ELECTRIC POWER RESEARCH INSTITUTE

Steam Dryer Integrity for Nuclear Power Uprates

EPRI has validated analytical methods for defining steam dryer pressure loading and structural response to support power uprate submittals.

EPRI's BWR Vessel and Internals Project (BWRVIP) has completed a comprehensive report documenting the technical basis and validation for a suite of methodologies that can be used to demonstrate the structural integrity of steam dryers at power uprate conditions. The methodologies can be used to support power uprate applications to regulatory bodies, and are expected to reduce time and resource requirements for analysis.

The steam dryer methodologies, based on proprietary technology from Continuum Dynamics Inc. (CDI), evolved in response to problems encountered at operating boiling water reactors. In 2002, shortly after increasing power to 117% of original licensed thermal power, Exelon Corporation's Quad Cities Unit 2 suffered a series of structural failures of its steam dryer assembly. Through extensive evaluation, the industry identified the root cause as acoustic resonances produced at the inlets to safety and relief valves attached to the main steam lines (MSLs). These resonances induced pressure fluctuations that acoustically propagated through the MSLs back to the reactor pressure vessel, damaging the steam dryer.

One-fifth scale test facility used to screen for potential main steam line acoustic excitation Photo courtesy of CDI.

The resonant frequency is related to the flow velocity in the MSLs as well as the opening diameter of the attached piping. In turn, the flow velocity is related to the reactor's operating power level. When evaluating power uprates, therefore, plant owners and regulators must have confidence in the methodologies used to predict the pressure loading on and structural response of steam dryers.

The EPRI steam dryer methodologies report, referred to as BWRVIP-194, provides methods for:

- Assessing the potential for MSL acoustic excitation
- Conducting in-plant tests to define MSL fluctuating pressures using strain gages
- Defining acoustic and hydrodynamic fluctuating pressures on the steam dryer based on MSL pressure measurements
- Using sub-scale tests to adjust data obtained at current licensed thermal power conditions to define steam dryer loading at extended power uprate conditions
- Using main steam line isolation valve closure tests to define steam dryer pressure loading at extended power uprate conditions

- Defining the pressure loading on all steam dryer surfaces using pressures measured at specific locations on the steam dryer
- Defining steam dryer stresses using a detailed finite element model of the steam dryer
- Conducting steam dryer fatigue and primary stress analyses using ASME Section XI, Subsection NG as a guide
- Defining MSL strain gage limit curves to support power increases to extended power uprate conditions

The steam dryer pressure load prediction methods have been validated against data from in-plant instrumented dryer tests at Quad Cities Unit 2, and the structural modeling approach has been validated by a series of separate tests. A unique structural analysis approach allows near real-time stress analysis that results in a significant reduction in the time required for power ascension testing.

EPRI has submitted BWRVIP-194 to the Nuclear Regulatory Commission to request a Safety Evaluation that will govern its use in evaluating steam dryers at power uprate conditions. The methodology contained in BWRVIP-194, however, will be applicable to steam dryer evaluations outside the United States as well.

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