

UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
OFFICE OF NUCLEAR REACTOR REGULATION  
OFFICE OF NEW REACTORS  
WASHINGTON, DC 20555-0001

June 14, 2013

NRC INFORMATION NOTICE 2013-10: PROGRAMS FOR MONITORING  
BOILING-WATER REACTOR  
STEAM DRYER INTEGRITY

## ADDRESSEES

All holders of operating licenses for boiling-water reactors (BWRs) under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

All holders of and applicants for a BWR early site permit, combined license, standard design certification, standard design approval, or manufacturing license under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants."

## PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees about the importance of establishing programs to monitor the structural integrity of steam dryers in BWR nuclear power plants, as evidenced by the examples provided in this IN, and to raise industry awareness regarding the possibility of cracking in new and existing steam dryers. The NRC expects that recipients will review the information contained in this IN for applicability to their facilities and consider actions, as appropriate, to avoid similar issues at their facilities. However, suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required.

## DESCRIPTION OF CIRCUMSTANCES

### New Steam Dryers

The licensee for the Susquehanna Steam Electric Station (SSES) replaced the steam dryers in SSES Units 1 and 2 as part of its license amendment request to allow operation of the SSES units at extended power uprate (EPU) conditions. The replaced steam dryers have a curved hood design developed by General Electric Hitachi. The licensee installed the new steam dryers at SSES Units 1 and 2 in 2008 and 2009, respectively. The EPU license amendment specifies periodic inspection of the steam dryers in SSES Units 1 and 2 during refueling outages to confirm their continued structural integrity. After one cycle of EPU operation for each SSES unit, the licensee identified intergranular stress corrosion cracking (IGSCC) in both of the replacement steam dryers. In addition to the IGSCC findings, a fatigue crack was identified in the steam dryer in SSES Unit 2. These findings were summarized in the licensee's letters to the NRC, dated July 15, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML102230125) and September 29, 2011 (ADAMS Accession No. ML112730314).

**ML13003A049**

The two major causal factors for the IGSCC findings were identified as inadequate quality control and fabrication stresses during welding of the replacement steam dryer assemblies. Since the IGSCC was observed after only one operating cycle at both SSES units, the NRC staff is alerting all BWR nuclear power plant licensees that the incubation period—the time necessary to initiate a crack—for IGSCC could be shorter than previously anticipated. The specific fatigue crack in the steam dryer in SSES Unit 2 was the result of a poorly designed weld joint, as well as fabrication and quality control issues.

The licensee implemented corrective actions for both SSES units in response to the identification of the cracking in the replacement steam dryers. These actions included necessary repairs followed by re-inspections during every refueling outage until the absence of crack growth can be confirmed in the existing cracks and no new cracks are identified.

### Existing Steam Dryers

Following initial EPU operation several years ago, Quad Cities Nuclear Power Station (Quad Cities), Units 1 and 2, experienced significant fatigue cracking of their original steam dryers with the generation of loose parts in the reactor coolant and main steam systems. The steam dryers were subsequently replaced with an improved design. In addition, modifications to several branch lines connected to the main steam lines were implemented to reduce acoustic loading on the steam dryer. NRC issued the following INs discussing steam dryer cracking issues: IN 2002-26, dated September 11, 2002, “Failure of Steam Dryer Cover Plate after a Recent Power Uprate,” IN 2002-26, Supplement 1, dated July 21, 2003, “Additional Failure of Steam Dryer after a Recent Power Uprate,” and IN 2002-26, Supplement 2, dated January 9, 2004, “Additional Flow-Induced Vibration Failures after a Recent Power Uprate.”

During its operating life, the existing steam dryer at Vermont Yankee Nuclear Power Station (Vermont Yankee) experienced IGSCC cracking. Pre-emptive modifications on the existing steam dryer were completed during its spring 2004 refueling outage (RFO); and all remaining modifications necessary to implement EPU operations were completed during its fall 2005 RFO. EPU operations were implemented prior to the spring 2007 RFO. Vermont Yankee submitted a license amendment request on December 22, 2011, to revise a license condition related to the monitoring, inspection frequency, and performance of its steam dryer, which the NRC approved on December 19, 2012 (ML12338A236). As indicated in the Vermont Yankee licensee’s response to an NRC request for additional information (RAI) concerning this amendment request, there have been no signs of crack growth activity and no cracking in the replaced hardware for the steam dryer, post EPU. Furthermore, the licensee stated that the inspection results show that the flaw indications caused by IGSCC have stabilized or arrested with no further or minimal growth expected, and that there is no evidence of crack growth post EPU for all other steam dryer flaws. Vermont Yankee continues to perform inspections to monitor the aging effects of IGSCC to ensure the functionality and structural integrity of its steam dryer. Additional information is available in the licensee’s response to the NRC RAI, dated October 3, 2012 (ADAMS Accession No. ML12284A478).

## **DISCUSSION**

The steam dryer in the reactor vessel of a BWR plant removes excess moisture from the steam generated by the reactor core before the steam is directed through piping to the turbine. Although the steam dryer performs a non-safety related function, it must maintain its structural integrity to prevent the occurrence of loose parts in the reactor vessel and attached steam lines that could adversely affect plant operation, including causing damage to safety-related components. Historically, BWR steam dryers experienced IGSCC over their operating life. This

IGSCC is caused by a lack of hydrogen water protection in the steam dome region of the reactor vessel. As a result, insufficient hydrogen is present in the steam to minimize IGSCC.

Steam dryers have also exhibited fatigue cracking due to acoustic and hydrodynamic loading caused by steam flow through and around the steam dryer, as well as through the steam lines. As discussed above, Quad Cities Units 1 and 2 experienced significant fatigue cracking of their original steam dryers following initial EPU operation several years ago. Subsequent improved steam dryer design and, in some instances, steam line modifications, have resulted in successful steam dryer performance to date at both Quad Cities units and other BWR units during normal operating and EPU conditions. The NRC staff issued Regulatory Guide (RG) 1.20, "Comprehensive Vibration Assessment Program for Reactor Internals during Preoperational and Initial Startup Testing," which addresses vibration assessment of the reactor vessel internal components during preoperational and initial startup testing. In addition, this RG provides information on methods for evaluating the potential adverse effects from pressure fluctuations and vibration in piping systems for all light water reactor plants. This RG can be used for establishing a power ascension testing program for operating plants that are proposing to implement an EPU.

Both IGSCC and fatigue are two active aging degradation mechanisms that could potentially create synergistic effects that might compromise the structural integrity of the steam dryer. Therefore, as part of implementing EPU operation, BWR licensees initiate an inspection program that is consistent with Boiling-Water Reactor Vessel and Internals Project (BWRVIP)-139-A, "BWR Vessel and Internals Project, Steam Dryer Inspection and Flaw Evaluation Guidelines." The NRC staff approved the BWRVIP-139-A report on July 30, 2008, and the NRC staff's safety evaluation (SE) is available at ADAMS Accession No. ML082070332. Topical Report BWRVIP-84, "BWR Vessel and Internals Project, Guidelines for Selection and Use of Materials for Repairs to BWR Internals," provides, in part, fabrication guidelines for repaired or replacement BWR vessel internals. The NRC staff approved the BWRVIP-84 report on September 23, 2008, and the NRC staff's SE is available at ADAMS Accession No. ML082321084. BWRVIP-84 identifies that tri-junction welds at seismic support blocks and other locations with high-stress concentrations in steam dryers are susceptible to fatigue cracking. Because the fabrication process can affect the occurrence of IGSCC, implementation of the fabrication guidelines in BWRVIP-84, in conjunction with the requirements addressed in the NRC staff's SE, could mitigate IGSCC. In addition, conformance with BWRVIP-139-A inspection criteria, in conjunction with implementing early corrective actions and monitoring and trending age-related degradation, can facilitate an effective aging management program for steam dryers, and help maintain the structural integrity of the steam dryer. By performing visual or other appropriate inspections, licensees will have an opportunity to identify potential issues with the structural integrity of steam dryers to allow corrective action that will prevent the generation of loose parts in the reactor vessel and attached steam lines.

Continued occurrences of steam dryer cracking illustrate that, for BWR units that have implemented EPU operation or are planning to request a license amendment to implement EPU operations, effective implementation of inspection programs to monitor the aging effects of IGSCC and fatigue for steam dryers is important. In addition to current operating BWR plants that have implemented or are considering EPU operation, the development of programs for monitoring the structural integrity of steam dryers is important for new BWR plants. The NRC staff is reviewing plans for developing steam dryer monitoring programs as part of design certification and combined operating license applications for new BWR plants under 10 CFR Part 52. The NRC staff's review of the steam dryer monitoring programs for new BWR

plants will be discussed in the SEs for the applicable design certification and combined operating license applications.

## CONTACTS

This information notice does not require any specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate NRC project manager.

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