UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
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NRC REGULATORY ISSUE SUMMARY 2003-13: NRC REVIEW OF RESPONSES TO BULLETIN 2002-01, "REACTOR PRESSURE VESSEL HEAD DEGRADATION AND REACTOR COOLANT PRESSURE BOUNDARY INTEGRITY"

ADDRESSEES

All holders of construction permits or 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.

INTENT

The U.S. Nuclear Regulatory Commission (NRC) is issuing this regulatory issue summary (RIS) to inform addressees of the results of NRC staff's review of the responses to Bulletin 2002-01, "Reactor Pressure Vessel Head Degradation and Reactor Coolant Pressure Boundary Integrity." This RIS also provides information on additional regulatory actions the NRC is considering based on its review of the bulletin responses and recent events at South Texas Unit 1. No specific action or written response to this RIS is required.

BACKGROUND

Following the discovery of significant degradation of the reactor head at Davis-Besse due to boric acid corrosion, the U.S. Nuclear Regulatory Commission (NRC) issued Bulletin 2002-01, "Reactor Pressure Vessel Head Degradation and Reactor Coolant Pressure Boundary Integrity," to obtain information needed to determine the adequacy of boric acid corrosion control (BACC) programs at pressurized water reactor (PWR) plants. Within 60 days of the date of this bulletin, the NRC required all PWR addressees to submit the basis for concluding that their boric acid corrosion control program for the reactor coolant pressure boundary (RCPB) is providing reasonable assurance of compliance with the applicable regulatory requirements. Bulletin 2002-01 indicated that the staff would use the information submitted to determine the need for, and to guide the development of, additional regulatory actions to address degradation of the reactor pressure vessel head and/or other portions of the reactor coolant pressure boundary. In the bulletin, the NRC also required 15-day and 30-day responses related to reactor vessel upper head inspections. The aspects of Bulletin 2002-01 pertaining to inspection of the reactor vessel upper head have been superceded by Bulletin 2002-02, "Reactor Pressure Vessel Head and Vessel Head Penetration Nozzle Inspection Programs," and NRC Order EA-03-009, "Interim Inspection Requirements for Pressure Vessel Heads at Pressurized Water Reactors."

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With respect to the licensees' 60-day responses to Bulletin 2002-01, the NRC staff determined that a request for additional information (RAI) was necessary to supplement the information provided in those responses. Following the receipt of the additional information, the staff review of the original 60-day responses and the RAI responses consisted of two basic phases. In the first phase, the staff reviewed the responses to determine whether there was reasonable assurance that the applicable requirements are being met. These requirements included the ASME Code, Section XI, requirements for visual inspection for leaks during system pressure testing in accordance with 10 CFR 50.55a, the technical specification requirements prohibiting pressure boundary through-wall leakage, and the technical specification requirements on allowable identified and unidentified reactor coolant system leakage. The staff reviewed the responses to determine whether licensees are implementing BACC programs as described in Generic Letter (GL) 88-05, "Boric Acid Corrosion of Carbon Steel Reactor Pressure Boundary Components in PWR Plants." The staff also reviewed these responses to identify potential weaknesses in licensee ASME Code pressure test and BACC inspection programs, in view of recent occurrences of cracking and subsequent corrosion and the potential for cracking to occur in other locations within the reactor coolant pressure boundary. In the second phase, the staff conducted audits at Calvert Cliffs; Duke Energy offices for the Oconee, McGuire and Catawba sites; and D.C. Cook to ensure that it had a clear and complete understanding of the state of these industry inspection programs.

SUMMARY OF ISSUE

The staff reviewed the Bulletin 2002-01 responses, in part, for their consistency with the technical specification requirements on allowable identified and unidentified reactor coolant system leakage, the technical specification requirements prohibiting through-wall leakage, and the ASME Code requirements on visual inspection for leaks during system pressure testing. It appears from the responses that licensees are complying with these requirements at the programmatic level. The staff did not review the implementation of these programs against applicable regulatory requirements, such as 10 CFR 50, Appendix B. However, experience at a number of plants in recent years has shown that Alloy 600/82/182 materials are beginning to crack and leak. While licensee programs and procedures are consistent with technical specification requirements that prohibit operating with through-wall cracking in the reactor coolant pressure boundary, most licensees do not perform inspections of these materials beyond those required by the ASME Code to identify potential cracking and leakage of components susceptible to primary water stress corrosion cracking (PWSCC). Such inspections are generally performed without removing insulation and are not capable, in many cases, of detecting through-wall leakage.

The staff believes that existing monitoring programs may need to be enhanced to ensure early detection and prevention of leakage from the RCPB. The staff is considering various regulatory options to address this issue. While such regulatory action would address the entire RCPB, including reactor vessel lower head penetrations, the staff is also considering the need for separate regulatory action to address inspections of PWR vessel lower head penetrations, given the safety significance of the recently discovered cracks in the vessel lower head penetrations at South Texas Unit 1.

The staff will make information available to the public on additional regulatory actions as soon as the staff has determined the appropriate method for implementing such actions. In the interim, the staff has prepared a summary (Attachment 1) of the staff's review of responses to Bulletin 2002-01. This summary reflects current staff thinking on steps to address potential cracking and leakage in materials susceptible to PWSCC and provides suggestions for improving monitoring programs. This summary also includes staff observations on strengthening other aspects of licensee's inspections for boric acid corrosion control. The suggestions and observations provided in Attachment 1 are provided for information only at this time.

BACKFIT DISCUSSION

This RIS requires no action or written response and therefore is not a backfit under 10 CFR 50.109. Consequently, the staff did not perform a backfit analysis.

FEDERAL REGISTER **NOTIFICATION**

A notice of opportunity for public comment on this RIS was not published in the *Federal Register* because it is informational.

PAPERWORK REDUCTION ACT STATEMENT

This RIS does not require any specific action or written response, and does not request the collection of any new information.

If you have any questions about this matter, please contact the person listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager for a specific vendor or industry group as indicated on the NRC Web site.

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Attachments:
1. NRC Review of Responses to Bulletin 2002-01, "Reactor Pressure Vessel Head Degradation and Reactor Coolant Pressure Boundary Integrity"
2. List of Recently Issued Regulatory Issues Summaries

NRC REVIEW OF RESPONSES TO BULLETIN 2002-01, "REACTOR PRESSURE VESSEL HEAD DEGRADATION AND REACTOR COOLANT PRESSURE BOUNDARY INTEGRITY"

Based on the review of the Bulletin 2002-01 responses and the RAI submittals, the staff concluded that licensees are complying with the technical specification requirements on allowable identified and unidentified reactor coolant systems leakage. While reviewing Bulletin 2002-01 and RAI responses and auditing selected licensees, the staff observed certain weaknesses in the current BACC and ASME Section XI programs for ensuring detection of cracking or leakage of components susceptible to primary water stress corrosion cracking (PWSCC). This attachment briefly discusses the weaknesses and suggested steps for licensees to strengthen their inspection programs to address potential cracking and leakage in materials susceptible to PWSCC.

1. Identification of Pressure Boundary Leakage

Licensee programs are generally implemented with the philosophy that boric acid leaks can be identified without removing insulation. For conducting the ASME Code-required visual inspections for leakage during system pressure testing (VT-2), the ASME Code only requires that insulation be removed from bolted connections in systems borated for the purpose of controlling reactivity. Similarly, GL 88-05 does not discuss the need to remove insulation to detect small leaks. In the time-frame when the ASME Code pressure test requirements were developed and GL 88-05 was written, concerns regarding reactor coolant leakage causing boric acid corrosion arose from non-pressure-boundary leaks, such as from gaskets, seal welds, and valve packing. Non-pressure-boundary leaks continue to occur and licensee programs appear to be effective in detecting and correcting these leaks. Because operating experience has revealed that most leaks are from non-pressure-boundary components and the leakage can be readily identified, licensees are confident of finding leaks during plant walkdowns. Inspection programs, procedures, and training are weighted toward steps to take in the area of corrective action after leaks are identified rather than the task of identifying leaks. At most plants inspection programs have not been upgraded to address potential through-wall cracking and leakage even though this is beginning to occur in the industry. The staff has identified a number of weaknesses in BACC and ASME Code inspection programs related to the identification of pressure boundary through-wall cracking and leakage.

A. Recent Experiences of Cracking. Experience at a number of plants in recent years has shown that Alloy 600/82/182 materials are beginning to crack and exhibit through-wall leakage. Examples of cracking in these components include reactor vessel upper head penetrations, reactor coolant system (RCS) hot leg instrument penetrations, pressurizer heater sleeves, the steam generator bowl drain nozzle weld, the vessel-to-hot leg dissimilar metal weld at V.C. Summer, and the reactor vessel lower head penetrations at

South Texas Unit 1. Although it is not clear at this time that the cracking in these penetrations at South Texas Unit 1 resulted from PWSCC as in the other examples noted, it is clear that the cracking is through-wall.

B. Identification of Locations Susceptible to Cracking. From the review of the Bulletin 2002-01 responses and the audits, the staff determined that many plants have not taken steps to identify locations that are susceptible to cracking. These locations would include any areas in the reactor coolant pressure boundary where PWSCC can potentially occur as well as locations susceptible to other potential degradation mechanisms based on plant-specific and industry experience. Identification of locations susceptible to cracking is a necessary step for BACC programs and ASME Code requirements to successfully identify through-wall leakage.

C. Performing Capable Inspections. Experience has shown that the amount of pressure boundary leakage from a through-wall crack over a refueling cycle is likely to be much less than would be detectable with insulation in place. It is not common for inspections to be performed that are capable of detecting leakage from through-wall cracks, such as performing bare metal visual examination (BMV) of locations susceptible to cracking. The exceptions the staff noted in its reviews involved Alloy 600/690 penetrations either with insulation modified to permit a BMV through an annular opening, through a removable donut around the penetration, or by lifting blanket insulation. As discussed above, experience at a number of plants has shown that Alloy 600/82/182 materials are beginning to crack. Licensees can strengthen their inspection programs and provide consistency with technical specification requirements that prohibit operating with through-wall leakage by establishing monitoring programs to identify leaks in susceptible locations through capable inspections, correcting the causes of any through-wall cracks, and preventing their recurrence.

D. Inspection in High Radiation Areas. The staff's review of Bulletin 2002-01 responses and the BACC audits indicated that relatively few plants perform BMV inspections of the in-core instrumentation penetrations in the reactor vessel lower head. At other plants, the area under PWR reactor vessels generally receive a walkdown during refueling outages and a VT-2 inspection at normal operating pressure and temperature conditions during startup. As noted above, these types of inspections are not capable of identifying typically small amounts of potential through-wall leakage from these penetrations.

Licensees can strengthen their inspection programs by performing examinations capable of detecting through-wall leakage in these locations.

2. *Leakage Path and Targets*

In GL 88-05, the NRC recommended that BACC programs "establish the potential path of the leaking coolant and the reactor pressure boundary components it is likely to contact. This information is important in detecting the interaction between the leaking coolant and reactor coolant pressure boundary components." Knowledge of potential leaking sources and targets of potential leaks is equally important for preventing damage due to boric acid corrosion. In the course of reviewing Bulletin 2002-01 responses and the BACC audits, the staff found that licensees focus on systematically performing walkdowns of piping to identify potential leaks. However, licensees do not prepare a list of components, i.e., targets, that are vulnerable to potential boric acid leaks. Licensees can strengthen their BACC programs by identifying targets potentially vulnerable to damage from leaks and inspecting for both leaks and the effects of leaks on targets.

3. *Looking for Boric Acid Crystals*

The nuclear industry has become increasingly aware that boric acid leakage can become airborne and that crystals can form in locations other than in the vicinity of the leak, such as in containment ventilation filters. Thus, the exact location or the magnitude of leaks may not be detected simply by looking for boric acid crystals on leaking components or their nearby targets. Licensees can improve their programs by incorporating all available information on boric acid accumulation.

4. *Additional Walkdowns*

Based on the review of Bulletin 2002-01 responses and the BACC audits, the staff determined that licensees typically perform two types of inspections for evidence of leakage. During shutdown, licensees perform inspections and walkdowns inside containment to look for leaks or evidence of leaks such as boric acid residue or rust stains. Upon startup licensees perform ASME Code visual examinations during system pressure tests at nominal pressure associated with 100% reactor power. The staff considers that, prior to conducting visual inspections after plant shutdown, system walkdowns performed when the plant is entering the hot shutdown mode while the piping systems are still hot will potentially assist in identifying leak locations from steam plumes or the sound of escaping steam. Licensees can strengthen their BACC programs by incorporating system walkdowns when the plant is entering or leaving the hot shutdown mode.

5. *Detection of Small Leaks During Normal Power Operation*

Detection of reactor coolant leakage during power operation depends upon inventory balance calculations, generally performed once per day, as supplemented by information from monitoring of humidity, radiation, and sump level. NUREG/CR-6582, "Assessment of Pressurized Water Reactor Primary System Leaks," indicates that due to large RCS volumes and instrument inaccuracies, this approach is not sufficiently sensitive to detect small leaks. Based on the staff reviews and audits, licensees generally do not take action to locate leaks until inventory balance calculations indicate an increase of between 0.1 to 0.2 gallons per minute (gpm) over the previous level of identified plus unidentified RCS leakage. At this leakage rate, licensees typically would promptly inspect charging and letdown systems outside containment but, if leakage is not found outside containment, may not take action for several days to inspect inside containment. Further, there is no uniform industry guidance on this issue. Industry procedures to address this issue are weak, with actions typically taken on a case-by-case basis. This topic is being addressed under the Davis-Besse lessons learned task force recommendations action plan on Assessment of Boundary Integrity Requirements.

6. Limitations on Bare Metal Visual Examinations

In the implementation of BACC programs, some licensees are relying solely on visual examinations in the course of walkdowns during refueling outages to look for evidence of leakage, such as rust stains or boric acid crystals. Similar to the conclusions reached with respect to inspection of reactor vessel upper head penetrations, the staff considers that the identification of small leaks by this process of visual examination may not be sufficient in all cases to ensure pressure boundary integrity, even using BMV techniques. BMV examination together with volumetric examination may be effective in some locations for preventing through-wall cracking and leakage.