



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
RELATED TO AN ASSESSMENT OF INDICATIONS IN HEAD PENETRATION 75
DONALD C. COOK NUCLEAR PLANT UNIT 2

DOCKET NO. 50-316

1.0 INTRODUCTION

In December 1991, cracks were found in an Alloy 600 vessel head penetration (VHP) in the reactor head at a French plant during a 10-year hydrotest. Additional plants in France were examined and additional cracks were found in Alloy 600 VHPs. In response to the French experience, other European reactors and Japanese reactors were inspected for VHP cracking in 1991 to 1993, and in 1994, the first U.S. reactor was inspected. Of 3339 VHPs inspected, 90 were found to contain cracks attributed to primary water stress corrosion cracking (PWSCC). The first inspection of a U.S. reactor uncovered no cracks in the VHPs.

As a result of the European experience, NRC staff implemented an action plan to address PWSCC of Alloy 600 VHPs at all U.S. pressurized water reactors (PWRs). This action plan included a review of safety assessments by owners groups, the development of VHP mock-ups by the Electric Power Research Institute (EPRI), the qualification of inspectors on the VHP mock-ups by EPRI, the review of proposed generic acceptance criteria from the Nuclear Utility Management and Resource Council (NUMARC)(now the Nuclear Energy Institute (NEI)), and VHP inspections. As part of this action plan, the NRC staff met with the Westinghouse Owners Group (WOG) on January 7, 1992, the Combustion Engineers Owners' Group (CEOG) on March 25, 1992, and the Babcock & Wilcox Owners Group (B&WOG) on May 12, 1992, to discuss their respective programs for investigating PWSCC of Alloy 600 and to assess the possibility of cracking of VHPs in their respective plants since all of the plants have Alloy 600 VHPs. Subsequently, the staff asked NUMARC to coordinate future industry actions because the issue was applicable to all PWRs. Meetings were held with NUMARC and PWR owners on the issue on August 18 and November 20, 1992, and March 3, 1993. In addition, EPRI is engaging in ongoing research on methods for PWSCC mitigation. EPRI also developed a qualification program to ensure that inspections performed on VHPs are highly reliable in detecting and measuring flaws. The qualification program includes standard, mock-up VHPs containing known flaws that are axial, circumferential, off-axis, and clustered (closely spaced) flaws. The inspector is required to identify the location, orientation, and depth of all of the flaws in the EPRI mock-up VHPs in order to be named a qualified inspector. The NRC has been following this program and has reviewed the qualification results for all of the inspectors that have been qualified by EPRI.

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2.0 DISCUSSION

The NRC staff met with the B&WOG, CEOG, and the WOG to discuss the PWSCC of PWR VHPs on several occasions during 1992 and 1993.¹ Each of the owners groups submitted a safety assessment through NUMARC to the NRC on this issue and the NRC submitted a safety evaluation (SE) of the safety assessments to NUMARC on November 16, 1993. After reviewing the industry's safety assessments and examining the overseas inspection findings, the staff concluded in the SE sent to NUMARC that VHP cracking is not a significant safety issue at this time. The bases for this conclusion are that if PWSCC occurred at VHPs: (1) the cracks would predominately be axial in orientation; (2) the cracks would result in detectable leakage before catastrophic failure; and (3) the leakage would be detected during visual examinations performed as part of surveillance walkdowns before significant damage would occur to the reactor vessel head. In addition, the staff had concerns related to unnecessary occupational radiation exposures associated with eddy current or other forms of nondestructive examinations if done manually. Field experience in foreign countries has shown that occupational radiation exposures could be significantly reduced if the industry would use remotely controlled or automatic equipment to conduct the inspections. The U.S. nuclear industry has developed such equipment for inspection and possible repairs.

As a follow-up to the safety assessments, NUMARC submitted proposed generic acceptance criteria for flaws identified during inservice examinations of VHPs to the NRC in July of 1993. The NRC prepared an SE on the generic acceptance criteria and submitted it to NUMARC in the fall of 1993. The NRC accepted the acceptance criteria for axial flaws above and below the J-groove weld (the weld that holds VHP to the vessel head and is part of the primary pressure boundary), and circumferential flaws below the J-groove weld, but rejected the criteria for circumferential flaws above the J-groove weld. Cracks below the J-groove weld do not violate the reactor vessel pressure boundary even if they are through wall, and axial and circumferential cracks below the J-groove weld were determined to be acceptable by the NRC staff. Axial cracks above the J-groove weld may result in a leak that would be detected by surveillance walkdowns before significant damage could occur. Circumferential cracks above the J-groove weld could result in the ejection of a control rod drive mechanism (CRDM) resulting a large break loss-of-coolant accident. Furthermore, the stress analyses conducted as part of the owners groups safety assessments predicted that it would be very unlikely that circumferential cracks would form due to the stress distributions in the VHPs. For these reasons, the NRC requested that circumferential crack-like indications above the J-groove weld be reported to the NRC for disposition.

Three licensees volunteered to conduct VHP inspections during 1994 as part of the NUMARC program. The eddy current inspection conducted by the Wisconsin Electric Power Company vendor (Westinghouse) at the Point Beach Nuclear

¹ Summaries of the meetings are available in the Commission's Public Document Room, the Gelman Building, 2120 L Street, N.W. Washington, DC 20037.

Generating Station in April 1994 uncovered no crack-like indications in any of the 49 VHPs.

The eddy current inspection by the Duke Power Company vendor (Babcock & Wilcox) at the Oconee Nuclear Generating Station in October and November 1994 revealed 20 crack-like indications in one penetration. Ultrasonic testing (UT) could not quantify the depth of these indications because they were shallow. (UT cannot accurately size defects that are less than one mil deep (0.03-mm)). These indications may be associated with the original fabrication and may not grow. Even if they do grow, the analysis conducted on the indications by the licensee indicates that they will not grow such that they exceed the acceptance criteria before the next outage. During the next outage, the affected VHP will be reexamined and analyzed to see if the indications will exceed the acceptance criteria before the next outage. This cycle of reexaminations will continue until no growth occurs for two cycles, or until the indications are projected to exceed the acceptance criteria before the next inspection cycle. In the latter case, the VHP will be repaired or replaced.

An examination of the VHPs by the Indiana Michigan Power Company vendor (Westinghouse) at D.C. Cook revealed three clustered crack-like indications in one penetration. The indications were 46-mm, 16-mm, and 9-mm in length and the deepest flaw was 6.8-mm deep. The tip of the 46-mm flaw was just below the J-groove weld. The acceptance criteria permits a through-wall, axial crack of any length below the J-groove weld since such a crack does not violate the primary pressure boundary. An analysis by the Indiana Michigan Power Company at D.C. Cook indicates that these flaws will not grow to exceed the acceptance criteria before the next outage when a reinspection will occur. During the next outage, the affected VHP will be reexamined and analyzed to see if the indications will exceed the acceptance criteria before the next outage. This cycle of reexaminations will continue until no growth occurs for two cycles, or until the indications are projected to exceed the acceptance criteria before the next inspection cycle. In the latter case, the VHP will be repaired or replaced. These results are consistent with the owners groups' analyses and the PWSCC found in the CRDMs in European reactors. The results observed during these three VHP inspections do not pose a threat to safe plant operation. Based on the owners groups' safety assessments, a leak in a VHP would be detected before significant damage could occur to the VHP or the reactor vessel. This would result in the deposition of boric acid crystals on the vessel head and surrounding area that would be detected during surveillance walkdowns.

The NRC staff continues to meet with the NEI (the former NUMARC) to establish a plan for the inspection of the remaining PWRs. Immediate inspections are not required since there is no immediate safety concern.

3.0 CONCLUSION

Based on the information submitted by the licensee at D.C. Cook Unit 2, the NRC staff has concluded that the submittal is acceptable. The flaws observed in the CRDM penetration are smaller than the criteria proposed by NUMARC. The crack growth projections are conservative based on laboratory data and field experience. The flaws are not expected to exceed the NUMARC flaw size criteria by the end of the next operating cycle. Therefore, the licensee can continue to operate the plant until the next refueling outage.

Principal Contributor: James A. Davis, NRR

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