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December 22, 1978

Director of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. A. Schwencer, Chief
Operating Reactors Branch 1
Division of Operating Reactors

Gentlemen:

INCREASED CAPACITY SPENT FUEL RACKS
NO. 1 UNIT
SALEM NUCLEAR GENERATING STATION
DOCKET NO. 50-272

Public Service Electric and Gas Company hereby submits additional information in support of its application to increase the spent fuel storage capacity at the Salem Nuclear Generating Station. This information is in response to discussions held with members of your staff.

This submittal consists of forty copies.

Should you have any questions regarding this application, please do not hesitate to contact us.

Very truly yours,

F. P. Librizzi
General Manager -
Electric Production

Attachment

REGULATORY DOCKET FILE COPY

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QUESTION 15

Verify that the racks will withstand the drop from the maximum transport height of any of the items which will be carried over the racks when impacting the racks both horizontally and vertically, without violating the appropriate acceptance criteria. In addition, discuss the effects of the total rack structure flexibility on the results of the postulated drop analyses.

ANSWER

See the response to Question 4 of our May 17, 1978 submittal for a list of tools carried over the Spent Fuel Pool; the attached table tabulates the significant loads carried over the spent fuel pool and their potential energies. The possibility of these tools falling over the spent fuel racks is highly improbable:

1. The fuel handling crane has a design factor of a least 5 to 1 at its rated capacity of 5 tons. The reeving system on the hoist consists of four wires each being 7/16" in diameter Regular Lay Wire Crane rope 6x37 IWRC. The minimum breaking strength load of the wire rope is greater than 7 tons. Therefore, the breaking strength load of the reeving system is four times that of one wire rope or greater than 28 tons. The cable is coated to reduce corrosion and thus preclude failure of the wire rope due to corrosion. If the cable is ever immersed in the pool water, although it is not supposed to be, it will be cleaned and relubricated per the manufacturer's recommendation. Also, the wire rope is inspected, as is the entire crane, per requirements of OSHA (ANSI B30.2) as a minimum.

ANSWER (Cont'd)

2. The load carrying capacity of the fuel handling crane over the spent fuel pool is limited by the Tech. Spec. to 2500 lbs.

3. The fuel handling crane is periodically tested in accordance with the Tech. Spec. and/or OSHA requirements. These tests are not conducted over the spent fuel pool.

4. The fuel handling crane hook has a hook-throat latch to prevent the inadvertant separation of the tools from the crane hook. Tools are connected to the crane hook in the transfer pool and not in the SFP which further eliminates the possibility of a drop accident.

To provide yet another redundant safety feature, a back-up cable will be attached to the tools. This feature consists of an attachment around the load block and around the supporting area of the tool. Should the tool weight be transferred from the hook to the cable, the load would be transferred to the block and thus back into the normal reeving and sheave assemblies; deformation of the block housing, should it occur in a tool drop accident, is considered acceptable as long as the back-up cable prevents the tool from dropping. The cable rating and design factors will be similar to those of the fuel handling crane. The attached drawing demonstrates the back-up cable.

X

ANSWER (Cont'd)

With the possibility of a tool drop eliminated, an analysis was performed on a fuel assembly drop on the spent fuel racks. Restricted by limit switches on the fuel handling crane, the fuel assembly movement is limited to a maximum height of 15 inches over the spent fuel racks. The energy of the dropped fuel assembly at this height is absorbed by local and elastic deformation of the top 7 inches of the fuel storage cell. In the complete model, a static load equivalent to the force required for the deformation of the top of the storage cell was imposed on the top of the rack. The rack members were analyzed and shown to be within the allowable loads of the design criteria for this maximum fuel drop load. The dynamic response of the rack structure

to the impulsive type loading of the fuel bundle drop accident has also been evaluated. Details of the response of elastic structures to impulsive loadings and the supporting theory are provided in Chapter 8 of the reference.

For cases where the fuel assembly is assumed to drop onto the top of the rack structure (both vertical and rotating), the resulting crushing of the fuel cells can be represented by a load increasing linerly to a maximum value followed by a vertical decay. Structural response details for this impulse profile are

ANSWER (Cont'd)

provided on Figure 8.22(c), 8.23 and 8.24 of the reference. The amplification of the maximum value of the impulsive load is a function of t/T, where t is the impulse duration and T is the natural period of the responding structural system. The maximum t/T is 0.19 for the vertical drop case and the corresponding load amplification factor is 0.6. The maximum response of the rack structure is, therefore, significantly lower than the peak value of the impulsive load, for which the structure was designed.

For the case where the fuel assembly is dropped inside the storage cell the resulting impact on the rack base is conservatively represented as a rectangular load impulse. Figures 8.17 and 8.18 of the reference describe the structural response for this impulse profile. The calculated t/T ratio is 0.17 and the corresponding load amplification factor is 1.0. The maximun response of the rack structure is, therefore, equal to the maximum value of the impulsive load.

In summary it can be concluded that the analyses previously presented conservatively shows that the design is acceptable for all postulated fuel drop accidents for both full and partially full conditions and that:

ANSWER (Cont'd)

1) Inelastic deformations are limited to the immediate area(s) of fuel assembly impact.

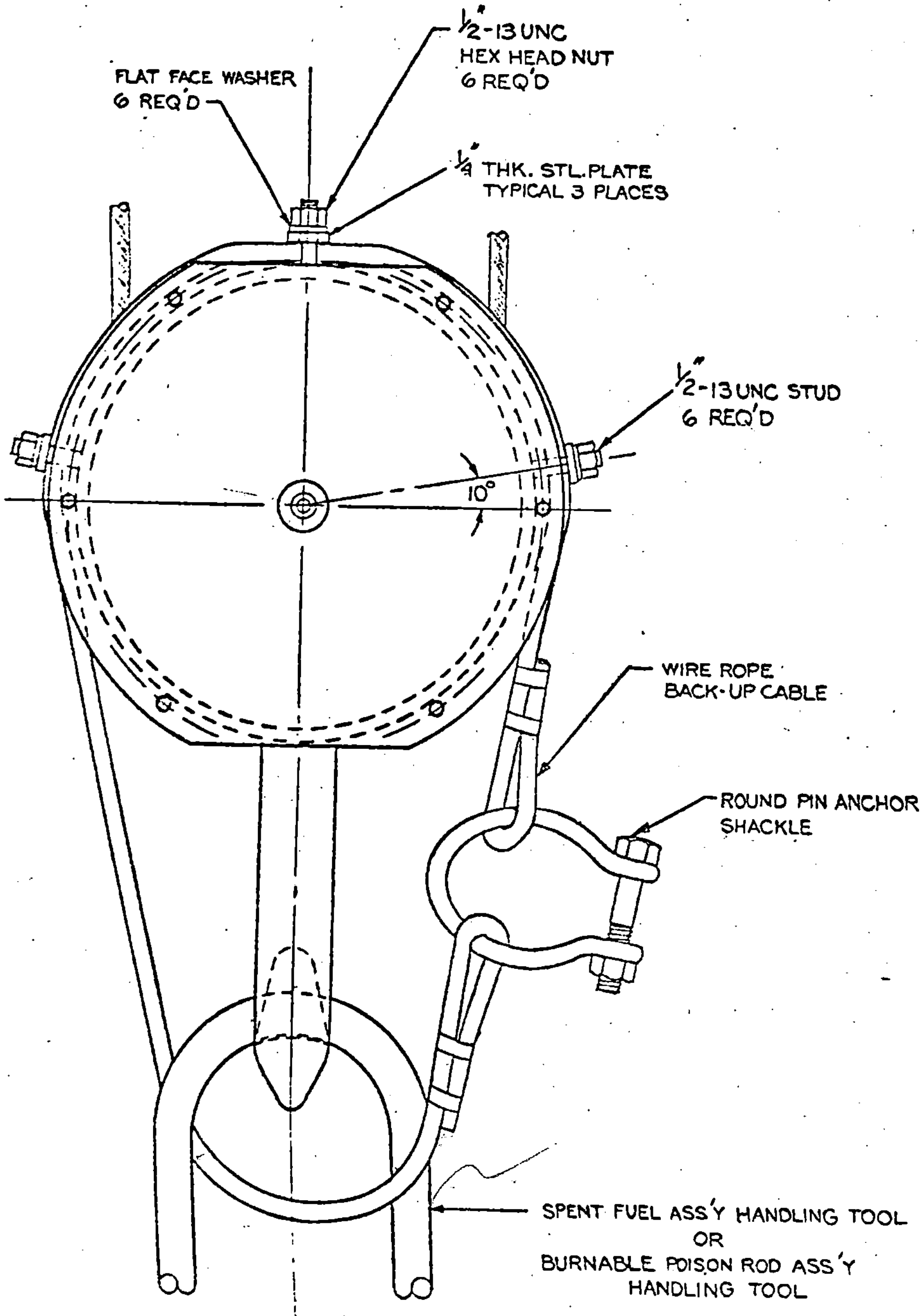
2) All other rack member stress are within the limits specified on Page 33 of the February 14, 1978 submittal.

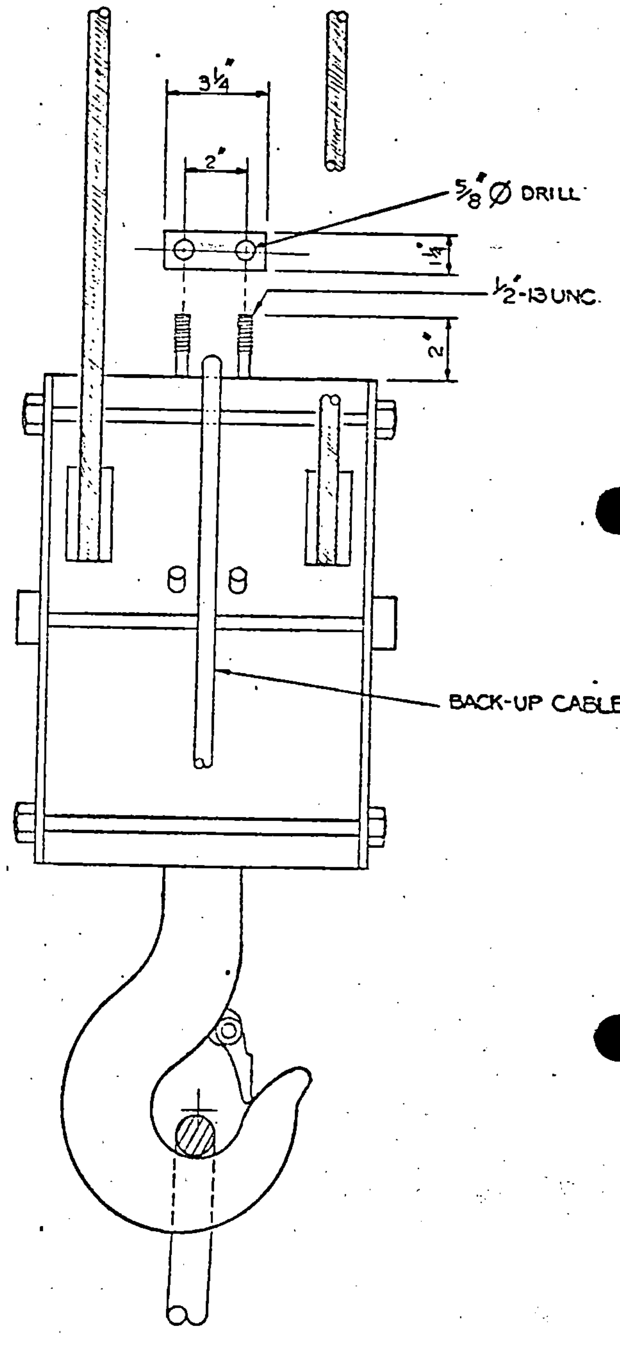
3) Deformations are not greater than the values presented in the February 14, 1978 submittal.

Reference: C. M. Harris and C. E. Crede, Shock and Vibration Handbook, Second Edition, McGraw Hill.

	Fuel Assembly Handling Fixture	Burnable Poison Rod Assembly Tool
Maximum Drop Height of Empty Tool over storage racks, ft.	15	15
Weight of Empty Tool, lbs.	350	650
Maximum Kinetic Energy at Impact, ft. lbs.	5250	9750
Maximum Drop Height of Loaded Tool over storage racks, ft.	1 1/4	1 1/4
Maximum Weight of Loaded Tool, lbs.	1965	2265
Maximum Kinetic Energy at Impact ft. lbs.	2456	2831
Unloaded Tool, Wire Rope Design Factor (based on breaking strength)	350/56000	650/56000
Loaded Tool, Wire Rope Design Factor (based on breaking strength)	1965/56000	2265/56000
Design Factor of remaining portions of fuel handling crane with respect to its load rating of 5 tons	5:1	5:1

Note 1: Fuel Handling crane is load tested per Chapter 2-2 of ANSI B30.2


FLAT FACE WASHER
6 REQ'D
1/2"-13 UNC
HEX HEAD NUT
6 REQ'D
1/4" THK. STL. PLATE
TYPICAL 3 PLACES
1/2"-13 UNC STUD
6 REQ'D
10°
WIRE ROPE
BACK-UP CABLE
ROUND PIN ANCHOR
SHACKLE
SPENT FUEL ASS'Y HANDLING TOOL
OR
BURNABLE POISON ROD ASS'Y
HANDLING TOOL


3 1/4"
2"
5/8" Ø DRILL
1 1/4"
1/2"-13 UNC.
2"
BACK-UP CABLE

2. LONG TERM FUEL STORAGE CELL SURVEILLANCE PROGRAM
NO. 1 & 2 UNITS
SALEM NUCLEAR GENERATING STATION

The long-term fuel storage surveillance program serves to verify that the spent fuel storage cell retains the material stability and mechanical integrity over the life of the spent fuel storage racks under actual spent fuel pool service conditions. Sample flat plate sandwich coupons and short fuel storage cell sections are provided for periodic surveillance and testing. The short fuel storage cell sections and flat plate sandwich coupons can be disassembled for examination when required. The short fuel storage cell sections are prototypic of the actual fuel storage cells and thus provide reasonable assurance that the periodic surveillance will yield characteristics that are prototypic of the fuel cells. One short fuel storage cell and one flat plate sandwich coupon will be prepared such that the Boral material will be exposed to the spent fuel pool environment.

The samples are of the same materials and are produced using the same manufacturing and QA/QC procedures specified for the fuel storage cells. All samples will be numbered on the outside. All Boral plates will be weighed after oven drying and numbered prior to sample assembly in order to provide a reference for any possible subsequent corrosion analysis based on weight gain or loss. The entire test section will be weighed after fabrication to establish a reference weight for detecting water ingress without resorting to destruction of the assembly.

The samples will be placed in an empty fuel storage cell in the racks as shown on Figure 1. The test sections will be positioned in a stainless steel fixture such that plane of the Boral plates is in the vertical direction. After examination, they will be moved to an empty fuel storage cell position near the most recent off-loaded fuel.

For examination, all samples will be removed from the pool at the end of each prescribed exposure. Visual examination will be made of all samples. Samples will be weighed. If any samples are found, as a result of visual or weight examination to have evidence of corrosion, weld cracking, or leaks of any type, further examination will be made. This could include selecting one of the suspect samples for further external visual and microscopic analysis. This sample may also be disassembled to verify the condition of the internal poison material. Remaining samples will be returned to the pool for further exposure.

The following is the sample examination program and frequency:

1. Place five short fuel storage cell section samples and five flat plate sections in the spent fuel pool.

2. Remove all samples from the pool for visual and weight analysis after one year. Any sample suspect of presenting a future problem will be retained for further examination. The remaining samples will be returned to the pool.

3. Repeat Step 2 every two years thereafter.

Should destructive examination of five samples be required, examination of the spent fuel racks would follow.

MOB:pd

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SALEM STORAGE RACK - FUEL ASSEMBLY LOAD ANALYSIS

An analysis was performed to calculate the component stresses on a fuel assembly stored in the spent fuel racks during a seismic event.

The fuel assembly was assumed to be positioned in the storage racks such that it was initially in contact with one of the storage cell walls. Based on that assumption, the maximum attainable fuel assembly deflection at any location was 0.60 inches. Static loads were applied to the fuel assembly grids to simulate the fuel assembly inertial forces.

The fuel assembly deflected shape resulting from the calculated load distribution is presented in Figure 1, and indicates that the fuel assembly experiences grid to cell wall contact at the third and higher grid elevations. The fuel assembly component maximum stresses obtained from the analysis were compared to the established allowable limit and are presented in Table 1.

TABLE 1

RATIO OF ALLOWABLE STRESSES TO FUEL ASSEMBLY COMPONENT MAXIMUM STRESSES

COMPONENT	ALLOWABLE STRESS LIMIT (P_M) / UNIFORM STRESS (${}_M$)	ALLOWABLE STRESS LIMIT (P_M P_B) / COMBINED STRESS (${}_M$ + ${}_B$)
Thimble	4.7	1.75
Fuel Rod	133.	26

For the seismically induced fuel assembly impact forces, it can be concluded based on a fuel assembly deflected shape that the stress margins for the various fuel assembly components are acceptable. It can also be concluded that the minimum experimental grid strength was substantially greater than the estimated grid maximum impact force of 540 lbs. or the 978 lbs. impact force calculated by the model for the two center grids.

Q. 19 Provide the increase in floor loadings in the spent fuel pool due to the proposed rack design and its effect, if any, on the overall structural stability and seismic response of the auxiliary building. Does the pool structure still meet the allowable limits imposed on the design by the FSAR?

A. 19 Pool floor loadings due to the fuel storage racks and fuel are as follows:

Total dry weight of rack module with fuel	196,100 lbs.
Total buoyant weight of rack module with fuel	175,600 lbs.
Floor loading due to buoyant weight of rack module with fuel	2,110 lbs/ft.^{2}
Maximum load on any 6" diameter module screw foot	53,100 lbs.

The increase in floor loading due to the proposed spent fuel storage racks is well under 1% of the total mass lumped at that level in the analytical model. The walls were investigated for the seismic effect of the heavier racks and stored fuel. It is concluded that the new high density racks have no appreciable effect on the structural stability and seismic response of the Fuel Handling Building. The pool structure meets all allowable limits imposed on the design in the FSAR including thermal loads.

Q. 20 In Section 3.4 of your February 14, 1978 submittal you state that materials are compatible with pool water that contains a nominal concentration of 2,000 ppm boron. Describe your surveillance program to maintain this level. Also, discuss the quality of the pool water in terms of pH value and available chlorides and fluorides.

A. 20 No surveillance is required to assure that the pool water contains a nominal concentration of 2,000 ppm boron. The design of the proposed spent fuel storage racks is such that the k_{eff} will be below 0.95 even with unborated water.
The pH value of the SFP water, which depends on the concentration of boric acid, will range from 4 to 4.7. Chlorides and fluorides in the water will be a maximum of 0.15 ppm.

The modulus of elasticity, E, has been considered constant between 70°F and 200°F. The value for the modulus of elasticity has been assumed to be 28.0×10^6 psi. Table I-5.0 of ASME Section III Division 1 Appendix I lists $E=28.3 \times 10^6$ psi at 70°F and $E=27.7 \times 10^6$ psi at 200°F. The assumption that $E=28 \times 10^6$ psi, through the range in temperatures, results in a deviation of less than 1%. Thus, we feel, this is a valid assumption.

The coefficient of thermal expansion, a, has been considered to have a constant value of 9.5×10^{-6} in/in/F. Table I-5.0 of ASME Section III Division 1 Appendix I listed $a=9.34 \times 10^{-6}$ in/in/F at 200F, $a=9.41 \times 10^{-6}$ in/in/F at 250F, $a=9.47 \times 10^{-6}$ in/in/F at 300F and $a=9.53 \times 10^{-6}$ in/in/F at 350F. The assumed constant value of 9.5×10^{-6} in/in/F results in a conservative value for a, the coefficient of thermal expansion. Thus, the assumed value is a valid assumption.