ACRSR-2001

June 20, 2002

The Honorable Richard A. Meserve
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: VESSEL HEAD PENETRATIONS AND VESSEL HEAD DEGRADATION

Dear Chairman Meserve:

During the 493rd meeting of the Advisory Committee on Reactor Safeguards, June 6-8, 2002, we heard presentations by and held discussions with representatives of the Electric Power Research Institute Materials Reliability Program (EPRI/MRP), First Energy Nuclear Operating Company (FENOC), and the NRC staff regarding cracking and leaking observed in pressurized water reactor (PWR) Alloy 600 reactor pressure vessel (RPV) head penetrations, including control rod drive mechanism (CRDM) nozzles, and the degradation observed at Davis-Besse Nuclear Power Station. This matter was also discussed during a meeting of the Materials and Metallurgy and the Plant Operations Subcommittees on June 5, 2002. During our reviews, we had the benefit of the documents referenced.

This report addresses technical issues associated with vessel head penetrations (VHP) cracking and degradation. We have excluded here issues of safety culture and the adequacy of the Reactor Oversight Process, which the Davis-Besse incident raises.

CONCLUSIONS AND RECOMMENDATIONS

1. The draft "Vessel Head Penetration Nozzle Cracking Action Plan," developed by the Office of Nuclear Reactor Regulation (NRR) is sufficiently comprehensive to allow the short- and long-term management of cracking issues associated with Alloy 600.

2. The approach proposed by industry to manage cracking incidents in VHP assemblies through the use of various inspection methods is reasonable in principle, and is in line with NRC's goal to move toward risk-informed regulation. Prior to issuance of another generic communication, certain questions regarding the specific inspection techniques and frequencies, now the subject of ongoing discussions between the staff and industry, should be resolved.

3. We agree with the staff's conclusion that there are no plants with conditions similar to those that led to the degradation at Davis-Besse. This conclusion is based on the initial responses to Bulletin 2002-01, "Reactor Pressure Vessel Head Degradation and Reactor Coolant Pressure Boundary Integrity," dated March 18, 2002, and on

interactions with licensees, resident inspectors, regional staff, and other information provided to the staff.

4. In order to define the inspection frequencies, corrosion rates in low-alloy steel adjacent to vessel head penetrations should be determined.

Background

Presentations on cracking in VHP assemblies were made by the staff and industry at subcommittee and full Committee meetings in July and November 2001, and again in April 2002 on the low-alloy steel corrosion observed at Davis Besse in April 2002. Following the meeting in July 2001, we issued a letter supporting the issuance of Bulletin 2001-01, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles." That letter included several technical questions associated with, for instance, the adequacy and qualification of visual inspection processes and the qualification of stress corrosion data bases that would be used to define inspection periodicities. In June 2002, presentations were made by the staff and industry on data relevant to these issues.

Discussion

The staff has developed a draft VHP Nozzles Cracking Action Plan, which addresses short- and long-term regulatory issues. The short-term actions relate, for example, to reviewing the responses to Bulletin 2001-01, addressing policy matters related to management of cracking through continued inspections for leakage, and dealing with plant-specific issues. The long-term actions relate to the criteria and regulatory tools for nozzle inspection requirements and considerable efforts to develop the technical basis to support the regulatory approach for managing this issue. This approach includes flaw evaluation criteria, crack growth rate evaluations, nondestructive examination, probabilistic fracture mechanics, and risk assessment. The MRP is performing a considerable amount of complementary work and engaging in a healthy communication with the staff.

A persistent question raised in all of the ACRS meetings relates to the completeness of cracking prediction methods, which must account for the combined effects of materials, environment, and stress parameters on crack initiation and propagation. All of these effects are being addressed in the draft NRR action plan and the ongoing MRP Alloy 600 project. Thus, the effect of environment (primarily temperature), stress (intensity), and the range of material conditions are accounted for in deriving the probabilistic fracture mechanics basis for defining inspection frequencies. There is, however, another method, based on time and temperature, that was used by the staff and industry in 2001 and 2002 to rank various plants for inspection prioritization. If this method continues to be used as a management tool, then it should be upgraded to cover not only operating time and temperature, but also material effects. These more complete algorithms have been used in France to manage CRDM cracking.

The draft action plan focuses on the evaluation of the cracking kinetics of Alloys 600 and 182, the materials currently used in the construction of the VHP assemblies. This focus is appropriate for managing the current problem. However, it is foreseen that many plants will choose to replace their pressure vessel heads with new heads equipped with VHP assemblies using Alloys 690 and 152. These alloys have performed well in laboratory tests, replacement

steam generators tubes, and VHP assemblies in France. However, there is an insufficient information base on Alloys 690 and 152 to achieve the same technical management objectives set forth in the current action plan for Alloys 600 and 182. Thus, it would be appropriate for the industry to initiate programs that will quantify improvements in stress corrosion resistance in VHP assemblies and determine the impact that this has on inspection methods and frequencies for Alloys 690 and 152.

The industry's proposed inspection plan for VHP assemblies indicates a choice of inspection techniques and frequencies of inspection for specific plants based on the impact of cracking on the risk of rod ejection. This plan has a sound technical foundation, and is consistent with the staff's objective of managing cracking incidents through adequate and timely inspection and with a sound risk-informed basis. However, the current focus of the industry's plan is limited to circumferential cracking, whereas, in addition to circumferential cracking, the staff's concern is throughwall cracking and RPV head material degradation. The industry's proposal is the subject of intensive discussions. Topics of discussion include inspection techniques (visual versus 100% volumetric), frequency of inspections, code requirements concerning leakage and depth of crack, and maintenance of the defense-in-depth principle.

Based on the initial responses to Bulletin 2002-01, the staff concluded that there are no plants with conditions similar to those that led to the degradation at Davis-Besse. This conclusion was based on visual inspections of the RPV head for boric acid deposits, interactions with licensees, resident inspectors, regional staff, and other information provided to the staff. It was agreed among staff and industry, however, that this inspection technique, though adequate for detecting gross degradation, is not capable of sizing any pressure vessel corrosion. Thus, there is a need to develop an inspection strategy (i.e., inspection technique and frequency) that is appropriate for this type of corrosion degradation and then factor it into the current proposed industry inspection plan which is centered on the CRDM cracking. Part of this upgraded inspection strategy must be based upon the kinetics of low-alloy steel corrosion in the annulus between the CRDM tube and the pressure vessel head. Several scenarios have been hypothesized that could lead to high corrosion rates with limiting conjoint criteria that would suggest that high corrosion rates in this location (circa 1 inch/year) would not be observed frequently. The plant design and operating conditions that control corrosion in this location is not now known. Therefore, there is an urgent need to confirm these hypotheses experimentally.

The staff and industry are working to resolve these problems, and we would like to be kept informed as the work progresses.

Dr. William J. Shack did not participate in the Committee's deliberations regarding this matter.

Sincerely,

/RA/

George E. Apostolakis
Chairman

References

1. Draft Memorandum from Brian Sheron, Office of Nuclear Reactor Regulation, NRC, to Samuel J. Collins, Office of Nuclear Reactor Regulation, NRC, Subject: Vessel Head Penetration Nozzles Cracking Action Plan, received March 29, 2002.
2. NRC RES-MRP Alloy 600 Meeting Slides (Inspection Plan and Inspection Plan Writeup), May 22, 2002,
3. U. S. Nuclear Regulatory Commission Bulletin 2001-01: Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles, August 3, 2001.
4. U. S. Nuclear Regulatory Commission Bulletin 2002-01: Reactor Pressure Vessel Head Degradation and Reactor Coolant Pressure Boundary Integrity, March 18, 2002
5. Letter dated May 21, 2002, from H. Bergendahl, First Energy Nuclear Operating Company, to J. E. Dyer, NRC Region III, Subject: Transmittal of Davis-Besse Nuclear Power Station, Unit 1 Return to Service Plan.
6. Letter dated May 15, 2002, from H. Bergendahl, First Energy Nuclear Operating Company, to J. E. Dyer, NRC Region III, Subject: Supplemental Information in Response to NRC Question Number 24 on the Preliminary Probable Cause Summary Report Dated March 22, 2002.
7. Letter dated April 18, 2002, from H. Bergendahl, First Energy Nuclear Operating Company, to J. E. Dyer, NRC Region III, Subject: Confirmatory Action Letter Response - Root Cause Analysis Report.
8. Letter dated May 3, 2002, from J. E. Dyer, Administrator, Region III, to H. Bergendahl, First Energy Nuclear Operating Company, Subject: Davis-Besse Nuclear Power Station NRC Augmented Inspection Team- Degradation of the Reactor Pressure Vessel Head - Report No 50-346/02-03(DRS).
9. NRC Information Notice 2002-13: Possible Indicators of Ongoing Reactor Pressure Vessel Head Degradation, April 4, 2002.