SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

BOILING WATER REACTOR VESSEL AND INTERNALS PROJECT

TOPICAL REPORT "BWRVIP-182: [EPRI REPORT NO. 1016166, JANUARY 2008]

GUIDANCE FOR DEMONSTRATION OF STEAM DRYER INTEGRITY

FOR POWER UPRATE" (TAC NO. MD9427)

PROJECT NO. 704

1.0 INTRODUCTION

1.1 Background

Recent experience with steam dryers at operating Boiling Water Reactors (BWRs), particularly those operating at extended power uprate (EPU) conditions associated with increased steam line flow velocities, have shown significant degradation in the steam dryers caused by acoustic resonance induced loads. As a result of inspections performed on steam dryers, repairs and modifications have been required at some plants. In some cases, the observed damage has been so extensive that replacement dryers have been installed. Therefore, the Boiling Water Reactor Vessel and Internals Project (BWRVIP) embarked on an effort to develop Topical Reports (TRs) to address steam dryer issues. By letter dated January 30, 2008 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML080380544), the BWRVIP submitted TR BWRVIP-182 "BWR Vessel and Internals Project, Guidance for Demonstration of Steam Dryer Integrity for Power Uprate," to the U.S. Nuclear Regulatory Commission (NRC) staff for review. By letter dated December 31, 2008 (ADAMS Accession No. ML083650080), the NRC staff sent a request for additional information (RAI) to the BWRVIP. By letter dated April 23, 2009 (ADAMS Accession No. ML091170684), the BWRVIP submitted its responses to the staff's RAIs.

1.2 Purpose and Applicability

The purpose of the BWRVIP-182 TR is to provide guidance in demonstrating the structural integrity of BWR steam dryers for power uprates greater than 2 percent of current licensed thermal power (CLTP) up to EPU conditions. This TR is intended to assist the BWR owners with guidelines and considerations in planning for power uprates. The TR does not address specific methods for predicting steam dryer pressure loading and steam dryer stresses, but presents an overall guidance in defining the process to be followed and criteria to be used when developing, documenting, validating, and applying methods to demonstrate steam dryer integrity.

This TR only addresses steam dryers. The pressure fluctuations inside the main steam lines (MSLs) may also have a detrimental effect on MSL instrumentation and other components such as relief valve operators. Techniques for conducting assessments of potential detrimental effects on components such as relief valve operators as a result of MSL vibrations at power uprate conditions are not in the scope of this TR.

2.0 SUMMARY OF THE TOPICAL REPORT

The BWRVIP-182 TR addresses only steam dryer related items such as: (1) screening to assess the potential for MSL acoustic excitation at power uprate, (2) defining MSL local pressure fluctuations based on in-plant tests, (3) prediction of MSL pressures at power uprate from pressure fluctuations measurements at CLTP, (4) defining steam dryer pressure loading at power uprate, (5) steam dryer structural response and stress margin, (6) supporting documentation, (7) power ascension monitoring, and (8) acoustic load mitigation.

The TR defines an overall approach for demonstrating steam dryer structural integrity that allows the use of subscale and full scale tests and analytical methods. The TR also addresses the technical basis, benchmarking, and documentation of any analytical or testing methodologies utilized in demonstrating steam dryer integrity. Specific acceptance criteria and values for key parameters to be used in the evaluation of steam dryers are defined. A description and the staff's evaluation of each section of the BWRVIP-182 TR is provided in Section 3.0, below.

3.0 STAFF EVALUATION

The steam dryer does not perform a safety function and is not required to prevent or mitigate the consequences of accidents. However, the steam dryer contributes to the thermal efficiency of the plant. Although the steam dryer is not a safety-related component, it is designed to withstand design basis events using ASME Code design and fabrication guidance. The structural integrity of the steam dryer is important from the perspective in regards to the potential for a degraded steam dryer in a cracked condition may continue to experience significant crack propagation and the associated safety consequences of any loose parts that may be generated.

Guidance on comprehensive vibration assessment programs for reactor internals during preoperational and initial startup testing is provided in Revision 3 of Regulatory Guide (RG) 1.20, "Comprehensive Vibration Assessment Program for Reactor Internals during Preoperational and Initial Startup Testing," which was issued in March 2007. Section 3.9.5 of Appendix A to the Standard Review Plan provides consideration of potential adverse flow effects on plant systems including steam dryers in BWR nuclear power plants. The BWRVIP-182 TR complies with the guidance provided in RG 1.20.

The staff has reviewed the BWRVIP-182 TR which provides guidance for demonstrating steam dryer integrity for power uprate conditions from the structural adequacy perspective. The TR provides general design guidance and an over-arching approach for demonstrating steam dryer integrity for power uprate. The staff recognizes that this is not a detailed technical methodologies report for demonstrating steam dryer integrity.

Section 1 of the BWRVIP-182 TR provides a brief introduction on the guidance that BWR utilities can follow to demonstrate the structural integrity of the steam dryer for power uprate

conditions exceeding 2 percent of the CLTP. The staff reviewed the information provided in this section and finds it acceptable because the guidance to the industry is reasonable and is in compliance with RG 1.20.

Section 2 of the BWRVIP-182 TR provides an overview of the approach along with a flowchart depicting the process for demonstrating structural integrity of the steam dryer. The need to document the technical basis, benchmarking and uncertainties associated with all methods used in the process of demonstrating steam dryer structural integrity is highlighted. Based on the staff's review of Section 2 of the TR, the staff identified the need to add several footnotes and requested revisions to the BWRVIP Steam Dryer Integrity Demonstration Flowchart (Figure 2-1), in order to provide further clarification. In its response to the staff's RAIs, the BWRVIP agreed to revise the flowchart in Section 2 of the TR. The staff reviewed the proposed changes to the flowchart and finds them acceptable because the notes regarding the five items proposed to be added by the BWRVIP provides adequate clarification regarding (1) sub-scale model tests (SMT) and main steam isolation valve closure tests, (2) bump up factors, (3) minimum alternating stress ratio of 2.0, (4) consideration for the installation of instrumentation, such as pressure transducers and strain gauges on replacement dryers, and (5) the pursuit of acoustic load mitigation.

Section 3 of the BWRVIP-182 TR provides guidance on screening methods to assess the potential for MSL acoustic excitation at power uprate conditions. The TR recommends a graded approach to screening for potential acoustic excitation starting with validated analytical methods. If analytical methods indicate a potential for MSL acoustic excitation, **[**

] The staff reviewed the information provided in this section and finds it acceptable because the BWRVIP adequately provided an overview of the use of analytical methods, **[** **]**

Section 4 briefly describes the measurement of MSL local pressure fluctuations based on inplant tests and also provides guidance on the appropriate locations, and the number of strain gages or pressure transducers used to obtain MSL fluctuating pressure measurements. The staff found the information provided in Section 4 of the TR acceptable because the BWRVIP has provided adequate guidance on MSL fluctuating pressure measurements using either pressure transducers or strain gages.

Guidance for predicting MSL pressures at power uprate conditions based on measured MSL pressure fluctuations at CLTP is briefly addressed in Section 5 of the TR. In Section 5.1, the TR states that MSL data shall be selectively filtered to eliminate extraneous strain measurements at the specific frequencies based on known sources of strain gage responses not related to internal fluctuating pressures. The staff requested the BWRVIP to clarify the magnitude of noise filtering, relative to the noise floor of the sensors and of the data acquisition system. In its response, the BWRVIP agreed to revise the TR by adding a paragraph to reflect the importance of establishing the noise floor of the data acquisition system, **[**

] This clarification proposed by the BWRVIP is satisfactory to the staff because the proposed paragraph clarifies the noise floor, as well as, the required checks as noted above.

In response to the staff's request for specific examples regarding alternative methodology to adjust the MSL pressures from highest power level tested at the plant to power uprate conditions, the BWRVIP agreed to add a paragraph in Section 5.3 of the TR, **[**

] This is acceptable to the staff because the BWRVIP's proposed revision clarified the alternative methodologies by providing specific examples.

In response to the staff's RAI on bump-up factors, the BWRVIP indicated that it would revise Section 5.3 of the BWRVIP-182 TR to state that **[**

] Based on a review of the above information, the staff finds the proposed revisions acceptable because the BWRVIP clarified that the minimum bump up factor used will not be less than the MSL velocities squared, even if the SMTs indicate a value less than the velocities squared ratio.

An outline on defining steam dryer pressure loading at power uprate conditions, using the predicted MSL pressure fluctuations is presented in Section 6 of the TR. The report also mentions the bias and random uncertainties associated with measurements of MSL pressure fluctuations and application of an analytical model for evaluating steam dryer pressure loading. **[**

] The staff finds Section 6 of the TR acceptable because the BWRVIP has provided adequate information on defining steam dryer pressure loading at power uprate conditions. The staff notes that adjusted MSL pressure fluctuations are used for steam dryer pressure loading.

Section 7 of the BWRVIP-182 TR briefly addresses the topic of steam dryer structural response and stress margins. The fluctuating pressure loading is dynamically applied to a detailed finite element model of steam dryer to determine its structural response. The staff sought clarification on structural damping, stress concentration factors for fillet welds, and minimum alternating stress ratio and stress margins. In its response, the BWRVIP proposed revisions to Section 7 of the TR to state that **[**

], are acceptable to the staff because they are in agreement with the staff's position and experience with current EPU applications under staff review as well as recently approved EPU applications.

An overview on the preparation and submittal of documentation on steam dryer integrity is addressed in Section 8 of the TR. In response to the staff's RAI regarding supporting documentation to include a detailed summary table of all known end-to-end bias errors and uncertainties associated with analytical or test methods used in developing fluctuating pressure loads, and an evaluation of any existing flaws in the steam dryer components and their impact on steam dryer operation at EPU conditions, the BWRVIP agreed to revise Section 8 of the TR. The staff reviewed the proposed revisions and finds them acceptable because the BWRVIP adequately addressed the staff's RAI on requiring the licensee to include in its documentation a table on end-to-end bias errors and uncertainties as well as evaluations for any existing unrepaired flaws in the steam dryer components and their impact on steam dryer operation at EPU conditions.

In Section 9, the preparation and submittal of supporting documentation describing the technical basis and validation of all analytical and test methods demonstrating the steam dryer integrity at power uprate conditions are addressed. Section 9 also provides an outline of the two approaches that can be used for power ascension monitoring and data evaluation. The two approaches to confirm that steam dryer stresses are within acceptable limits during power ascension are **[**

] In Section 9 of the TR, the staff noted that the BWRVIP did not address actions to be taken by the licensee when the level 2 limit curve is exceeded during power ascension monitoring. In its response to the staff's RAI, the BWRVIP agreed to revise the section by including a paragraph clarifying that when **[**

] The staff reviewed the proposed changes and finds them acceptable because they adequately provide reasonable assurance regarding the structural integrity of the steam dryer and are in conformance with the staff's position and experience with the recently approved EPU applications.

The quality assurance (QA) program for the design and testing associated with the evaluation of structural integrity of the steam dryer is briefly addressed in Section 10 of the TR. The staff found the QA program acceptable because the design and testing activities associated with the evaluation of the structural integrity of the steam dryer are to be conducted under an augmented QA program that meets the intent of the design and fabrication requirements of

10 CFR Part 21 or 10 CFR Part 50, Appendix B, as the steam dryer is not a safety-related component. Section 11 lists the applicable references cited in the body of the TR.
A brief discussion on acoustic load mitigation is provided in Appendix-A of the TR. The staff also reviewed the proposed clarification by the BWRVIP in Appendix A of the TR regarding load mitigation devices for blind standpipes in steam flow path, and finds that the BWRVIP agreed to adequately revise the TR to include this clarification.

Based on the staff's review of the BWRVIP-182 TR and the responses to the staff's RAIs provided by the BWRVIP, the staff agrees that the over-arching guidance provided in the TR is useful in providing the BWR owners, considering power uprates, with an overview of the demonstration of structural integrity of the steam dryers. The guidance provided in the BWRVIP-182 TR adequately captures the issues, requirements, and experiences from recently granted EPU licenses, as applicable.

4.0 CONCLUSION

The NRC staff has reviewed the BWRVIP-182 TR and additional information the BWRVIP provided in its RAI responses, and found that the TR, as modified and clarified to incorporate the staff's comments above, is acceptable for providing guidance on the steam dryer integrity demonstration for power uprate conditions. The BWRVIP shall include the modifications and clarifications, as discussed in the body of this SE in the "-A" version of this TR. Based on its review of the TR and the RAI responses provided by the BWRVIP, the staff concludes that the implementation of the guidance in the BWRVIP-182 TR, as modified to incorporate the resolution of the RAIs as discussed in this SE, by licensees seeking power uprates greater than 2 percent CLTP and up to EPU, provides an acceptable technical basis for demonstrating integrity of the steam dryers in BWR plants.

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Dated: January 11, 2010