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STAFF EVALUATION REPORT BY THE OFFICE OF NUCLEAR REACTOR RESEARCH

RELATED TO THE REVIEW OF THE INDIVIDUAL PLANT

EXAMINATION OF EXTERNAL EVENTS

INDIANA MICHIGAN POWER COMPANY

DONALD C. COOK NUCLEAR PLANT, UNITS 1 AND 2

DOCKET NOS. 50-315 AND 50-316

I. INTRODUCTION

On June 28, 1991, the NRC issued Generic Letter 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 May 1, 1992, the licensee, American Electric Power Service Corporation (AEPSC), submitted its response to NRC.

The staff initiated a Step 1 review of the licensee's IPEEE submittal and its associated documentation in October 1992 and sent a request for additional information (RAI) to the licensee in May 1993. The licensee responded to the RAI in July 1993. On the basis of the results of the Step 1 review, the staff concluded that the aspects of high winds, floods, and transportation and others were adequately addressed; however, the seismic and fire portions of the IPEEE needed a Step 2 review because of specific concerns related to seismic response and fragility analyses and fire modeling, detection, and suppression analyses.

The staff contracted with Energy Research, Inc. (ERI) in February 1994 to support the Step 2 review, mainly to perform walkdowns and to evaluate the licensee's technical analyses and documentation held at the site. The site audit took place on July 26-28, 1994, and a number of questions and concerns were brought to the attention of the licensee at the audit exit meeting. The licensee responded to these concerns, made some modifications to its IPEEE submittal, and presented the results to the NRC at a meeting held on October 25, 1994. The review team presented its remaining concerns to the licensee at the end of that meeting. Subsequently, the licensee revised its IPEEE submittal for D.C. Cook in February 1995 to address these remaining concerns, and ERI completed its technical evaluation report in May 1995. Staff and contractor review findings are summarized in the evaluation section below. Details of the contractor's findings are presented in the technical evaluation report which is included as Enclosure 2.

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ENCLOSURE 1

In accordance with Supplement 4 to GL 88-20, the licensee proposed to resolve Unresolved Safety Issue (USI) A-45, "Shutdown Decay Heat Removal Requirements," Generic Issue (GI) 131, "Potential Seismic Interaction Involving Movable In-Core Flux Mapping System Used in Westinghouse Plants"; USI A-17, "Systems Interactions in Nuclear Power Plants." No other specific USIs or GIs were proposed by the licensee for resolution as part of the D.C. Cook IPEEE.

II. EVALUATION

The D.C. Cook Nuclear Plant is a two-unit, Westinghouse 4-loop pressurized-water reactor (PWR) with an ice condenser containment. The plant was designed to a seismic acceleration level of 0.2g PGA (peak ground acceleration) anchored to a Housner spectral shape and was categorized in NUREG-1407 as a 0.3g focused-scope plant. The licensee has performed a Level 1 probabilistic risk assessment (PRA), following the guidance described in NUREG/CR-4840, and a qualitative containment performance assessment for the D.C. Cook IPEEE.

Core Damage Frequency Estimates

The licensee originally estimated a seismic core damage frequency (CDF) of $1.8E-5$ /reactor-year (RY), using a site-specific hazard curve developed by Rizzo Associates, and $3.1E-4$ /RY, using the 1989 seismic hazard estimates developed by Lawrence Livermore Laboratory (LLNL). The seismic CDF was revised to $3.2E-6$ /RY after the licensee refined the fragility calculations in response to concerns raised before and during the audit. The licensee originally estimated a fire CDF of $1.7E-7$ /RY and later revised it to $3.8E-6$ /RY as a result of adding a few scenarios to its fire risk analyses during the audit. Other external events (e.g., external floods and high winds) are considered by the licensee as insignificant contributors to severe accidents at the D.C. Cook site. (The licensee estimated a CDF due to internal events of about $6.3E-5$ /RY, including internal flooding.)

The revised D.C. Cook CDF estimates compare reasonably with those of other plants.

Dominant Contributors

Seismically induced loss of the offsite power contributes the most, about 90%, and seismically induced steamline break and loss of the essential service water (ESW) system contribute the rest of the seismic CDF. The important system/equipment contributors to the estimated seismic CDF that appear in the top sequences are loss of electric power systems (600 VAC transformers and diesel generator fuel oil day tank failures resulting from seismically induced block wall failures) and loss of the auxiliary building (failure of steel column supporting crane girders). The ranking of the dominant contributors to seismic CDF remains the same regardless of which seismic hazard curve is used to determine the component fragilities.

The fire CDF is dominated by a fire in the diesel generator rooms, fire zones associated with the ESW system, switchgear rooms, motor control center (MCC) room, auxiliary building, control room, and turbine building. The important system/equipment contributors to the estimated fire CDF that appear in the top sequences are mostly associated with the loss of component cooling water or ESW systems with a minor contribution from a loss of a single train of 250 VDC power in the MCC room.

The licensee's IPEEE Level 1 PRA analysis appears to have examined the significant initiating events and dominant accident sequences.

Containment Performance

The licensee has assessed containment performance under seismic conditions at D.C. Cook by reviewing the seismically induced core damage sequences and, on the basis of the progression of these sequences, making comparisons to the Level 2 internal events containment performance analysis. The licensee has performed seismic containment walkdowns, including the assessment of the capability of containment mechanical penetrations and containment isolation valves to withstand seismic events. The licensee has also assessed the containment failure modes caused by fire and concluded that the Level 2 internal events containment performance analysis applies to the D.C. Cook plant's fire PRA.

The licensee's containment performance analyses for seismic and internal fire events appear to have considered important severe phenomena and are consistent with the intent of Supplement 4 to Generic Letter 88-20.

Generic Safety Issues

As a part of the IPEEE, a set of generic and unresolved safety issues (e.g., USI A-45, GSI-131, GSI-103, and the Sandia Fire Risk Scoping Study [FRSS] issues) were specifically identified during the initial planning of the IPEEE program and explicitly discussed in Supplement 4 to GL 88-20 and its associated guidance in NUREG-1407 as needed 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"

The licensee's process of addressing USI A-45 external events was very similar to that used for internal events quantification. The seismic and fire PRA event trees and plant system fault trees were based on the internal event/fault trees and modified for seismic and fire events. The staff finds that the licensee's USI A-45 evaluation is consistent with the guidance provided in Section 6.3.3.1 of NUREG-1407.

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

The licensee's process of addressing GI-131 involved an evaluation of the seismic adequacy of flux-mapping cart supports. As a result of that evaluation, the hold-down straps attached to the top of the cart were redesigned and strengthened, and a lower lateral restraint to the flux mapping cart was installed at an elevation just above the seal table. The staff finds that the licensee's GI-131 evaluation and improvements are consistent with the guidance provided in Section 6.2.2.1 of NUREG-1407.

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

The licensee has addressed GSI-103 and concluded that the Probable Maximum Precipitation (PMP) criteria will not have any impact on D.C. Cook. The staff finds that the

licensee's GI-103 evaluation is consistent with the guidance provided in Section 6.2.2.3 of NUREG-1407.

4. USI A-17, "System Interactions in Nuclear Power Plants"

The licensee addressed the external event aspects of USI A-17 as part of plant walkdowns (seismic, fire, and internal flooding walkdowns). USI A-17 items discovered during the walkdowns were incorporated into the seismic, fire, or internal flooding analyses; addressed administratively; or fixed at D.C. Cook. The staff finds that the licensee's process is consistent with the guidance provided in Section 6.2.2.1 of NUREG-1407.

5. Fire Risk Scoping Study Issues

The licensee has explicitly addressed the Sandia Fire Risk Scoping Study issues. The staff finds that the licensee's evaluation is consistent with the guidance provided in NUREG-1407.

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

Although, the licensee's IPEEE submittal did not explicitly discuss GSI-57, the information provided in the submittal addressing the seismic-fire interactions (Sections 3.1.2 and 4.8.5) and the seismically induced fire suppression system actuations (Section 4.8.5) is related to this issue. The staff finds that the licensee's evaluation is consistent with the guidance provided in NUREG-1407.

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 that should be resolved under the IPEEE program; thus, they were not explicitly discussed in Supplement 4 to GL 88-20 and NUREG-1407. However, subsequent to the issuance of the generic letter, the NRC evaluated the scope and the specific information as requested in the letter and its associated 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 safety issues. The following discussions summarize the staff's evaluations and resolutions of these safety issues at D.C. Cook.

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

The licensee's IPEEE submittal contains information (Section 4.8.1 of the D.C. Cook IPEEE submittal) addressing this issue. The licensee performed a review following the guidance provided in EPRI TR-100370, "Fire-Induced Vulnerability Evaluation (FIVE)," concerning control system interactions, and concluded that all circuitry associated with remote shutdown to be electrically independent of the control room. Based on the results of the IPEEE submittal review, the staff considers that the licensee's process is capable of identifying potential vulnerabilities associated with this issue. On the basis that no vulnerability associated with this issue was identified in the IPEEE submittal, the staff considers this issue resolved for D.C. Cook.



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

The licensee's IPEEE submittal contains information (Sections 4.8.2 and 4.8.3) addressing this issue: The licensee performed a review of the D.C. Cook's fire protection program and its associated fire brigade training program related to this issue. Based on the results of the IPEEE submittal review, the staff considers that the licensee's process is reasonable and is capable of identifying potential vulnerabilities associated with this issue. On the basis that no vulnerability associated with this issue was identified in the IPEEE submittal, the staff considers this issue resolved for D.C. Cook.

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

The licensee's IPEEE submittal contains information to directly address some of the external-event-related SEP issues: settlement of foundations and buried equipment (Sections 3.1.5 and 3.2.5); dam integrity and site flooding (Section 5.2); site hydrology and ability to withstand floods (Section 5.2); industrial hazards (Section 5.3C); and tornado missiles (Section 5.1.3.3). Although the licensee's IPEEE submittal did not contain information explicitly addressing the other SEP issues (i.e., design codes, criteria, and load combinations; and seismic design of structures, systems, and components), a conclusion may be drawn that these issues were implicitly addressed as part of the licensee's IPEEE process at D.C. Cook because the seismic PRA has taken the as-built, as-operated conditions into consideration in its structural response and component fragility analyses, and no potential seismic vulnerabilities were identified. Therefore, on the basis that no vulnerability associated with this issue was identified in the IPEEE submittal, the staff considers this issue resolved for D.C. Cook.

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

The licensee's IPEEE submittal contains information directly addressing the following external events-related MSRP issues: effects of fire protection system actuation on safety related equipment (Section 4.8.3), smoke control and manual fire-fighting effectiveness (Sec. 4.8.2 and 4.8.3), seismically induced spatial interactions (Sec. 3.1.2 and 3.2.2), seismic-fire interactions (Sec. 3.1.2 and 4.8.5), seismically induced fire suppression system actuations (Sec. 4.8.3), seismically induced flooding (Sec. 3.2.7), seismically induced relay chatter (Sec. 3.2.8), evaluation of earthquake magnitude greater than safe shutdown earthquake (Sec. 3), and the IPEEE-related aspects of common cause failures related to human errors (Sec. 3.1.5.3), non-safety-related control system/safety-related system dependencies (Sec. 4.8.1), and effects of flooding and/or moisture intrusion on non-safety related and safety-related equipment (Sec. 3.2.7, 4.8.3, and 5.2). It should be noted that the effects of hydrogen line rupture were not explicitly discussed in the D.C. Cook IPEEE submittal; nonetheless, hydrogen system fires were considered in the assessment of turbine building fire (CDFs are insignificantly low). In addition, the staff and its contractor performed a walkdown during the site audit and did not find that the hydrogen line rupture issue is of concern. Based on the results of the IPEEE submittal review, the staff considers that the licensee's process is capable of identifying potential external events-related vulnerabilities associated with GSI-172. Therefore, on the basis that no potential

vulnerability associated with this issue was identified in the IPEEE submittal, the staff considered the IPEEE-related aspects of this issue resolved for D.C. Cook.

Unique Plant Features, Potential Vulnerabilities, and Improvements

The licensee reported no unique safety features at the plant.

The licensee did not identify any seismic, fire, or other external events related severe accident vulnerabilities. However, some procedural changes and a number of minor equipment enhancements have been implemented in response to the D.C. Cook IPEEE walkdown findings. These licensee-identified improvements are listed below:

1. An earthquake procedure was modified as a precaution to instruct the operator to isolate the heating, ventilation, and air conditioning (HVAC) in the control room following an earthquake until it can be verified that no hydrazine stored onsite has been spilled.
2. A procedure was developed to instruct the operator to isolate the control room if smoke from an external fire is affecting control room habitability.
3. Instrument rack supports were modified to attach to the containment only.
4. The restraint supports for the ESW system were modified to attach to the auxiliary building only.
5. Loose, broken, or missing anchor bolts were tightened or replaced.
6. Relays which affect proper operability of safety-related equipment under seismic conditions were replaced.

High Winds, Floods and Other External Event (HFO)

SCREENING OF EXTERNAL HAZARDS

The licensee used a screening approach to identify those external hazards which could be screened from further consideration based on very general considerations. These screening criteria were derived from those described in NUREG-1407 and NUREG/CR-2300. The use of these screening criteria minimized the possibility of omitting any significant risk contributors while at the same time reducing the amount of detailed bounding analysis required. Specifically examined in the high winds, floods, and other external event (HFO) analyses were high winds, external flooding, aircraft accidents, ship impact accidents, off-site and on-site hazardous materials accidents, turbine missiles, and external fires. Walkdowns were performed as part of the licensee's review and found that there were no other plant-unique external events that pose a significant threat of severe accidents within the context of the NUREG-1407 screening approach.



HIGH WINDS

Based on the review of the original design, the licensee identified that the wind design at the D.C. Cook site does not conform fully to the criteria specified in the 1975 Standard Review Plan (SRP). The D.C. Cook Seismic Category I structures were designed to withstand a design basis tornado with a tangential wind speed of 300 mph and a translational speed of 60 mph and a negative pressure drop of 3psi in 3 seconds. The spectrum of tornado missiles considered in the D.C. Cook design consisted of three types of missiles, namely, a bolted wood decking (weighing 450 lbs traveling at 200 mph), a corrugated sheet siding (weighing 100 lbs traveling at 225 mph), and an automobile (weighing 3000 lbs traveling at 50 mph). The licensee performed additional analyses to determine if any of these structures represent plant vulnerabilities to tornado which could result in unacceptable core damage frequencies. Based on the results of its analyses, the licensee estimated that the probability of a tornado with 360 mph wind speed (i.e., 1975 SRP tornado design criterion) causing structure failures is $8E-8$ per reactor year; thus, the licensee concluded that the core damage frequency as a result of direct tornado wind pressure forces is sufficiently low.

EXTERNAL FLOODS

The licensee performed an evaluation by examining potential external flooding events which might initiate an accident sequence leading to core damage at the D.C. Cook site. The potential flooding events considered include: dam failures, lake flooding, river flooding, and intense precipitation. The licensee did not identify any significant changes to D.C. Cook since the operating license was issued with regard to flood design basis. Based on the results of the analysis, the licensee concluded that the contribution to plant risk from external flooding is insignificant.

The licensee also evaluated flooding based on probable maximum precipitation [i.e., Generic Issue (GI)-103, "Design for Probable Maximum Precipitation (PMP)"] and found that D.C. Cook will not be endangered by the flooding based on PMP.

TRANSPORTATION AND NEARBY FACILITY ACCIDENTS

The licensee performed additional analyses evaluating potential accidents associated with aircraft, ship impact, and off-site and on-site hazardous materials. Based on the results of these analyses, the licensee concluded that the contributions to plant risk due to accidents associated with aircraft, ship impact, and off-site hazardous materials are insignificant. However, the licensee identified that a hydrazine spill on-site might result in a control room concentration that exceeds the human toxicity limit; and, as a result, the seismic procedures dealing with the control room habitability were modified to require the control room operators to take specific steps considering a hydrazine spill accident.

The licensee has performed a walkdown and determined that no significant changes were found to impact the plant's original design conditions. No potential vulnerabilities associated with HFO events were identified.



OTHER PLANT-UNIQUE EXTERNAL EVENTS

The licensee performed additional evaluations on turbine-generated missiles and external fires. The licensee found that the contributions to plant risk due to turbine-generated missiles and external fires are insignificant.

GSI RESOLUTION

The licensee's IPEEE submittal contains information to directly address the HFO-related Systematic Evaluation Program (SEP) items: dam integrity and site flooding (Section 5.2); site hydrology and ability to withstand floods (Section 5.2); industrial hazards (Section 5.3C), severe weather effects on structures, and design codes, criteria (Sections 5.1 and 5.2); and tornado missiles (Section 5.1.3.3). Section 2.3.3 of ERI's TER provides a brief description of these items. The staff finds that the licensee's evaluation is consistent with the guidance provided in NUREG-1407. Therefore, on the basis that no vulnerability associated with this issue was identified in the IPEEE submittal, the staff considers this issue resolved.

III. CONCLUSION

On the basis of the above findings, the staff notes that (1) the licensee's IPEEE is complete with regard to the information requested by Supplement 4 to Generic Letter 88-20 (and associated guidance in NUREG-1407), and (2) the IPEEE results are reasonable given the D.C. Cook design, operation, and history. Therefore, the staff concludes that the licensee's IPEEE process is capable of identifying the most likely severe accidents and severe-accident vulnerabilities, and therefore, that the D.C. Cook IPEEE has met the intent of Supplement 4 to Generic Letter 88-20 and the resolution of specific generic safety issues discussed in this SER.

It should be noted that the staff focused its review primarily on the licensee's ability to examine D.C. Cook for severe-accident vulnerabilities. Although certain aspects of the IPEEE were explored in more detail than others, the review is not intended to validate the accuracy of the licensee's detailed findings (or quantification estimates) that 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 resolving the generic safety issues discussed in Section II.

