UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555-0001

June 1, 2005

NRC INFORMATION NOTICE 2005-14: FIRE PROTECTION FINDINGS ON LOSS OF SEAL COOLING TO WESTINGHOUSE REACTOR COOLANT PUMPS

ADDRESSEES

All holders of operating licenses for pressurized water reactors, except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

PURPOSE

The U.S. Nuclear Regulatory Commission is issuing this information notice (IN) to inform addressees about recent inspection findings on post-fire procedural requirements related to loss of cooling to reactor coolant pump (RCP) seals. NRC anticipates that recipients will review the information for applicability to their facilities and consider taking actions, as appropriate, to avoid similar issues. However, no specific action or written response is required.

BACKGROUND

Assuming a fire results in loss of cooling to the RCP seals, licensees may comply with 10 CFR Part 50, Appendix R, "Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979," by protecting the cooling to the seals or by demonstrating that the plant can cope with RCP seal leakoff flow rates. Many licensees have installed RCP seal packages using high-temperature O-rings that will not result in uncontrolled leakage from RCP seals for conditions with loss of all RCP seal cooling. Licensees also ensure adequate makeup capability to compensate for any RCP seal leakoff and maintain reactor coolant system (RCS) inventory according to requirements of Appendix R, Sections III.G.2, III.G.3, and III.L.1 and performance goals of Appendix R, Section III.L.2. Note that a plant licensed before January 1, 1979, must meet the provisions of Appendix R, Section III.G and III.L and a plant licensed after January 1, 1979, must implement the fire protection provisions of its operating license.

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DESCRIPTION OF CIRCUMSTANCES

At Surry, NRC inspectors found that certain postulated fires could result in the loss of cooling to the RCP seals. The inspectors noted that the RCP seal vendor, Westinghouse, advised that increased seal leakage, to around 21 gpm, could occur if seal cooling is lost and not restored before hot RCS fluid reaches the RCP seals. Additionally, the Westinghouse Owners Group (WOG) revised their generic emergency response guidelines for the station blackout event to recommend that RCP seal cooling not be restored following a prolonged loss of seal cooling in which the seal temperature exceeds the RCP seal vendor's recommendations. The licensee incorporated this guidance into its emergency operating procedures for the response to a loss of all alternating current (AC) power event but not in its procedures for safe shutdown of the reactor after a fire. Restoration of seal injection after the seals become hot could lead to increased leakage beyond the RCS makeup capability needed to satisfy the performance goals in Appendix R, Section III.L.2 (NRC Inspection Reports 50-280/03-07 and 50-281/03-07).

Similar findings were made at other nuclear power plants. At Turkey Point, NRC inspectors found that the post-fire procedures did not provide timely operator action to restore seal injection and could result in increased RCP seal leakage beyond the capacity of equipment dedicated to achieve and maintain post-fire safe shutdown according to Appendix R, Section III.G.2 (NRC Inspection Reports 50-250/04-07 and 50-251/04-07). At North Anna, NRC inspectors found, similar to the Surry finding, that certain fires could result in a loss of seal cooling. Seal cooling could be restored after the seal had heated up, thereby potentially resulting in increased seal leakage beyond the RCS makeup capability required to satisfy Appendix R, Section III.L.2 (NRC Inspection Reports 50-338/03-06 and 50-339/03-06). At Summer, the inspectors were concerned that the licensee's fire emergency procedure did not direct personnel to reestablish seal cooling flow in a timely manner, potentially leading to increased seal leakage beyond the RCS makeup capability needed to satisfy Appendix R, Section III.L.2 (NRC Inspection Report 50-395/01-10).

DISCUSSION

The NRC uses "deterministic" information to determine the existence of performance deficiencies. The risk significance of an identified performance deficiency is evaluated using probabilistic risk assessment (PRA) models.

In each case cited above, the NRC inspectors attributed the performance deficiency to inconsistent recovery procedures. They observed that the plant emergency procedures for a loss of all AC power did not agree with the plant procedures for mitigating the effects of a postulated fire. The post-fire procedures failed to direct plant personnel to restore RCP seal cooling before the seal temperature exceeds the vendor-specified limit. The inspection findings from Turkey Point also indicate that the fire mitigation procedures fail to consider that restoration of seal cooling is a time-critical operator action.

For seal packages in general, the makeup capability must exceed the seal leakoff to ensure that a hot standby condition can be achieved (according to the requirements in Appendix R, Section III. L.1. (c) and that the pressurizer level is maintained in the indicating range (according to the performance goals in Appendix R, Section III L.2.b). Furthermore, protecting seal integrity would be assisted if procedures for operating equipment needed for post-fire shutdown are consistent with vendor recommendations. For the Westinghouse RCP seals, as discussed in a recently submitted document on RCP seal performance (Reference 3), a leakage rate of 21 gpm per RCP may be assumed in the licensee's safe shutdown assessment following the loss of all RCP seal cooling. Assumed leakage rates greater than 21 gpm are only warranted if increased seal leakage is postulated as a result of deviations from seal vendor recommendations. Test or operating experience may be used to justify other RCP seal leakage rates.

Licensees with Westinghouse RCP seals have developed fire emergency procedures to cope with a loss of all RCP seal cooling by either reestablishing seal cooling to the RCPs before increased seal leakage occurs (to prevent increased leakage) or by providing sufficient RCS makeup to achieve and maintain post-fire safe shutdown.

Performance deficiencies and violations of regulatory requirements can result from all of the following: (1) procedural deviations from the manufacturer's recommendations without a documented basis, (2) inadequate procedures, and (3) inadequate documented analysis to show that Appendix R, Section III.L requirements are met.

If a performance deficiency exists, it is evaluated in the significance determination process (SDP) using PRA models. The loss of RCP seal cooling has been extensively modeled in PRA applications. In particular, the NRC used PRA information from its closure of a generic safety issue involving RCP seal failure (Reference 1) and from its safety evaluation of an industry model of RCP seal leakage (Reference 2) as the SDP framework to evaluate the risk significance of certain fire protection inspection findings. In the Surry case, the NRC estimated that the increase in the core damage frequency was between 1E-6 and 1E-5 per year (a white inspection finding). This finding is highly dependent on the plant-specific electrical switchgear room arrangement and the fire mitigation strategy.

In the recently submitted document on RCP seal performance (Reference 3), the NRC has not found sufficient new information to improve PRA models from previously issued industry models (Reference 4) or safety evaluation reports (Reference 2).

The PRA modeling considers two cases. In case 1 (plants with Westinghouse high-temperature O-rings and seals), Westinghouse, the RCP seal vendor, states that after loss of seal cooling, the seals with high-temperature O-rings will leak at about 21 gpm per pump. If the licensee implements vendor guidelines, this condition is not expected to proceed to failures resulting in leak rates greater than 21 gpm per pump. Even if seal cooling is not reestablished, degradation of the seals for leakage rate to significantly increase is not expected for an

indefinite period of time if the RCPs are secured before the seal temperature exceeds 235 degrees F. Restoration of seal cooling may result in cold thermal shock of the seal and possibly cause increased seal leakage. If seal cooling is restored using component cooling water (CCW) to the thermal barrier cooler, water hammer may occur and possibly compromise the integrity of the CCW system. As discussed in the recently submitted document on RCP seal performance (Reference 3), if the CCW system is damaged, then plant shutdown after a fire accident may not be possible in all scenarios.

To be consistent with 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," protection of seal integrity depends on fire protection and RCP recovery procedures being consistent with the manufacturer's recommendations and that the associated instrumentation, alarms, and recovery procedures are available after a fire.

In case 1 (plants with Westinghouse high-temperature O-rings and seals), the NRC PRA modeling accounts for two failure scenarios, given a loss of seal cooling with no RCPs operating. In failure scenario 1 (hot shock), during initial heating of the seals, hydraulic instability caused by fluid flashing can potentially open (pop) the second-stage seal faces (Reference 2). For this scenario, the NRC PRA model assumes that the popping failure of the second-stage seal occurs at 13 minutes after loss of RCP seal cooling.

In case 1, failure scenario 2 (cold shock), if RCP seal cooling is restored after the seal temperature exceeds the vendor-specified limit, given survival from the initial hot shock of the seals, the NRC uses seal failure probabilities and consequential seal leakage sizes similar to those used in failure scenario 1.

In case 2 of the NRC PRA model (Westinghouse plants with "old," pre-high-temperature RCP seals), Westinghouse, the RCP seal vendor, states that after loss of seal cooling, the "old" seals could fail after about 30 minutes. Therefore, protection of seal integrity requires the restoration of seal cooling within the appropriate time limit. However, this time limit is approximate. Plant-specific vendor guidance may differ based on (1) commitments made with respect to the station blackout analysis and (2) licensee-specific vendor recommendations.

CONTACT

This information notice requires no specific action or written response. Please direct any questions about this matter to the technical contact(s) listed below or the appropriate NRR project manager.

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Attachment: References

Note: NRC generic communications may be found on the NRC public Web site, http://www.nrc.gov, under Electronic Reading Room/Document Collections.

REFERENCES

1. NRC Regulatory Information Summary 2000-002, “Closure of Generic Safety Issue 23, Reactor Coolant Pump Seal Failure,” February 15, 2000 (ADAMS ML003680402)

2. NRC Office of Nuclear Reactor Regulation, “Safety Evaluation of WCAP-15603, Revision 1, WOG 2000 Reactor Coolant Pump Seal Leakage Model for Westinghouse PWRs,” Westinghouse Owners Group Project No. 694, May 2003 (ADAMS ML0314003760)

3. Westinghouse Owners Group, “Reactor Coolant Pump Seal Performance for Appendix R Assessments,” WCAP-16396-NP, Revision 0, January 2005 (ADAMS ML050320187)

4. Westinghouse Electric Company, LLC, “WOG 2000 Reactor Coolant Pump Seal Leakage Model for Westinghouse PWRs,” WCAP-15603, Revision 1, May 2002 (ADAMS ML021500485)