ACTION PLAN FOR ADDRESSING DAVIS-BESSE LESSONS LEARNED TASK FORCE RECOMMENDATIONS REGARDING ASSESSMENT OF BARRIER INTEGRITY REQUIREMENTS

Last Update: 06/30/04
Lead Division: RES/DET
Supporting Divisions: DRAA,DSARE
Supporting Offices: NRR, Regions

TAC No.	Description
KC0042	Develop and implement action plans based on recommendations of the Davis-Besse reactor vessel head degradation Lessons-Learned Task Force (LLTF)
MB7287	NRR support for development of action plan
MC0036	NRR Support to RES for action plan activities

Milestone	Date (T=Target) (C=Complete)	Lead	Support
Part I: Leakage			
1. a. Review PWR TS to identify plants that have non-standard RCPB leakage requirements	7/03 (C) ML031980277	NRR/DIPM	
b. Take appropriate action to make TS consistent among all plants. [LLTF 3.3.4(9):High]	9/04 (T)		
2. Inspect plant alarm response procedure requirements for leakage monitoring systems to assess whether they provide adequate guidance for the identification of RCPB leakage. [LLTF 3.2.1(3)]			
a. Revise inspection procedures.	05/04 (C)	NRR/DIPM	RES/DET NRR/DE NRR/DSSA
b. Assess adequacy of licensee procedure requirements based on results of inspections.	05/05 (T)	NRR/DIPM	Regions

Milestone	Date (T=Target) (C=Complete)	Lead	Support
3. Develop inspection guidance pertaining to RCS unidentified leakage that includes action levels to trigger increasing levels of NRC interaction with licensees in response to increasing levels of unidentified RCS leakage [LLTF 3.2.1(2):High]	1/05 (T)	NRR/DIPM	RES/DET NRR/DE NRR/DSSA
4. Evaluate RCS leakage requirements and leakage detection systems.			
a. Perform research study to reevaluate basis for RCS leakage requirements and assess the capabilities of currently used and state-of-the-art leakage detection systems.	7/04 (T)	RES/DET	NRR
b. Form team to review report and make recommendations.	8/04 (T)	NRR	RES
c. Determine whether PWR plants should install on-line enhanced leakage detection systems on critical plant components, which would be capable of detecting leakage rates of significantly less than 1 gpm. [LLTF 3.1.5(1):High]	3/05 (T)	NRR	RES
d. Recommend improvements in the requirements pertaining to RCS unidentified leakage and RCPB leakage to ensure that they are sufficient to: (1) provide the ability to discriminate between RCS unidentified leakage and RCPB leakage; and (2) provide reasonable assurance that plants are not operated at power with RCPB leakage.	3/05 (T)	NRR	RES
e. Obtain management concurrence on recommended changes.	4/05 (T)	NRR	RES
f. Determine appropriate regulatory			

Milestone	Date (T=Target) (C=Complete)	Lead	Support
tools to implement recommendations.	5/05 (T)	NRR	
g. Implement recommended changes in RCS and RCPB leakage requirements. [3.2.1(1):High]	TBD	NRR	
Part II. Performance Indicators (PI)			
1. Continue ongoing efforts to review and improve the usefulness of the barrier integrity PIs. Evaluate the feasibility of establishing a PI which tracks the number, duration, and rate of primary system leaks that have been identified but not corrected. [LLTF 3.3.3.(3):High]	5/05 (T)	NRR/DIPM	RES/DRAA RES/DET NRR/DE NRR/DSSA Regions

<u>Description</u>: The Reactor Pressure Vessel Head degradation event at the Davis Besse Nuclear Power Station has many safety implications. One concern is the integrity of the reactor coolant pressure boundary. This action plan was developed to improve some of the requirements intended to ensure an effective barrier to the release of radioactivity. This plan describes the required actions, establishes milestone schedules, identifies responsible parties, and estimates resource requirements.

<u>Historical Background</u>: In March, 2002, while conducting inspections in response to Bulletin 2001-01, the Davis-Besse Nuclear Power Station identified three control rod drive mechanism (CRDM) nozzles with indications of axial cracking, which were through-wall, and resulted in reactor coolant pressure boundary leakage. During the nozzle repair activities, the licensee removed boric acid deposits from the RVH, and conducted a visual examination of the area, which identified a 7 inch by 4-to-5 inch cavity on the downhill side of nozzle 3, down to the stainless steel cladding. The extent of the damage indicated that it occurred over an extended period and that the licensee's programs to inspect the reactor pressure vessel (RPV) head and to identify and correct boric acid leakage were ineffective.

One of the NRC follow-up actions to the Davis-Besse event was formation of a Lessons Learned Task Force (LLTF). The LLTF conducted an independent evaluation of the NRC's regulatory processes related to assuring reactor vessel head integrity in order to identify and recommend areas of improvement applicable to the NRC and the industry. A report summarizing their findings and recommendations was published on September 30, 2002. The report contains several consolidated lists of recommendations. The LLTF report was reviewed by a Review Team (RT), consisting of several senior management personnel appointed by the EDO. The RT issued a report on November 26, 2002, endorsing all but two of the LLTF recommendations, and placing them into four overarching groups. On January 3, 2003, the EDO issued a memo to the Director, NRR, and the Director, RES, tasking them with developing a plan for accomplishing these recommendations. This action plan addresses the Group 4 recommendations of the Davis-Besse Lessons Learned Task Force Review Team regarding the Assessment of Barrier Integrity Requirements. The 6 high priority recommendations in the "Assessment of Barrier Integrity Requirements" grouping are included in this Action Plan. The LLTF recommendations are listed in the attached Table 1, and have been identified under the appropriate milestone(s).

Proposed Actions: The specific LLTF recommendations within this category are focused on reviewing and improving leakage detection requirements. However, simply improving leakage detection and lowering allowable leakage may not be sufficient to provide increased assurance of reactor coolant pressure boundary (RCPB) integrity. Leakage monitoring assumes that the pressure boundary will fail only under a leak-before-break (LBB) scenario. Small leak rates associated with tight stress corrosion cracks or cracks which may be partially plugged are not necessarily associated with small flaws in the RCPB. Therefore, the scope of this action plan also includes methods which may be capable of detecting crack initiation and monitoring crack growth before a through-wall crack develops and leakage occurs. Other degradation modes, such as boric acid corrosion and erosion-corrosion, which can lead to failure without leakage as a precursor will also be considered.

First, a comprehensive review and evaluation of plant experiences and current leakage detection systems will be performed. A similar study was performed by Argonne National Laboratory in the late 1980's. This task would essentially be to update that work. The technical bases for the current requirements on leak rates will also be reviewed. If changes should be made to leak rate limits, the impacts of these changes to other plant systems and analyses need to be identified. An evaluation of state-of-the-art systems capable of detecting leaks and cracks will also be completed. This evaluation includes, but is not limited to, acoustic emission technology. An evaluation will also be done to determine if leak rates can be correlated to unacceptable levels of degradation. It should be noted that this evaluation will be more difficult for tight stress-corrosion cracks which typically have low leak rates. Results of these reviews and analyses will then be used to develop an updated basis for leak rate requirements. Once this basis is complete, recommendations will then be made for improving leak rate limits, plant alarm response procedures, TS, and inspection guidance. Then a determination will be made to select which recommendations should be imposed as new requirements. The appropriate regulatory tools and procedures will be used to develop and implement these new requirements. A regulatory analysis will probably be needed to help establish the appropriate leakage criteria. It may not be possible or practical to implement leakage requirements small enough to preclude failure. Therefore, a regulatory impact analysis will be necessary to establish appropriate risk-informed leakage limits.

The second group of milestones relate to LLTF recommendation 3.3.3(3) regarding the review and improvement of barrier integrity performance indicators (PI). The NRC/Industry ROP Working Group will review the feasibility of establishing a PI that tracks the number, duration and rate of primary system leaks that have been identified but not corrected, as well as other possible PIs that could monitor RCPB leakage.

Completion of this action plan may require participation in public meetings and establishing communications with stakeholders. These items will be scheduled as needed.

Originating Documents:
Memorandum from Travers, W.D. to Collins, S. and Thadani, A. C., dated January 3, 2003, "Actions Resulting From The Davis-Besse Lessons Learned Task Force Report Recommendations." [ML023640431]

Memorandum from Paperiello, C.J. to Travers, W.D., dated November 26, 2002, "Senior Management Review of the Lessons-Learned Report of the Davis-Besse Nuclear Power Station Reactor Pressure Vessel Head." [ML023260433]

Memorandum from Howell, A.T. to Kane, W.F., dated September 30, 2002, "Degradation of the Davis-Besse Nuclear Power Station Reactor Pressure Vessel Head Lessons-Learned Report." [ML022740211]

Regulatory Assessment: The reactor coolant pressure boundary forms one of the 3 defense-in-depth barriers to the release of radioactive products. General Design Criteria 14, 30, and 32 of Appendix A to 10 CFR Part 50 specifiy requirements for the reactor coolant pressure boundary.

- GDC 14 states in part that "[t]he reactor coolant pressure boundary shall be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage."

- GDC 30 states in part that "[m]eans shall be provided for detecting and, to the extent practical, identifying the location of the source of reactor coolant leakage."

- GDC 32 states in part that "[c]omponents which are part of the reactor coolant pressure boundary shall be designed to permit periodic inspection and testing of important areas and features to assess their structural and leaktight integrity."

In addition, the NRC has developed Regulatory Guide 1.45 "Reactor Coolant Pressure Boundary Leakage Detection Systems."

From a practical standpoint, it was recognized that the RCPB cannot be made completely leaktight since some leakage is to be expected from equipment such as pump and valve seals. Therefore, it becomes important to identify the source of any leaks. Identified leaks, such as from valves or pump seals, should be measured, collected, and isolated so as not to interfere with detection of leakage from an unknown source which could indicate a breach of the RCPB. Specific limitations on leakage are stated in the Technical Specifications (TS) for each plant. In general, the TS place a limit on unidentified leakage (usually to 1 gpm) and state that continued operation with RCPB leakage is not allowed. In addition Title 10, Section 50.55a of the *Code of Federal Regulations* requires plants to meet the requirements of the ASME Boiler and Pressure Vessel Code. Section XI (Inservice Inspection of Nuclear Power Plant Components) of this code provides acceptance criteria for flaws found during inspection and evaluation procedures for determining the acceptability of flaws exceeding these standards.

Since the vessel head penetration (VHP) nozzles are considered part of the RCPB and significant degradation of the RPV head occurred at Davis-Besse, the issues raised by this event extend beyond problems of stress corrosion cracking in CRDM nozzles to issues of RCPB integrity in general. Primary water stress corrosion cracking of the VHP nozzles and their associated welds has been experienced by both U.S. and foreign plants. In addition, the degradation mechanism that occurred at Davis-Besse was also known. Therefore, one of the conclusions from the LLTF report was that this incident was preventable, but occurred because of a failure to follow-up and integrate relevant operating experience and other available information.

The TS for Davis Besse set a 1 gpm limit for unidentified leakage. In general, unidentified leakage was kept below 0.2 gpm. Despite this conservatism, the leakage eventually caused the degradation found in the vessel head. Therefore, the requirements associated with RCS leakage need to be reviewed and improved as warranted.

Current Status: To address the first milestone in Part I, NRR completed a review of PWR plant technical specifications in July 2003 and identified plants with nonstandard RCS leakage requirements. The evaluation of this data indicated that only one plant had significant differences from the standard TS. Subsequently, this plant submitted a TS change that was approved in May 2004.

The second milestone in Part I calls for an inspection of plant alarm response procedure requirements for leakage monitoring systems to assess whether they provide adequate guidance for identifying RCPB leakage. To address this recommendation, inspection guidance has been revised to verify that licensees have programs and processes in place to (1) monitor plant-specific instrumentation that could indicate potential RCS leakage, (2) meet existing requirements related to degraded or inoperable leakage detection instruments, (3) use an inventory balance check when there is unidentified leakage (4) takes appropriate corrective action for adverse trends in unidentified leak rates, and (5) pays particular attention to changes in unidentified leakage. The revised procedures include Inspection Manual Chapter 2515 Appendix D (Plant Status Review), Inspection Procedure 71111.22, and Inspection Procedure 71111.08. These revisions were issued in May 2004. The assessment of the adequacy of licensee procedure requirements will be completed as part of the annual ROP self assessment process.

The third milestone is also addressed in the revision to IMC 2515, Appendix D. Inspectors are to monitor leakage for adverse trends and notify plant management and regional management if any are noted.

The fourth milestone is being addressed by the Barrier Integrity Research Program that is being performed at the Argonne National Laboratory. The objective of this program is to reevaluate the technical basis for RCS leakage requirements. There are 3 main tasks associated with this effort. The first task is an assessment of the leakage associated with the degradation of various RCPB components. This includes a review of leak rate experiments and models to identify correlations between crack size and leak rate. A set of leak rate calculations are also being performed using an updated version of the Seepage Quantification of Upsets in Reactor Tubes (SQUIRT) code developed by the NRC. The second task is a review of leakage operating experience by developing a database of leakage events. The information in this database includes (1) leak location, (2) leak rate, (3) cause of leakage, (4) operation of reactor when leak was detected, and (5) action taken. The third task is an evaluation of the capabilities of various leakage detection systems. To date the systems that have been evaluated included acoustic emission, humidity detection, and localized airborne radioactivity monitoring. In addition, this task is evaluating the capabilities of acoustic emission systems to monitor and detect cracking in RCS components before leakage occurs. On March 24, 2004 a program review meeting was held at headquarters in which Argonne and its subcontractors presented interim results of this program to the staff.

At the end of May 2004, ANL provided a draft NUREG report on barrier integrity research. This draft report contains an updated review of RCS leak rate experiments and leak rate models and identifies correlations between crack size, crack opening displacement (COD), and leak rate. Although the focus of this work is on components susceptible to stress corrosion cracking (SCC), other types of materials and cracking mechanisms are considered.

A database was developed which identifies the number, source, rate, and resulting actions from RCS leaks discovered in U.S. LWRs. It describes for each incident what equipment detected the leakage, how it was determined that the leakage was through the pressure boundary, the cause of leakage, and comparisons with applicable leakage requirements. If the leakage was from a crack in the pressure boundary, the crack size, crack type, and measured leak rates are also described. For each incident the database notes what, if any, indications in identified or unidentified leakage were present (i.e., change in some measurement when the pressure boundary was breached).

The capabilities of each type of leakage detection system were evaluated to determine their sensitivity, reliability, response time, and accuracy. The scope of technology considered includes the state-of-the-art in this area, but was limited to technology that can be applied to the monitoring of RCPB conditions in U.S. LWRs. The evaluations also included crack monitoring systems capable of detecting crack initiation and growth. In addition, technology that can monitor or detect other (non-cracking) degradation modes such as boric acid corrosion or erosion/corrosion was studied. The sensitivity, reliability, response time, and accuracy of these systems, as well as the feasibility of using this technology in nuclear power plant applications have been considered. The systems, procedures, and equipment used in nuclear power plants of other countries to detect leakage were also evaluated.

The RES and NRR staff are currently reviewing this draft report and will provide draft comments by the end of July 2004, for inclusion in the final report.

A working group will be formed to use the information contained in the ANL report, as well as other pertinent plant information, to (a) determine if PWR plants should install on-line enhanced leakage detection systems [LTTF No: 3.1.5(1)], and (b) recommend improvements in the requirements for RCS unidentified leakage and RCPB leakage [LLTF No: 3.2.1(1)].

The Part II milestones regarding Performance Indicators have been revised to indicate more clearly that the response to LLTF 3.3.3(3) is continuation of the ongoing process of working with the industry to improve the Barrier Integrity PIs and to evaluate the feasibility of a PI that tracks the number, duration and rate of primary leaks that have been identified but not corrected.

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References:

NRC Bulletin 2001-01, “Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles,” August 3, 2001

Memorandum from Ledyard Marsh, Deputy Director Division of Licensing and Project Management, to John Grobe, Chair, Davis-Besse Reactor Oversight Panel, dated December 6, 2002, “Response to Request for Technical Assistance - Risk Assessment of Davis-Besse Reactor Head Degradation (TIA-2002-01)” [ML023330284]

10 CFR Part 50 Appendix A

NRC Regulatory Guide 1.45 “Reactor Coolant Pressure Boundary Leakage Detection Systems”

NUREG/CR 4813, “Assessment of Leak Detection Systems for LWR’s,” May 1988, Argonne National Laboratory.

Table 1
LLTF Report Recommendations Included in Barrier Integrity Action Plan

High Priority

RECOMMENDATION NUMBER	RECOMMENDATION
3.1.5(1)	The NRC should determine whether PWR plants should install on-line enhanced leakage detection systems on critical plant components, which would be capable of detecting leakage rates of significantly less than 1 gpm.
3.2.1(1)	The NRC should improve the requirements pertaining to RCS unidentified leakage and RCPB leakage to ensure that they are sufficient to: (1) provide the ability to discriminate between RCS unidentified leakage and RCPB leakage; and (2) provide reasonable assurance that plants are not operated at power with RCPB leakage.
3.2.1(2)	The NRC should develop inspection guidance pertaining to RCS unidentified leakage that includes action levels to trigger increasing levels of NRC interaction with licensees in order to assess licensee actions in response to increasing levels of unidentified RCS leakage. The action level criteria should identify adverse trends in RCS unidentified leakage that could indicate RCPB degradation.
3.2.1(3)	The NRC should inspect plant alarm response procedure requirements for leakage monitoring systems to assess whether they provide adequate guidance for the identification of RCPB leakage.
3.3.3(3)	The NRC should continue ongoing efforts to review and improve the usefulness of the barrier integrity PIs. These review efforts should evaluate the feasibility of establishing a PI which tracks the number, duration, and rate of primary system leaks that have been identified but not corrected.
3.3.4(9)	The NRC should review PWR plant TS to identify plants that have non-standard RCPB leakage requirements and should pursue changes to those TS to make them consistent among all plants.