Davis-Besse Reactor Vessel Head Damage
NRC UPDATE

June 2003

This is the tenth 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 Resident Inspector Staff Changes

The NRC is adding a third resident inspector to its Davis-Besse staff as a result of the performance deficiencies associated with the reactor vessel head degradation. Most plants typically have two resident inspectors. The third resident inspector will remain at Davis-Besse until the agency decides there is no longer a need for such additional oversight.

Christopher S. "Scott" Thomas remains the senior resident inspector at Davis-Besse. Prior to coming to Davis-Besse in January 2002, Scott was a resident inspector at the Prairie Island Nuclear Power Station in Minnesota. He specialized in nuclear engineering with the U.S. Navy for 15 years before joining the NRC. He holds a master's degree in environmental engineering.

Douglas S. Simpkins recently left Davis-Besse, where he had been a resident inspector since 1999, to assume the responsibilities of senior resident inspector at the Edwin I. Hatch Nuclear Power Station in Georgia.

John E. "Jack" Rutkowski has recently assumed resident inspector duties at Davis-Besse, replacing Simpkins. Prior to joining the NRC in 2002, Jack held a wide range of technical and management positions in the nuclear industry. He also

Ongoing and Planned NRC Inspections

The NRC has a series of inspections planned before any decision on whether or not the Davis-Besse plant may resume operations. These inspections include:

- **Ongoing -** Management and Human Performance, Phase III (Safety Culture) - This inspection focuses on FENOC's actions to improve management effectiveness and human performance and its processes to survey and assess the safety culture among the staff at Davis-Besse – how the management and workers will deal with safety concerns.
- **Ongoing** - Corrective Action Team Inspection - This inspection looks at the effectiveness of the corrective action program at Davis-Besse – how the utility finds, evaluates, and fixes problems.
- **Ongoing -** Safety System Design Reviews - The utility's Systems Health verification program and earlier NRC inspections had found potential design questions that needed to be resolved. This inspection will look at the effectiveness of the design reviews.
- **Planned -** Reactor Vessel Test (Normal Operating Pressure) - This inspection will monitor the plant's test of the reactor vessel and associated piping to assure there are no leaks in the system.
- **Planned -** Assessment of Backlog Issues - This inspection will evaluate the work Davis-Besse plans to defer until after the plant has resumed operations or to be performed during future outages. This review will consider the appropriateness and safety impact of the proposed deferrals.
- **Planned -** Restart Assessment Team - As the utility nears the point where it will seek NRC authorization for restart, this team inspection will thoroughly review the readiness of the plant and the plant staff to resume plant operations safely and in compliance with NRC requirements.

served in the U.S. Navy. He holds a master's degree in nuclear science and engineering and a master's degree in business administration.

Monica P. Salter-Williams will be joining Thomas and Rutkowski in September 2003. Prior to joining the NRC last year, she worked as an engineer at the Three Mile Island Nuclear Power Station in Pennsylvania. Salter-Williams has a master's degree in nuclear engineering.

Resident inspectors document the results of their activities in publicly available reports every six-to- eight weeks. The most recent ***Resident Inspector Report 03-04*** *for Davis-Besse was issued on May 9. All Davis-Besse inspection reports can be viewed on the NRC's Davis-Besse web pages.*

Ongoing Engineering Issues at Davis-Besse

FirstEnergy is dealing with several engineering and design issues which emerged during the company's extensive design and functional reviews of important plant safety systems.

The utility met with the NRC Oversight Panel on May 7 in the Region III Office (Lisle, Illinois) to review the status of the resolution of the engineering and design issues. FirstEnergy concluded that with the resolution of the engineering and design issues, there would be reasonable assurance that the Davis-Besse systems would be able to perform their intended safety functions.

Among the issues being addressed by FirstEnergy:

- The emergency diesel generator room ventilation system may not have sufficient cooling capability when outside temperatures are high.
- Certain relays that are part of the system that starts safety equipment were replaced earlier in the outage, but the replacement relays do not have the correct voltage rating.
- Deficiencies were found in the analysis of whether the plant's electrical distribution system provided the necessary minimum voltage to safety equipment throughout the plant. The electrical distribution analyses are being updated.
- A design issue with the high pressure injection pumps was identified by FENOC where under certain specific accident conditions, the pumps could be damaged. The utility is reviewing options to correct the problem, including possible replacement of the pumps.
- FirstEnergy identified a problem with several air-operated valves requiring modifications and adjustments to valve actuators to make sure they will operate properly during certain accident conditions.

The NRC continues to evaluate the safety systems and the ongoing work by FirstEnergy to resolve these engineering and design issues.

Reactor Test Planned to Check for Possible Leakage

FirstEnergy is planning a special seven-day test of the reactor cooling system to assure there are no leaks, particularly where tubes pass through the bottom of the reactor. The reactor will not be started up for the test; heat added through the operation of the reactor cooling pumps will be sufficient to reach normal operating pressure and approach normal operating temperature.

Update: "Red" Safety Significance Determination Now Final

The NRC staff has issued the final determination of the safety significance of the performance deficiencies at the Davis-Besse Nuclear Power Plant which led to the cracking of the control rod drive tubes and the resulting corrosion damage to the reactor vessel head, finding that those deficiences were of "high safety significance." Under its safety significance determination process, NRC officials classify inspection findings at nuclear power plants as being one of four colors which delineate increasing levels of safety significance, beginning with "green" and progressing to "white," "yellow" or "red." A "red" category indicates high safety significance.

In February the NRC staff issued its preliminary "red" findings, and on April 24, 2003, FirstEnergy responded that it did not contest the preliminary finding and provided some recommended minor changes to the NRC's evaluation.

Under the agency's Reactor Oversight Process, a "red" finding would result in strong actions by the NRC to improve plant performance, including development of a performance improvement plan by the utility and follow-up NRC inspections. In the case of Davis-Besse, the NRC implemented its procedure for plants in extended shutdown with performance problems and established a special NRC Oversight Panel to coordinate the agency's response to the performance problems which led to the reactor vessel head damage. This oversight process goes beyond that which would apply to plants where a "red" finding was identified.

Resolved Restart Checklist Items

The Oversight Panel has created a "restart checklist" categorizing 29 actions in seven major areas FirstEnergy needs to complete before the NRC can consider making a decision on whether Davis-Besse may restart. The NRC oversight panel has determined that the utility has adequately completed eleven of those actions:

Items closed in the past month:

3.d, e,f,g - Boric Acid Corrosion Management Program, Reactor Coolant System Unidentified Leakage Monitoring Program, In-Service Inspection Program, and Modification Control Program.

Items previously closed:

1. a The technical part of the root cause evaluation of the corrosion damage to the reactor vessel head.
6.a-f Licensing issues related to the installation and operability of the new reactor vessel head.

Pending NRC Inspection Reports

The following inspection reports are in preparation and will be posted on the NRC web site on the Davis-Besse news and correspondence page. Go to http://www.nrc.gov and select 'Davis-Besse' from the key topics list.

Radiation Protection - This inspection examined the Davis-Besse program for radiation protection for workers at the plant as well as for the general public. The inspection was an outgrowth of earlier inspections of worker radiation exposures and minor radioactive contamination that was found in offsite locations. The inspection findings were discussed in a public meeting April 15, and an inspection report is pending.

Note: Change in Day and Location from Previous Meetings
Next Davis-Besse Oversight Panel Meetings - 2 p.m. and 7 p.m. - Wed., July 9
Oak Harbor High School Auditorium - 11661 West State Route 163, Oak Harbor

Containment Sump Modification - This inspection, completed April 11, reviewed the design and installation of new screens for the containment sump, which increased the surface area to avoid possible clogging of the screens during certain accident conditions. The inspection results are under review, and a report is pending.

Integrated Containment Leak Rate Test - This inspection monitored the testing by the plant staff of the reactor containment to assure that it meets the NRC requirements for "leak-tightness" of the containment. The results of the test, conducted April 8-9, are under review, and the inspection team's report is pending.

Program Effectiveness - This inspection examined the effectiveness of the plant's safety-significant programs. This review included the corrective actions program, boric acid corrosion control program, the plant's in-service inspection, the operating experience programs, including the adequacy of improvements and their implementation, and others. The inspection results are under review, and the inspection team's report is pending.

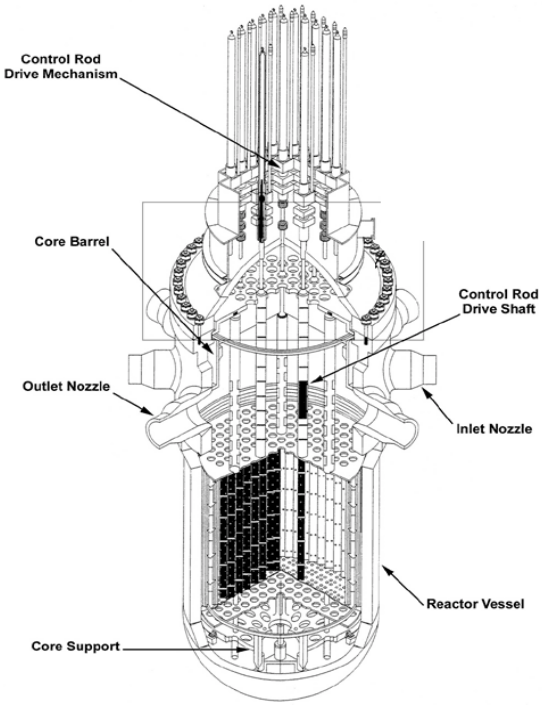
Background: What Happened at Davis-Besse

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. Subsequent examination by Framatome, FirstEnergy's contractor, found evidence of a series of cracks in the liner, none of which was entirely through the liner wall.

Typical Pressurized Water Reactor



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.

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.

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 acid 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 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.

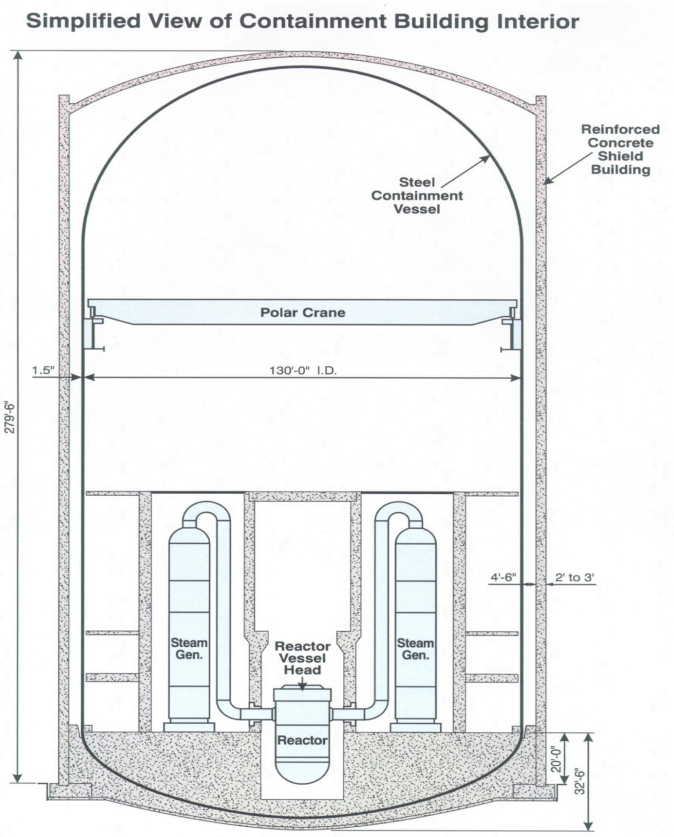
1. <u>Fuel Pellets and Rods</u>

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 made of a zirconium alloy. At Davis-Besse, each fuel rod is about 13 feet long. The rods are assembled into bundles, with each assembly containing 208 rods. The 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 requires leakage monitoring and contains limits on the maximum allowable leakage of radioactive materials from the fuel rods.

2. Reactor Coolant System

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 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 any leakage. 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. Containment Building

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 ½ 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.

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 plants. The agency began a review of its regulatory activities as well.

Davis-Besse

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.

Generic

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. In October, the agency also requested PWR licensees to provide additional information on their boric acid inspection program with greater detail than initially covered in the responses to Bulletin 2002-01.

On February 11, 2003, the NRC an order to all Pressurized Water Reactor operators establishing interim inspection requirements for reactor pressure vessel heads. The Order requires specific inspections of the reactor pressure vessel head and associated penetration nozzles depending on the licensee's susceptibility to primary water stress corrosion cracking.

NRC Davis-Besse Oversight Panel

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.

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 Ruland, 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 are being 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.
- Resolution of radiation protection issues associated with the radiation exposure to workers during steam generator work and the particle contamination found in offsite locations.
- Modification of the strainer system for the containment sump, which would be the source of cooling water for recirculation in the event of a loss-of-coolant accident.

What Happens If the Plant is Allowed to Restart

If the facility is permitted to restart, the NRC 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 NRC 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.