



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D.C. 20555-0001

STAFF EVALUATION REPORT OF  
PUBLIC SERVICE ELECTRIC AND GAS COMPANY  
INDIVIDUAL PLANT EXAMINATION OF EXTERNAL EVENTS (IPEEE) SUBMITTAL  
SALEM NUCLEAR GENERATING STATION, UNIT NOS. 1 AND 2

1.0 INTRODUCTION

On June 28, 1991, the U.S. Nuclear Regulatory Commission (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 January 29, 1996, the licensee, Public Service Electric and Gas Company (PSE&G, the licensee), submitted its response to the NRC.

The NRC staff contracted with Brookhaven National Laboratory and Sandia National Laboratories to conduct screening reviews in the seismic and fire areas, respectively, of the licensee's IPEEE submittal. The staff conducted a screening review of the high winds, floods, transportation, and other external events (HFTO) area of the submittal. In October 1997, the IPEEE Senior Review Board (SRB) met to discuss the review results in the seismic, fire and HFTO areas. The SRB is comprised of RES and NRR staff and RES consultants (Sandia National Laboratories) with probabilistic risk assessment expertise in external events. Based on the results of the screening reviews, a request for additional information (RAI) in the seismic and HFTO areas was sent to the licensee in February 1998. The licensee responded to the RAI in April 1998. Based on the results of the original review, and the additional information provided in the response to the RAI, the staff concluded that the aspects of seismic; fires; and HFTO events were adequately addressed. The review findings are summarized in the evaluation section below. Details of the staff's and contractors' findings are presented in the three technical evaluation reports attached to this staff evaluation report (SER).

In accordance with Supplement 4 to GL 88-20, the licensee provided information to address the resolution of Unresolved Safety Issue (USI) A-45, "Shutdown Decay Heat Removal Requirements," Generic Safety Issue GSI-103, "Design for Probable Maximum Precipitation (PMP)," GSI-131, "Potential Seismic Interaction Involving Movable In-Core Flux Mapping System Used in Westinghouse Plants," GSI-57, "Effects of Fire Protection System Actuation on Safety-Related Equipment," and the Sandia Fire Risk Scoping Study (FRSS) issues. These issues were explicitly requested in Supplement 4 to GL 88-20 and its associated guidance in NUREG-1407. Staff and contractor findings regarding these issues are included in this SER. The licensee did not propose to resolve any additional USIs or GSIs as part of the Salem IPEEE.

Enclosure

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## 2.0 EVALUATION

The Salem Nuclear Generating Station is a two-unit plant; both units being Westinghouse four-loop pressurized water reactors (PWRs) and each with a thermal power output of 3411 MWt. Salem Unit 1 began commercial operation in June 1977 and Unit 2 in October 1981. The two units are essentially identical and share a 700-acre site with the Salem Generating Station on the east bank of the Delaware River in Salem County, New Jersey.

The licensee used a PRA to perform its seismic assessment. The approach was generally consistent with the methodology of NUREG-1407. The risk quantification was done for both Electric Power Research Institute (EPRI) and the revised Lawrence Livermore National Laboratory (LLNL) hazard curves. For fire events, the licensee utilized the EPRI Fire Induced Vulnerability Evaluation (FIVE) methodology to do the initial screening. Then, a PRA quantification was performed for a detailed analysis of the unscreened fire areas. The licensee evaluated the other external events (HFTO) using the progressive screening approach from NUREG-1407 and GL 88-20, Supplement 4. Salem was not designed to the 1975 standard review plan (SRP) criteria; however, the licensee's HFTO evaluation used the 1975 SRP criteria for initial screening supplemented by bounding probabilistic analyses. In addition, since Salem is located on the same site as the Hope Creek Generating Station, which is an SRP plant, site-related information from the Hope Creek updated Final Safety Analysis Report (UFSAR) that is not design dependent was utilized in the Salem screening. Plant walkdowns were also performed to confirm that there were no significant changes in the plant design or operation that occurred since the plant's licensing.

### Core Damage Frequency Estimates

The licensee estimated the contribution to plant core damage frequency (CDF) from seismic events to be about  $5E-6$ /reactor year (RY) using the EPRI hazard curve and about  $1E-5$ /RY using the revised LLNL curve. A quantification for fire events, that utilized the EPRI FIVE methodology, indicated that the contribution to plant CDF from fire was about  $2E-5$ /RY. The contribution to CDF from HFTO was estimated by the licensee to be less than the NUREG-1407 screening criteria (i.e.,  $1E-6$ /RY). The licensee estimated that the overall CDF due to internal events was about  $6E-5$ /RY.

### Dominant Contributors

The licensee determined the dominant contributors to CDF resulting from seismic events were a loss of offsite power combined with random failures of the diesel generators, loss of offsite power and seismic failure of the service water system, loss of offsite power and battery trains A&B due to block wall failure, and loss of offsite power combined with a loss of instrumentation and control due to ceiling collapse in the main control room.

The dominant contributors to fire CDF (60% of the total estimated fire contribution) were fires in the relay room, the main control room, the room peripheral to the control room, and the ventilation rooms. Lesser contributions were from fires in the 460 V and 4160 V switchgear rooms and in the lower electrical penetration area. The contribution due to HFTO was estimated to be below the  $1E-6$ /RY screening criterion.

The licensee's IPEEE assessment appears to have examined the significant initiating events and dominant accident sequences.

### Containment Performance

The licensee has assessed containment performance under seismic conditions at Salem by investigating containment structural integrity during seismic events, the ruggedness of containment isolation equipment to protect against containment bypass (including the potential for a unique seismic-caused containment bypass), and containment cooling systems. The licensee evaluated the impact of fires on containment performance and found them to be of little significance, similar to the IPE evaluation, with no unique accident sequences as a result of fire.

The licensee's containment performance analyses for seismic and internal fire events appeared to have considered important severe 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 unresolved safety issues (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"

This issue was addressed in Section 3.2.1 of the Salem IPEEE submittal for seismic conditions and in Section 4.9 for fire. No vulnerabilities to the decay heat removal system were found due to either seismic or fire from the licensee's walkdowns and assessments. The staff finds that the licensee's evaluation of USI A-45 is consistent with the guidance provided in Section 6.3.3.1 of NUREG-1407 and, therefore, the staff considers this issue resolved.

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

The licensee reported in Section 3.2.7 of its submittal that a seismic analysis pertaining to the interaction of the movable in-core flux mapping system indicated that no seismic vulnerabilities were found. The staff finds that the licensee's GSI-131 evaluation is consistent with the guidance provided in Section 6.2.2.1 of NUREG-1407 and, therefore, the staff considers this issue resolved.

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

The licensee evaluated this issue and reported in Section 5.5.3 of its submittal that while the additional rainfall from PMP gave rise to site ponding and increased roof loading, both Units 1 and Unit 2 are adequately robust when assessed against the new PMP. The staff finds that the licensee's GSI-103 evaluation is consistent with the guidance provided in Section 6.2.2.3 of NUREG-1407 and, therefore, the staff considers this issue resolved.

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

The licensee has assessed the impact of inadvertent actuation of fire protection systems on safety systems which is also one of the issues identified in the FRSS. The submittal addresses this issue in Sections 3.1.7, 3.2.6 and 4.8.1. The staff finds that the licensee's GSI-57 evaluation is consistent with the guidance provided in EPRI's FIVE methodology that was accepted by the NRC staff and, therefore, the staff considers this issue resolved.

5. Fire Risk Scoping Study (FRSS) Issues

In Section 4.8 of its submittal, the licensee has explicitly addressed the FRSS issues. The licensee states in its submittal that it has not identified any unacceptable risks or outliers at Salem due to the FRSS issues. The staff finds that the licensee's evaluation is consistent with the guidance provided in NUREG-1407 and, therefore, the staff considers these issues resolved.

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, after 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 to resolve the external event aspects of these four safety issues. The following discussions summarize the staff's evaluation of these safety issues at Salem.

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

The licensee's IPEEE submittal contains a discussion addressing this issue in Sections 4.6.2.1.3.3 and 4.8.5 on Fire Risk Scoping Study Issues. In the discussion, the licensee states that Salem has a safe shutdown facility that is 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.

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

The licensee's IPEEE submittal contains information addressing this issue in Sections 4.6.2.1.5.2, 4.8.3 and 4.8.4. The licensee addressed this issue and concluded that the Salem fire protection systems and procedures provide adequate assurance that manual fire fighting effectiveness will not be significantly degraded from smoke and other fire effects. 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 Salem.

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

Salem is not an SEP plant.

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

The licensee's IPEEE submittal contains information directly addressing the following external-event-related MSRP issues: (1) effects of fire protection system actuation on safety-related and non safety-related equipment (Section 3.2.6); (2) seismically induced fire suppression system actuation (Section 4.8.1); (3) seismically induced fires (Section 3.1.7); (4) effects of hydrogen line rupture (Section 4.8.1); (5) the IPEEE-related aspects of common cause failures associated with human errors (Sections 3.1.5.3.2 and 3.1.5.6.3) for seismic events and (Section 4.6.1.3) for fires; (6) non safety-related control system/safety-related system dependencies (Sections 3.2.3 and 4.8.5); (7) effects of flooding and/or moisture intrusion on non safety-related and safety-related equipment (Section 4.8.1.2 ); (8) seismically induced spatial interactions (Section 3.2.3); (9) seismically induced flooding (Section 3.1.7); (10) seismically induced relay chatter (Section 3.1.5.4.3); and (11) evaluation of earthquake magnitude greater than safe shutdown earthquake (Section 3).

Based on the overall results of the IPEEE submittal review, the staff considers that the licensee's process is capable of identifying potential 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 considers the IPEEE-related aspects of this issue to be resolved for Salem.

No other specific USIs or GSIs resolved as part of the Salem IPEEE.

Unique Plant Features, Potential Vulnerabilities, and Improvements

In Section 7 of its submittal the licensee discussed the Salem unique safety features and plant improvements. A unique feature that was reported was that Salem Units 1 and 2 have a full time dedicated fire department staff. The licensee stated that no fundamental weaknesses or vulnerabilities with regard to external events were identified during its evaluation. Section 7 of the submittal did, however, discuss a number of improvements that have been implemented as a result of the IPEEE review. These enhancements include:

Seismic area:

- The reinforcement of an 8-foot masonry wall in the 4kV switchgear room.
- A procedural change to ensure long term alternate ventilation for the Auxilliary Building.
- The replacement of identified low ruggedness relays with higher seismic capacity relays (e.g., 4kV Phase A/B/C diesel generator differential relays).

Fire area:

- A procedural change for the control of transient combustibles in the turbine building.
- A procedural change to enhance cooling in the switchgear and control areas in the event of a fire.

HFTO area:

- Improved penetration seals to protect against flooding between the Service and Auxiliary buildings. This improvement is discussed in Sections 5.0, 5.1, and 5.2 of the licensee's submittal. The licensee reports in its discussion that the improved penetration seals resulted in a reduction in the estimated contribution to core damage frequency from flooding of about  $1E-4/R$ Y to  $1E-7/R$ Y. As discussed in its RAI response, the licensee intends to monitor the continuing integrity of the improved seal penetrations using sample-based visual inspections.
- Improved hold downs for the hydrogen tanks to protect against tornadoes
- Modifications to the plant circulating water intake structure to protect against detritus (blockage).

These improvements are intended to improve plant safety and reduce the potential for severe accident vulnerabilities at Salem.

### 3.0 CONCLUSIONS

On the basis of the overall review findings, the staff concludes that: (1) the licensee'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 Salem 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 Salem IPEEE has met the intent of Supplement 4 to GL 88-20 and the resolution of specific generic and unresolved safety issues discussed in this SER.

It should be noted that the staff focused its review primarily on the licensee's ability to examine Salem 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 the licensee'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 and unresolved safety issues discussed in this SER.

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**Attachment 1**

**Salem GENERATING STATION  
INDIVIDUAL PLANT EXAMINATION OF EXTERNAL EVENTS (IPEEE)  
TECHNICAL EVALUATION REPORT  
SEISMIC EVENTS**