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STAFF EVALUATION REPORT OF

INDIVIDUAL PLANT EXAMINATION OF EXTERNAL EVENTS (IPEEE) SUBMITTAL

ON INDIAN POINT NUCLEAR GENERATING UNIT NO. 2

1.0 INTRODUCTION

On June 28, 1991, the NRC issued Generic Letter (GL) 88-20, Supplement 4 (with NUREG-1407, Procedural and Submittal Guidance) requesting all licensees to perform individual plant examinations of external events (IPEEE) to identify plant-specific vulnerabilities to severe accidents and to report the results to the Commission together with any licensee-determined improvements and corrective actions. In a letter dated December 6, 1995, the licensee, Consolidated Edison Company of New York, Inc. (Con Ed), submitted its response to NRC.

The NRC staff contracted with Energy Research, Inc. (ERI) to conduct a "Step 1" review (a review for completeness and reasonableness) of Con Ed's IPEEE submittal and its associated documentation and sent a request for additional information (RAI) to Con Ed on September 22, 1997. Con Ed responded to the RAI on February 24, 1998. Based on the results of the review, the staff concluded that the aspects of seismic; fires; and high winds, floods, transportation and other external events were adequately addressed. However, the Fire Risk Scoping Study issue associated with misdirected manual fire suppression failing equipment was not addressed. This issue is also part of the generic safety issue (GSI), GSI-148, "Smoke Control and Manual Fire-Fighting Effectiveness."

The review findings are summarized in the evaluation section below. Details of the contractor's findings are in the technical evaluation report (TER) attached to this staff evaluation report. In addition, in a separate attachment, there is a TER on the internal floods analysis, which Con Ed submitted as part of its IPEEE.

In accordance with Supplement 4 to GL 88-20, Con Ed has provided information on the Fire Risk Scoping Study (FRSS) issues, generic safety issue (GSI)-57, "Effects of Fire Protection System Actuation on Safety-Related Equipment," GSI-131, "Potential Seismic Interaction Involving the Movable In-Core Flux Mapping System Used In Westinghouse Plants," GSI-103, "Design for Probable Maximum Precipitation (PMP)," and Unresolved Safety Issue (USI) A-45, "Shutdown Decay Heat Removal Requirements." This information was explicitly requested in Supplement 4 to GL 88-20 and its associated guidance in NUREG-1407. Con Ed regards these issues as resolved and also considers as resolved the following issues: unresolved safety issue (USI) A-17, "System Interactions at Nuclear Power Plants;" USI A-40, "Seismic Capability of Large Safety-Related Above-Ground Tanks;" and the Eastern US Seismicity (Charleston Earthquake) Issue.

2.0 EVALUATION

Indian Point Nuclear Generating Unit No. 2 (IP2) is a Westinghouse four-loop pressurized water reactor (PWR) with a large dry containment. The plant is located on the east bank of the Hudson River, in upper Westchester County, about 24 miles from the New York City boundary line. The owner/operator is Consolidated Edison Company of New York, Inc. The operating license was issued on September 28, 1973.

Core Damage Frequency Estimates

Seismic

The plant is classified in NUREG-1407 as a 0.3g full scope plant. For the seismic evaluation, Con Ed performed a seismic probabilistic risk assessment, with screening based on seismic margin and Seismic Qualification Utility Group methods. The mean estimate of the seismic core damage frequency (CDF) is given as 1.46E-5 per year by Con Ed, with the LLNL hazard curves, and about 10% lower when the EPRI curves are used. Con Ed made a modification to the component cooling water (CCW) surge tank supports; after the modification Con Ed's mean estimate of the seismic core damage frequency was reduced to 1.1E-5 per year.

Fire

For fire, Con Ed used the Electric Power Research Institute's fire-induced vulnerability evaluation (FIVE) methodology for both qualitative and quantitative screening, and used probabilistic risk assessment (PRA) methodology for the detailed evaluation. The total fire CDF from the scenarios surviving screening is estimated at 1.8E-5 per year.

High Winds, Floods, Transportation, and Other (HFO) External Events

HFO events, except for high winds and tornadoes, were screened out using the screening criteria given in NUREG-1407. For high winds and tornadoes, a PRA was performed. The contribution to the CDF from tornadoes and extratropical cyclones was estimated by Con Ed as 1.7E-5 per year and 1.1E-5 per year, respectively. Hurricane events were estimated to contribute 2.4E-6 per year to the CDF.

Internal Flooding

Con Ed's flooding analysis included a screening analysis, and a detailed risk evaluation on nine flood scenarios which survived the screening. Con Ed's estimate of the total flood-induced CDF is 6.7E-6 per year.

Dominant Contributors

Seismic

Four seismic damage states (SDS) contributed about 92% of the seismic CDF. These are:

- Loss of instrumentation and control, due to structural failures of the turbine building frame and the Unit 1 superheater stack, contributing 45%
- Loss of CCW, due to failure of the CCW surge tank or failure of the steel superstructure of the fuel storage building, contributing 29%
- Loss of 480 VAC electric power, due to seismic failure of cable trays and the seismic failure of 480 VAC motor control centers, contributing 9%
- Loss of service water, due to seismic failure of the pumps or heat exchangers, or sliding failure of the intake structure, contributing 9%

Fire

The main contributors to the fire CDF are:

- Control room fires, contributing 7E-6 per year to the CDF
- Cable spreading room fires, contributing 4E-6 per year to the CDF
- Switchgear room fires, contributing 4E-6 per year to the CDF

These fires contribute, in total, 1.5E-5 per year to the CDF; this is about 85% of the total fire CDF of 1.8E-5 per year.

HFO

Except for high winds, screening analyses were used. The major HFO contributors to the CDF are tornadoes and extratropical cyclones, contributing 1.7E-5 per year and 1.1E-5 per year, respectively. The dominant high wind core damage sequences are station blackout sequences, responsible for 87% of the high wind CDF. For tornadoes, the dominant structural failures are turbine building failure (leading to consequential failure of the control building), failure of the control building itself, and failure of the diesel generator building together with the gas turbine shelter. The EDG building failures are more important for extratropical cyclones than they are for tornadoes. The reason is evident that the dominant failure mode for the EDG building is that of suction failure of the roof. If the tornado is not accompanied by rain, the equipment in the EDG building may not fail.

Internal Flooding

The largest contributor to the internal flood CDF was initiated by a break in a 3-inch diameter service water pipe located in the emergency switchgear room. The resulting water flow could not be totally accommodated by the drains, and consequently damage could result in as little as 4 minutes after the break occurs, assuming no credit for flood detection and isolation due to the limited time available. The second highest contributor was a turbine building flood which resulted in the non-recoverable loss of normal power to the emergency buses due to damage to 6.9 kV buses in the vicinity of the flood. The third highest contributor was a fire protection system pipe break in the deluge valve room located in the control building. The flood propagated to the emergency switchgear room via an

interconnecting door. These three highest contributors to the internal flooding CDF account for 94% of the internal flooding CDF.

Assessment of Licensee's Determination of Dominant Contributors

For seismic, fire, HFO events, and internal flooding, Con Ed appears to have identified the significant initiating events and dominant accident sequences.

Containment Performance

Seismic

Con Ed did not find, in their IPEEE, any seismic vulnerabilities which could lead to early containment failure or bypass directly as a result of seismic failures of major structures or systems. About 65% of the seismic CDF results in plant damage states with initial loss of containment pressure suppression and heat removal functions. If these functions are not regained, long-term overpressure failure of the containment would likely result, but the conditional probability of early containment failure (e.g., by direct containment heating) would be no more likely than for long-term station blackout sequences resulting from internal events initiators.

Fire

Containment performance was evaluated for the potential of fire-induced containment bypass and failure of containment isolation. No significant sequences involving containment bypass or failure of containment isolation were found. Con Ed did not evaluate the likelihood of long-term containment failure by overpressure.

HFO

HFO events other than high winds were addressed by a screening analysis, consistent with NUREG-1407 guidelines. Although an explicit containment performance analysis is not required for these events, Section 6.2.6 of the IPEEE submittal addresses containment performance for high winds. The section concludes that no vulnerabilities which cause early failures or containment bypass were identified. About 87% of the wind-induced core damage frequency is due to station blackout sequences; in such sequences all containment pressure suppression and heat removal systems are lost. If these functions are not regained, these sequences would likely lead to long-term containment overpressure and failure, but the conditional probability of early containment failure (e.g., by direct containment heating) would be no more likely than for long-term station blackout sequences resulting from internal events initiators.

Internal Flooding

No explicit discussion of containment performance is given in the IPEEE internal flooding analysis. However, internal flooding sources which result in a loss of primary or secondary reactor coolant outside the containment (for example, interfacing system loss-of-coolant accidents or steam line breaks with failure to isolate) are treated in the Individual Plant Examination (IPE), not the IPEEE. Looking at the dominant contributors to the internal

flooding CDF, as given in the IPEEE, it appears that these are equivalent to station blackout core damage sequences. They may lead to long-term overpressurization of the containment and containment failure, but the conditional probability of early containment failure (e.g., by direct containment heating), would be no more likely than for long-term station blackout sequences resulting from internal events initiators.

Assessment of Licensee's Containment Performance Analysis

Con Ed's containment performance analyses for seismic, fire, high winds, and internal flooding events appears to have considered the important severe accident phenomena and are consistent with the intent of Supplement 4 to GL 88-20.

Generic Safety Issues

As a part of the IPEEE, a set of generic and USI A-45, GSI-131, GSI-103, GSI-57, and the Sandia Fire Risk Scoping Study (FRSS) issues were identified in Supplement 4 to GL 88-20 and its associated guidance in NUREG-1407 as needing to be addressed in the IPEEE. The staff's evaluation of these issues is provided below.

1. USI A-45, "Shutdown Decay Heat Removal Requirements"

   Con Ed performed a seismic PRA, a fire PRA, and a PRA for high winds. These are capable of finding vulnerabilities which involve loss of decay heat removal capability. No such vulnerabilities were found. The screening analysis done by Con Ed for HFO events other than high winds is capable of finding vulnerabilities associated with loss of decay heat removal capability. Since the staff judges that the process used by Con Ed is capable of finding decay heat removal vulnerabilities, and no vulnerabilities were found, the staff considers that the external events aspects of USI A-45 are resolved for IP2.

2. GSI-131, "Potential Seismic Interaction Involving the Movable In-Core Flux Mapping System used in Westinghouse Plants"

   The flux monitoring cart which is the subject of GSI-131 is seismically robust, with a high confidence low probability of failure (HCLPF) value in excess of 0.5g. (That is, there is 95% confidence that the probability of failure of the cart is less than 5% for a peak ground acceleration of 0.5g). The cart had been previously modified in response to Information Notice 85-45, which had identified the issue. Since the IPEEE determined that there was no vulnerability with respect to the flux monitoring cart, using acceptable techniques, the staff considers this issue to be closed for IP2.

3. GSI-103, "Design for Probable Maximum Precipitation"

   Con Ed has assessed the effects of the potential for increased plant area flood runoff depth and increased roof loads as a result of the revised Probable Maximum Precipitation (PMP). (See GL 89-22.) This issue is discussed in Section 6.2.2.3 of NUREG-1407. The staff finds that Con Ed's procedure for evaluating GSI-103 is capable of identifying severe accident sequences resulting from onsite flooding and roof ponding when the revised PMP criteria are used. Some plant improvements were made, as a result of the PMP analysis. These are discussed below, under the heading "Unique Plant Features, Potential

Vulnerabilities, and Improvements." On the basis that Con Ed's procedure for identifying severe accident sequences associated with the PMP is satisfactory, and on the basis of the improvements that were made, the staff considers that GSI-103 is resolved for IP2.

4. GSI-57, "Effects of Fire Protection System Actuation on Safety-Related Equipment"

   The IPEEE submittal, in its discussion of seismic actuation of fire suppression systems (p. 4-43 of the submittal), notes that "fixed fire suppression systems have not been installed where their operation or failure could cause unacceptable damage to safety-related equipment." The submittal also notes, on p. 4-43, that a Con Edison review of Information Notice 83-41 issues concluded that adequate consideration of suppression system actuation effects on safety-related equipment has been integrated into the existing Fire Hazards analysis. The staff finds that Con Ed's GSI-57 evaluation is consistent with the guidance provided in EPRI's FIVE, which was accepted by the NRC staff, and therefore, the staff considers this issue resolved.

5. Fire Risk Scoping Study (FRSS) Issues

   As noted in the attached TER on the IPEEE submittal, Con Ed closely followed the FIVE methodology in addressing the FRSS issues. The FIVE methodology has been accepted by the staff. However, FIVE does not give guidance on the treatment of smoke-induced misdirected manual fire suppression activities, and its potential for failing equipment. The Fire Risk Scoping Study (NUREG/CR-5088) discusses this issue on p.37ff.

   Con Ed has not provided any discussion in the submittal on smoke-induced misdirection of manual fire suppression efforts. (See Section 2.4.2 of the attached TER.) The staff considers the FRSS issues, except for the effects of misdirected manual fire suppression activities, resolved for IP2, on the basis that Con Ed has used the FIVE methodology for addressing them, and the FIVE methodology has been accepted by the staff.

In addition to those safety issues discussed above that were explicitly requested in Supplement 4 to GL 88-20, four generic safety issues were not specifically identified as issues to be resolved under the IPEEE program; thus, they were not explicitly discussed in Supplement 4 to GL 88-20 or NUREG-1407. However, subsequent to the issuance of the GL, the NRC evaluated the scope and the specific information requested in the GL and the associated IPEEE guidance, and concluded that the plant-specific analyses being requested in the IPEEE program could also be used, through a satisfactory IPEEE submittal review, to resolve the external event aspects of these four GSIs (GSI-147, GSI-148, GSI-156, and GSI-172). The following discussions summarize the staff's evaluation of these GSIs at IP2:

1. GSI-147, "Fire-Induced Alternate Shutdown/Control Room Panel Interactions"

   Con Ed has followed the guidance provided in FIVE concerning control systems interactions. Additional details are provided in Section 2.4.1 of the attached TER on the IPEEE submittal.

   Because the FIVE methodology has been accepted by the staff, the analysis of this issue by Con Ed is considered acceptable, and the staff considers this issue resolved.

2. GSI-148, "Smoke Control and Manual Fire-Fighting Effectiveness"

   As noted above, under the discussion of the FRSS issues, the particular aspect of this issue associated with misdirected manual fire suppression because of smoke-induced loss of visibility was not addressed by Con Ed in the IPEEE, and is not resolved. Other aspects of operator action effectiveness are addressed (see Section 4.8.5.3 of the IPEEE submittal), and the hindering of short-term (less than 4 hours) operator recovery actions were considered (see the attached TER, Section 2.4.2)

3. GSI-156, "Systematic Evaluation Program (SEP)"

   The SEP issues are a set of issues associated with plants that were licensed prior to the time the 1975 Standard Review Plan was issued.

   - Settlement of Foundations and Buried Equipment

     The IP2 site is a rock site, and there are no foundation settlement concerns. As noted in Section 2.4.3 of the attached TER on the IPEEE, buried equipment is not expected to be of concern.

   - Dam Integrity and Site Flooding

     The 1982-1983 Indian Point Probabilistic Safety Study evaluated the frequency of probable maximum precipitation and failure of an upstream dam leading to flooding at the plant site to be less than 1E-8 per year. The attached TER notes that the IPEEE submittal does not discuss seismically-induced dam failure. However, during the licensing of Indian Point Unit 3, as noted in Section 6.3 of the IP2 IPEEE submittal, an analysis concluded that the maximum sustained water surface elevation at the plant is 14.0 feet based on the combined effect of a Hudson River maximum flood, probable maximum precipitation over the Esopus Creek Basin resulting in failure of the Ashokan Dam, and a hurricane at New York Bay. The minimum critical flood height at IP2 is at 15 feet 6 inches, so that the analyzed flood does not threaten the plant. The event analyzed bounds the seismically-induced failure of the Ashokan Dam.

   - Site Hydrology and Ability to Withstand Floods

     The Indian Point IPEEE submittal includes a satisfactory screening analysis of external floods, consistent with NUREG-1407 guidelines, and also satisfactorily analyzed the PMP event (see GSI-103 discussion, above).

   - Industrial Hazards

     The IPEEE contains, in its HFO analysis, a satisfactory treatment of these hazards.

   - Tornado Missiles

     The effects of tornado missiles were satisfactorily considered in the HFO analysis.

- Severe Weather Effects on Structures

  The effects of high winds and floods were satisfactorily analyzed in the HFO section of the IPEEE.

- Design Codes, Criteria, and Load Combinations

  Since the IPEEE presents a satisfactory analysis of seismic and HFO events, and found no vulnerabilities, it can be inferred that the Category I structures have adequate capacity.

- Seismic Design of Structures, Systems, and Components (SSCs)

  Since the IPEEE presents a satisfactory analysis of seismic and HFO events, and found no vulnerabilities, it can be inferred that the seismic design of SSCs is adequate.

- Shutdown Systems and Electrical Instrumentation and Control Features

  A satisfactory IPEEE analysis, as was done by Con Ed for IP2, automatically includes the study of systems required to remove decay heat, and the instrumentation and control systems required for safe shutdown.

Based on the overall results of the IPEEE submittal review, the staff considers that Con Ed's process is capable of identifying potential vulnerabilities associated with GSI-156. Although seismically-induced dam failures were not explicitly considered, a scenario which bounds the effects of seismically induced failure of the Ashokan dam was considered. On the basis that no potential vulnerability associated with these issues was identified in the IPEEE submittal, the staff considers the IPEEE-related aspects of these issues resolved.

4. GSI-172, "Multiple System Responses Program (MSRP)"

   - Effects of fire protection system actuation on safety-related equipment

     This is issue GSI-57, and is discussed under that heading. See also the attached TER, Section 2.4.4.

   - Seismically induced fire suppression system actuations

     This is a FRSS issue, and is discussed as such in Section 4.8.2 of the IPEEE submittal.

   - Seismically induced fires

     This is a FRSS issue. Seismically induced fires were addressed in the seismic capability walkdowns performed as part of the seismic IPEEE; the walkdowns are discussed in Section 3.1.3 of the IPEEE submittal. They were also discussed in Section 4.8.2 of the submittal, as part of the discussion of the FRSS issues.

- Effects of hydrogen line ruptures

  The effects of earthquakes on gas lines is addressed in the seismic capability walkdowns, discussed in Section 3.1.3 of the IPEEE, and, in particular, in the discussion of seismic/fire interactions. Hydrogen fire sources are discussed in Section 4.3.2.2 of the submittal (see, in particular p. 4-25 of the submittal).

- The IPEEE-related aspects of common cause failures associated with human errors

  With respect to fire, the impact of fires on human actions after a fire initiator is addressed by the IPEEE, in Section 4.6.1.2. Human errors were included in the seismic PRA models (see Section 3.1.6.3 of the IPEEE), and contributed less than 5% to the seismic CDF. As for HFO events, screening analyses were used for all HFO events other than high winds, and no assessment of human error probability was required. For high winds, the methodology developed "wind damage states" which acted as entries to IPE internal events models. These IPE internal events models included the effects of human error.

- Non-safety-related control system/safety-related system dependencies

  As far as the IPEEE is concerned, this issue reduces to that of seismically induced spatial and functional interactions, a MSRP issue already discussed above, and GSI-147, on fire-induced alternate shutdown and control room panel interactions, which has also already been discussed.

- Effects of flooding and/or moisture intrusion on non-safety related and safety-related equipment

  Flooding from external floods is discussed in the HFO analysis in the IPEEE; a screening analysis was used. Flooding from the actuations of fire protection systems is a GSI-57 issue, and is discussed under that heading. Internal flooding is discussed in Chapter 5 of the IPEEE submittal, and the internal flooding core damage frequency, dominant sequences and containment performance are discussed above.

- Seismically induced spatial and functional interactions

  Seismically induced spatial interactions were addressed in the seismic capability walkdowns performed as part of the IP2 seismic IPEEE, discussed in Section 3.1.3 of the submittal. Seismic functional interactions are addressed as part of the seismic PRA process used by Con Ed.

- Seismically induced flooding

  Seismically induced flooding was addressed in the seismic capability walkdowns performed as part of the seismic IPEEE, and is discussed in Section 3.1.3 of the submittal.

- Seismically-induced relay chatter

  Seismically-induced relay chatter was addressed in Section 3.3 of the IPEEE.

- Evaluation of earthquakes greater than the SSE

  The seismic analysis in the IPEEE was a PRA, which automatically includes the effects of earthquakes greater than the SSE.

Based on the overall results of the IPEEE submittal review, the staff considers that Con Ed's process is capable of identifying potential vulnerabilities associated with GSI-172. On the basis that no potential vulnerability associated with these issues was identified in the IPEEE submittal, the staff considers the IPEEE-related aspects of these issues resolved.

Unique Plant Features, Potential Vulnerabilities, and Improvements

Unique safety features are described in Section 8.1 of the IPEEE. Those which specifically refer to external events are:

- The Alternate Safe Shutdown System was modified as a result of the original Indian Point Probabilistic Safety Study to more quickly and easily allow power to be provided to key shutdown equipment using power sources which bypass the IP2 control building areas which contain those buses. This capability is not only useful for fire sequences but also other events such as flooding which may threaten the 480 V buses.

- In addition to the three emergency diesel generators, IP2 has three gas turbine generators. Since two of the three gas turbines are located some distance from the site, they represent an additional recovery potential for some localized tornado sequences.

The IPEEE used the guidelines provided in the Nuclear Energy Institute (NEI) Severe Accident Closure Guidelines NEI 91-04 to determine whether there were any vulnerabilities which merited physical modification or immediate procedural changes. The IPEEE did not identify any vulnerabilities. However, some improvements in the seismic and HFO areas were made. In particular:

- The hold down bolts for the component cooling water surge tank were replaced by higher tensile strength bolts, reducing the estimated seismic core damage frequency by 29%.

- For the probable maximum precipitation event, a drain flapper valve, located in the manhole to which the control building drains flow, has been added to the preventive maintenance surveillance inspection program.

- In addition, for the probable maximum precipitation event, weather stripping was to be added to the doors leading into the switchgear room from the transformer area to reduce the bottom door gap, and screens are being placed on the equipment hub drains located in the 480V switchgear room to preclude foreign material intrusion. Also, a drain flapper valve, located in the manhole to which the control building drains flow, has been added to the preventive maintenance surveillance inspection program.

3.0 CONCLUSIONS

On the basis of the overall review findings, the staff concludes that: (1) Con Ed's IPEEE is complete with regard to the information requested by Supplement 4 to GL 88-20 (and associated guidance in NUREG-1407), and (2) the IPEEE results are reasonable given the IP2 design, operation, and history. Therefore, the staff concludes that Con Ed's IPEEE process is capable of identifying the most likely severe accidents and severe accident vulnerabilities, and therefore, that the IP2 IPEEE has met the intent of Supplement 4 to GL 88-20 and the resolution of specific generic safety issues discussed in this SER, with the exception of the FRSS issue associated with equipment damage caused by operators misdirecting manual fire suppression actions because of smoke. This is also part of GSI-148, "Smoke Control and Manual Fire Fighting Effectiveness." The need for any additional assessment or actions related to the resolution of this FRSS issue and GSI-148 will be addressed by the NRC staff separately from the IPEEE program.

It should be noted that the staff focused its review primarily on Con Ed's ability to examine IP2 for severe accident vulnerabilities. Although certain aspects of the IPEEE were explored in more detail than others, the review was not intended to validate the accuracy of Con Ed's detailed findings (or quantification estimates) that underlie or stemmed from the examination. Therefore, this SER does not constitute NRC approval or endorsement of any IPEEE material for purposes other than those associated with meeting the intent of Supplement 4 to GL 88-20 and the resolution of specific generic safety issues discussed in this SER.

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