

October 3, 2005

LICENSEE: Exelon Generation Company, LLC.

FACILITY: Quad Cities Nuclear Power Station

SUBJECT: SUMMARY OF AUGUST 29, 30, 31, AND SEPTEMBER 1, 2005, MEETING WITH EXELON GENERATION COMPANY, LLC ON THE RESULTS OF THE TESTING AND EVALUATION OF THE STEAM DRYER PERFORMANCE AT QUAD CITIES, UNITS 1 AND 2 (TAC NOS. MC4397 AND MC4398)

From August 29 through September 1, 2005, the Nuclear Regulatory Commission (NRC) staff held a public meeting with Exelon Generation Company, LLC (Exelon, the licensee) to discuss the results of the licensee's evaluation of the data collected during the restart of Quad Cities, Units 1 and 2 with power ascension up to extended power uprate (EPU) conditions to support long-term EPU operation of those units. NRC staff from Office of Nuclear Reactor Regulation (NRR) and Region III, and NRC contractors from Argonne National Laboratory with a consultant from Pennsylvania State University participated in the public meeting with the licensee and its supporting organizations. A copy of the lists of attendees is available in the Agencywide Documents Access and Management System (ADAMS) at Accession Number M052500109.

During the meeting, Exelon presented the data obtained from the instrumentation installed on the new Quad Cities, Unit 2, steam dryer and the main steamline (MSL) components for both units, and its assessment of that data. A copy of the non-proprietary version of the licensee's presentation is available in ADAMS at ML052550169. The licensee discussed its evaluation of the design pressure loads that were used in support of the design of the replacement steam dryers for Quad Cities, Units 1 and 2. As part of this evaluation, the licensee conducted an assessment of the acoustic circuit model (ACM) that was used in the stress analysis for the steam dryers to calculate the steam dryer pressure loads based on input from four strain gages installed in a quadrant array at two locations on each of the four main steam lines (MSLs). The licensee compared pressure load data obtained from the Quad Cities, Unit 2 steam dryer instrumentation at 790 MWe during power ascension to the pressure loads calculated by the ACM using MSL strain gage input. Based on that comparison, the licensee adjusted several assumptions in the ACM prior to conducting another assessment of the ACM to calculate Quad Cities, Unit 2 steam dryer pressure loads at 930 MWe. The licensee again modified the ACM following this assessment in an effort to best match the pressure loads measured by the 26 sensors on the Quad Cities, Unit 2 steam dryer. The licensee used a "modified 930 MWe" version of ACM to evaluate stress on the Quad Cities, Unit 1 steam dryer (except the skirt) and a "minimum error" version of the ACM to evaluate the stress on the Quad Cities, Unit 1 steam dryer skirt. The licensee also used the "modified 930 MWe" version of the ACM to evaluate the stress on the entire Quad Cities, Unit 2 steam dryer. The licensee relied on five strain gages installed on the Quad Cities, Unit 2 steam dryer to provide confidence in the overall stress analysis (including the ACM) by comparing the measured steam dryer strain to the calculated strain at those sensor locations.

The licensee discussed its overall startup test reports for Quad Cities, Units 1 and 2. In those reports, the licensee discussed the performance of the reactor coolant, steam, and feedwater

systems and their components during EPU restart. The licensee did not identify any problems with the performance of the Quad Cities, Units 1 and 2 steam dryers, or other steam and feedwater components. The NRC staff noted that the pressure, strain, and acceleration data obtained from the Quad Cities, Unit 2 steam dryer instrumentation revealed a rapid increase in measured parameters for some of the steam dryer sensors as the plant reached the highest achieved thermal power level (less than full EPU thermal power). The staff indicated that the rapid increase in Quad Cities, Unit 2 steam dryer data is important in determining the appropriate extrapolation of steam dryer stress to full EPU conditions. The staff also noted that the vibration measurements associated with the safety relief valves and electromechanical relief valves indicated significant response at specific frequencies that corresponded to frequencies identified by the ACM as important for the performance of the Quad Cities, Units 1 and 2 steam dryers.

Personnel from General Electric (GE) presented the results of the evaluation of the design pressure loads for the Quad Cities, Units 1 and 2 steam dryers derived from tests conducted at the GE Scale Model Test (SMT) facility. GE indicated that the SMT data replicated the types of loading mechanisms on the steam dryers at Quad Cities. However, GE is evaluating the cause of the failure of the SMT facility to predict the presence of a significant resonance in the 150 to 160 Hz range acting on the Quad Cities steam dryers. GE plans to conduct specific benchmark tests at the SMT facility for the as-built layout of the Quad Cities, Unit 2 steam system later in 2005. The licensee indicated that the SMT predictions are not being used in assessing the structural capability of the Quad Cities, Units 1 and 2 steam dryers at this time. The NRC staff indicated its agreement for the need to determine the cause for the omission of the significant resonance peak above 150 Hz before relying on the SMT data in predicting steam dryer loads. The staff acknowledged encouraging aspects of the SMT as a predictive tool and as a means to help identify the source of steam dryer loads.

Exelon discussed its evaluation of the impact of the loss of one strain gage from the four strain gage array at specific MSL locations when detecting pressure fluctuations inside the MSL piping. Exelon also reported on its collection of direct strain measurements for four versus three strain gages at Quad Cities, Unit 2. The NRC staff did not identify any concerns with the licensee's evaluation of the loss of one strain gage. The staff did note that the potential uncertainty associated with strain gage loss indicates the importance of using at least four strain gages at each MSL location when detecting internal pressure fluctuations.

Exelon evaluated the pressure loads on the Quad Cities, Unit 2 steam dryer calculated by the ACM using MSL strain gage data. The ACM was modified to better match the pressure data from 26 operational sensors installed on the Quad Cities, Unit 2 steam dryer and collected at the 930 MWe power level. Exelon was satisfied with the accuracy of the ACM based on the results of its stress analysis, and its comparison of the strain measurements from five strain gages installed directly on the Quad Cities, Unit 2 steam dryer. The NRC staff noted its concerns with the significant underprediction of certain frequency peaks for several pressure sensors on the outer hood of the Quad Cities, Unit 2 steam dryer that might result in high stress at specific dryer locations.

The staff reviewed the design documentation for the ACM made available during the meeting, and did not consider it to be sufficient to fully validate the computer code. Further, the licensee reported that the ACM was not reliable for measuring pressure loads at frequencies below 18 Hz on the steam dryer. From the information presented by the licensee, the theoretical uncertainty of the ACM in determining steam dryer pressure loads based on MSL strain gage data was not clear. Therefore, it was difficult to assign an appropriate uncertainty for the ACM

in the stress analysis for the steam dryer. The ACM uncertainty is more significant for the evaluation of the steam dryers at Quad Cities, Unit 1 and Dresden, Units 2 and 3 than for Quad Cities, Unit 2, which has instrumentation installed on its steam dryer.

Exelon presented its stress analysis for the steam dryers at Quad Cities, Units 1 and 2, using the ACM and a finite element model (FEM) of the steam dryers. The licensee calculated that there was at least 20 percent margin from the American Society of Mechanical Engineers' fatigue stress limit for the steam dryers in Quad Cities, Units 1 and 2 at an extrapolated power level of 2957 MWt (the maximum licensed power). The licensee relied on five strain gages on the Quad Cities, Unit 2 steam dryer to support the overall adequacy of the stress analysis (including accuracy of the ACM and FEM). The licensee indicated that it would be difficult to develop a specific uncertainty for the ACM over its applied frequency range. As an alternative, an end-to-end evaluation of the uncertainty of the stress analysis could be performed which would consider the specific uncertainties of MSL strain gage data input, direct comparison of the steam dryer strain gage measurements to calculated strain, and dryer strain gage measurement error. To use the Quad Cities, Unit 2 strain gage data to confirm the stress analysis, the staff considered that the licensee would need to (1) evaluate the sensitivity of the dryer strain gages to location and orientation; (2) analyze the transfer function from the dryer ring tests, including the high frequency range; and (3) correlate the dryer strain gage measurements to the maximum stress locations on the Quad Cities, Unit 2 steam dryer. The staff considered that the EPU operation of Quad Cities, Unit 2 with regard to steam dryer capability could be supported by an end-to-end uncertainty evaluation. Steam dryer capability during EPU operation of Quad Cities, Unit 1 could be supported (at least for the short term) by the similarity of the steam dryers in Quad Cities, Units 1 and 2 by comparing the MSL strain gage data. However, the staff noted that the ring test results appear to indicate that the Quad Cities, Unit 1 steam dryer might be more responsive to loading than the Quad Cities, Unit 2 steam dryer. The staff noted that to support the stress analysis for long-term EPU operation at Quad Cities, Unit 1 and Dresden, Units 2 and 3, the licensee will need to confirm the application of the ACM for other than Quad Cities, Unit 2 at 930 MWe, such as by (1) evaluating another power level at Quad Cities, Unit 2; (2) confirming the dryer damping assumptions; and (3) matching the most significant frequency peaks as part of the +/- 10 percent time step evaluation. The staff also noted that the Quad Cities, Unit 2 steam dryer data presented in the EPU restart report suggests that the pressure load and strain on the dryer might increase at a greater rate than assumed in the licensee's extrapolation from the highest achieved thermal power level to the full EPU power level of 2957 MWt.

The licensee indicated that steam dryer inspections are planned for Dresden, Unit 2 in the fall of 2005, and for Quad Cities, Unit 2 in the spring of 2006. The NRC staff stated that it believes that these inspections will provide direct information on steam dryer performance during EPU operation. The licensee agreed to provide the results of those inspections to the NRC staff. The licensee also agreed to provide a discussion of the application of the lessons learned from the evaluation of the Quad Cities, Unit 2 steam dryer data to Dresden, Units 2 and 3 following the steam dryer inspection at Dresden, Unit 2. The licensee indicated that one MSL in Dresden, Unit 2 will be instrumented with a four strain gage array at one location in the fall of 2005 to evaluate MSL pressure trends. Exelon discussed its ongoing design of replacement steam dryers for Dresden, Units 2 and 3. The licensee is planning to install the replacement steam dryer in Dresden, Unit 3 in 2006 and Dresden, Unit 2 in 2007. The licensee will install MSL strain gage arrays at Dresden, Unit 3 for input to the ACM following the steam dryer replacement.

In its summary, Exelon acknowledged the need to improve its presentation of the evaluation of uncertainties in the stress analysis for the steam dryers in Quad Cities, Units 1 and 2. The licensee indicated its view that the strain gages on the Quad Cities, Unit 2 steam dryer confirm the stress analysis results, including the application of the ACM and FEM. The licensee pointed to significant margin suggested by the stress analysis for steam dryer locations under the greatest load conditions. The licensee stated that a test program would be initiated at the end of September 2005 to identify the source of the significant frequency peaks of the pressure loading on the steam dryers at Quad Cities, Units 1 and 2. The licensee stated that it had considered the steam dryer loading for Dresden, Units 2 and 3 based on lessons learned from Quad Cities, and that more details will be provided following the steam dryer inspection at Dresden, Unit 2 during the fall 2005 outage.

Prior to meeting adjournment, the licensee and the NRC staff discussed the questions that remained. The questions can be summarized as follows:

1. Why does the ACM underpredict pressures at specific locations on the Quad Cities, Unit 2 steam dryer, and what impact does this underprediction have on the uncertainty of the stress analysis?
2. If the uncertainty of the individual aspects of the stress analysis (such as the ACM) will not be determined, combined, and applied, what is the end-to-end uncertainty of the entire stress analysis for the steam dryers in Quad Cities, Units 1 and 2?
3. With the modifications to the ACM to best match the Quad Cities, Unit 2 steam dryer pressure data at 930 MWe, what is the confidence in the application of the ACM to Quad Cities, Unit 1 and Dresden, Units 2 and 3?
4. Is it sufficient to use a +/- 10 percent time step on the frequency spectrum in the stress analysis without considering significant peaks within that range?
5. How significant is the omission of low frequency pressure loads on the steam dryer by the ACM?
6. Are the differences in the resonance response of the Quad Cities, Units 1 and 2 steam dryers during the hammer tests significant?
7. Is the methodology used to extrapolate the loads to 2957 MWt appropriate based on the Quad Cities, Unit 2 steam dryer data?
8. Does a comparison of the MSL strain gage data for Quad Cities, Units 1 and 2 support interim EPU operation for Quad Cities, Unit 1 until the stress analysis uncertainty issue is resolved?
9. Are the criteria used for strain gages S-5, S-7, and S-9 (outer hood locations) during the recent EPU restart of Quad Cities, Unit 2 met with the most recent stress analysis?

10. What is the uncertainty of the steam dryer strain gages installed in Quad Cities, Unit 2, and how does it impact available margin for steam dryer structural integrity?
11. What are the results of the application of the lessons learned from the Quad Cities, Unit 2 steam dryer data with regard to EPU operation at Dresden, Units 2 and 3?
12. What is the source of the significant frequency peaks in the pressure loading on the steam dryers in Quad Cities, Units 1 and 2, and what impact will those peaks have on plant equipment during long-term EPU operation?

The licensee agreed to address the 12 questions prior to completing resolution of the issue of steam dryer performance for Quad Cities and Dresden. For the short term, it was agreed that the licensee would focus on the questions directly related to the operation of Quad Cities, Units 1 and 2. After the licensee assesses the time and level of effort required to complete the remaining items, there will be a technical meeting at the Exelon corporate office to discuss the results followed by an NRC-Exelon management meeting to review the results and make a decision regarding the long-term operation of the Quad Cities units at EPU power levels.

/RA/

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Office of Nuclear Reactor Regulation

Docket Nos. 50-254 and 50-265

10. What is the uncertainty of the steam dryer strain gages installed in Quad Cities, Unit 2, and how does it impact available margin for steam dryer structural integrity?
11. What are the results of the application of the lessons learned from the Quad Cities, Unit 2 steam dryer data with regard to EPU operation at Dresden, Units 2 and 3?
12. What is the source of the significant frequency peaks in the pressure loading on the steam dryers in Quad Cities, Units 1 and 2, and what impact will those peaks have on plant equipment during long-term EPU operation?

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