Davis-Besse Reactor Vessel Head Damage

NRC UPDATE

October 2002

This is the second periodic update on the NRC response to the reactor vessel head damage at the Davis-Besse Nuclear Power Station. The updates will be available at public meetings of the NRC Davis-Besse Oversight Panel which is coordinating the agency's activities related to the damage. Each update will include background information to assist the reader in understanding issues associated with the corrosion damage.

NRC Lessons Learned Task Force Report Issued

The Nuclear Regulatory Commission staff has issued a "lessons learned" report on the agency's handling of issues associated with the corrosion damage to the reactor vessel head. A Lessons Learned Task Force, which completed the report, was formed to review the full scope of NRC regulatory activities related to the Davis-Besse damage, including the agency inspection and assessment program, industry-wide generic activities, research work, and international practices. It was comprised of NRC staff members not previously associated with the oversight of the Davis-Besse plant. The findings and recommendations will be reviewed by a panel of senior NRC managers who will issue recommended actions by the end of November.

The Task Force concluded that the Davis-Besse reactor head damage was preventable, but was not prevented because: (1) the NRC, Davis-Besse, and the nuclear industry failed to adequately review, assess, and followup on relevant operating experience; (2) Davis-Besse failed to assure that plant safety issues would receive appropriate attention; and (3) the NRC failed to integrate known or available information into its assessments of Davis-Besse's safety performance.

The Task Force will present its findings in a public meeting tentatively set for 7 p.m. on November 6 at the Oak Harbor High School Auditorium in Oak Harbor, Ohio. Members of the public attending the meeting will have the opportunity to make comments and ask questions of the task force. The Task Force report is available on the NRC web site: http://www.nrc.gov - select "Davis-Besse" under the list of key topics.

Ongoing NRC Inspections:

The schedule for these inspections has been adjusted to the pace of ongoing work by FirstEnergy at the plant. In some cases the NRC has not been able to continue the inspections until additional work is completed by the plant staff. Such changes in schedule are not unexpected.

- Management and Human Performance Inspection, which is evaluating FirstEnergy's root cause analysis associated with management, organizational effectiveness and human performance factors that are believed to have led to the degradation of the reactor head. The inspection is also reviewing the licensee's efforts towards creating a more safety-focused environment.

- Program Effectiveness Inspection, which is reviewing the plant's progress in creating more effective programs for corrective actions, boric acid corrosion control, modification control and other activities.

- Systems Health Inspection, which is reviewing the plant's assessment of important plant safety systems. The inspection is assessing the adequacy of FirstEnergy's work and will include an independent system adequacy evaluation of three systems conducted by the NRC. This inspection is intended to provide assurance that important safety systems can perform as designed.

Augmented Inspection Team Follow-Up Inspection

On October 2, the Nuclear Regulatory Commission issued the AIT follow-up inspection report which focused on FirstEnergy's compliance with NRC regulations related to the degradation of the reactor vessel head. Inspectors identified ten apparent violations and findings. The safety significance and possible enforcement action will be determined later.

1. Operating the reactor with leakage from the reactor cooling system through cracks in the Control Rod Drive Mechanism (CRDM) nozzles.
2. Failing on numerous occasions to thoroughly clean the continuing buildup of boric acid on the reactor vessel head, which eventually led to the corrosion of the head.
3. Failure to identify the cause and take appropriate corrective actions for recurrent accumulations of boric acid on the fins of the containment air coolers, which resulted in reduced air flow through the coolers.
4. Failure to identify boric acid corrosion as the cause of the repeated clogging of radiation filters in the containment building and take appropriate corrective actions.
5. Failure to implement a modification to the service structure above the reactor vessel head for better access to inspect and clean the head and the control rod nozzles.
6. Failure to follow the corrective action procedure and complete a prescribed corrective action for adverse trends in reactor cooling system leakage, thereby missing an opportunity to identify the nature of the leakage and find the growing cavity on the reactor vessel head.
7. Failure to establish an adequate boric acid control procedure, which contributed to the failure, over the years, to properly identify and evaluate the leaking CRDM nozzles and the expanding cavity in the reactor head.
8. Recurrent failures to follow the boric acid control procedure designed to prevent extensive boric acid corrosion, which resulted in the failure to remove boric acid deposits and inspect the metal base of the reactor head as directed by the procedure.
9. Failure to follow the station's corrective action program, designed to properly identify the cause of a problem, devise and implement a solution, which contributed to the utility's failure to recognize that a through-wall leak had developed in the CRDM nozzles.
10. Failure to provide complete and accurate information to the NRC and maintain internal documents necessary to diagnose and resolve problems at the plant. Completeness and accuracy of these documents may have provided an earlier alert to the utility staff and the NRC about the problem with the CRDM nozzle leakage or may have caused the NRC to establish a different regulatory position on the urgency for inspecting the reactor vessel head.

Boric Acid Corrosion Extent of Condition Inside Containment Inspection

On July 26, the NRC completed a special inspection associated with FirstEnergy's plan and its implementation to review the extent of boric acid corrosion inside the containment. The report was issued September 13.

The inspection found that many of the inspection activities by the utility staff were well performed. However, FirstEnergy failed, in some instances, to provide proper criteria for performing the containment inspections and to adequately train and certify inspectors working in this area. The utility has corrected these problems and is reperforming the inspections. NRC inspectors also identified other weaknesses in the utility's implementation of the inspections that the utility needs to address.

Successful implementation of this plan is required for restarting the plant. The NRC will perform additional inspections to ensure that the condition of boric acid corrosion inside containment has been properly identified and problems corrected.

Inspection Reports and other documents related to the Davis-Besse reactor head damage,
as well as public meeting details and transcripts, are available on the NRC's web site: http://www.nrc.gov

Enforcement and Significance Determination Process for Inspection Findings

In determining the appropriate NRC response to performance issues related to the vessel head damage, the NRC will consider both its inspection findings and investigation findings. The agency response may include formal notices of violations, fines, and increased oversight activities. The scope of the inspections will include the causes of the vessel head damage and the utility's ongoing corrective actions. The NRC's Office of Investigations is conducting an investigation to determine if there were willful violations of NRC requirements. The NRC will also refer Office of Investigation findings to the Department of Justice for prosecutive determination if there appears to be criminal violations within the NRC's jurisdiction.

The agency's reactor oversight process uses four levels of safety significance to determine the agency's response, ranging from green, for findings of very low safety significance, through white and yellow to red, for findings of high safety significance. The greater the safety significance, the greater the response by the NRC, including additional inspections, meetings with utility management, and possible orders for corrective actions. In determining the appropriate level of safety significance, the NRC uses a procedure called the Significance Determination Process.

The significance of willful violations and violations involving inaccurate or incomplete information is determined using the traditional enforcement process. This process includes assigning severity levels and determining if fines are warranted. There are four severity levels increasing from IV to I. Fines may also be levied in cases processed using the reactor oversight process for particularly significant violations. The agency is authorized by statute to levy fines of up to $120,000 per violation per day.

Once the findings from the inspections and investigations have been consolidated, the NRC will schedule a meeting with the utility to discuss the nature of the findings and to consider appropriate actions. In determining the appropriate enforcement actions, the agency will consider its inspection and investigation findings and information provided by the utility.

Current NRC Davis-Besse Activities

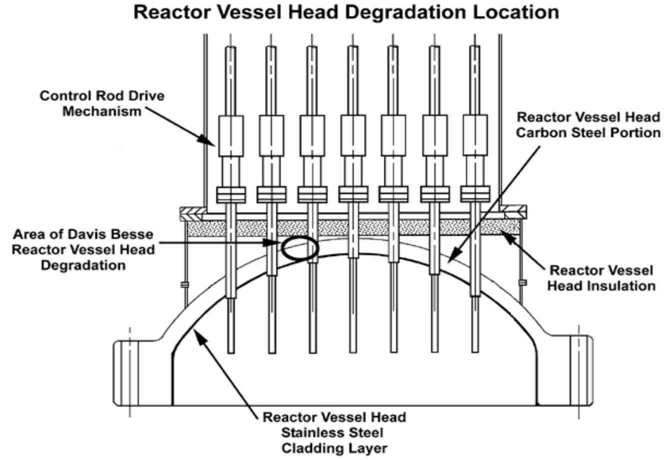
Since the NRC Davis-Besse Oversight Panel public meeting on September 17, the NRC has undertaken the following:

- Continued to monitor activities associated with the reactor vessel head replacement process, including welding of the service structure, opening and closing of the containment, and examining the quality of containment welds and shield building concrete.

- Continued the NRC-authorized series of inspections of the corroded vessel head to better understand the mechanisms that led to the corrosion of the reactor vessel head and to investigate the condition of head materials. These inspections were conducted by Framatome in Lynchburg, Virginia. As a result of initial inspections of the portion of the vessel head containing the corrosion cavity, Framatome reported that the remaining stainless steel liner was thinner at some points than previously known and that a crack, about 3/8 inches long with some additional adjacent cracking, was identified in the surface of the liner. Framatome is conducting further analysis to characterize the cracking.

- Met on September 18, 2002, with FirstEnergy to discuss the planned corrective actions to address the Davis-Besse organizational and human performance problems presented to the NRC during the August 15, 2002, public meeting.

Reactor Vessel Head Degradation Location



Background: What Happened at Davis-Besse

In March 2002 plant workers discovered a cavity in the head or top of the reactor vessel while they were repairing control rod tubes which pass through the head.

The tubes which pass through the reactor vessel head are called control rod drive mechanism nozzles. Cracks were detected in 5 of the 69 nozzles. In three of those nozzles, the cracks were all the way through the nozzle, allowing leakage of reactor cooling water, which contains boric acid.

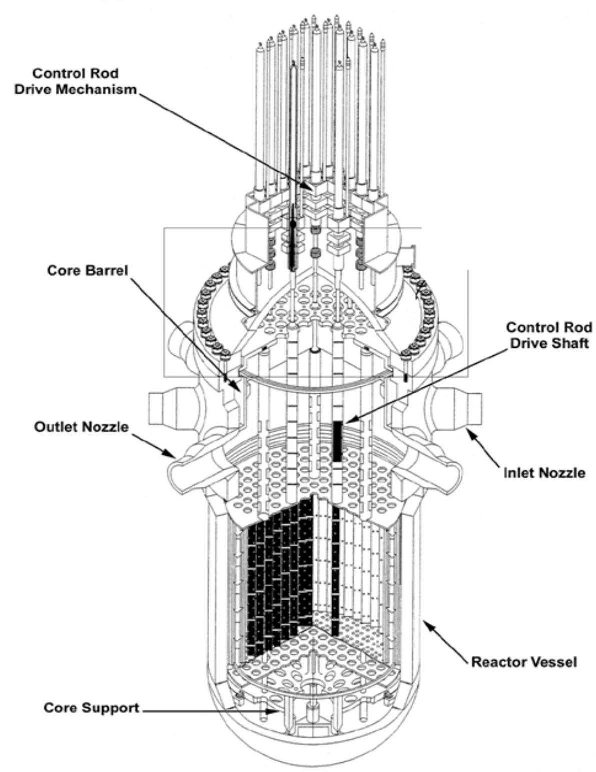
Corrosion, caused by the boric acid, damaged the vessel head next to Nozzle No. 3, creating an irregular cavity about 4 inches by 5 inches and approximately 6 inches deep. The cavity penetrated the carbon steel portion of the vessel head, leaving only the stainless steel lining. The liner thickness varies somewhat with a minimum design thickness of 1/8 inch.

Earlier indications of the problem: Through-Wall Cracking of Nozzles in France and at the Oconee Nuclear Power Station in South Carolina

In the early 1990's control rod drive mechanism nozzle cracking was discovered at a nuclear plant in France. These cracks penetrated the nozzle wall along the length of the nozzle (referred to as 'axial' cracking). In 1997 the NRC issued Generic Letter 97-01 to gather information on the inspection activities for possible cracking in the control rod drive mechanism nozzles in plants in the United States. Subsequently, through-wall circumferential cracks -- around the nozzle wall -- were discovered in two control rod drive mechanism nozzles at the Oconee Nuclear Power Station, Unit 3, in 2001. While axial cracking had been found at several other plants and repaired, circumferential cracking had not been seen before. Circumferential cracking is more significant because it could lead to complete separation of the nozzle and a resulting loss of coolant accident.

After the Oconee discovery, the NRC issued Bulletin 2001-01, requiring all pressurized water reactor (PWR) operators to report to the NRC on structural integrity of the nozzles, including the extent of any nozzle cracking and leakage and their plans to ensure that future inspections would guarantee structural integrity of the reactor vessel boundary. The NRC's Bulletin instructed nuclear power plants with similar operating history to Oconee Unit 3, including Davis-Besse, to inspect their reactor vessel head penetrations by December 31, 2001, or to provide a basis for concluding that there were no cracked and leaking nozzles.

Typical Pressurized Water Reactor



FirstEnergy Nuclear Operating Company requested an extension of the inspection deadline until its refueling outage beginning March 30, 2002, and provided the technical basis for its request. The NRC did not allow the plant to operate until March 30, but agreed to permit operation until February 16, provided that compensatory measures were taken to minimize possible crack growth during the time of operation. The NRC was unaware that nozzle leakage or corrosion had occurred at Davis-Besse when it agreed to the February 16 date.

Boric Acid Corrosion Control Procedure

The water that circulates through a pressurized water reactor to cool the nuclear fuel contains a low concentration of boric acid. This borated water can potentially leak through flanges, pump and valve seals, and other parts of the reactor cooling system and cause corrosion, especially if the boric acid becomes a concentrated liquid.

The NRC has taken steps to make sure that PWR operators are aware of and pay attention to the corrosion boric acid can cause in certain environments:

- In 1986-89, the NRC issued a series of documents, called "generic communications," informing PWR licensees that boric acid can corrode and damage steel reactor components.

- The NRC's Generic Letter 88-05 requested PWR operators to implement a program to ensure that boric accid corrosion does not lead to degradation of the reactor cooling system components. All nuclear power plants with PWRs, including Davis-Besse, reported to NRC that the Boric Acid Control Procedures had been established and would be implemented.

Barriers Built into Nuclear Plants to Protect Public Health and Safety

The design of every nuclear power plant includes a system of three barriers which separate the highly radioactive material in the reactor fuel from the public and the environment. The Davis-Besse reactor head damage represented a significant reduction in the safety margin of one of these barriers, the reactor coolant system. The reactor coolant system, however, remained intact, as well as the other two barriers, the fuel and the containment.

1. <u>Fuel Pellets and Rods</u>

The first barrier is the fuel itself. The fuel consists of strong, temperature-resistant ceramic pellets made of uranium-oxide. The pellets are about the size of a little finger-tip. They retain almost all of the highly radioactive products of the fission process within their structure.

The pellets are stacked in a rod-shape with metal cladding made of a zirconium alloy. At Davis-Besse, each fuel rod is about 13 feet long. The rods are assembled and held into bundles, with each assembly containing 208 rods. The entire reactor core contains 177 fuel assemblies. Any fission products which escape from the pellets are captured inside the cladding of the rod, which is designed to be leak-tight. Small pin hole leaks do occasionally occur, however, and the operating license contains limits on the maximum allowable amount of leakage of radioactive materials from the fuel rods, and it specifies requirements for leakage monitoring.

2. <u>Reactor Coolant System</u>

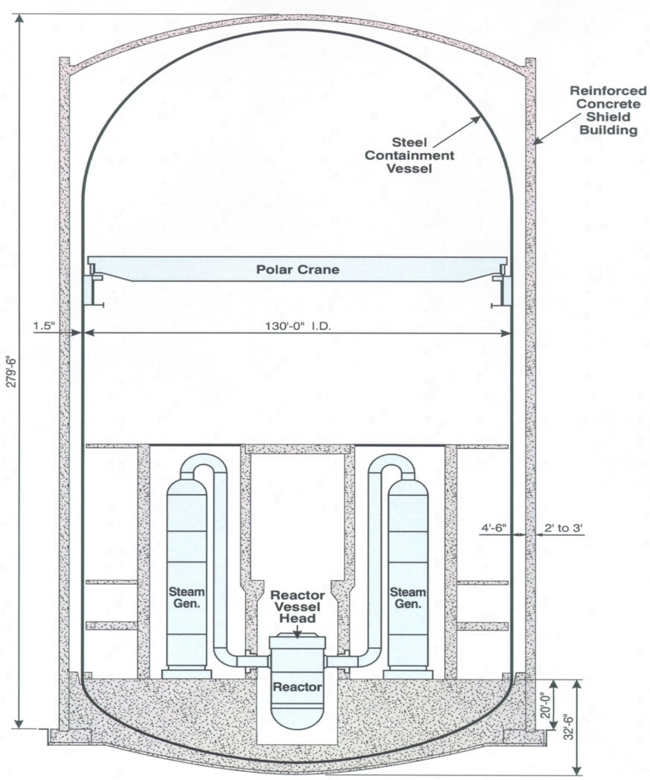
The second barrier is the reactor coolant system pressure boundary. The reactor core is contained inside the reactor pressure vessel, which is a large steel container. Thick steel pipes supply cooling water to the reactor, and carry away the heated water after it passes through the reactor core. The pressure vessel, the connected piping, and other connected components make up the reactor coolant system pressure boundary. At Davis-Besse, the reactor coolant system contains about 60,000 gallons of cooling water, circulated by four very large pumps at a rate of about 360,000 gallons per minute.

This system is designed to be leak-tight at operating conditions which include a water temperature of 605° F and a water pressure of 2,150 pounds per square inch. The operating license contains limits on the maximum allowable amount of leakage from the system, and it specifies requirements for monitoring the leak rate. If a leak is identified as being through any solid wall of the system (reactor vessel, cooling pipes or other components) continued operation of the plant is prohibited, no matter how small the leak rate.

3. <u>Containment Building</u>

The third barrier is the containment building. This is a large cylindrical building which contains the entire reactor coolant system. None of the piping that contains the high-temperature and high-pressure reactor coolant water extends outside the containment building. The containment is a 1 1/2 inch thick steel cylinder, rounded at the top and bottom, which is designed to be leak-tight. This steel structure is surrounded by a reinforced concrete shield building, which is the round building visible from the outside of the plant. Its walls are 2 to 3 feet thick.

Simplified View of Containment Building Interior



NRC's Response to Vessel Head Damage

The NRC responded to the vessel head degradation with a series of actions, some specific to Davis-Besse and others aimed at other PWR operators. The agency began a review of its regulatory activities as well.

<u>Davis-Besse</u>

On March 12, 2002, the NRC initiated an Augmented Inspection Team to examine conditions that led to the head degradation and on March 13, 2002, the NRC issued a Confirmatory Action Letter to Davis-Besse documenting a number of actions the plant needed to implement for the unit to be allowed to restart. On April 29, 2002, the NRC established an Oversight Panel under the Agency's Manual Chapter 0350, to coordinate and oversee NRC activities necessary to address repairs and performance deficiencies at the plant in order to guarantee that it can operate safely. The plant will not restart until the NRC is satisfied that plant operators have met all necessary safety requirements.

<u>Generic</u>

On March 18, 2002, the NRC issued Bulletin 2002-01, instructing PWR licensees to report on the condition of their head, past incidents of boric acid leakage and the basis for concluding that their boric acid inspection programs were effective. All plants sent their responses and indicated that no evidence of extensive corrosion of reactor vessel heads was found at these plants. On August 9, 2002, the NRC issued Bulletin 2002-02 advising PWR operators that more stringent inspection techniques may be necessary to detect head penetration nozzle cracks. Visual examination of reactor vessel heads and nozzles may need to be supplemented with other inspection techniques, such as the use of ultrasound, electric currents and liquid dyes.

<u>NRC Davis-Besse Oversight Panel</u>

An NRC Davis-Besse Oversight Panel was created to make sure that all corrective actions, required to ensure that Davis-Besse can operate safely, are taken before the plant is permitted to restart and that Davis-Besse maintains high safety and security standards if it resumes operations. Should the plant restart, the Oversight Panel will evaluate if Davis-Besse's performance warrants reduction of the NRC's heightened oversight and, if so, recommend to NRC management that the plant return to a regular inspection schedule. The panel was established under the agency's Manual Chapter 0350 and thus is often referred to as the "0350 panel."

The panel brings together NRC management personnel and staff from the Region III office in Lisle, Illinois, the NRC Headquarters office in Rockville, Maryland and the NRC Resident Inspector Office at the Davis-Besse site. The eight-member panel's chair and co-chair are John Grobe, a senior manager from Region III and William Dean, a senior manager from NRC headquarters.

As part of determining if plant corrective actions are adequate to support restart, the Oversight Panel will evaluate FirstEnergy's return to service plan, which is divided into seven areas of performance that the utility calls "building blocks." A series of NRC inspections will be performed to verify the company is taking proper actions in each of the seven areas. These reviews will include the work by the FirstEnergy staff and, in addition, the NRC staff will perform independent inspections in each of the "building block" areas.

Issues to be resolved in order for Davis-Besse to restart

The NRC Oversight Panel will only consider recommending that Davis-Besse resume operations when the plant has demonstrated its readiness to operate safely. Key elements will include:

- Davis-Besse management and personnel properly understand the technical, organizational, programmatic and human performance problems that led to the extensive degradation of the plant's reactor vessel head.
- Davis-Besse enhances programs for operating the plant safely, detecting and correcting problems, controlling boric acid corrosion, and is fostering a more safety-conscious environment among plant managers and workers.
- Davis-Besse improves the performance standards of its managers and workers, including their "ownership" of the quality of work products and the safety focus of decision-making.
- The replacement of the vessel head is technically sound and all reactor components are inspected, repaired as necessary, and demonstrated to be ready for safe operation.
- Plant safety systems inside and outside containment are inspected, repaired as necessary, and have been confirmed to be ready to resume safe operation of the plant.
- Plant operators demonstrate appropriate safety focus and readiness to restart the plant.
- Any organizational or human performance issues resulting from the ongoing investigation conducted by the NRC's Office of Investigations are addressed.
- All licensing issues that have arisen as a result of the reactor head replacement have been resolved.

What Happens If the Plant is Allowed to Restart

If the facility is permitted to restart, the 0350 Oversight Panel will continue to monitor plant activities and operations until panel members are confident that the root cause(s) of the problem have not recurred. Should FirstEnergy achieve that performance level, the 0350 Oversight Panel would recommend to NRC management that responsibility for the plant oversight be transferred back to the Region III line organization for monitoring under the Reactor Oversight Process. The panel would then cease to exist. Should FirstEnergy not demonstrate sustained improved performance, the panel will recommend appropriate regulatory actions.

Public Participation in the Process

The NRC's experience is that members of the public, including public officials and citizens, often raise questions or provide insights that are important to consider. If you have questions or want to provide information or a point of view, please contact us. For feedback on this newsletter, contact Viktoria Mitlyng 630/829-9662 or Jan Strasma 630/829-9663 (toll free 800/522-3025 - ext -9662 or -9663). E-mail: opa3@nrc.gov. Extensive information about the Davis-Besse reactor vessel head damage and the ensuing activities is available on the NRC web site: http://www.nrc.gov - select "Davis-Besse" under the list of key topics.