MECHANICAL AND CIVIL ENGINEERING BRANCH/DIVISION OF ENGINEERING

FATIGUE ANALYSIS OF BOILING WATER REACTOR STEAM DRYERS

FOR EXTENDED POWER UPRATE CONDITIONS

RATIONALE FOR STAFF POSITION ON

STRUCTURAL INTEGRITY OF STEAM DRYERS

(PBLE METHODOLOGY OR METHOD 2 FOR OPERATING FLEET), REVISION 1

By letter dated February 22, 2010, GE Hitachi Nuclear Energy (GEH) submitted a request to the U.S. Nuclear Regulatory Commission (NRC) staff to provide the technical basis for its position specifying a minimum alternating stress ratio of 2.0 (Reference 1). The NRC staff's technical basis is documented in this enclosure.

The Boiling Water Reactor (BWR) steam dryers are subject to transient dynamic pressure loading under extended power uprate (EPU) conditions. These loads have the potential to cause high-cycle fatigue failure and generate loose parts, challenging the functionality of safety-related components, such as the safety relief valves. The pressures acting on the steam dryer are currently estimated from the real-time measurements of acoustic pressures from the main steam lines (MSLs). The plant based load evaluation (PBLE) methodology transforms the measured acoustic pressures from the MSLs into the pressures acting on the steam dryer. [

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As a result of its review of several EPU applications that utilize the PBLE methodology for the evaluation of steam dryers, the NRC staff has identified the following two recommendations when applying the PBLE methodology to other plants: (1) the MSLs and the steam dome of the candidate plant should be similar to that of the reference plant [

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(i.e., the MSL layout and geometry, steam dome geometry, relative locations of the strain gages, and the shape of the outer hood should be similar); and (2) at the projected EPU conditions, a minimum alternating stress ratio of 2.0 for the fatigue stress of the steam dryer is recommended to address the uncertainties and bias errors.

The minimum alternating stress ratio is defined as the ratio of the allowable alternating stress intensity to the maximum alternating stress intensity in the steam dryer components. The

rationale for the NRC staff's recommendation of a minimum alternating stress ratio of 2.0 is as follows:

1. [

] Until that time, the NRC staff is not in a position to consider lowering its minimum recommended alternating stress ratio from the currently recommended value of 2.0.

2. The loads estimation procedure has the following apparent deficiencies:
   (a) the strain gage arrays, mounted to the MSLs at two locations, are nearly 'blind' at frequencies which correspond to acoustic half wavelengths that match the array spacing such that loads may be underestimated significantly at those frequencies;
   (b) measured data are filtered to remove signals at several 'exclusion frequencies,' usually set to multiples of electrical supply frequencies (60 Hz) and plant machinery dominant frequencies (pump tones), and as a result, any significant loads at those frequencies would be masked; and
   (c) since the MSL strain gage approach is a remote sensing method, other sources may impact the steam dryer that are not accounted for (e.g., structure-borne loads transmitted through the steam dryer supports and any low frequency flow-induced or acoustic loads within the reactor pressure vessel not detected by the MSL strain gage arrays). These sources may lead to higher steam dryer stresses that could result in fatigue cracking.

3. The current benchmarking of the PBLE methodology (Method 2) does not account for Low Flow (LF) noise and Electrical Interference Check (EIC) signals (signals measured with very low excitation voltage applied to the MSL strain gage array) at the QC2 plant. Therefore, the PBLE methodology cannot account for the differences in the EIC signals and LF plant noise between QC2 and other plants. This deficiency could produce non-conservative results for the pressure loading on the steam dryer when the EIC and LF signals are lower than those in the QC2 benchmark data.

4. [

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Given that [

], the NRC staff is of the position that a minimum alternating stress ratio of 2.0 for fatigue should be maintained to ensure that there is adequate margin, and the Advisory Committee on Reactor Safeguards agreed with the NRC staff's position.

The above-mentioned uncertainties in the current stress analysis procedure justify the staff's current position of a minimum alternating stress ratio of 2.0. However, when monitoring data is available from sufficient dryer instrumentation at two additional plants during power ascension (e.g., pressure sensors to assess acoustic loads, strain gages to evaluate the overall dryer stress condition, and accelerometers to monitor any structure-borne loads), the NRC staff will assess its current position of a minimum alternating stress ratio of 2.0.

In conclusion, the NRC staff has the following two recommendations when applying the PBLE methodology to other plants:

(1) the MSLs and the steam dome of the candidate plant should be similar to that of the reference plant [
] (i.e., the MSL layout and geometry, steam dome geometry, relative locations of the strain gages, and the shape of the outer hood should be similar); and

(2) at the projected EPU conditions, a minimum alternating stress ratio of 2.0 is justified to be applied to account for fatigue stresses of the steam dryer to address the uncertainties and bias errors.

The NRC staff welcomes the opportunity to participate in a public meeting with GEH to further discuss the issues addressed above.

Reference

1. Letter from GEH to NRC, MFN 10-077, "February 18, 2010 Meeting Regarding Steam Dryer Plant Based Load Evaluation for Operating Plants," dated February 22, 2010. (ADAMS Accession No. ML100541504)