Nuclear Services/Engineering Services

Enhanced BWR Engineering Services: Steam Dryer Acoustic Technology

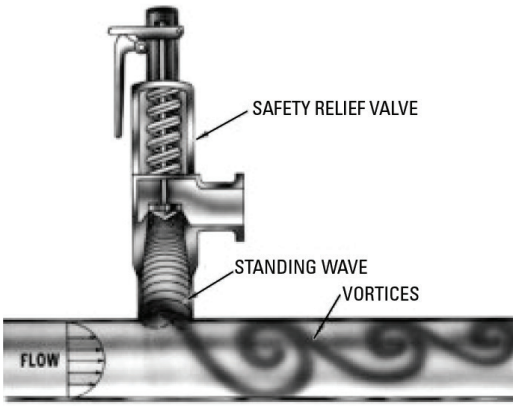
Background

The steam dryer creates higher-quality steam by removing moisture from the steam before it passes through the steam turbine. This results in greater power generation and reduced turbine blade degradation. In recent years, boiling water reactor (BWR) plants have experienced degradation to their steam dryers as a result of the higher steam mass flow rates required to achieve uprated conditions. The resulting higher steam velocity promotes and enhances the formation of vortices in proximity to side branches, such as safety relief valves, in the main steam lines (MSLs). These vortices, which are generated and shed over the side branch, trigger the formation of an acoustic wave that propagates throughout the MSLs and eventually reaches and damages the steam dryer. Therefore, there was a need for validated methods to predict acoustic loads on the steam dryer at power uprate conditions for these phenomena.

Westinghouse now provides validated and complete steam-dryer solutions — including steam dryer analysis, mitigation, repair and replacement options — for nuclear power plant customers that operate BWRs. The industry users group that focused on BWR vessel internal issues — the Boiling Water Reactor Vessel and Internals Project — selected this proprietary technology as the standard method for addressing the acoustic and structural analyses required to implement extended power uprates (EPUs) in a BWR plant.

Description

Westinghouse's acoustic technology is based on a combination of analytical and experimental methods to screen for potential acoustic resonant conditions that could exist in the side branches located on the MSLs. The technology is based on an acoustic circuit model (ACM), which combines the acoustic pressure measured on the MSLs using strain gages with advanced three-dimensional models of the acoustic field developed inside the steam dome.



Vortex shedding at MSL/safety relief valve interface

Westinghouse can provide the following customer-focused engineering services:

- Screening analysis for acoustic resonance issues
- MSL strain gauge installation methods
- Steam dryer acoustic loads definition
- Scale model testing methods and equipment
- Method of analysis that uses circuit model algorithm and state-of-the-art, three-dimensional acoustic field simulation for BWRs
- Steam dryer structural analyses
- Limit curve generation for power ascension
- Real-time stress monitoring during power ascension
- Mitigation of resonance issues in the steam lines using an acoustic side branch design tailored to the specific resonant frequency to be removed from the steam-delivery system

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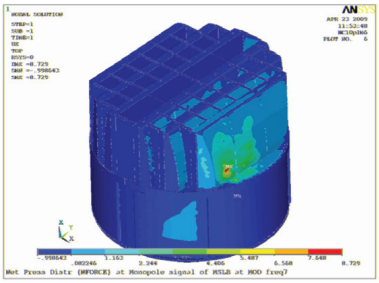
Benefits

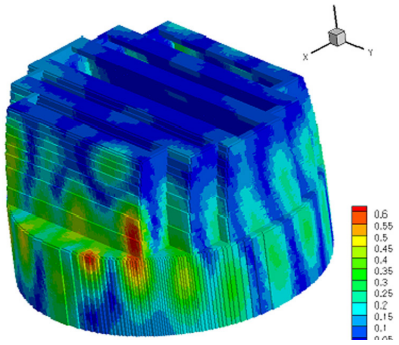
Westinghouse's proprietary technology provides an integrated solution to screen potential acoustic excitation within BWR MSLs to conduct in-plant measurements using strain gauges and to define acoustic and hydrodynamic loads on steam dryers. Real-time monitoring of the stresses on the steam dryer during power ascension allows the plant to quickly monitor steam dryer structural integrity and to rapidly achieve EPU conditions. With this methodology, a direct instrumentation program of the steam dryer is not required. Moreover, Westinghouse's approach provides a more detailed and complete mapping of the acoustic loads and stresses on the steam dryer as compared to an instrumentation program of the steam dryer. Also, the methodology provides a basis for evaluating the loading and response of the steam dryer at power uprate flow conditions without the need to operate the plant above the current licensed thermal power (CLTP).

Experience

This technology can be applied to any BWR to demonstrate the structural integrity of the steam dryer under CLTP and EPU flow conditions. This technology provides a state-of-the-art approach to evaluating the steam dryer's structural integrity, as required by current regulatory guidelines. All acoustic loads developed for U.S. BWR plants and approved by the U.S. Nuclear Regulatory Commission, in support of an EPU program, were developed using these methodologies.

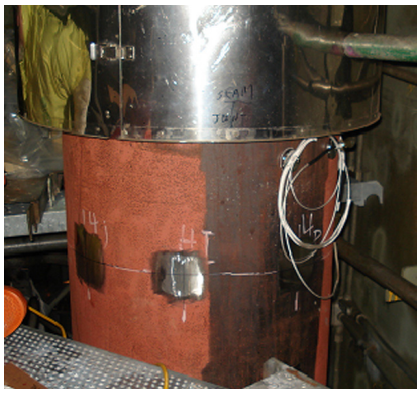


Steam dryer finite element model



High resolution three-dimensional acoustic pressure field surrounding steam dryer

State-of-the-art subscale model testing facility



Typical installation of strain gauges on a main steam line

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