UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555

January 9, 2004

NRC INFORMATION NOTICE 2002-26, SUPPLEMENT 2: ADDITIONAL FLOW-INDUCED VIBRATION FAILURES AFTER A RECENT POWER UPRATE

Addressees

All holders of an operating license or a construction permit for nuclear power reactors, except those that have permanently ceased operations and have certified that fuel has been permanently removed from the reactor.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this supplement to a previously issued information notice (IN) to alert addressees to the failure of the steam dryer and other plant components at Quad Cities Nuclear Power Station, Unit 1 (QC-1), a boiling water reactor (BWR), during operations following a power uprate. The NRC expects that the recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements. Therefore, no specific action or written response is required.

Description of Circumstances

As discussed in IN 2002-26, “Failure of Steam Dryer Cover Plate After a Recent Power Uprate” (ML022530291), a cover plate on the outside of the steam dryer at Quad Cities Nuclear Power Station, Unit 2 (QC-2), broke loose in June 2002 and caused pieces of the dryer to be swept down the main steamline. The failure followed completion of a refueling outage in March 2002 and subsequent implementation of an extended power uprate (EPU) from 2511 MWt to 2957 MWt (17.8% increase). Before the unit was shut down in 2002, steam dryer degradation was indicated by an increase in moisture carryover and minor perturbations in reactor pressure, water level, and steam flow. The licensee evaluated the cause of the steam dryer cover plate failure and determined that the failure of the plate was due to high-cycle fatigue. The licensee recovered all loose dryer pieces and did not identify any additional damage other than minor scratches and gouges to the main steamline. Prior to returning the unit to service, the licensee modified the steam dryer by installing thicker cover plates with higher strength welds, and implemented enhanced monitoring of steam moisture content, reactor steam dome pressure, main steamline flow rates, and reactor water level.

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The second failure of the steam dryer in May 2003 at QC-2 was discussed in IN 2002-26, Supplement 1, “Additional Failure of Steam Dryer After a Recent Power Uprate” (ML031980434). In that case, the licensee again noted increasing moisture carryover in late May 2003; however, there were no discernible changes in other reactor parameters. On May 28, 2003, the licensee reduced power on QC-2 to the pre-EPU 100% power level. Moisture carryover levels remained above normal, and on June 11, 2003, the licensee shut down QC-2 to inspect the dryer. Inspection of the dryer revealed (1) through-wall cracks (about 90 inches long) in the vertical and horizontal portions of the outer bank hood, 90-degree side, (2) one vertical and two diagonal internal braces detached from the outer bank hood, 90-degree side, (3) one severed vertical internal brace on the outer bank hood, 270-degree side, and (4) three cracked tie bars on top of the dryer. The licensee believes the most probable cause of the failure of the steam dryer in QC-2 is low-frequency, high-cycle fatigue driven by flow-induced vibrations associated with the higher steam flows present during EPU operating conditions.

In late October 2003 at QC-1, the licensee observed changes in main steamline flows, steamline pressure drop, and increasing moisture carryover measurements. The symptoms observed were consistent with previous events at QC-2 that resulted in the discovery of damage to the steam dryer. The licensee subsequently reduced the power level of QC-1 to pre-EPU conditions. After power was reduced, the moisture carryover was lower than before the power reduction, but higher than the anticipated level. On November 12, the licensee shut down QC-1 to inspect the steam dryer and identified significant damage to several areas. For example, an identified crack was determined to have initiated at the top corner portion of the steam dryer hood and then extended horizontally toward the center of the hood and downward into the vertical section of the hood. The crack terminated in the vertical section where a portion of the dryer was missing. This missing piece of the steam dryer outer bank hood is approximately 6.5 inches (16.5 cm) by 9.0 inches (22.9 cm) and 0.5 inches (1.3 cm) thick. The licensee believes that a piece or pieces the size of this opening or smaller broke off due to fatigue cracking. The licensee performed an extensive but unsuccessful search for the lost part or parts. However, the licensee did identify impact marks on the impeller of the 1B recirculation pump that suggested that the missing part or parts passed through the pump. The licensee concluded that the missing part or parts migrated to the bottom head region of the reactor vessel. In addition to damage to the steam dryer at QC-1, the licensee identified significant flow-induced vibration damage to main steam line tieback supports and a main steam electromatic relief valve (including its attached drain line, actuator, and support), as well as loose clamps on the main steam line supports. Before restarting QC-1 on November 29, the licensee repaired the steam dryer and other damaged plant components identified during its inspections. With respect to the missing steam dryer metal plate, the licensee performed an operability evaluation for continued operation with the missing part or parts and will decide, prior to the next refueling outage, whether to continue efforts to locate and retrieve the missing dryer material.

Discussion

When operating above the original licensed thermal power (OLTP) level, BWR plants can experience a significant increase in the velocity of the steam generated from feedwater in the reactor core and directed through piping to the plant turbine generator. This increased steam velocity could damage plant components through flow-induced vibration. While major safety-related components undergo detailed review to demonstrate their capability to perform the applicable safety functions, nonsafety-related components and safety-related subcomponents have received less attention by the licensee and the NRC during preparation for nuclear power plant operation above the OLTP level.

Although performing a nonsafety-related function, the steam dryer in a BWR plant must maintain its structural integrity to avoid loose dryer parts from entering the reactor vessel or steam lines and adversely affecting plant operation. Industry representatives say that cracking occurred in steam dryers during the early operational phase of some BWR plants. The steam dryer failures at Quad Cities while operating at EPU conditions have led the BWR Owners Group (BWROG) to ask its BWR Vessel and Internals Project (BWRVIP) to develop inspection and evaluation guidelines for BWR steam dryers. In addition, General Electric (GE) Nuclear Energy issued Service Information Letter (SIL) 644, "BWR/3 steam dryer failure," on August 21, 2002, and Supplement 1 to SIL 644 on September 5, 2003, to provide monitoring and inspection recommendations for BWR plants that are operating, or plan to operate, at power levels greater than the OLTP.

In addition to the BWR steam dryers, flow-induced vibration during nuclear power plant operation above the OLTP level can potentially damage other plant components. For example, the QC-1 licensee identified significant flow-induced vibration damage to a main steam electromatic relief valve (including its attached drain line, actuator, and support), as well as main steam line support clamps and tieback supports. Therefore, information obtained from the review of the flow-induced vibration damage at QC-1 might also be applicable to other BWR plants with different steam dryer designs and to pressurized water reactor (PWR) plants operating at conditions above their OLTP level. The significance of the lessons learned is increased because operation of a nuclear power plant under conditions above the OLTP level might place additional reliance on the capability of plant equipment, such as relief valves or seismic restraints, to perform their intended functions as a result of higher reactor power levels and steam and feedwater flow rates.

The NRC staff is reviewing plant-specific and industry-wide activities to address the potential for flow-induced vibration damage to steam dryers and other plant components in BWR plants operating or planning to operate at conditions above the OLTP level. Although it is very unlikely that loose parts would adversely affect the safe shutdown of a plant, it is important to understand the extent of damage that might be caused by steam dryer failures and to identify the lessons learned from recent steam dryer failures for application to steam dryers at other BWR plants. It is also important to address the potential for similar failures in other plant components in BWR or PWR plants operating or planning to operate at conditions above the OLTP level.

Licensees should be alert to the possibility of unanticipated effects from increasing flow, power, or differential pressure associated with a major modification such as a power uprate. This information notice requires no 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 Office of Nuclear Reactor Regulation (NRR) project manager.

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LIST OF RECENTLY ISSUED
NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
2003-11, Sup 1	Leakage Found on Bottom-Mounted Instrumentation Nozzles	01/08/2004	All holders of operating licenses or construction permits for nuclear power reactors, except those that have permanently ceased operations and have certified that fuel has been permanently removed from the reactor.
2003-22	Heightened Awareness for Patients Containing Detectable Amounts of Radiation from Medical Administrations	12/09/2003	All medical licensees and NRC Master Materials License medical use permittees.
2003-21	High-Dose-Rate-Remote-Afterloader Equipment Failure	11/24/2003	All medical licensees.
2003-20	Derating Whiting Cranes Purchased Before 1980	10/22/2003	All holders of operating licenses for nuclear power reactors, except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel; applicable decommissioning reactors, fuel facilities, and independent spent fuel storage installations.

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