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December 6 , 1982

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

Attention: Mr. Steven A. Varga, Chief
Operating Reactors Branch No. 1
Division of Licensing

Subject: Indian Point Unit 2
Docket No. 50-247

Indian Point Unit 3
Docket No. 50-286

Indian Point Probabilistic Safety Study

Dear Mr. Varga:

In fulfillment of a commitment made during the October 13, 1982 Albuquerque meeting with Sandia National Laboratories regarding the Indian Point Probabilistic Safety Study, attached herewith are analyses of the control room ceilings of Indian Point Units 2 and 3 dealing with the fragility of the ceiling structures and the effects of their failure on core melt frequency due to seismic events.

The analyses indicate that the impact on overall risk at Units 2 and 3 due to ceiling structure fragility will be negligible. Nonetheless, an evaluation of the removal of the ceiling panels or modification of their supports is presently being conducted. The staff will be notified of the results of this evaluation as soon as they become available.

Very truly yours,

for J. P. Bayne
Executive Vice President
Power Authority of the State
of New York

John D. O'Toole
Vice President
Consolidated Edison Company
of New York, Inc.

Att.

A001

Attachment A

CONTROL ROOM CEILING ANALYSIS

The initial analysis for the control building for each unit assumed that the failure of the ceiling structure in the control room and the possible incapacitation of all the operators was a highly unlikely event. Loss of the control room operators was therefore based on the failure of the control building. This current analysis evaluates the fragility of the ceiling structures and consequence of their failure on core melt. The analysis considers the Unit 2 control building as modified with shock absorbers installed at the roof level adjacent to the Unit 1 superheater (Reference 1), and considers the Unit 3 control building as constructed.

Structural Mechanics Associates, Inc., provided the fragility analysis of the ceiling structures. The results of that analysis are incorporated here.

UNIT 2 CONTROL ROOM CEILING

The Unit 2 control room in the control building is open to the Unit 1 control room located in the adjacent superheater building. Light fixtures for the Unit 2 control room are hung from the room framing by 1-1/2" x 1-1/2" x 1/8" angles. Transite panels 3' x 10' x 1/4" thick are supported along their length by flanges of the light fixtures. An egg crate panel ceiling below is supported by an aluminum tee-bar grid which, in turn, is hung from the light fixture supports by 1/4" diameter rods. Perforated aluminum acoustical end panels typically span between the tee-bar grid and structure. Other light fixtures located flush with the egg crate ceiling are hung from the roof framing by 2" x 2" x 1/4" angles.

At the interface between the Unit 1 and 2 control rooms, there is a row of transite panels supported on one side by hangers to the Unit 2 control building roof framing and on the other side by hangers to the Unit 1 superheater building floor framing. The two structures are separated by a 3-1/2" thick expansion joint partially filled by rubber pads. This expansion joint permits the structures to displace relative to each other under seismic response. The light fixture supports at the opposing edges of the transite panels at the structures' interface are constrained to displace with the structures to which they are connected. The transite panels were cut and installed in the field so that the gap between the panel edges and the vertical faces of the light fixtures does not exceed the overlap between the panel and light fixture flange. Therefore, the transite panels could only fall if the space between adjacent fixtures was to increase through deflection of many fixtures so that their gaps would accumulate sufficiently to allow a given panel to fall. If sufficient relative displacement between the transite panel edge supports were to occur, certain panels would drop through and impact upon the egg crate ceiling below. The egg crate ceiling system probably does not have adequate strength to restrain the transite panels once the panels had been dislocated from their supports.

Based on (1) an observed median amount of overlap between representative transite panels and their light fixture flange supports of approximately 0.5 to 0.75 inches per edge, and (2) calculations of the structure displacements at the roof of the Unit 2 control building and corresponding elevation of the Unit 1 superheater building under seismic response (Reference 1), relative displacements sufficient to permit the transite panels to drop through in the localized region of the control building/superheater building interface are expected at a median ground acceleration of approximately 0.15g. For this failure mode, logarithmic standard deviations associated with randomness and uncertainty of approximately 0.31 and 0.41, respectively, are estimated. Under such conditions the transite panels may be expected to fall and carry the unrestrained egg crate panels with them to the floor.

The next lowest failure mode also involves dropping of the transite panels. This is expected to occur in regions adjacent to the flush mounted light fixtures and would be caused by the out of phase motion between the flush mounted light fixtures and the remainder of the lighting support system. These panels have approximately the same clearances and bearing support as discussed above. The median peak effective ground acceleration level that would cause these panels to fall is estimated to be approximately 0.40g with logarithmic standard deviations associated with randomness and uncertainty of 0.30 and 0.45, respectively. Somewhat higher capacities can be expected for the remainder of the panels since they could only fall if their supports deflected and the deflections of many fixtures could accumulate sufficiently to allow a gap of at least 1/2-inch to form and thereby allow the panel in that location to fall.

Therefore, there are several groups of failures. The first is the falling of transite panels located along the building line between the Unit 1 superheater building and Unit 2 control building (a = 0.15g). The second group of panels are those adjacent to the fixtures that provide lighting over key control panel locations. The transite panel supports at these locations have higher capacities (a = 0.40g). All the other panels have supports with still higher capacities.

For the purpose of this analysis, there are three reactor operators on duty each shift. Normally, two reactor operators are inside the control room. The third, the Watch Supervisor, has an office which is adjacent to the control room and has no panelled ceiling. The Watch Supervisor leaves his office, as needed, to visit the control room and other areas in the plant. In this analysis, it is estimated that the fraction of time that all three operators are inside the control room each shift is 0.13. A fourth reactor operator is also available at the site, thereby reducing the conditional probability of the possible incapacitation of all operators; however, this is not accounted for in this quantification and is considered a conservatism.

The transite panels are of such dimensions that each weighs about 50 to 60 pounds. When such flat panels are presumed to fall onto individuals, they are likely to inflict glancing blows rather than impart their full inertia. Further, the panels are relatively thin and fragile and are expected to shatter on impact, thereby imparting less force on an object below. However, it is conservatively assumed that an operator hit by a falling panel would be incapacitated. If panels were to fall on the equipment in the control room, it is expected that the heavy gauge metal electronic cabinets might be dented from an impact, but that their contents would not be adversely affected.

In addition to the core melt logic and frequency presented in IPPSS Section 7.2.4, consideration is now also given to core melt resulting from the loss of control by incapacitation of all three operators due to control room ceiling failure. This is done in the following manner:

Let (C_1) represent the failure of ceiling panels at the building line between Units 1 and 2 and (C_2) represent the failure of the ceiling panels in the balance of the control room (it is conservatively assumed that the capacity of all these other panels is the same as for the weaker panels at the lighting fixures mounted over operator positions).

The fraction of time any one operator is likely to be underneath the panels between Units 1 and 2 is judged to be less than 5×10^{-2}. The probability that an operator would be under the other panels is then very nearly 1.0.

It is highly unlikely that if one panel of a given fragility would fail, that all panels of that fragility might fail. Yet, there is some likelihood that if one fails, several might fail. It is judged that if panels in an area fail, considering some dependency of panel failures, the probability of an operator in the area being under a failed panel is 0.6.

Let us consider that an operator is either beneath the most fragile panels or under those adjacent to the lighting fixtures over operator positions, but never under the other panels with the higher capacity. Conservatively, consider also that any impact of a panel on an operator will incapacitate him. Then, the conditional probability of operators being under those panels at the Unit 1/Unit 2 building line and being incapacitated is:

$5.0 \times 10^{-2} \times 0.6 = 3.0 \times 10^{-2}$ for 1 operator
9.0×10^{-4} for 2 operators
2.7×10^{-5} for 3 operators

Similarly, the conditional probability of operators being under the other panels and being incapacitated is:

0.60 for 1 operator
0.36 for 2 operators
0.22 for 3 operators

The fraction of time all three operators are in the control room approximately equals 1 hour in 8 hours = 0.13. Therefore, we can express core melt, M_4, from loss of control due to control room ceiling failure as

$$M_4 = 0.13\,[2.7 \times 10^{-5}\ \text{Ⓒ}_1 \vee (9.0 \times 10^{-4}\ \text{Ⓒ}_1 \wedge 0.6\ \text{Ⓒ}_2)$$

$$\vee\ (3.0 \times 10^{-2}\ \text{Ⓒ}_1 \wedge 0.36\ \text{Ⓒ}_2) \vee 0.22\ \text{Ⓒ}_2]$$

$$= 3.5 \times 10^{-6}\ \text{Ⓒ}_1 \vee (1.2 \times 10^{-4}\ \text{Ⓒ}_1 \wedge 7.8 \times 10^{-2}\ \text{Ⓒ}_2)$$

$$\vee\ (3.9 \times 10^{-3}\ \text{Ⓒ}_1 \wedge 4.7 \times 10^{-2}\ \text{Ⓒ}_2) \vee 2.9 \times 10^{-2}\ \text{Ⓒ}_2$$

We add M_4 to the core melt expression M_S, using the ceiling fragilities as follows:

$$C_1 : \tilde{\tilde{a}} = 0.15g,\ \beta_R = 0.31,\ \beta_U = 0.41$$

$$C_2 : \tilde{\tilde{a}} = 0.40g,\ \beta_R = 0.30,\ \beta_U = 0.45$$

The annual frequency for core melt due to seismic events is recalculated in the manner presented in IPPSS Section 7.2.4. The mean value for annual core melt frequency is 9.9×10^{-6}. Comparing this value to the mean frequency of 7.9×10^{-6} previously determined as a result of the control building shock absorber modification, core melt frequency increases by a factor of 1.25 for seismic events when the above-described control room ceiling failures are considered. Logically, the same can be stated for the impact on release category 2RW. Thus, the increase is insignificant considering the uncertainty, and does not effect risk.

UNIT 3 CONTROL ROOM CEILING

The Unit 3 control room ceiling system utilizes light fixture hangers typically consisting of Unistrut channels bolted to continuous Unistrut concrete inserts embedded in the slab above. One-quarter inch thick transite panels are supported by flanges of the light fixtures. The egg crate panel ceiling below is supported by an aluminum tee-bar grid which, in turn, is hung from the light fixture supports by 1/4-inch diameter rods. Perforated aluminum acoustical end panels typically span between the tee-bar grid and the structure.

The light fixtures which support the 1/4-inch thick transite panels are bolted to the hangers. Other light fixtures located flush with the egg crate ceiling are hung from the Unistrut concrete inserts by Unistrut channel sections.

The fraction of time all three operators are in the control room approximately equals 1 hour in 8 hours = 0.13.

Let $\textcircled{C_1}$ represent the failure of ceiling panels in the control room. We can then express core melt, M_4, from loss of control due to control room ceiling failure as

$$M_4 = 0.13 \times 0.22 \times \textcircled{C_1}$$

$$= 2.9 \times 10^{-2} \times \textcircled{C_1}$$

We add M_4 to the core melt expression M_S, using the ceiling fragility as follows:

$$\textcircled{C_1}: \; \tilde{\tilde{a}} = 0.40g, \; \beta_R = 0.30, \; \beta_U = 0.45$$

The annual frequency for core melt due to seismic events is recalculated in the manner presented in IPPSS Section 7.2.5. The mean value for annual core melt frequency is 5.4×10^{-6}. Comparing this value to the mean freqency of 3.1×10^{-6} previously determined, core melt frequency increases by a factor of 1.7 for seismic events when the above-described control room ceiling failures are considered. Logically, the same can be stated for the impact on release category 2RW. Thus, the increase is insignificant considering the uncertainty, and does not affect risk.

REFERENCES

1. Consolidated Edison Company of N. Y. Letter to the NRC dated October 8, 1982, O'Toole to Varga

The transite panels bear on the light fixture flanges without any positive, mechanical connections. The transite panels were cut and installed in the field so that the gap between the panel edges and the vertical faces of the light fixtures does not exceed the overlap between the panel and light fixture flange. Therefore, the transite panels could only fall if the space between adjacent fixtures was to increase through deflection of many fixtures so that their gaps would accumulate sufficiently to allow a given panel to fall.

The lowest failure mode is expected to occur in regions adjacent to the flush mounted light fixtures. The median peak effective ground acceleration for these panels to fall is estimated to be approximately 0.40g with logarithmic standard deviations associated with randomness and uncertainty of 0.30 and 0.45, respectively. Somewhat higher capacities may be expected for the remainder of the panels.

There are three reactor operators on duty each shift. Normally, two reactor operators are inside the control room. The third, the shift Supervisor, has an office which is adjacent to the control room and which has no paneled ceiling. The Shift Supervisor leaves his office, as needed, to visit the control room and other areas in the plant. In this analysis it is estimated that the fraction of time that all three operators are inside the control room each shift is 0.13.

Flat panels falling are likely to inflict glancing blows rather than their full inertia, and further, they are relatively thin and fragile and are expected to shatter on impact, thereby imparting less force on a target. However, it is conservatively assumed that an operator hit by a falling panel will be incapacitated. If panels were to fall on the equipment in the control room, it is expected that the heavy gauge metal electric cabinets may be dented from an impact, but that their contents would not be adversely affected.

In addition to the core melt logic and frequency presented in IPPSS Section 7.2.5, consideration is now given to core melt resulting from the loss of control by incapacitation of all three operators due to control room ceiling failure.

It is highly unlikely that if one panel would fail, that all fail. Yet, there is some likelihood that if one fails, several might fail. It is judged that, considering some dependency of panel failure, if any panels fail, the probability of an operator in the control room being under a failed panel is 0.6. Conservatively, consider also that any impact of a panel on an operator will incapacitate him. Then, the conditional probability of operators being under these panels and being incapacitated is:

0.60 for 1 operator
0.36 for 2 operators
0.22 for 3 operators