United States Nuclear Regulatory Commission Official Hearing Exhibit

In the Matter of: Entergy Nuclear Operations, Inc.
(Indian Point Nuclear Generating Units 2 and 3)

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The shield wall analysis showed rebar stresses of 64.6 ksi assuming all concrete was cracked assuming a pressure buildup of 600 psi inside the pit due to release of reactor contents. Since the integrity of the wall is not jeopardized the integrity of the vessel support which is supported on the wall will not be jeopardized. Deflection of the shield wall will not cause large stresses in the vessel support since a sliding surface is provided on the shoes, allowing the vessel support to slide.

Circumferential Cracking

The worst circumferential crack location from the standpoint of downward missiles is just below the RCS piping nozzles. As the following calculations show, the missile will not violate the containment structure and liner integrity.

As a consequence of this circumferential crack, the downward missile represented by the bottom vessel head has the following characteristics at the time of impact on the cavity floor:

1.	Weight:	381,000 lbs
2.	Cross sectional area of crater:	63 ft
3.	Downward velocity:	213 ft/sec
4.	Concrete crushing strength:	4,000 psi

The depth of penetration was calculated by using the Petri formula for penetration into an infinitely thick concrete slab, as reported in Nav. Docket P-51.

$$D=K\ (W/A)\ \log_{10}(1 + V^2/215{,}000)$$

Where: D=depth of penetration, ft.
K=penetration coefficient for 4,000 psi concrete
W=missile weight, lb.
A=missile area, ft^2
V=missile velocity, lb/sec.

The following parameters were used:
$K=2.8 \times 10^{-3}$
W=381,000 lb.
A=63 ft^2
V=213 ft/sec.

The result is a depth of penetration of 1.4 feet.

Since the ¼" base mat liner is covered by 2' – 0" of concrete and topped with a 1" steel plate, it can be readily seen that the liner will not be reached, even neglecting the 1" steel plate in the penetration calculations.

Loading Due to Temperature Gradient

During normal operations, the only significant transient temperature gradients in the reactor containment interior structures occur during startup. The minimum containment internal temperature is limited to 50°F. The maximum operating containment internal temperature is 130°F. Forced movement of containment air is used to limit the concrete temperature

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surrounding the reactor vessel. This forced air movement of the containment air, as well as, normal convection and radiation is expected to limit the concrete temperature differentials in the range of 5 to 10°F. To demonstrate the large margin available in the concrete crane wall and the primary shield wall, a conservative assumption of a 300°F temperature gradient was evaluated. The evaluation included the gradient effect through the crane wall, the 6' thick portion of the primary shield wall below the reactor coolant pipe nozzle, the 5' thick portion of the primary shield wall where the nozzles penetrate the wall, and the 4'thick wall above the shield wall.

The maximum rebar stress was found to be 4500 psi and occurred in the vertical rebar in the crane wall. The maximum compressive concrete stress was found to be 226 psi and occurred in the hoop direction on the 5' portion of the primary shield wall. These stresses are approximately 20% of the allowable working stress values and have no significant effect on the design adequacy of the structures analyzed.

16.4.2. Class I Structures and Components Potentially Endangered by Failure of Class II or Class III Structures and Components

Seismic Class I structures and components which are so located that they could be potentially endangered by failure of seismic Class III structures are the Control Building, and the main steam piping, and feedwater piping, which could be endangered by seismic Class III Turbine Building. The Turbine Building was analyzed, using a multidegree of freedom modal dynamic analysis, for the Design Basis Earthquake, (0.15g maximum ground acceleration) and the building as constructed is capable of carrying the load without failure. A similar dynamic analysis was also performed to insure that no potential gross failure of the Indian Point 1 stack or superheater building could occur for the design basis earthquake and the design basis tornado for Indian Point 3.

The Containment Access Facility, which is situated atop the west end of the seismic Class I Primary Auxiliary Building, is partially a seismic Class III structure, however, the structural steel for this facility, as well as the structural interfaces with the PAB, were procured and installed to meet seismic Class I requirements. Although the Containment Access Facility is not a safety related structure, it has been designed to retain its structural integrity during a design basis seismic event. Also, the PAB and adjoining pipe penetration tunnel have been seismically evaluated to demonstrate their ability to resist seismic loads with the addition of the Containment Access Facility. Postulated failure of the Containment Access Facility due to design basis tornado loads would not adversely affect the operation of safe shutdown equipment located in the PAB or elsewhere. The seismic Class I PAB Ventilation System would not be adversely affected by any postulated failures of connected exhaust ductwork in the Containment Access Facility.

A Systems Interaction (SI) Study was conducted to determine the potential endangerment of seismic Class I components by failure of seismic Class II and Class III components (Refer to References 2,3, and 4). The Authority has resolved all potentially unacceptable interactions identified by this study.

The Fuel Storage Building overhead crane is a seismic Class III crane. The crane bridge, trolley, and building crane supports were dynamically analyzed at various positions of the trolley, both loaded and unloaded using response spectra modal analysis for the design basis earthquake. The analysis showed that neither the crane bridge or trolley would derail or overturn during the DBE and thus would not endanger the spent fuel pit or other seismic Class I functions.

The seismic Class III Jib crane, hoist and associated control equipment, located in the NE sector of the containment building operating floor, were analyzed for seismic loading and found to maintain structural integrity during a DBE. Therefore no seismic Class I structures and components would be affected by its failure.

The manipulator crane in the Containment Building, a seismic Class III crane, is restrained from overturning and will not endanger seismic Class I structures.

16.4.3 Tornado Protection

As discussed in Section 16.2.2, all equipment which must be protected from tornados and tornado generated missiles is contained within tornado proof structures or protected by redundancy.

The tornado proof structures, which were constructed of reinforced concrete, were designed to prevent missile penetration and spalling (by selection of moderate degree of damage allowable stress indices for structural design in accordance with Reference (1) of concrete from the walls, roof slab or dome impacted by the missile). Therefore, secondary missiles are not created which could damage or make inoperable seismic Class I systems which must be protected from tornados.

Further discussion of criteria for determining missile protection requirements is presented in Section 16.2.3.

Tornado Load Capacity of Structures

Containment Structure

The containment can withstand all loads put on it by the design tornado specified in Section 16.2. Details are given in the Containment Design Report (Appendix 5A).

Primary Auxiliary Building (PAB) and Control Building

These structures are capable of resisting any wind loads generated by the design tornado specified.

Fuel Storage Building

Based on information furnished by the siding manufacturer, the siding panel on this structure will blow out at 170 psf (i.e., 1.18 psi) negative pressure. Panels fail at 60 psf external pressure which is equivalent to 162 mph external wind load. The girts will fail at 90 psf (i.e., 0.62 psi) negative pressure.

The 60 psf mentioned above controls the external loading condition.

Block walls are located below Elevation 95'0" on the south and east sides of the Fuel Storage Building. The Primary Auxiliary Building protects the south wall from tornado loads. The block wall located on the west side above elevation 95'0" does not present an interaction concern.

The east wall would fail under tornado wind but would not affect safety related equipment. A missile through the east wall could damage small bore piping associated with the CCW system. FSAR Section 9.3 discusses operator action to maintain CCW function.

Intake Structure

The concrete sub-structure and the structural steel super structure of the service water enclosure are capable of resisting tornado wind loads.

Tornado Missile Resistance of Structures

Containment Structure, Primary Auxiliary Building, Control Building, Diesel Generator Building and Auxiliary Feedwater System Building

The Containment, Primary Auxiliary Building, Diesel Generator Building and Auxiliary Feedwater System Building will not be penetrated by the design tornado missiles. These missiles are:

Horizontal missiles

a) 4" x 12" x 12' wood plank at 300 mph

b) 4000 lb auto at 50 mph less than 25' above the ground

Vertical missiles

a) 4" x 12" x 12' wood plant at 90 mph

b) 4000 lb auto at 17 mph less than 25' above the ground

Fuel Storage Building

The 3" thick siding panels on this structure are not capable of resisting any tornado generated missiles.

Intake Structure

The intake structure is capable of resisting any missile loads generated by a tornado. This is true only for the structure and does not necessarily include equipment, although the circulating water pump and service pump motors are dispersed so that a single missile could not cause all of them to fail.

Spent Fuel Pool Dewatering by Tornado

Dewatering of the Spent Fuel Pool is discussed in proprietary report WCAP-7313-L "Tornado Induced Water Removal from Spent Fuel Storage Pool," submitted in May 1969. Two geometric configurations were considered: One in which the tornado funnel passes at such a distance from the pool center as to produce over it the largest pressure gradients and wind velocities. The other in which the tornado funnel centers over the pool. The results of this study indicate that for the non-aligned tornado, the pool water level will drop 6 feet at the most, leaving over 17 feet of water over the top of fuel assemblies. A centered tornado of such strength that its tangential wind velocity at the pool rim equals 300 mph, will leave at least 10 feet of water over the top of the spent fuel assemblies, if such a tornado remained stationary over the pool center from some 100 seconds. Even if the tornado residence time were that long which, according to field observations, is an unusually long period, the ability of the pool to cool the spent fuel assemblies and to offer radiation protection will not be impaired.

16.4.4 Cathodic Corrosion Protection

A complete survey and tests to determine the need for cathodic protection on Indian Point 3 was made by the A.V. Smith Engineering Company of Narberth, Pennsylvania. Electrical resistivity measurements and visual inspection of the area away from the river, where the Turbine Generator Building, Reactor Building, Primary Auxiliary Building, and associated facilities are located, indicated that the environment is mostly rock with areas of dry sandy clay. The electrical resistivity of the soil ranged from 3,500 to 30,000 ohm-centimeters with the majority of the readings being above 10,000 ohm-centimeters. On this basis, it was determined that cathodic protection was not required on underground facilities in areas of the containment building liner away from the river, although protective coating on pipes was recommended to eliminate any random localized corrosion attack.

An analysis of Hudson River water data, obtained from the Consolidated Edison plant chemist, showed the electrical resistivity of the water to vary over an extremely wide range due to salt intrusion from the ocean. The range of resistivity has been from 59 to 10,000 ohm-centimeters with a large number of readings in the 300 ohm-centimeter area. This value was considered to be extremely corrosive and the following structures in the area near the river were placed under cathodic protection:

1) De-icing lines
2) Bearing piles
3) Sheet piling (earth and water side) and wing wall anchorage system
4) Metallic structures inside intake structure (traveling screens, bar racks, circulating water pump suction, service water pump suction).

The cathodic protection system was not functional and was removed for the Intake Structure Enclosure modification to facilitate installation of the building's structural steel. The removal was temporary, pending the design and installation of a new cathodic protection system.

It should be noted that the service water pumps, structural steel gratings in the intake bay were replaced with materials of a greater resistance to corrosion.

The circulating water lines and service water lines are protected by concrete encasement in areas of high corrosion and do not require cathodic protection.

16.4.5 Thermal Stresses in Walls of Spent Fuel Pit

The thermal stresses in the walls of the spent fuel pool resulting from temperature gradients were evaluated by the procedure outlined in ACI 349-80 "Code Requirements for Nuclear Safety-Related Concrete Structures" and presented in a plant specific report applicable to the maximum density spent fuel pool racks, in which every cell is presumed to be fully loaded with a fuel assembly and a control rod assembly (Reference 6). For the portion of the pool below grade a linear gradient with 200°F water temperature and a 50°F outside temperature was assumed for the analysis. A gradient of 200°F water temperature and 0°F outside temperature was used for the structure above grade. For accident conditions (loss of pool cooling), a water temperature of 212°F was used. Under these conditions, maximum linear and pool anchor strain were calculated, as well as strain-induced loads, maximum average shear and maximum bending moment. In all cases, the resultant values for the pool mat, the interior wall, the exterior wall and the canal mat were within allowable limits.

Provisions were made to limit cracking and prevent leakage through the concrete by means of porous intercept channels, even though the pit is lined with a leak proof stainless steel liner. All welds were vacuum-box tested during construction to assure a leak tight membrane, and all shop welds were dye penetrant inspected on the water side in the shop. In addition, there is a leak collection system behind all field welds. The effect of a thermal gradient would be to compress the linear, thereby preventing any leakage. This leakage collection system is brought to common drain line provided with a manually operated isolating valve. The valve serves as a backup means of limiting leakage from the pit should cracks develop in any of the pit liner joints.

16.4.6 Rainfall Accumulation

Buildings or structures housing safety related items were evaluated for effects from rainfall accumulation. Roof drains were sized to handle 5-5-½ inches rainfall per hour. Roof design loadings were 40 lbs/ft^2 max. The following rainfall accumulations were evaluated:

Hours	Rainfall Accumulations*	Rainfall Accumulation**
1	9.1 inches	4.1 inches
2	12.7 inches	2.7 inches
3	16.0 inches	1.0 inches
6	23.9 inches	---
12	29.0 inches	---

NOTE *Rainfall accumulation only
**Rainfall accumulation with 5"/hr roof drainage

For these accumulations** the largest roof loading realized was 21.4 lbs/ft^2 which occurred during the first hour.

References

1) TM5-855-1, Department of the Army Technical Manual, "Fundamentals of Protective Design (Non-Nuclear)," 1965

2) Letter from J.P. Bayne to S.A. Varga dated November 30, 1983, entitled "Indian Point 3 (IP-3) Systems Interaction (SI) Study" – Attachment A.

3) Letter from J.P. Bayne to S.A. Varga dated March 6, 1984, entitled "Indian Point 3 (IP-3) Systems Interaction (SI) Study."

4) Letter from J.P. Bayne to S.A. Varga dated October 31, 1984, entitled "IP-3 Systems Interaction (SI) Study."

5) Nuclear Safety Evaluation No. 86-03-138 IS, Rev. 5: Intake Structure Enclosure Building – Phases I, II, & III

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6) “Structural Evaluation of the Spent Fuel Storage Building for Storage of U.S. Tool and Die Maximum Density Racks Containing 1345 Fuel Assemblies,” dated March 25, 1988, Ebasco Services, Inc.