fundamental horizontal impulse mode of the tank and the fluid system should be estimated. It is unacceptable to assume a rigid tank unless the assumption can be justified. The horizontal impulsive-mode spectral acceleration is then determined using this frequency of fundamental horizontal impulsive mode and tank-shell damping. The maximum horizontal spectral acceleration associated with the tank support at the tank-shell damping level may be used instead of determining frequency of fundamental horizontal impulsive mode.

CP&L Response

The computer program, Dynamic 2037, was utilized to determine the horizontal natural frequencies and mode shapes for the tank and fluid system. The maximum horizontal acceleration for each mass point was then calculated for the given earthquake record and damping factor. See response to (a) above.

c. Staff Criteria

Damping values used to determine the spectral acceleration in the impulsive mode should be based upon the values for tank shell material as specified in the current SRP Section 3.7.1.

CP&L Response

The damping factors utilized to determine the spectral acceleration in the impulsive mode were 2% for the OBE and 4% for the DBE. These damping values are consistent with Regulatory Guide 1.61 (Revision 0) for welded steel structures as required by SRP 3.7.1.

d. Staff Criteria

In determining the spectral acceleration in the horizontal convective mode, the fluid damping ratio should be 0.5% of critical damping unless a higher value can be substantiated by experimental results.

CP&L Response

In order to determine spectral acceleration for the horizontal convective mode (sloshing effect), response spectra values for 0.5% critical damping were developed at the tank elevations for the site OBE and DBE.

e. Staff Criteria

The maximum overturning moment M_B at the base of the tank should be obtained by the modal and spatial combination methods discussed in the SRP Section 3.7.2.II. The uplift tension resulting from M_B should be resisted either by tying the tank to the foundation with anchor bolts, etc., or by mobilizing enough fluid weight on a thickened base skirt plate. The latter method of resisting M_B must be shown to be conservative.

CP&L Response

The maximum overturning moment at the base of each tank was calculated by using Ebasco's in-house computer program "Dynamic 2037." This program follows Regulatory Guide 1.92 for combination of modal responses as required by SRP 3.7.2.II., The maximum overturning moment is resisted by tying the tank to the slab with anchor bolts. The tensile stress developed in the anchor bolts is less than the allowable defined by the American Institute of Steel Construction Code.

f. Staff Criteria

The seismically-induced hydrodynamic pressures on the tank shell at any level can be determined by the modal and spatial combination methods in the SRP Section 3.7.2. The hydrodynamic pressure at any level should be added to the hydrostatic pressure at the level to determine the hoop tension in the tank shell.

CP&L Response

The maximum seismically-induced hydrodynamic forces on the tank shell at various levels were determined by following Regulatory Guide 1.92 "Combining Modal Responses and Spatial Components in Seismic Response Analysis." Hydrostatic and hydrodynamic pressures were not combined in the original design calculations to determine hoop tension in tank shell. Therefore, the calculation has been revised, and included in the seismic qualification report. The calculation shows that the tank shell is acceptable for hydrodynamic plus hydrostatic pressure.

g. Staff Criteria

Either the tank top head should be located at an elevation higher than the slosh height above the top of the fluid or else should be designed for pressures resulting from fluid sloshing against this head. The method in current design codes for calculating slosh height is not necessarily conservative. Formulas given in Ref. 1 can be used to calculate slosh height.

CP&L Response

The roofs of the tanks are not at an elevation higher than the calculated slosh height. The calculation methodology utilized to determine slosh height is from formulas given in "Dynamic Pressure on Fluid Containers" (Chapter 6), Nuclear Reactors and Earthquakes, TID 7024. The roof of the tanks have been designed for pressures resulting from the fluid sloshing.

h. Staff Criteria

The tank foundation (see also SRP Section 3.8.5) should be designed to accommodate the seismic forces imposed by the base of the tank. These forces include the hydrodynamic fluid pressures imposed on the base of the tank as well as the tank shell longitudinal compressive and tensile forces resulting from M_B.

CP&L Response

The tanks are not supported by foundations, but are supported by the Elevation 261.00' reinforced concrete slab in the Tank Building. This slab has been designed to accommodate longitudinal compressive and tensile seismic forces imposed by the base of the tank including hydrodynamic fluid pressures and overturning moment.

i. Staff Criteria

In addition to the above, consideration should be given to prevention of buckling of tank walls and roof, failure of connecting piping, and sliding of the tank.

CP&L Response

The tank shell design has been checked for local buckling. For all load cases buckling stresses are less than the allowable stress.

Evaluation of loads from connecting piping has been performed for both tanks and stress levels are less than code allowables.

Anchor bolts at the tank base have been designed for the tensile load described in item 'e' above and shear load due to sliding of the tank.