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TO: V. Stello

FROM: Flordia Power & Light Co.
Miami, Flordia
R.E. Uhrig

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Supplemental Information related to the Evaluation of Spent Fuel Transfer Process....... W/Attachments

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PLANT NAME: Turkey Pt. # 3 & 4

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FLORIDA POWER & LIGHT COMPANY

June 29, 1976
L-76-238

Director of Nuclear Reactor Regulation
Attn: Mr. Victor Stello, Jr., Director
Division of Operating Reactors
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Stello:

Re: Turkey Point Plant Units 3 and 4
Docket Nos. 50-250 and 50-251
Supplemental Information

Attached herewith is supplemental information related to our submittal of June 23, 1976, L-76-234.

Very truly yours,

Robert E. Uhrig
Vice President

REU/GDW/hlc

Attachment

cc: Mr. Norman C. Moseley, Region II
Jack R. Newman, Esq.

6696

The potential for loss of load due to sudden stopping of the hoist has been evaluated. The condition of simultaneous main hoist cask crane brakes setting while the cask is being lowered at the maximum rated speed of 7 fpm can be accommodated. (See Appendix B provided by Licensee's letter of May 25, 1976.) For this analysis the wire ropes were considered to be only 50 inches long (the cask is at near maximum lift) to minimize the energy absorption of the wire ropes. The cask weight analyzed was 51,200 lbs., elongation of a given wire rope was 0.023 inches and the approximate cask stopping time was 0.017 seconds.

The potential radiological consequences of the rupture of one or more fuel assemblies resulting from a cask drop are less than those evaluated in the fuel handling accident (FSAR Section 14.2.1) and found acceptable by the Staff in its Safety Evaluation report at page 50. The Staff concluded 17 rem thyroid and < 2 rem whole body were acceptable offsite exposures for this low probability event. The calculation assumptions are listed in Table 5, and the potential whole body and thyroid doses at the site boundary are shown in Figures 2 and 3, as a function of decay time and number of assemblies damaged respectively. Forty fuel element assemblies in the unit 4 pool have the shortest decay (1416 hours as of June 15, 1976 --- see Table 1). It is concluded that even if all 40 assemblies are damaged the potential exposures are at least an order of magnitude below those calculated for the fuel handling accident. It must also be noted that these 40 assemblies will be transferred last. At time of transfer, there will be about 90 days decay (2160 hours) on these assemblies.

During transit between units the cask will pass over buried pipes and duct banks, as well as, piping in trenches, which also may be routed along the transfer corridor. A failure mode effect analysis assuming damage to piping is provided infra. The <u>in situ</u> protection afforded buried pipes and duct banks is discussed below.

All but a few buried pipes are protected by a 4" concrete slab, plus the earth cover. The buried pies not afforded the additional protection of the 4" concrete slab have at least 5'3" of compacted fill cover. The electrical duct banks are reinforced concrete structures at least 3'3" below the concrete slab. The buried pipes are 30" and 36" nominal pipe with 7/8" and 1" wall thickness respectively. In addition, the pipes are cement lined. ⚠1

To assess the penetrability capability of the 25 ton cask in the <u>in situ</u> protection, a 40 foot free fall in air at an 11.37 degree tilt was evaluated. The modified Petry equation yields a penetration of 3.2 inches in concrete. Additionally, the equations of dynamic equilibrium were solved and potential penetrability into the earth calculated utilizing the Sandia report by C. Wayne Young, "Depth Prediction for Earth-Penetrating Projectiles", ASCE, May 1976. Penetration from 40 feet in soil only was calculated to be 6.4 inches, and in soil, plus the 4 inch concrete slab, to be 4.5 inches. Thus, even for a substantial drop (40 feet), penetration of <u>in situ</u> protection is modest.

During transit between units the elevation of the cask above grade will be limited to one foot by administrative controls. The surcharge load on buried pipe and duct banks has been determined for a vertical cask drop from one foot and for horizontal impact of the cask. Since the soil would not transmit load to the pipe greater than its resistance (impact area times soil bearing capacity) the vertical drop is the limiting case.

The surcharge has been evaluated for both the areas with and without the 4 inch concrete cover slab. The soil resistance (59.4 kips, based on a bearing capacity of 10 ksf and an impact area of 5.94 ft^2) is less than the dynamic force of the falling cask assumed (100 kips). Thus, the cask will expend all the energy in the penetration of the soil. The soil will not transmit the dynamic effect from the falling cask to the buried duct banks or pipes. For this evaluation, it was assumed that after penetration, there is no energy transfer consideration, and at the last instant, the weight is suddenly applied using a dynamic load factor of 2.0. This assumption is considered extremely conservative and quite unrealistic because at the last instant when all energy is expended, there is no dynamic load. Even with this assumption, buried pipes and duct banks are within allowable stresses.

The assumptions, etc., associated with the analysis of buried pipes and duct banks follows:

Assumptions:

1. Drop height - 1'
2. Cask Weight - 50,000 lbs.
3. Cask Diameter - 37"
4. Drop is vertical
5. Static load (equivalent) = 46 psi
6. Dynamic load factor (DLF) = 2
7. Modulus of Elasticity of Concrete = 4×10^6 psi
8. Modulus of Elasticity of Soil = 28,000 psi
9. Internal Pressure in Pipe = 50 psi
10. Modulus of Elasticity of Pipe Material = 29×10^6 psi
11. Modulus of Subgrade reaction = 1500 k/ft^3

Methodology:

1. Using Burmister two layer theory and influence curve, an equivalent stress at top of pipe was determined. Boussinesq theory is used for soil cover.

2. Equivalent soil cover to produce stress was calculated and added to actual soil depth.

3. The pipe thickness required to carry the soil depth was determined using USAS A21.1 1967 method of ring test load equivalent to earth load.

4. Required thickness was compared to actual pipe thickness.

5. The bending stresses in the pipe and in the duct bank were calculated assuming the pipe and the duct bank act as beams supported on an elastic foundation.

Acceptance Considerations

1. If required thickness was less than actual, there would be no failure of pipe.

2. If the bending stresses in the pipe are within the allowable limits, there would be no failure of the pipe.

3. If the bending stresses in the electrical duct bank are within the allowable limits, there would be no failure of the duct bank.

4. If equivalent stress at top of duct bank was less than allowable concrete capacity (2,000 psi), then no failure would occur.

References:

1. Yoder & Witizak "Pavement Design", 2nd Edition
2. Foundation Engineering by Bowles
3. USAS A21.1, 1967
4. ASA A21.4 - 1964
5. Roark, "Formulas for Stresses and Strain" Fourth Edition

In transit (between units) drop evaluations indicate that penetration of in situ protection is slight and the additional load imposed on buried duct banks and pipes can be accommodated within allowable working stresses.

During transit between units, only trolley motion or only bridge motion will be allowed. Combined simultaneous bridge/trolley motion will be precluded by administrative controls. Reference to Figure 1 clearly illustrates that the transfer between units is straightforward — trolley motion "only" moves the cask from the washdown area out to the transfer corridor between units, bridge movement "only" moves the cask along the transfer corridor, and finally, trolley movement "only" moves the cask to the adjacent units' washdown area. Thus, any cask swing potential due to sudden stopping of bridge or trolley is along the allowable hook envelope.

The kinetic energy associated with tranverse motion of the cask precludes significant swinging of the cask. Sudden stopping of the bridge or trolley will result in a maximum cask rise of not greater than about 0.004 feet. The horizontal distance from the vertical will not exceed 1-1/2 feet. The transfer corridor is about 17 feet wide.

The potential for cask swing in transit is not great due to the simplex nature of this transfer operation, any swing will be along the hook envelope and the maximum swing distance is acceptably small. Thus, cask swing during transfer does not pose a threat to safety related equipment.

The east wall of the auxiliary building area runs adjacent to the transfer corridor between units. The unit 3 and 4 CCW areas are located behind this wall. There is one location in each unit that a CCW line is partially supported by the auxiliary building wall. In Unit 3, a hanger provides vertical support only and there is a 3 inch gap between the wall and the pipe. In Unit 4, the hanger is of a different design, but even considering the maximum wall deflection, the piping stresses are within elastic limits. For the reasons cited supra swinging of the cask into this wall is not a consideration. However, a cask drop and tip into the wall could be postulated. This has been evaluated. Penetration into the wall is negligible and the deflection of the wall will not exceed 1/2 inch. (Note that Appendix C to Licensee's June 1, 1976, letter L-76-203 erroneously stated penetration of 1/2"). Structural integrity is not threatened by the impact. ⚠1

The assumptions, etc., associated with cask drop and tip into the CCW area wall are as follows:

Assumptions:

1. Work done by tilting cask = 34,500 ft-lbs.
2. The resisting work will be represented by deflection of the wall times the load acting on it.
3. Effective width = 6 ft.
4. Impact elevation = 14 ft.
5. Work done by cask = W = $P_x \Delta$
6. Cask weight = 50,000 lbs.
7. Cask height = 16 ft.
8. Cask tilt from horizontal = 66°; distance = 6.5' ⚠1
9. Assume vertical wall acts as slab for deflection calculations.
10. Dynamic compressive strength of the wall = 4500 psi.
11. Reinforced concrete wall, height = 17'; thickness = 12" ⚠1

Methodology:

1. Deflection was calculated using:

   $W_c = P \times \Delta$

   $P = k\,\Delta$ then $W_c = k\,\Delta^2$

   and, therefore, $\Delta = (W/k)^{1/2}$, where $k = 3.146 \times 10^6$ lbs/inch

   W_c = work done by cask

   P = load ⚠1

   Δ = deflection

   k = spring constant

   μ = ductility ratio ⚠1

2. Penetration by Petry formula.

3. $W_c = \frac{P^2}{k} (\mu - 1/2)$ |1

Acceptance Considerations

1. Deflection calculated (Δ = 0.36 in) was less than allowable for slabs by ACI 318-71 (allowable Δ = 0.43 in).

2. Ductility Ratio calculated (μ = 2.5). Refer to BC-TOP-9A, Section 4.3. |1

References

1. Building code requirements for reinforced concrete (ACI 318-71).

2. BC-TOP-9A, Rev. 2 (9/74), Design of Structures for Missile Impact. |1

The discussion supra demonstrates that maintenance of the spent fuel pool function is maintained, that in situ protection for buried pipes and duct banks is adequate and the integrity of the wall enclosing the CCW area is not imperiled. Thus, attention can now be focused on the consequences of damaging various process lines that are subject to cask impact to determine the potential impact on the ability to achieve and maintain safe shutdown conditions. Reference to Table 4 is important. It demonstrates the copious amount of water on site. Water requirements are about 30,000 gallons to accommodate moderator shrink during cooldown and about 18 gpm to compensate for spent fuel pool boil-off.

Normal Refueling Cask Handling:

The vulnerability of process lines in the cask washdown area has been addressed heretofore. The lines are close to the surface of the spent fuel building wall and will not likely be struck by a dropped cask (see Licensee's letter to Mr. Lear of January 2, 1976 and to Mr. Goller of January 10, 1975 for further detailed discussion). Table 6 provides a listing of lines in the cask washdown area and the effect of loss of function on the ability to achieve and maintain safe shutdown or to maintain spent fuel pool function. The two noteworthy potential occurrences are loss of spent fuel cooling function (with a partial loss in fuel pool inventory) and interruption of the component cooling water non-essential header function.

The severing of fuel pool cooling lines is discussed supra. Partial loss of inventory will not result in loss of an adequate supply of water for cooling and shielding of stored spent fuel. The loss of this inventory will not result in flooding of any essential areas, i.e., loss of essential components due to inundation is not possible. There are at least 13 hours before the remaining pool inventory could achieve boiling conditions. Ample makeup is available to compensate for the 18 gpm or so boil-off rate. The sheared lines will be plugged, the pool refilled, and repairs to restore the cooling function will be initiated.