

# DAVIS-BESSE

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*Oak Harbor, OH*

**Owner:** Toledo Edison Company

**Outage dates (duration):** February 16, 2002 to March 16, 2004 (2.1 years)

**Reactor type:** Pressurized water reactor

**Reactor age when outage began:** 23.5 years

**Commercial operations began:** July 31, 1978

**Fleet status:** Oldest of four reactors owned by the company

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## Synopsis

Davis-Besse was shut down on February 16, 2002, to enter a refueling outage. The refueling outage had been scheduled to start in late March, but it was moved up to accommodate the NRC's concerns about potential cracking of the control rod drive mechanism (CRDM) nozzles. Workers inspecting the CRDM nozzles identified crack indications in five of the 69 CRDM nozzles with through-wall leak indications at three nozzle locations. During the attempted repair to one of the cracked, leaking nozzles, workers discovered significant damage to the reactor vessel head. Borated water leaking from the cracked CRDM nozzle had formed boric acid that corroded the carbon steel head down to its stainless steel liner. Ensuing inquiries into that serious problem identified many other hardware problems, each stemming from a poor safety culture at the plant. The hardware problems were largely corrected by fall 2003, but it took until the following spring for the NRC to be convinced that the safety culture had been sufficiently restored to permit restart.

## Process Changes

The NRC's Lessons Learned Task Force made 51 recommendations on things the agency should do to prevent an event similar to the one at Davis-Besse from happening again. The NRC commissioners accepted 49 of the recommendations and directed its staff to implement them. The industry developed a formal, specific process for periodically evaluating safety culture at each plant site. The NRC, at the urging of the U.S. Senate, also incorporated measures into its reactor oversight process to formally handle safety culture issues.

## Commentary

Prior to the discovery of the gaping hole in the reactor head, the NRC had considered Davis-Besse to be among the best, if not the best, performing plant in Region III. The Institute for Nuclear Power Operations was somewhat less enamored with Davis-Besse, but still rated the overall performance as good. The gaping hole in the reactor head symbolized the gap between perception and reality. The perception that Davis-Besse was a top performer prevented the NRC from looking for evidence to the contrary and to dismiss evidence that it did see. While the lessons learned by the NRC may make it harder for them not to look for problems, and harder to overlook those problems that are found, there will almost undoubtedly be another

event like that at Davis-Besse. Davis-Besse was not caused by a lack of data or an inaccurate assessment of available data; it was caused by an underlying belief system that Davis-Besse was safe and no data could show otherwise. Until that belief system is exorcised from the regulatory process, the names and circumstances will change but extended outages will continue to produce nuclear power at higher costs and lower safety levels than is necessary.

## NRC Systematic Assessment of Licensee Performance (SALP) History

Date	Operations	Radiological Controls	Maintenance	Surveillance Testing	Emergency Preparedness	Fire Protection	Security	Outage Management	Quality Assurance	Licensing	Training
12/1980	2	2	2	2	3	2	3	2	2	n/a	n/a
9/1982	2	1	3	2	1	2	2	1	3	2	n/a
10/1983	2	1	3	2	2	2	2	1	n/a	2	n/a
12/1984	2	1	3	2	3	3	2	1	3	2	3
9/1987	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6/1988	2	1	2	3	2	3	1	1	2	2	2
	Operations	Radiological Controls	Maintenance/Surveillance Testing		Emergency Preparedness	Security		Engineering and Technology		Safety Assessment and Quality Verification	
7/1989	2	2	2		1	1		2		2	
11/1990	2	2	2		1	1		2		2	
	Operations		Maintenance		Engineering			Plant Support			
4/1992	2		1		2			2/1/1			
9/1993	2		1		1			2/1/1			
3/1995	1		1		1			1			
3/1997	2		1		1			1			

NOTE: A rating of 1 designated a superior level of performance where NRC attention may be reduced. A 2 rating designated a good level of performance with NRC attention at normal levels. A rating of 3 designated an acceptable level of performance where increased NRC attention may be appropriate.

## Details

*March 21, 1997:* The NRC regional administrator tells FirstEnergy during a public meeting, “You obviously are doing very well in identifying problems. This is certainly one of the better, if not the best, performers in the region.”<sup>1</sup>

*September 4, 1997:* The NRC issued the report from its Architect/Engineer Design Inspection team evaluation of the high-pressure injection (HPI) and low-pressure injection (LPI) systems at Davis-Besse:

*“The team concluded that the HPI and LPI systems were capable of performing their safety functions required by their design bases, adhered to the licensing basis, and were consistent with the commitments in the UFSAR [updated final safety analysis report].”<sup>2</sup>*

*April 25, 1998:* Condition Report (CR) 1998-0767 was initiated by a worker at Davis-Besse following a videotaped inspection of the reactor vessel head the previous day “indicated several ‘fist’ size clumps of Boric Acid.... Where clumps were not present, a light dusting of Boric Acid was found covering the surface area of the vessel head.”<sup>3</sup>

*June 24, 1998:* A tornado caused damage to the electrical switchyard, cooling tower, and turbine building at Davis-Besse. The reactor automatically shut down from 99 percent power after the turbine tripped. Operators declared an alert due to the loss of offsite power.<sup>4</sup>

*June 27, 1998:* The NRC sent Centerior Service Company its Restart Issues List for the items required to be resolved prior to restarting Davis-Besse from the tornado outage. The NRC developed this list in accordance with its Manual Chapter 0350. The list contained 19 items, including (1) determine why 345 kV switchyard breaker 34562 cycled opened and closed many times; (2) determine why the #1 emergency diesel generator could not be started from the main control room but could be started at a local panel; (3) determine why the control room emergency ventilation system would not operate in the water-cooled mode; (4) determine why the control rod group 7 position indication remained at 89 percent event after the reactor trip; (5) determine why the #2 atmospheric vent valve stayed at 10 to 14 percent open despite its demand signal being zero percent; (6) determine why the pressurizer quench tank level indicated a loss of about 3,500 gallons of water but no water was found in the reactor coolant drain tank or containment sump; (8) determine why the emergency notification system was disabled by the loss of offsite power; and (11) determine if the fire detection system remained functional following the loss of offsite power.<sup>5</sup>

*September 18, 1998:* Workers call the NRC's Incident Response Center to report that the nuts on two of eight body-to-bonnet bolts on pressurizer spray valve RC-2 were found missing. Workers observed a buildup of boric acid crystals on the valve, which had been replaced at the refueling outage in spring 1998.<sup>6</sup>

*September 24, 1998:* Operators manually tripped the reactor from 100 percent power after a feedwater regulating valve unexpectedly closed during testing.<sup>7</sup>

*October 14, 1998:* Operators manually tripped the reactor from 100 percent power after cooling water flow to the reactor coolant pumps was unexpectedly lost during maintenance.<sup>8</sup>

*October 19, 1998:* The reactor automatically tripped from four percent power during startup. An operator placed the anticipatory reactor trip system channel 1 bypass switch in normal position (instead of bypass) and the reactor unexpectedly tripped.<sup>9</sup>

*December 1, 1998:* The NRC approved the transfer of the operating license for Davis-Besse from Toledo Edison to FirstEnergy Nuclear Operating Company (FENOC).<sup>10</sup>

*June 4, 1999:* The NRC issued a notice of violation to FirstEnergy for two violations related to boric acid damage to the RC-2 valve.<sup>11</sup>

*July 1, 1999:* FirstEnergy responded to the NRC's notice of violation regarding boric acid damage to the RC-2 valve. FirstEnergy stated, "[We] do not believe that the apparent violations are indicative of recurring problems with the material control or the corrective action programs" and "The collective lack of sensitivity during maintenance and corrective action of the component bolting represented an unacceptable, but isolated, breakdown in the control of licensed activities to maintain the RCPB [reactor coolant pressure boundary]." FirstEnergy promised it was "developing a revision to the Boric Acid control program and the Work Process Guideline on plant leakage, including the benchmarking of industry standards and practices, to reflect higher standards for monitoring, evaluating, documenting and controlling boric acid leakage; and providing additional training to management and the technical staff to address the technical issues of boric acid control, the DBNPS [Davis-Besse Nuclear Power Station] Boric Acid Control Program and requirements, lessons learned from the RC-2 event, and industry experience."<sup>12</sup>

*July 30, 1999:* Condition Report 1999-1300 was initiated at Davis-Besse based on results from laboratory analysis of materials deposited on radiation monitors inside containment. The results indicated the material was primarily iron oxide with an indication that corrosion caused the iron oxide granules.<sup>13</sup>

*April 6, 2000:* Condition Report 2000-0782 was initiated at Davis-Besse during the spring 2000 refueling outage. Workers performing the initial reactor vessel head inspection the previous day reported “Boron deposits were ‘lava-like’ and originating from the ‘mouse hole’ and CRDM flanges.”<sup>14</sup> A copy of this CR, with seven color photographs attached including the now infamous “Red Photo,” was handed to an NRC inspector evaluating in-service inspection program.

*September 11, 2000:* The NRC issued a report for the first safety system design and performance capability inspection performed at Davis-Besse. The NRC inspection team examined one system—the component cooling water system—and identified seven Green findings, two no-color findings, and five violations of NRC requirements.<sup>15</sup>

*November 15, 2000:* FirstEnergy submitted to the NRC a listing of new and revised licensing commitments made during the past operating cycle pursuant to the Nuclear Energy Institute document, “Guideline for Managing NRC Commitments.” FirstEnergy revised its February 1, 1986, and August 14, 1986, commitments to test the containment air cooler fans monthly by measuring the inlet plenum differential pressure to allow alternate methods, such as measuring fan motor currents.<sup>16</sup>

*April 23, 2001:* Condition Report 2001-0110 was initiated at Davis-Besse because the filters on the radiation monitors inside containment were being changed out more frequently. Filters that used to last several months were being replaced every 14 days. According to the CR, “All filters contained Boron crystals.”<sup>17</sup>

*July 23, 2001:* Condition Report 2001-1822 was initiated at Davis-Besse because the filters on the radiation monitors inside containment were being changed out more frequently. The replacement frequency increased to every two to seven days. The CR stated, “Currently we still have a small RCS [reactor coolant system] leak in CTMT [containment]. This is indicated by boron deposits on the clogged filters.”<sup>18</sup>

*August 3, 2001:* The NRC issued Bulletin 2001-01 to the owners of pressurized water reactors, including FirstEnergy. The owners were required to submit information to the NRC regarding the condition of CRDM nozzles. Owners of plants susceptible to CRDM nozzle cracking that were not planning to conduct nozzle inspections on or before December 31, 2001, were requested to provide the NRC with justification for continued operation.<sup>19</sup>

*September 25, 2001:* NRC staff briefed the NRC executive team on the responses to Bulletin 2001-01 and the staff’s recommended next steps. Twelve reactors were identified as having high susceptibility to CRDM nozzle cracking. Four reactors—including Davis-Besse—were identified as having high susceptibility but management was not planning to conduct inspections by December 31, 2001. The NRC staff proposed contacting the owners of these four reactors by October 1, 2001, to encourage them to conduct the inspections by the end of the year.<sup>20</sup>

*September 28, 2001:* The NRC staff called the owners of Davis-Besse, H.B. Robinson, North Anna Unit 2, and Surry Unit 2 to discuss the CRDM nozzle issue. These were the four reactors identified by the NRC as having high susceptibility to CRDM nozzle cracking but no plans to inspect the nozzles by December 31, 2001.<sup>21,22</sup>

*October 2, 2001:* The NRC staff briefed the NRC executive director for operations (EDO) about the responses to Bulletin 2001-01. The NRC staff told the EDO: "Information to date provides a technical basis to show that conditions adverse to quality are being managed for most, but not all plants in the short-term." The NRC staff identified Davis-Besse, H.B. Robinson, North Anna Unit 2, and Surry Unit 2 as lacking a technical basis.<sup>23</sup>

*October 3, 2001:* The NRC staff briefed the NRC commissioners' technical assistants about the responses to Bulletin 2001-01. The NRC staff told the technical assistants: "Information to date provides a technical basis to show that conditions adverse to quality are being managed for most, but not all plants in the short-term." The NRC staff identified Davis-Besse, H.B. Robinson, North Anna Unit 2, and Surry Unit 2 as lacking a technical basis.<sup>24</sup>

*October 11, 2001:* The NRC staff briefed the NRC's Committee to Review Generic Requirements (CRGR) about the responses to Bulletin 2001-01. The NRC staff told the CRGR: "Information to date provides a technical basis to show that conditions adverse to quality are being managed for most, but not all plants in the short-term." The NRC staff identified Davis-Besse, North Anna Unit 2, and Surry Unit 2 as lacking a technical basis.<sup>25</sup>

*October 11, 2001:* FirstEnergy representatives briefed the NRC commissioners' technical assistants about Davis-Besse's position relative to Bulletin 2001-01. According to the NRC summary of this meeting, First Energy stated, "All CRDM penetrations were verified to be free from the characteristic boron deposits using video recordings from the previous 2 refueling outages. These videos were made before and after cleaning the head."<sup>26</sup>

*October 15, 2001:* The NRC staff distributed a draft order requiring the shutdown of reactors by December 31, 2001, for CRDM nozzle inspections.<sup>27</sup>

*October 24, 2001:* The NRC staff met with FirstEnergy representatives about Davis-Besse and the CRDM nozzle issue. FirstEnergy informed the NRC that 24 CMDR nozzle penetrations were not examined during the April 2000 refueling outage.<sup>28</sup>

*November 2001:* The merger between FirstEnergy and GPU Inc. was completed. FirstEnergy paid \$4.5 billion in cash and common stock for GPU.<sup>29</sup>

*November 5, 2001:* The NRC staff briefed the NRC's director of the office of nuclear reactor regulation (NRR) and the EDO on the status of the draft shutdown order for Davis-Besse.<sup>30,31</sup>

*November 8, 2001:* FirstEnergy showed NRC staff selected portions of the reactor vessel head inspection videotapes from the 1998 and 2000 refueling outages.<sup>32</sup>

*November 9, 2001:* The NRC staff, industry representatives, and FirstEnergy representatives briefed the NRC's Advisory Committee on Reactor Safeguards (ACRS) about the CRDM nozzle cracking issue in general and Davis-Besse's status in particular. FirstEnergy told the ACRS: "The two inspections done in 1998 and 2000 were really looking for the impact of boric acid leakage from leaky flanges that we had subsequently repaired that what was the impact to that. So the view that we got from those was in many cases some of the drives you couldn't even get a good view of. There were many cases, the camera angle was looking upwards because it was looking at the structure material of the service structure on top of the head... So what really comes down to it, the best video we have on this goes all the way back to 1996."

Commissioner Edward McGaffigan appeared before the ACRS to state: “There are some issues that are going to come before us that I am not sure you are fully on top of. That is whether we are going to shut down some people early by order. Davis-Besse was before you. They are probably the one with the most at stake.”<sup>33</sup>

*November 14, 2001:* The NRC staff briefed the NRC commissioners’ technical assistants on the status of the reactors having high susceptibility to CRDM nozzle cracking. Only Davis-Besse and DC Cook Unit 2 remained on the list of such reactors that were not planning to inspect the nozzles by December 31, 2001.<sup>34</sup>

*November 16, 2001:* The NRR director transmitted to the EDO the draft order requiring FirstEnergy to shut down Davis-Besse on or before December 31. The NRR director informed the EDO of his intention to issue the order five days after the EDO provides the order to the Commission.<sup>35</sup>

*November 21, 2001:* The EDO transmitted to the NRC chairman and commissioners the order requiring Davis-Besse to be shut down on or before December 31, 2001. The EDO indicated the order would be issued no sooner than five working days from November 21.<sup>36</sup>

*November 28, 2001:* NRC staff met with FirstEnergy. The company committed to a number of measures if Davis-Besse could operate until February 16, 2002, instead of shutting down by the end of 2001.<sup>37</sup>

*November 29, 2001:* The NRC staff briefed the EDO about the decision NOT to issue the order requiring Davis-Besse to be shut down by December 31, 2001, but to allow the reactor to operate until February 16, 2002. In the final summation slide, the NRC staff outlined the five criteria governing the decision and how Davis-Besse basically did not meet them:

- Current regulations are met. “It is likely that current regulations are not met with respect to TS [technical specifications; part of the operating license issued by the NRC] requirements and GDC [general design criteria in federal regulations]”
- Defense-in-depth philosophy maintained. “It is likely that one of 3 barriers is lost.”
- Sufficient safety margins are maintained. “It is likely that safety margins are reduced.”
- Only a small increase in CDF [core damage frequency] results. “Incremental CDF (no comp measures) is 1.1E-06/ry to 1.3E-04/ry.”
- The basis of risk measurement is monitored during performance. “Will not occur until inspection is performed.”<sup>38</sup>

*December 4, 2001:* The NRC informed FirstEnergy that Davis-Besse could operate until February 16, 2002, without conducting the CRDM nozzle inspections requested in Bulletin 2001-01.<sup>39</sup>

*January 9, 2002:* The NRC staff briefed the staff of the House Energy & Commerce Committee about the CRDM nozzle issue.<sup>40</sup>

*February 16, 2002:* Operators shut down Davis-Besse for a scheduled refueling outage.

*February 21, 2002:* Condition Report 2002-00685 was initiated at Davis-Besse after workers discovered boric acid on the reactor vessel head: “The large boron accumulation is in the same region as seen in 12RFO [the 12<sup>th</sup> refueling outage in April 2000], but not as deep.”<sup>41</sup>

*February 26, 2002:* Condition Report 2002-00846 was initiated at Davis-Besse after workers noted “more boron than expected was found on the top of the head.”<sup>42</sup>

*February 27, 2002:* Condition Report 2002-00891 was initiated at Davis-Besse when “Ultrasonic testing (UT) performed on the #3 Control Rod Drive Mechanism (CRDM) nozzle (location G9) revealed indications of through wall axial flaws in the weld region.... These indications represent potential leakage paths.”<sup>43</sup> The CRDM nozzle crack indication was reported to the NRC that same day.<sup>44</sup>

*February 28, 2002:* Condition Report 2002-00932 was initiated at Davis-Besse when workers completed the ultrasonic examination of all 69 CRDM nozzles. Five CRDM nozzles were determined to have axial crack indications with three of them exhibiting through-wall leakage.<sup>45</sup>

*March 4, 2002:* The NRC sent FirstEnergy its annual assessment of performance at Davis-Besse. The NRC stated:

*“Davis-Besse operated in a manner that preserved public health and safety and fully met all cornerstone objectives. Plant performance for the most recent quarter, as well as the first two quarters of the assessment cycle, was within the Licensee Response Column of the NRC’s Action Matrix, based on all inspection findings being classified as having very low safety significance (Green) and all PIs indicating performance at a level requiring no additional NRC oversight (Green).”*<sup>46</sup>

*March 8, 2002:* Condition Report 2002-01128 was initiated at Davis-Besse after “Evaluation of bottom up ultrasonic test data in the area of reactor pressure vessel head nozzle number 3 shows significant degradation of the reactor vessel head pressure boundary.”<sup>47</sup> The NRC publicly reported significant “metal loss” in the reactor vessel head.<sup>48</sup>

*March 11, 2002:* The NRC wrote to the Nuclear Energy Institute requesting answers by March 13, 2002, to questions about whether CRDM nozzle inspections conducted at other plants could have identified the reactor vessel head damage discovered at Davis-Besse.<sup>49</sup>

*March 12, 2002:* The NRC chartered an Augmented Inspection Team to travel to Davis-Besse and determine (1) the history of reactor coolant system operational leakage, (2) the history of reactor vessel head material condition issues, (3) the history of reactor vessel head inspections, and (4) the characterization of all reactor vessel head corrosion damage.<sup>50</sup>

*March 12, 2002:* The NRC issued information to the owners of all other operating pressurized water reactors about the reactor vessel head damage discovered at Davis-Besse.<sup>51</sup>

*March 13, 2002:* The NRC issued a Confirmatory Action Letter to FirstEnergy requiring the company to (1) quarantine components needed to address the root cause of the reactor vessel head damage, (2) determine the root cause of the head degradation, (3) evaluate the extent of condition relative to the entire reactor coolant system, (4) obtain NRC approval for the repair of the reactor vessel head, (5) obtain NRC approval for restarting the reactor, and (6) submit a plan within 15 days for assessing the safety significance of the reactor vessel head damage.<sup>52</sup>

*March 18, 2002:* The NRC required the owners of all other operating pressurized water reactors to provide the agency with information about reactor vessel head inspections at their facilities.<sup>53</sup>

*March 19–20, 2002:* The NRC conducted two days of public meetings with industry representatives and FirstEnergy representatives on the reactor vessel head degradation at Davis-Besse and its generic implications.<sup>54, 55</sup>

*March 21, 2002:* A financial company reported to its clients that the stocks of Dominion Energy, Duke Power, Exelon, and Entergy were sold off the day before in response to an NRC request for information about reactor vessel head degradation.<sup>56</sup>

*March 22, 2002:* FirstEnergy completed its preliminary probable cause analysis of the reactor vessel head degradation. FirstEnergy's root cause team reported that CRDM nozzle #3 had a crack develop in the 1987 to 1993 time frame; the crack propagated through-wall and began leaking in the 1994 to 1996 time frame; efforts during the 1998 refueling outage neither identified the leaking nozzle nor removed boric acid covering the nozzle #3 region; significant corrosion at nozzle #3 occurred during 1999 as evidenced by iron oxide in the containment atmosphere; and efforts during the 2000 refueling outage neither identified the leaking nozzle nor removed boric acid covering the nozzle #3 region.<sup>57</sup>

*April 4, 2002:* The NRC alerted the owners of all other operating pressurized water reactors to the warning signs of reactor vessel head corrosion that had been overlooked at Davis-Besse. The NRC informed these owners that the containment air coolers (CACs) were cleaned many times during the period between 1998 and 2000 to remove boron deposits that had been fouling the coolers' performance. In summer 1999, the NRC stated that workers noticed the "boric acid deposits removed from the CAC number 1 exhibited a rust-like color." During the 2002 refueling outage, 15 five-gallon buckets of boric acid were removed from the CAC ductwork and plenum. The NRC also informed the owners that air sampling systems inside the Davis-Besse containment had experienced problems beginning in 1999. Their filters had to be changed out more frequently. A chemical analysis in fall 1999 of the deposits on the filters identified the presence of ferric oxide and boric acid crystals.<sup>58</sup>

*April 9, 2002:* The NRC staff and industry representatives made presentations to a subcommittee of the NRC's Advisory Committee on Reactor Safeguards about the CRDM nozzle cracking problem and the reactor vessel head degradation at Davis-Besse.<sup>59</sup>

*April 10, 2002:* FirstEnergy proposed to the NRC staff in a public meeting its plan to cut out the damaged portion of the reactor vessel head at Davis-Besse and patch in a metal plug.<sup>60</sup>

*April 11, 2002:* The NRC's Advisory Committee on Reactor Safeguards was briefed by its subcommittee about the CRDM nozzle cracking problem and the reactor vessel head degradation at Davis-Besse.<sup>61</sup>

*April 16, 2002:* The Nuclear Information and Resource Service (NIRS) filed a Freedom of Information Act (FOIA) request for all records between the NRC and FirstEnergy related to the decision to allow Davis-Besse to operate past December 31, 2001, without the CRDM nozzle inspections requested by Bulletin 2001-01.<sup>62</sup>

*April 18, 2002:* FirstEnergy submitted its root cause report for the reactor vessel head degradation to the NRC. Among the contributing causes identified by the root cause team:

*"The boric acid deposits on the head changed from white to red. The expected color is white, with red indicating metal oxide.*

*The radiation monitor filter paper analysis contained metal oxide. There would have been no carbon steel in the leakage path from a postulated CRDM flange leak.*

*Reactor coolant system leakage would normally flash to steam, resulting in snowy boric acid deposits. The 1996 head inspection the deposits were solid flow, not loose powder.*

*Deposits of boric acid repeatedly formed on the CACs [containment air coolers], even after the proposed source had been repaired in mid-1999.*

*There was an increasing rate of boric acid accumulation on the head without a known corresponding increase in CRDM flange leakage.*<sup>763</sup>

*April 24, 2002:* A coalition of organizations and individuals petitioned the NRC to require FirstEnergy to have an independent party verify issues related to the reactor vessel head problem.<sup>64</sup>

*April 29, 2002:* The NRC announced that it had invoked its Manual Chapter 0350 process to oversee the restart activities at Davis-Besse.<sup>65</sup>

*May 8, 2002:* The NRC reported several senior management changes: Gary Leidich was hired from the Institute of Nuclear Power Operations to fill the newly created position of Executive Vice President, Lew Myers moved from being the senior vice president at Beaver Valley into the newly created position of chief operating officer, and L. William Pearce moved from being plant manager at Beaver Valley into the vice president of oversight.<sup>66</sup>

*May 15, 2002:* The NRC issued Revision 1 to its Confirmatory Action Letter on Davis-Besse. The revision expanded the scope of the original letter, which covered the proposed repair to the damaged reactor vessel head, to include the option of replacement with an undamaged head.<sup>67</sup>

*May 15, 2002:* The NRC chartered a Lessons Learned Task Force to “conduct an independent evaluation of the NRC staff’s regulatory processes related to assuring reactor vessel head integrity in order to identify and recommend areas of improvement applicable to the NRC and/or the industry.”<sup>68</sup>

*May 21, 2002:* FirstEnergy submitted its “Return to Service Plan” for Davis-Besse to the NRC. The plan detailed tasks to be performed related to seven areas: (1) reactor head resolution, (2) containment extent of condition, (3) system health assurance, (4) program technical compliance, (5) management and human performance excellence, (6) restart and post-restart testing, and (7) restart oversight. The second paragraph of the plan stated:

*“Prior to this point, the Davis-Besse plant had good operational performance. All NRC cornerstones were GREEN. Previous Institute of Nuclear Power Operations (INPO) evaluations also showed no significant weaknesses, with generally improving trends.”*<sup>69</sup>

*May 21, 2002:* At the company’s annual stockholders meeting in Akron, Ohio, FirstEnergy Chief Executive Officer H. Peter Berg stated that Davis-Besse could be restarted by the end of 2002.<sup>70</sup>

*May 22, 2002:* The NRC reported that Steve Moffitt, director of nuclear engineering at Davis-Besse, had been replaced by Jim Powers who held this position at the Perry nuclear plant.<sup>71</sup>

*May 23, 2002:* It was reported that FirstEnergy was the focus of a criminal investigation by the NRC related to the reactor vessel head damage at Davis-Besse.<sup>72</sup>

*May 23, 2002:* FirstEnergy announced that it had purchased an unused reactor vessel head from the owners of the unfinished Midland nuclear plant in Michigan and would use it to replace the damaged reactor vessel head at Davis-Besse.<sup>73</sup>

*May 23, 2002:* Consumers Energy, sellers of an unused reactor vessel head to FirstEnergy, filed a 10 CFR Part 21 report with the NRC for having failed since 1986 to maintain that component in accordance with the requirements of 10 CFR Part 50, Appendix B.<sup>74</sup>

*May 29, 2002:* Several additional senior management changes were reported at Davis-Besse: Guy Campbell, vice president at Davis-Besse from 1999 until 2002, was transferred to the newly created position of vice president over non-operating nuclear facilities (Three Mile Island Unit 2 and Saxton); John Wood, head of engineering for FirstEnergy, left the company; and Steve Moffitt moved from director of nuclear engineering at Davis-Besse to manager of lifecycle management at Perry.<sup>75</sup>

*June 24, 2002:* The Union of Concerned Scientists (UCS) filed a formal allegation with the NRC contending that the longstanding reactor coolant system leak at Davis-Besse deposited boric acid into containment that had not been considered when determining the minimum amount of trisodium phosphate dodecahydrate (TSP) placed in containment to control pH level following a loss of coolant accident.<sup>76</sup>

*July 2, 2002:* Condition Report 2002-02950 was initiated at Davis-Besse by a worker in the Operations department to ask whether the buildup of boric acid inside containment affected the ability of TSP to control pH level in event of a loss of coolant accident.<sup>77</sup>

*July 12, 2002:* FirstEnergy submitted Revision 1 of its return to service plan for Davis-Besse to the NRC. This revision contained the same focus areas as in the original plan, but added more specificity.<sup>78</sup>

*July 15, 2002:* UCS formally posed a question to the NRC's 0350 panel regarding the ability of the backup safety systems to have functioned in event that stainless steel cladding for the damage reactor vessel head burst to initiate a loss of coolant accident. UCS pointed out that Generic Safety Issue 191 raised the potential for the backup safety systems to fail due to debris generated by the loss of coolant accident clogging the screens for the containment sumps, the source of water for the safety pumps.<sup>79</sup>

*August 15, 2002:* FirstEnergy presented the results from its root cause evaluation of management failures at Davis-Besse to the NRC in a public meeting. FirstEnergy defined the root cause as:

*"There was a focus on production, established by management, combined with taking minimum actions to meet regulatory requirements, that resulted in the acceptance of degraded conditions."*<sup>80</sup>

*August 16, 2002:* The NRC issued the Restart Checklist identifying items the agency must verify are complete prior to restart of Davis-Besse.<sup>81</sup>

*September 5, 2002:* FirstEnergy issued a plan, signed by both its chief executive officer and its president, to remedy the management problems identified by its root cause evaluation. FirstEnergy's plans addressed five areas: (1) nuclear safety culture; (2) management and personnel development; (3) standards and decision-making; (4) oversight and assessments; and (5) programs, corrective action, and procedure compliance.<sup>82</sup>

*September 18, 2002:* During a public meeting conducted by the NRC's 0350 Panel, FirstEnergy outlined its plans to restart Davis-Besse on December 4 and commence full power operations on December 7. NRC staffers at the meeting stated they were not driven by FirstEnergy's schedule.<sup>83</sup>

*September 30, 2002:* The NRC's Lessons Learned Task Force issued its final report, which contained 51 recommendations the agency should consider doing to prevent another event similar to the one at Davis-Besse from happening again.<sup>84</sup>

*October 15, 2002:* The NRC denied the petition filed by a coalition of organizations and individuals that requested the NRC require FirstEnergy obtain independent verification that its corrective actions for the reactor vessel head damage were sufficiently broad and effective. In its denial, the NRC pointed out that since the petition was filed on April 24, 2002, the NRC formed a Manual Chapter 0350 Panel (May 3) and a Lessons Learned Task Force (May 15) and FirstEnergy submitted a Return to Service Plan (May 21) that included an independent Restart Oversight Panel, an internal Engineering Assessment Board, and a Restart Station Review Board.<sup>85</sup>

*October 30, 2002:* The NRC issued Revision 1 to its Davis-Besse Oversight Panel Restart Checklist. The revision added the requirement to complete the containment sump modification identified by UCS on July 15, 2002, prior to restart.<sup>86</sup>

*November 26, 2002:* During a public meeting conducted by the NRC, FirstEnergy outlined its re-designed containment sump.<sup>87</sup>

*December 30, 2002:* The NRC's Office of the Inspector General (OIG) released a report for its inquiry into how the NRC staff handled FirstEnergy's response to Bulletin 2001-01 in fall 2001. Among other findings, the OIG reported:

*"OIG found that Federal regulations authorize NRC to initiate enforcement action whenever it lacks 'reasonable assurance' that the licensee can operate safely. However, many NRC staff expressed to OIG their unwillingness to pursue enforcement action against a licensee without absolute proof of a regulatory violation."*<sup>88</sup>

*February 4, 2003:* The NRC commissioners were briefed by NRC staff, FirstEnergy representatives, and NIRS's Paul Gunter about Davis-Besse.<sup>89</sup>

*February 13, 2003:* FirstEnergy reported 2000 earnings of one billion dollars before accounting for a \$139.2 million charge for costs associated with Davis-Besse.<sup>90</sup>

*February 25, 2003:* The NRC issued a preliminary Red finding to FirstEnergy for violations resulting in the reactor vessel head damage at Davis-Besse.<sup>91</sup>

*May 5, 2003:* FirstEnergy reported to the NRC that the original design of the HPI pumps was vulnerable in that both pumps could be disabled by debris in the water. The pumps feature a hydrostatic bearing supplied by process water. Debris in the water could plug the inlet port to the hydrostatic bearings resulting in damage to the pumps.<sup>92</sup>

*May 6, 2003:* During a public meeting conducted by the NRC, FirstEnergy provided an update on its progress toward completing the tasks in its Return to Service Plan.<sup>93</sup>

*May 7, 2003:* During a public meeting conducted by the NRC, FirstEnergy provided an update on its progress resolving engineering issues at Davis-Besse. FirstEnergy informed the NRC about the modification to the HPI pumps to eliminate a common mode failure mechanism dating back to original construction, about the re-validation of inputs and assumptions used in electrical distribution analyses and the ensuing re-analyses, about the changes to 19 air-operated valves at Davis-Besse that would not have functioned under design basis conditions, and about the revised calculation of emergency diesel generator loading based on corrected starting voltages and frequency responses.<sup>94</sup>

*May 29, 2003:* The NRC issued a final Red finding to FirstEnergy for violations resulting in the reactor vessel head damage at Davis-Besse.<sup>95</sup>

*October 7, 2003:* The NRC issued a final Yellow finding to FirstEnergy for violations resulting in the high pressure injection pumps having been vulnerable to a common cause failure since Davis-Besse began operating in the 1970s.<sup>96</sup>

*October 17, 2003:* The NRC's OIG sent the NRC chairman a report on its inquiry into NRC oversight at Davis-Besse during the April 2000 refueling outage.<sup>97</sup> The OIG documented:

- The NRC issued Generic Letter 88-05 to Toledo Edison and other owners of pressurized water reactors requiring them to implement programs to address reactor coolant system leaks below technical specification limits to ensure that boric acid corrosion did not result in reactor coolant pressure boundary degradation. The NRC took this action in response to an actual event at another U.S. reactor. The NRC issued Inspection Procedure (IP) 62001, "Boric Acid Corrosion Prevention Program," for use by NRC inspectors in verifying the adequacy of owners' boric acid corrosion control programs. NRC Region III never used IP 62001 at Davis-Besse and, in fact, only used it at one facility in Region III.
- NRC inspection report 50-346/99008 dated July 20, 1999, described higher than normal reactor coolant system leakage and FirstEnergy's attempts to determine the sources.
- NRC inspection reports 50-346/99009 dated August 20, 1999, and 50-346/99010 dated October 8, 1999, discussed the reactor coolant system leakage that was causing the containment radiation monitor filters to become clogged. Inspection report 50-346/99009 noted that FENOC had the debris on the filters analyzed and determined it to be iron oxide, a corrosion byproduct. This inspection report additionally documented that clogging of the radiation monitor filters required their replacement every 24 to 48 hours.
- NRC inspection report 50-346/98021 dated June 4, 1999, addressed the complete boric acid corrosion of two nuts on pressurizer spray valve RC-2. This inspection report noted that maintenance practices at Davis-Besse related to boric acid control required improvement, more oversight, and more assessment.
- There were 38 entries in a logbook maintained by the NRC senior resident inspector at Davis-Besse between April 1999 and April 2000 about boric acid deposits, accumulation, and effects on components. The NRC resident inspectors told the OIG that they informed NRC Region III about several of these boric acid events during their daily phone conferences.
- The service water system engineer at Davis-Besse initiated CR 2002-0782 on April 6, 2000, because "Inspection of the Reactor flange indicated Boric Acid from the weep holes.... The leakage is brown in color. The leakage is worst on the east side weep holes. The worst leakage from one of the weep holes is approx. 1.5 inches thick on the side of the head and pooled on top of the flange." The service system engineer told the OIG that he told the NRC resident inspector about the accumulation of boric acid on the reactor vessel head and described it as being "molten, lava-like, rust colored boric acid debris." The service water system engineer handed the NRC resident inspector a copy of CR 2002-0782 with color pictures attached. One of those color pictures is the infamous "Red Photo."
- The NRC resident inspector told the OIG that he did not recall having been given CR 2002-0782 by the Davis-Besse service water system engineer, but he had no reason to doubt what the system engineer stated. He told the OIG he "had been assigned at Davis-Besse for only 6 months, and he was not sufficiently training to recognize the significance of boric acid on the RPV head or the red/brown rust deposits depicted in the photographs."

- The NRC senior resident inspector told the OIG that he did not recall having reviewed CR 2002-0782 or seeing the color pictures, but he might have done so. The NRC resident inspector told the OIG that even if he had reviewed CR 2002-0782 and the attached photographs, he “would not have considered the matter safety significant” because “at the time the Condition Report was issued the plant was shut down; therefore, the condition of the RPV [reactor pressure vessel] head would not have posed an immediate safety concern.”
- An NRC in-service inspection inspector told the OIG that he observed “a light coating of boric acid throughout the Davis-Besse containment area” during the April 2000 refueling outage. The ISI inspector told the OIG he’d asked the NRC senior resident inspector at Davis-Besse about the boric acid and was told that there had been problems “for at least 2 years.”

*October 21, 2003:* During a public meeting conducted by the NRC, FirstEnergy described its testing program and proposed modification to the HPI pumps at Davis-Besse to resolve the hydrostatic bearing debris blockage problem.<sup>98</sup>

*October 24, 2003:* FirstEnergy provided information to the NRC about its auditing of material provided to the NRC between January 1996 and March 2002 to evaluate the completeness and accuracy of that information. The audit identified six submittals that may have been incomplete and/or inaccurate. Further evaluation eliminated two of the suspect submittals. FirstEnergy corrected the remaining four submittals and described to the NRC its revised process to ensure future submittals would be complete and accurate.<sup>99</sup>

*February 2004:* The NRC reported that its inspections had verified FirstEnergy’s adequate completion of 27 items on the agency’s 31-item restart checklist. The four remaining items requiring NRC verification: (a) HPI pump modification; (b) system readiness for restart; (c) operations readiness for restart; and (d) completion of all Confirmatory Action Letter items.<sup>100</sup>

*February 5, 2004:* Ohio Citizen Action and UCS formally ask the NRC chairman and commissioners to conduct a briefing about the restart of Davis-Besse. Other than one briefing in February 2003, the NRC commissioners had not been briefed in public about the activities undertaken by FirstEnergy and NRC staff to ensure the safe restart of the reactor.<sup>101</sup>

*February 12, 2004:* During a public meeting conducted by the NRC, FirstEnergy requested approval from the NRC for restart of Davis-Besse.<sup>102</sup> FirstEnergy described the major tasks completed during the two-year outage, including:

- Upgrading the containment sump
- Installing a decay heat valve tank
- Refurbishing the reactor coolant pump
- Installing a permanent reactor cavity seal
- Replacing coatings in containment
- Removing fibrous insulation
- Upgrading cranes and bridges
- Upgrading containment air coolers
- Repacking approximately 100 valves
- Completing approximately 2,500 restart corrective actions
- Replacing and repairing ductwork, cable trays, and coatings inside containment
- Completing more than 140 modifications to improve safety and reliability
- Completing more than 600 restart corrective actions

*February 25, 2004:* NRC Chairman Nils Diaz declines the request of Ohio Citizen Action and UCS for a public briefing about the restart of Davis-Besse.<sup>103</sup>

*March 8, 2004:* The NRC closed the Confirmatory Action Letter and approved the restart of Davis-Besse. The NRC issued a Confirmatory Order requiring FirstEnergy to arrange annual independent assessment in the areas of operations, engineering, corrective actions, and safety culture for five years. NRC inspections completed in recent weeks and document in reports issued shortly before this date verified completion of the final restart checklist items.<sup>104</sup>

*March 11, 2004:* Operators achieved criticality of the reactor.<sup>105</sup>

*March 16, 2004:* The unit was connected to the electrical grid to end its extended outage.<sup>106</sup>

*March 17, 2004:* Operators manually shut down Davis-Besse to repair three valves.<sup>107</sup>

## Notes

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