



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

October 31, 2016

Mr. Peter P. Sena, III
President and Chief Nuclear Officer
PSEG Nuclear LLC - N09
P.O. Box 236
Hancocks Bridge, NJ 08038

SUBJECT: HOPE CREEK GENERATING STATION – REVIEW OF POST-EXTENDED
POWER UPRATE STEAM DRYER STRESS CALCULATION ACOUSTIC
CIRCUIT MODEL SOFTWARE ERROR (CAC NO. MF7077)

Dear Mr. Sena:

By letter dated November 10, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15314A710), PSEG Nuclear LLC (PSEG or the licensee) submitted to the U.S. Nuclear Regulatory Commission (NRC) Region I Regional Administrator a summary of a courtesy notification made to the NRC Region I staff regarding information that was previously supplied by PSEG to the NRC that was not accurate in accordance with Title 10 of the *Code of Federal Regulations* Section 50.9(a). By letter dated June 29, 2016 (ADAMS Accession No. ML16181A178), PSEG provided additional information.

The inaccurate information submitted was due to an error discovered in the Acoustic Circuit Model software used for calculating the acoustic pressure loading on the Hope Creek Generating Station (HCGS) steam dryer. As noted in the letter, the results of this analysis were included in the licensee's submittals that supported the extended power uprate (EPU) application. The NRC staff has reviewed the information provided by the licensee and determined that there is reasonable assurance that the HCGS steam dryer will maintain its structural integrity for continued operation at EPU conditions.

If you have any questions, please contact me at 301-415-1603 or Carleen.Parker@nrc.gov.

Sincerely,

A handwritten signature in black ink, appearing to read "Carleen J. Parker", is written over a horizontal line.

Carleen J. Parker, Project Manager
Plant Licensing Branch I-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-354

Enclosure:
NRC Staff Evaluation

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OFFICE OF NUCLEAR REACTOR REGULATION REVIEW OF
POST-EXTENDED POWER UPRATE STEAM DRYER STRESS CALCULATION
ACOUSTIC CIRCUIT MODEL SOFTWARE ERROR

PSEG NUCLEAR LLC
HOPE CREEK GENERATING STATION
DOCKET NO. 50-354

INTRODUCTION

By letter dated November 10, 2015 (Reference 1), PSEG Nuclear LLC (PSEG or the licensee) submitted to the U.S. Nuclear Regulatory Commission (NRC) Region I Regional Administrator a summary of a courtesy notification made to the NRC Region I staff regarding information that was previously supplied by PSEG to the NRC that was not accurate in accordance with Title 10 of the *Code of Federal Regulations* Section 50.9(a). By letter dated June 29, 2016 (Reference 2), PSEG provided additional information.

ACOUSTIC CIRCUIT MODEL SOFTWARE ERROR

The inaccurate information submitted was due to an error that was discovered in the Acoustic Circuit Model (ACM) software (ACM 4.0) used for calculating the acoustic pressure loading on the Hope Creek Generating Station (Hope Creek) steam dryer. As noted in the November 10, 2015, letter, the results of this calculation were included in the licensee's submittals that supported the extended power uprate (EPU) application. The NRC staff approved the licensee's EPU request on May 14, 2008 (Reference 5).

PSEG provided the following information regarding the software error:

The software that determines the pressure load distribution as a function of frequency solves the Helmholtz equation numerically. During software development, an alternate representation (the "analytical skirt model") of the solution in the thin gap between the reactor pressure vessel wall and steam dryer skirt was considered as a means of improving accuracy and lowering computational cost. The formulation and implementation of this alternate solution were correct, but the iteration algorithm used to obtain the skirt solution omitted a linearized coupling term that resulted in the skirt solution not being properly converged. Moreover, the alternate skirt solution was invoked using a switch hardwired into the code that could be set to 0 or 1 by the software operator to omit or invoke this alternate skirt model.

Enclosure

Testing and benchmarking of the Helmholtz solver against Quad Cities data were carried out using the baseline software without this analytical skirt model. However, in subsequent evaluation of the steam dryer pressure load on the Hope Creek steam dryer, the analytical skirt model was inadvertently exercised in violation of Quality Procedure [of PSEG's contractor, Continuum Dynamics Incorporated].

When the pressure load was recomputed correctly, the pressure loadings increased. However, areas of the dryer which incorrectly had negligible pressure loading now saw a substantial load increase. The loads were changed at all locations on the dryer. The resulting limiting alternating stress ratios were found to occur primarily on the welds involving the steam dryer hoods or welds connecting the drain channels to the skirt.

STEAM DRYER INTEGRITY REVIEW

Subsequent to the ACM error notification, the NRC staff requested additional information from the licensee related to ACM error impact; steam dryer minimum alternating stress ratio (MASR), before and after ACM error correction; and any new approaches and conservatism. The licensee responded with the details of the ACM error and its impact on the fluctuating pressure loads acting on the steam dryer as described above.

After the licensee corrected the ACM error, the recomputed dryer pressure loading increased substantially. In recomputing the pressure loading, the licensee did not use any new approaches or methodologies. PSEG stated that the only difference in the load recomputation was that the licensee retained the loading in 75-85 hertz (Hz) frequency (did not filter it out), which was previously considered as fictitious or noise. The NRC staff finds this acceptable because the recomputed loads did not contain any fictitious peak around 80 Hz. Utilizing the recomputed pressure loading, finite element structural analysis of the steam dryer was performed by the licensee.

The reevaluation of the steam dryer acoustic stresses indicates a 100 percent or more decrease in the MASR. MASR is defined as the ratio of high cycle fatigue (HCF) stress limit for stainless steel to the maximum computed HCF stress. The locations with the lowest MASR before and after the error correction are presented in the table below.

Hope Creek Dryer Component	MASR at EPU Conditions before ACM Error Correction (2008 analysis based on which EPU was authorized)	MASR at EPU Conditions after ACM Error Correction (2016 re-analysis)
Backing Bar/Middle Hood	> 4.0	1.07
Hood Support/Inner hood Weld	2.36	1.16

There is a significant increase in the dryer stresses after the ACM error was corrected (from 2.36 to 1.07). However, the increased stresses are still below the ASME Code HCF stress limit

(MASR ratio of 1.0).

The structural integrity of the steam dryer has been demonstrated by the licensee's successful operation without any fatigue cracking since EPU implementation in 2008 (the plant has completed four refueling outages during this time). Furthermore, the moisture carryover (MCO) measurements since EPU implementation are around 0.029 percent, indicating a satisfactory performance of the dryer. The long-term inspection of the Hope Creek steam dryer will be performed by the licensee in accordance with BWRVIP-139NP-A, "BWR Vessel and Internals Project, 'Steam Dryer Inspection and Flaw Evaluation Guidelines'" (Reference 3) as required by Hope Creek License Condition 2.C(22)2.e. Therefore, the staff believes that there is reasonable assurance that the Hope Creek steam dryer will maintain its structural integrity for continued operation at EPU conditions.

SUMMARY AND CONCLUSION

The Hope Creek post-EPU re-analysis of the steam dryer after correcting the ACM error demonstrates that the steam dryer stresses from fluctuating pressure and acoustic loading meet the American Society of Mechanical Engineers' HCF fatigue stress limit of 13,600 pounds per square inch (psi) for stainless steels with a 7 percent margin ($1.07 > 1.0$). Since EPU implementation in 2008, Hope Creek has completed four refueling outages. The structural integrity of the steam dryer has been demonstrated by the licensee's successful operation without any fatigue cracking. MCO measurements since EPU implementation are around 0.029 percent, indicating a satisfactory performance of the dryer. The long-term inspection of the Hope Creek steam dryer will also be performed in accordance with NRC-approved BWRVIP-139NP-A guidelines. Based on the above, the NRC staff concludes that there is reasonable assurance that the Hope Creek steam dryer will maintain its structural integrity for continued operation at EPU conditions.

REFERENCES

1. Letter LR-N15-0230, from Paul J. Davison, Site Vice President, Hope Creek Generating Station, PSEG Nuclear LLC, to Daniel Dorman, Regional Administrator, Region 1, U.S. Nuclear Regulatory Commission, "Summary of Courtesy Notification for Completeness and Accuracy of Information," November 10, 2015 (ADAMS Accession No. ML15314A710).
2. Letter LR-N16-0119, from Paul J. Davison, Site Vice President, Hope Creek Generating Station, PSEG Nuclear LLC, to U.S. Nuclear Regulatory Commission Document Control Desk, "Response to Request for Additional Information Regarding Review of Post-Extended Power Uprate Steam Dryer Stress Calculation Acoustic Circuit Model Software Error (CAC No. MF7077)," June 29, 2016 (ADAMS Accession No. ML16181A178).
3. BWRVIP-139NP-A, BWR Vessel and Internals Project, "Steam Dryer Inspection and Flaw Evaluation Guidelines," July 2009 (ADAMS Accession No. ML101270123).
4. Letter from William J. Shack, Chairman, Advisory Committee on Reactor Safeguards Chairman, to Dale E. Klein, Chairman, U.S. Nuclear Regulatory Commission, "Hope

Creek Generating Station Extended Power Uprate Application,” May 2, 2008 (ADAMS Accession No. ML081050422).

5. Letter from John G. Lamb, Senior Project Manager, U.S. Nuclear Regulatory Commission to William Levis, President & Chief Nuclear Officer, PSEG Nuclear LLC, “Hope Creek Generating Station – Issuance of Amendment Re: Extended Power Uprate (TAC No. MD3002),” May 14, 2008 (ADAMS Accession No. ML081230581).

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Sincerely,
/RA/

Carleen J. Parker, Project Manager
Plant Licensing Branch I-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

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Enclosure:
NRC Staff Evaluation

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*by memorandum

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