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AUTH.NAME AUTHOR AFFILIATION
TUCKER,H.B. Duke Power Co.
RECIP.NAME RECIPIENT AFFILIATION
DENTON,H.R. Office of Nuclear Reactor Regulation, Director
STOLZ,J.F. Operating Reactors Branch 4

SUBJECT: Forwards responses to 830523 request for addl info re spent fuel pool.Info suppls 830310 ltr.

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DUKE POWER COMPANY
P.O. BOX 33189
CHARLOTTE, N.C. 28242

HAL B. TUCKER
VICE PRESIDENT
NUCLEAR PRODUCTION

TELEPHONE
(704) 373-4531

June 24, 1983

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. John F. Stolz, Chief
Operating Reactors Branch No. 4

Subject: Oconee Nuclear Station
Docket Nos. 50-287

Dear Sir:

Please find attached responses to the staff's request for additional information concerning the proposed reracking of Oconee Unit 3's Spent Fuel Pool. J. F. Stolz's May 23, 1983 letter had transmitted the staff's eight structural related questions. The information supplements that provided by my letter of March 10, 1983.

Very truly yours,

Hal B. Tucker

Hal B. Tucker

PFG/php

Attachment

cc: Mr. James P. O'Reilly, Regional Administrator
U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30303

Mr. Hayward Shealey, Chief
Bureau of Radiological Health
South Carolina Department of Health and
Environmental Control
2600 Bull Street
Columbia, South Carolina 29201

Mr. John F. Suermann
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Mr. J. C. Bryant
NRC Resident Inspector
Oconee Nuclear Station

A001
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HRD/PFG
June 24, 1983

Duke Power Company
Oconee Nuclear Station Unit 3
Request for Additional Information
Spent Fuel Pool Expansion

Request No. 1:

Provide structural drawings of the pool and liner showing reinforcement of the walls and floor and attachment of the liner to the concrete.

Response:

Enclosed for your review are prints of the Duke drawings 0-2154S, 0-2154T, 0-2154U, 0-2154W, 0-2154X, 0-2154Y, 0-2155G, 0-2155H.

Request No. 2:

How are seismic effects modeled to account for a three-dimensional earthquake input for the sliding/tipping analysis?

Response:

In the seismic sliding/tipping analysis, a two-dimensional model is used. Seismic loads in one horizontal and in the vertical direction are applied at the same time. The results from this two-dimensional analysis are then combined with the results of another loading case where the other horizontal seismic shock and the vertical shock have both been applied. The results from the two two-dimensional loading conditions are combined by the SRSS method to account for the three-dimensional earthquake effects.

Request No. 3:

Provide results of key structural calculations and comparison with allowable values for the design of the racks.

Response:

The following table lists the results of the structural calculations. The ASME Code defines the margin of safety as:

$$\text{M.S.} = \frac{\text{Allowable Stress}}{\text{Design Stress}} - 1$$

The major loads considered for the normal and upset conditions are dead weight plus OBE seismic loads, and dead weight plus thermal plus OBE seismic, respectively.

The SSE seismic allowables are twice the OBE seismic allowables and since the SSE loads are less than twice the OBE loads, the SSE margins of safety are higher than the OBE margins.

SUMMARY OF DESIGN STRESSES AND MINIMUM MARGINS OF SAFETY

Normal & Upset Conditions

	Design Stress (psi)	Allowable Stress (psi)	Margin of Safety
1.0 Leveling Pad Assembly			
1.1 Leveling Pad			
Shear	1423	11000	6.73
Axial and Bending	11819	16500	0.39
Bearing	10480	24750	1.36
1.2 Leveling Pad Screw			
Shear	7090	11000	0.55
1.3 Support Plate			
Shear	1928	11000	4.70
Weld Shear (Thermal)	20662	31735	0.53
1.4 Stand-off Pad (Top Plate)			
Bending	18457	20625	0.11
Shear	1392	11000	6.90
1.5 Stand-off Pad Plate to Block Welds			
Weld Shear	20855	24000	0.15
1.6 Stand-off Pad Lower Block			
Axial and Bending	*	*	0.33
1.7 Support Plate (Failed Fuel Region)			
Weld Shear	18544	24000	0.29
2.0 Cell Assembly			
2.1 Cell to Bottom Grid Weld			
Weld Shear	19572	24000	0.22
2.2 Cell to Top Grid Weld			
Weld Shear (Thermal)	21705	31735	0.46
2.3 Cell			
Axial and Bending	*	*	0.14
2.4 Cell Seam Weld			
Weld Shear	7276	24000	2.30
2.5 Cell to Wrapper Weld			
Weld Shear	7129	11000	0.54

*Reference Equation (20) of ASME XVII - 2215

	Design Stress (psi)	Allowable Stress (psi)	Margin or Safety
3.0 Grid Assembly			
3.1 Top Grid Box Member			
Shear	5970	11000	0.84
Axial and Bending	3384	16500	3.87
3.2 Top Grid Members Welds			
Weld Shear	14335	24000	0.67
3.3 Top Grid Outer Member			
Axial and Bending	3041	16500	4.42
Shear	9071	11000	0.21
3.4 Bottom Grid Box Member			
Shear	5587	11000	0.96
Axial and Bending	13366	16500	0.23
3.5 Bottom Grid Members Welds			
Weld Shear	16181	24000	0.48
3.6 Bottom Grid Base Plate Weld			
Weld Shear	12614	24000	0.90
3.7 Bottom Grid Outer Member			
Axial and Bending	11733	16500	0.40
Shear	1406	11000	6.82
3.8a Top Grid Member (Failed Fuel Region)			
Axial and Bending	6980	16500	1.36
3.8b Top Grid Members Welds (Failed Fuel Region)			
Weld Shear	2671	24000	7.98
3.8c Bottom Grid Member (Failed Fuel Region)			
Axial and Bending	10915	16500	0.51
Shear	10360	11000	0.06
3.8d Bottom Grid Members Welds (Failed Fuel Region)			
Weld Shear	10063	24000	1.38

Request No. 4:

Provide results of key structural calculations and comparison with allowable values for the analysis of the pool structure under the new rack loads.

Response:

The following table presents the allowable moments for the pool structure and stress for the pool liner as defined by the most severe loading combinations.

	Load Combination	Allowable Moment	*Safety Factor
Pool Slab	1.0D+1.0E'+1.0Ta	316 KiP-ft./ft.	1.73
Pool Floor Stiffening Member	1.0D+1.0E'+1.0Ta	12965 KiP-ft.	1.93
		Allowable Stress	***Safety Factor**
Liner Plate	1.0D+1.0E'+1.0Ta	27.0 KSI	1.58
Weld in Liner	1.0D+1.0E'+1.0Ta	32.0 KSI	1.33

$$* \text{ Safety Factor} = \frac{\text{Allowable Value}}{\text{Design Value}}$$

D = dead loads
E' = seismic loads based on maximum hypothetical earthquake (SSE)
Ta = abnormal thermal load condition

Request No. 5:

Describe the method used to account for fluid inertia effects in the following analysis:

a. fuel bundle/rack impact analysis
b. rack sliding/tipping analysis
c. seismic design of the rack structure
d. seismic analysis of the pool structure

Response:

(a,b,c) The fluid inertia effects of both the fuel bundle within the cell and the rack module within the fuel pool are accounted for in the seismic analysis by the use of mass matrices between the fuel and cell and between the cell and pool walls. The mass matrices contain the hydrodynamic mass and fluid coupling terms (M_{11}, M_{12}, and M_{22}) which have been determined for the fuel to cell interaction and for the cell to pool wall interaction. The hydrodynamic mass and fluid coupling terms have been calculated using the methods described by R. J. Fritz ("The Effect of Liquids on the Dynamic Motions of Immersed Solids") and by G. R. Sharp and W. A. Wenzel ("Hydrodynamic Mass Matrix for a Multibodied System").

(d) The seismic analysis of the Unit 3 fuel pool was done in accordance with the methods described in Section 3.7.2 of the Oconee FSAR. The method is based on AEC publication TID 7024, "Nuclear Reactors and Earthquake".

Request No. 6:

Provide numerical results of the sliding/tipping analysis which indicates minimum gaps between racks and/or pool structure for worst case sliding and tipping compared to nominal gaps for the racks as placed in the pool.

Response:

Evaluation of Rack Lateral Displacements
The nonlinear time history analysis shows that during a seismic event the fuel rack sliding distance is 0.025 inches and the maximum top of the rack structural deflection is 0.17 inches. In this portion of the evaluation, the rack to rack, rack to floor obstructions, and rack to wall gaps will be examined to show that there is no impact due to the lateral motion.

Rack to Rack

To evaluate the rack to rack gap of 0.76 inch, the gap will be modified to account for thermal growth of hot operating conditions, and compared with the rack's maximum seismic displacement to show that impact between rack modules does not occur.

Rack Thermal Displacement

Since the pool temperature during installation is below the hot operating condition, the gap must be reduced by the thermal expansion of the rack. The rack to rack thermal displacement shown in the following calculation is for maximum normal condition and also the accident condition of cooling system not operational.

			Maximum Normal Condition	Accident Condition
Pool Temperature During Installation	T_I	°F	70	70
Temperature at Rack Top During Operation	T_R	°F	150	239
Maximum Rack Width (12 Cell Side)	W	in	127.2	127.2
Coefficient of Thermal Expansion	α	in/in °F	8.20 E-6	8.50 E-6
Rack Thermal Growth $\delta_T = W\alpha(T_R-T_I)$	δ_T	in	.083	.183

Response (Cont'd):

Maximum Rack Seismic + Thermal Displacement

The condition which produces the maximum fuel rack seismic response is all fuel racks filled with fuel. For this configuration the racks responses (sliding and structural deflection) will be in phase, thus the rack to rack gap is not affected. The major factor which produces the phase relationship for this condition is the hydrodynamic coupling effect of the submerged structure.

However, due to variation of friction or for other than racks full of fuel, there may be a condition where one rack slides and the adjacent rack does not slide. For this condition the rack to rack gap will be reduced by the amount of one rack sliding, two racks structurally deflecting, and the thermal movement of the racks for the installed temperature to the maximum normal temperature. Since the structural displacements of the racks are out of phase or unrelated, the combined seismic displacements will be obtained by the SRSS method.

In addition to this condition, the thermal accident condition must be addressed. Since it is highly unlikely that the thermal accident condition and the SSE seismic event occur simultaneously, only the sliding distance of the SSE event, without the structural displacements, will be combined with the thermal accident displacement.

SSE Seismic + Maximum Normal Thermal

			SSE Seismic + Normal Thermal
Max. Sliding Distance, μ = .2 (N-Linear Results)	Δs	in	.025
Max. Structural Defl., μ = .8 (N-Linear Results)	δ	in	.170
Total Displacement One Rack $\Delta = \Delta s + \delta$	Δ	in	.195
SRSS Combined Displace 2 Racks with only 1 sliding $\Delta_{max} = \sqrt{\Delta^2 + \delta^2}$	Δ_{max}	in	.259
Max. Normal Thermal Displacement	δ_T	in	.083
Max. Combined Thermal & Seismic Displacements $\overline{\Delta} = \delta_T + \Delta_{max}$	$\overline{\Delta}$	in	.342
Rack to Rack Gap		in	.760

Response (Cont'd):

SSE Seismic Sliding + Max. Accident Thermal

			SSE Seismic Sliding + Thermal Accident
Max. Sliding Distance, $\mu = .2$	Δ	in	.025
Max. Accident Thermal Displacement	δ	in	.183
Combined Thermal & Seismic Sliding $\bar{\Delta} = \Delta_S + \delta_T$		in	.208
Rack to Rack Gap	G	in	.760

Thus it is seen that the maximum rack to rack movement is less than the rack to rack gap, and there is no rack to rack collision.

Rack to Floor Obstruction

The minimum rack to floor obstruction gap is large (>0.5"). Since this gap is much larger than the combination of sliding distance, structural deflection, and thermal displacement, there is no impact between the rack and floor obstruction.

Rack to Wall

The minimum rack to wall gap is 4.71". Since this gap is much larger than the combination of sliding distance, structural deflection, and thermal displacement, there is no impact between the rack and wall.

Request No. 7:

Describe the potential structural consequences of a cask drop accident on the pool floor, walls and liner. Provide results of computations showing comparisons of calculated and allowable values for pool structural components including the liner.

Response:

A description of the potential structural consequences of a cask drop accident was presented in a letter by Mr. W. O. Parker of Duke Power to Mr. Donald C. Rusche of the Nuclear Regulatory Commission dated November 3, 1975. The calculations concerning the structural consequences of a cask drop determine that a free fall of the cask impacting directly on the pool floor and liner would produce the worst case condition. The results of the previous analysis are still applicable.

Request No. 8:

For the design of the rack cells, describe the calculation procedure and acceptance criteria for local buckling of the thin gage material.

Response:

Appendix XVII of the ASME Code specifies a procedure to be followed to account for possible local buckling of the cell material. Section XVII-2220 defines the equations to account for the local buckling of thin gage material by the reduced effective width method, and also defines equations to be used to obtain a reduced stress allowable for axially loaded compression members. It is this procedure described in Appendix XVII-2220 that was used in the Oconee analysis to account for possible local buckling of the thin gage material.