Lecture 21
Davis Besse - Near Miss 2002
Topics to Be Covered

- History of Davis Besse
- Review of Alloy 600 cracking
- Review of Davis Besse Vessel Head Leakage
- Contributing Factors
- Failures of Operator, NRC, INPO, Oversight
- Lessons Learned
History of Davis Besse

• 1995 World Record of a 99.2% capacity factor
• 2001 - 99.7% capacity factor
• 2001 – 500 day run completed in October 2001
• 5.5 million hours worked without lost time accident in 2001
• Considered a good performing plant by NRC and INPO
Primary Water Stress Corrosion Cracking of Vessel Head Penetrations

- First observed in France – Bugey 3 Reactor in 1991
- Associated with PWSCC of Alloy 600 (inconel)
- PWSCC function of temperature, pressure and time
- NRC sent out information notices – required inspections
- Industry did assessment of susceptibility of reactors (BW/CE)
  - Established a scale based on full power hours of operation
  - Based on head temperature
  - Industry did not consider this a significant issue since US reactor head were built differently than French reactors.
- Inspections difficult due to access and dose
• Perception was that if cracks occurred they would be axial not circumferential and detectable

• Carbon steel vessel degradation was considered but not judged to be significant due to flashing of steam and leaving boron crystals (>500F) – not as a liquid – 4 inches/yr if water

• Inspection of Oconee Nuclear Station 1 (Nov. 2000), Arkansas Unit 1 (Feb. 2001), Oconee Unit 3 (Feb. 2001) and Oconee Unit 3 (April 2001) showed both axial and circumferential cracks in Control Rod Drive Mechanisms.


• NRC prepares a shutdown order for Davis Besse
Figure 3-1  Time Line Relating Significant Items of Interest

IN (Information Notice) 86-108, "Degradation of Reactor Coolant System Pressure Boundary Resulting from Boric Acid Corrosion"
GL (Generic Letter) 88-05, "Boric Acid Corrosion of Carbon Steel Reactor Coolant Pressure Boundary Components in PWR Plants"
GL 97-01, "Degradation of Control Rod Drive Mechanism Nozzle and Other Vessel Closure Head Penetrations"
BL (Bulletin) 2001-01, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles"

- PCAQ 90-0120: Leaking CRDM flanges and boric acid on reactor head
- Service structure access opening modification re-authorized after numerous deferrals
- PCAQ 96-0651: Boric acid on reactor head, brown deposits
- PCAQ 96-0757: Boric acid on reactor head
- Frequent CAC cleaning and more frequent containment atmosphere radiation monitor filter changes
- Two CRs describing boric acid on head: Closed on incomplete cleaning
- RC-2 presentation by First Energy
- Degraded Head Discovered
- Break of CAC
- NRC letter to FirstEnergy deferring VHP inspection to February 2002
- IP62001 canceled
- NRC inspection reports continued to note RCS leakage after midcycle outage
- NRC inspection on OG evaluations
- NRR trip report discussing foreign experience
- Bugey VHP cracking
- 1990
- 1995
- 2000
- 2002

NUMARC letter to NRC forwarding OG VHP cracking evaluations

• 1972 - NRC letters on foreign event
• 1987 - Turkey Point/Salem (IN 86-108)

BA - Boric Acid
BAC - Boric acid corrosion
CAC - Containment air cooler
CRDM - Control rod drive mechanism
EPRI - Electric Power Research Institute
NRR - Office of Nuclear Reactor Regulation
NUMARC - Nuclear Management and Resource Council
OG - Owners Group
RCS - Reactor coolant system
RFO - Refueling outage
RPV - Reactor pressure vessel
VHP - Vessel head penetration

PCAQs (Potential Condition Adverse to Quality) and CRs (Condition Reports) are issued by the licensee.
Results

- Davis Besse requests an extension to next spring outage.

- NRC grants extension February to 16, 2002.
Nozzle 3 with insulation removed and shielding installed 03-16-02
Vessel Degradation

Figure 2-4
DBNPS VHP NOZZLE NO.3 DEGRADATION CAVITY

Degradation Between Nozzle#3 and Nozzle#11. The Sketch Provided by the Licensee

Nozzle #3 Area Cut Away From Reactor Head

Close-Up View of Cavity

Rubberized Impression of Cavity

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Boric Acid Deposits

Figure 2-6  BORIC ACID DEPOSITS ON THE RPV HEAD (top) AND AREA RELATIVELY FREE OF DEPOSITS (bottom)

Reflective Insulation Above RPV Head

Boric Acid Deposits

VHP Nozzle

RPV Head

RFO12 April 2000

RFO12 April 2000
Davis-Besse Reactor Vessel
Control Rod Drive Mechanisms
Figure 2.3  SCHEMATIC VIEW OF TYPICAL B&W VHP NOZZLE
Davis Besse Experience with Primary Coolant Leaks

- All BW plants reported boric acid leakage problems including vessel head penetrations
- RPV head vent to steam generator (1992)
- RCS thermowells
- CRDM flange leaks
- Pressurizer spray valve
- Letdown isolation cooler isolation valve
- Pressurizer safety relief valves.
Davis Besse Indicators

- Containment Air Cooler Clogging with Boron Crystals
  - Cleaning monthly instead of yearly
  - Ultimately required replacement every 2-3 days
  - Found brown stains with boron crystals.
- Some bolts on pressurizer spray valves corroded off due to spray valve leakage.
- Leakage increased by a factor of 10 but still within technical specification limits.
Missed Opportunities
Breakdowns

- Utility
- Industry – NEI and EPRI
- NRC
- INPO

Oversight Boards
Lessons Learned

• Could have set nuclear industry back (again) – major non-isolable leak – break – in reactor pressure vessel
  – We are judged by our poorest performer

• Complacency based on good record

• Poor management oversight and awareness

• You can go to jail (several charged with criminal violations – falsification of records)

• Conservative decision making is important

• Not allowing unacceptable conditions to exist.

• Strong questioning attitude needed
More lessons

- Focus should be on causes not symptoms
- Engineering organization needs to be engaged in problem resolution not just enabling management decisions.
- Mind set of it can never happen needs to be challenged.
- Oversight organizations need to be aggressive.
  - INPO should have identified the problem
  - Outside Nuclear Safety Review Boards should not only listen to management presentations
- NRC resident inspectors did not do their job
- Group think should be avoided
Even more lessons

- Failure to use experience reports and believe them
- Power production is important but if safety compromised the plant and the industry will suffer.
- Safety culture differentiates excellent performers from bad.
Consequences

• Davis Besse Replaced reactor vessel head.
• Repairs cost $600 million – loss of revenue
• Plant shutdown for 2 years
  – Restart issue was not of adequacy of repairs
  – *Restart was predicated on whether or not the safety culture of the plant was acceptable for operation!*
• Fortunately this event was considered as an isolated event by the public but a failure of the regulatory and oversight process.
Homework

- Review the FENOC (Davis Besse) request for continued operation sent in late 2001 to justify operation until the spring out.

- Based on the information provided and the experience with Alloy 600, provide a technically based answer to the request – you may want to review the NRC letter granting approval to see if you agree – why and why not.
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