
Reactor Pressure Vessel Head Material Degradation



Dr. Brian W. Sheron

Associate Director for Project Licensing and Technical Analysis
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission

Penn State University
September, 2002

207
B/130

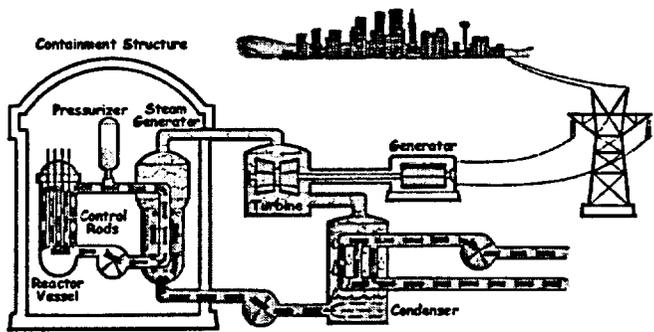
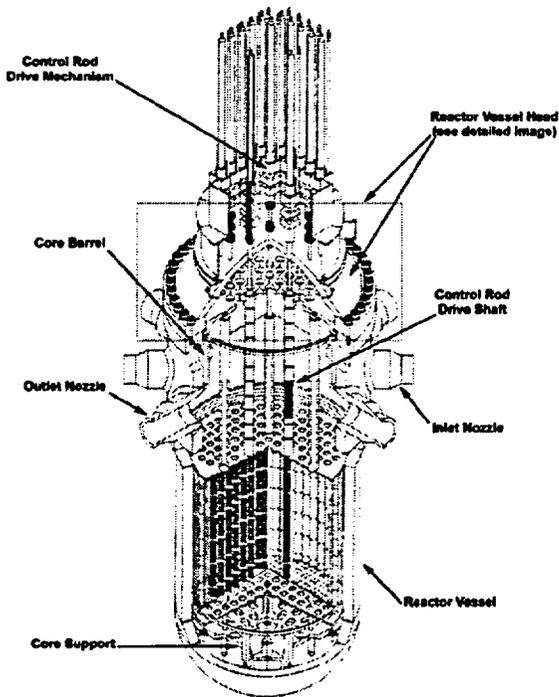
Overview of Presentation

- Description of Degradation
- Safety Implications
- NRC's Actions
- Licensee's Actions

September 2002



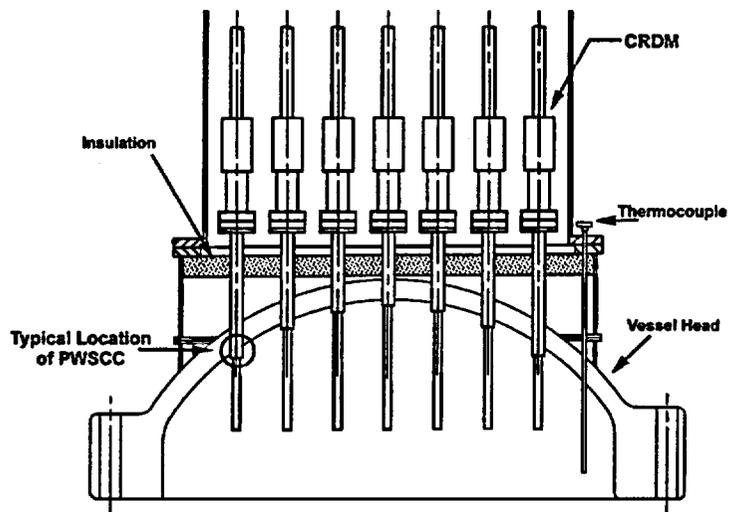
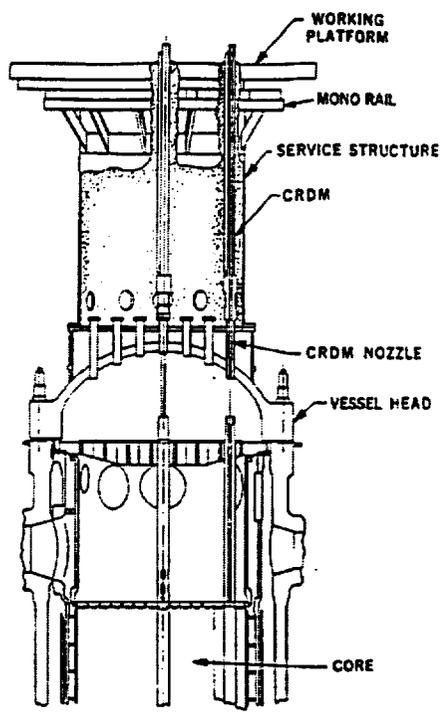
Typical Pressurized Water Reactor



September 2002



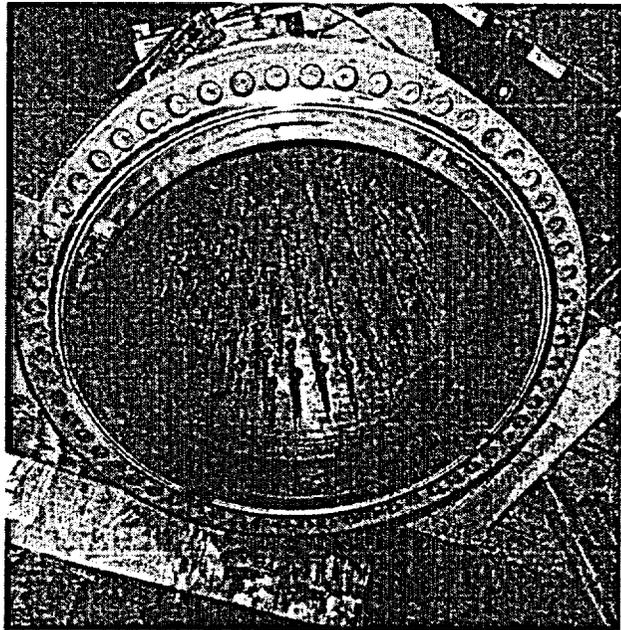
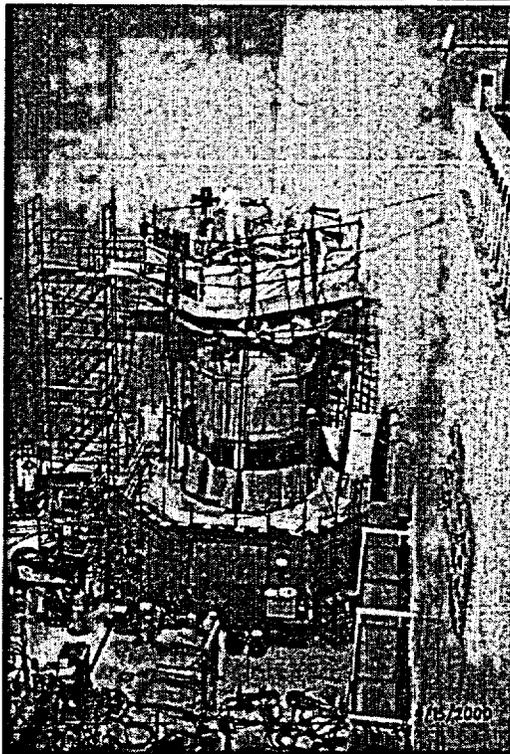
Typical Reactor Vessel Head



September 2002



Davis-Besse Reactor Vessel



September 2002

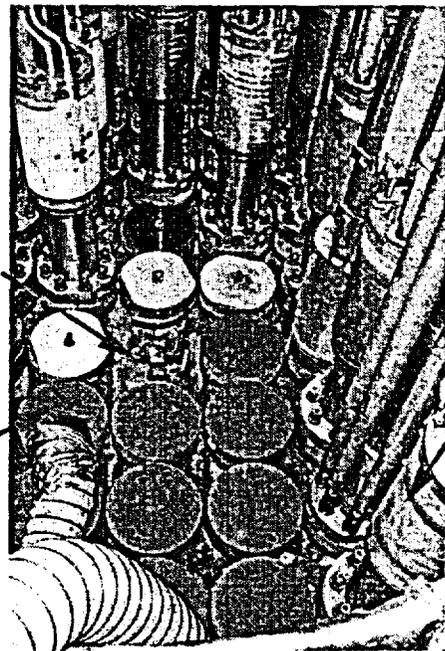


Control Rod Drive Mechanisms



Nozzle #3
Removed

Reactor
Vessel
Head
Nozzle
to CRDM
Flange

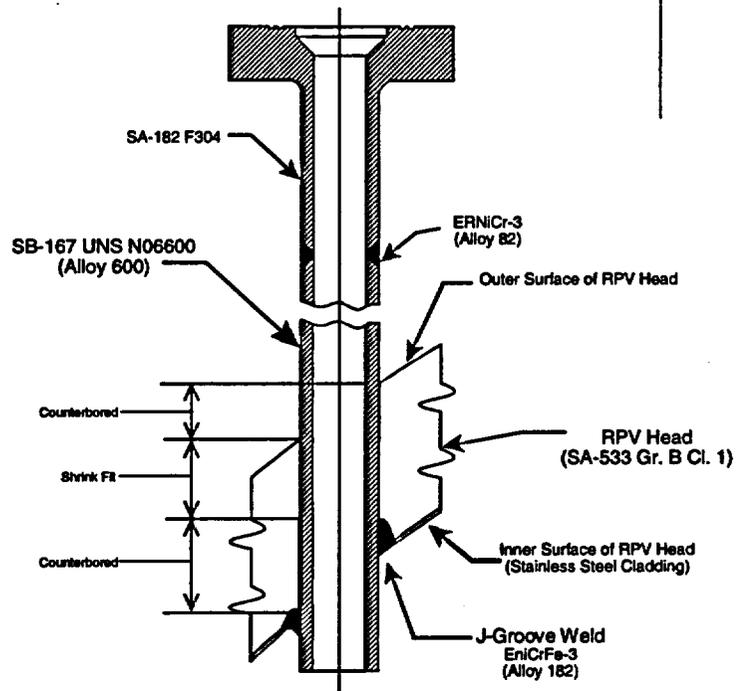


Control
Rod Drive
Mechanism
Still Bolted
to Nozzle

September 2002



Typical CRDM Nozzle



September 2002



J-Groove Weld
ENiCrFe-3
(Alloy 182)

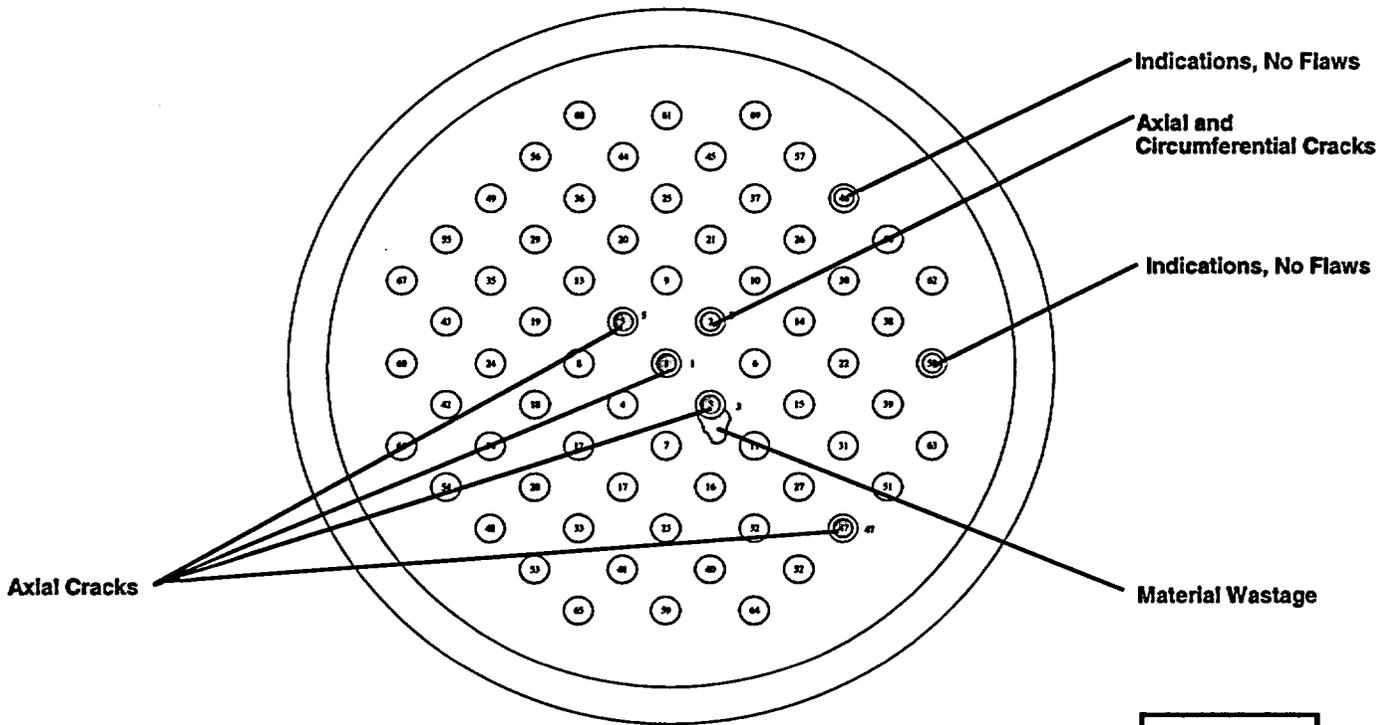
Davis-Besse RPV Head Inspection

- Davis-Besse Visual Inspection of RPV Head per NRC Bulletin 2001-01
 - February - March 2002
- UT Inspection of All 69 CRDM Nozzles
 - 5 Nozzles with Indications, 3 with Throughwall Cracks
 - Cavity Found Adjacent to Nozzle #3
 - Degraded Area Near Nozzle #2
 - Significant Boron and Corrosion Deposits on the RPV Head

September 2002



CRDM Nozzle Map

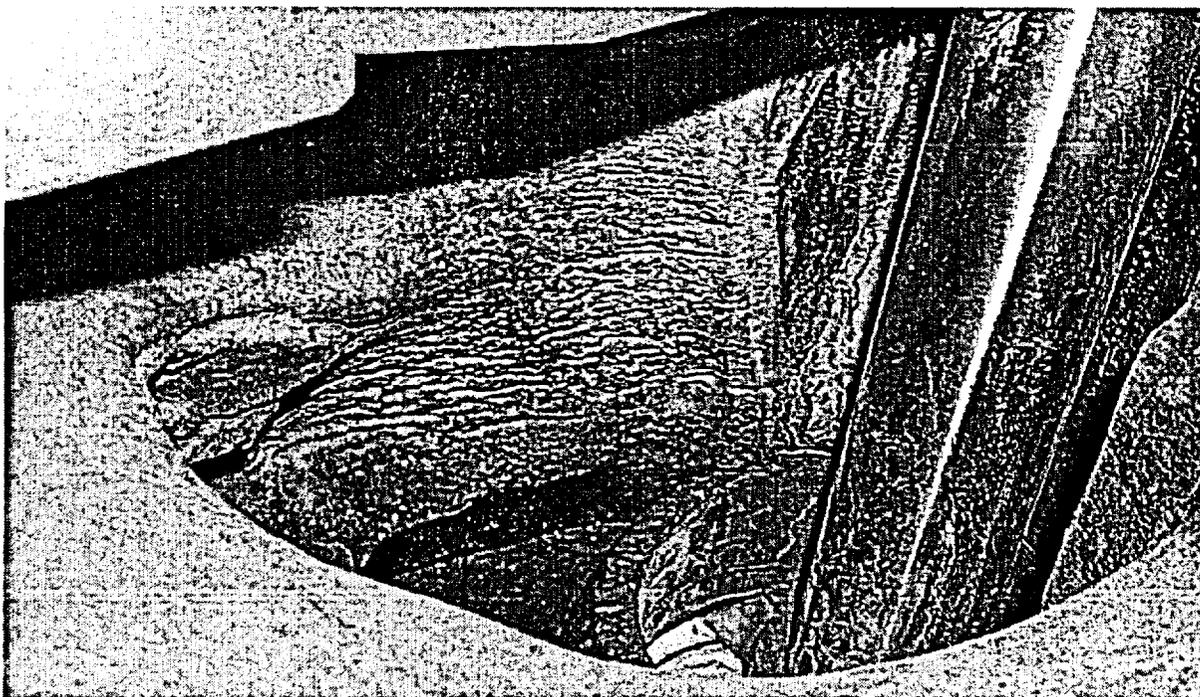


September 2002



J-Groove Weld
EniCrFe-3
(Alloy 182)

RPV Head Degradation



September 2002



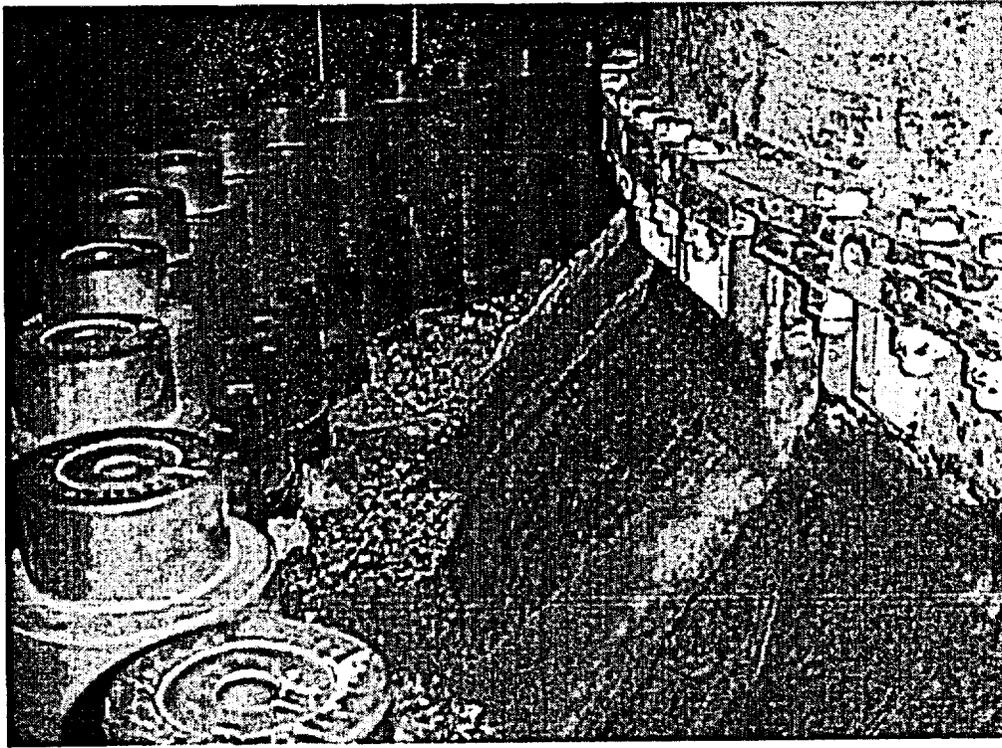
Contributors to Degradation

- **Primary Water Stress Corrosion Cracking**
 - **Susceptible Materials**
 - Alloy 600 Nozzles
 - Alloy 82/182 Welds
 - **Highly Susceptible Heat of Material**
 - 4 Out of the 5 Nozzles with M3935 Were Cracked
 - **High Tensile Stress Because of Weld Residual Stresses (J-Groove Weld)**
 - **Aggressive Environment, High Head Operating Temperature**
 - **Leakage Through Cracks in the Nozzles**

September 2002



Davis-Besse RPV Head



September 2002



Opportunities to Identify Degradation

- Boric Acid Buildup on RPV Head
- Corrosion on Vessel Flanges
- Containment Radiation Monitor Filter Clogging
- Containment Air Cooler Clogging

September 2002



Safety Implications

- Structural Margins Were Significantly Degraded
- Potential for Loss-of-Coolant Accident



- Plants Are Designed to Handle Loss-of-Coolant Accidents
- Prompt Action Warranted to Verify Condition of Other Plants



NRC Actions - Davis-Besse

- Special Inspections to Assess Compliance with Regulations
- Special Inspections for Modifications, Repair, or Replacement of RPV Head
- Confirmatory Action Letter
 - Determine Root Cause
 - Evaluate Rest of Reactor Coolant System for Corrosion
 - Obtain NRC Approval for Any Repair or Modifications
 - Obtain NRC Approval for Restart

September 2002



NRC Actions - Generic

- Ongoing Evaluation of Other Plants
 - Most Licensees Repair Leaks and Remove Any Deposits
 - Some Licensees Leave Minor Debris and Isolated Boron Deposits on RPV Head

- Reevaluating the Basis for Licensee's RPV Head Inspection Programs
 - Bulletin 2002-02 Issued in August 2002
 - Programs that Rely on Visual Examinations May Need to Be Supplemented with Non-Visual NDE

September 2002



NRC Actions - Internal

- Identifying Improvements to Regulatory Processes
- Identifying Improvements to Inspection Programs
- Identifying Improvements to Regulations
- Initiated Confirmatory Research Studies

September 2002



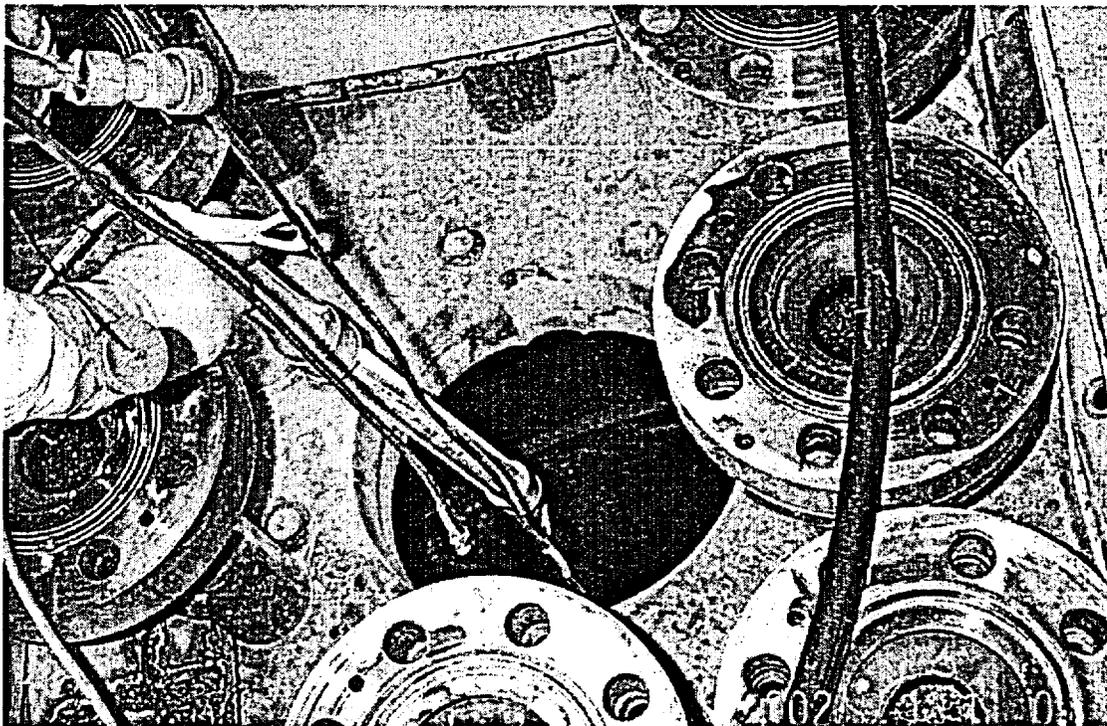
Davis-Besse Actions

- Plant in Safe, Shutdown Condition
- Investigating Extent and Cause of Degradation
- Conducting Root Cause Analysis
 - Technical
 - Management and Human Performance
- Replacing RPV Head with One from a Canceled Nuclear Power Plant

September 2002



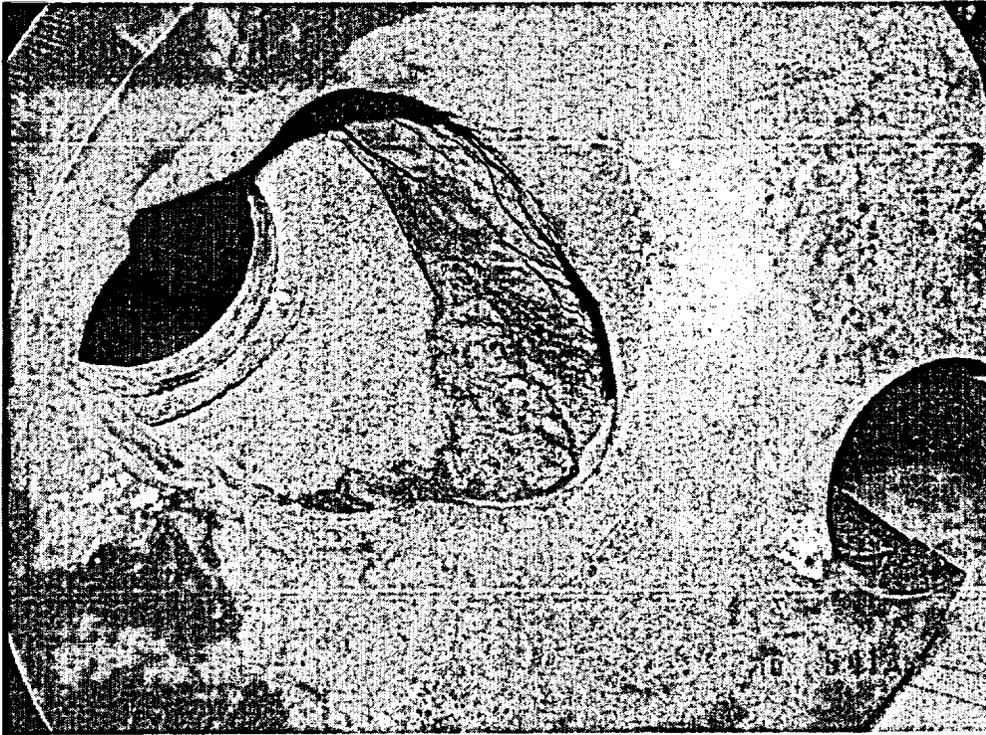
Licensee's Investigation



September 2002



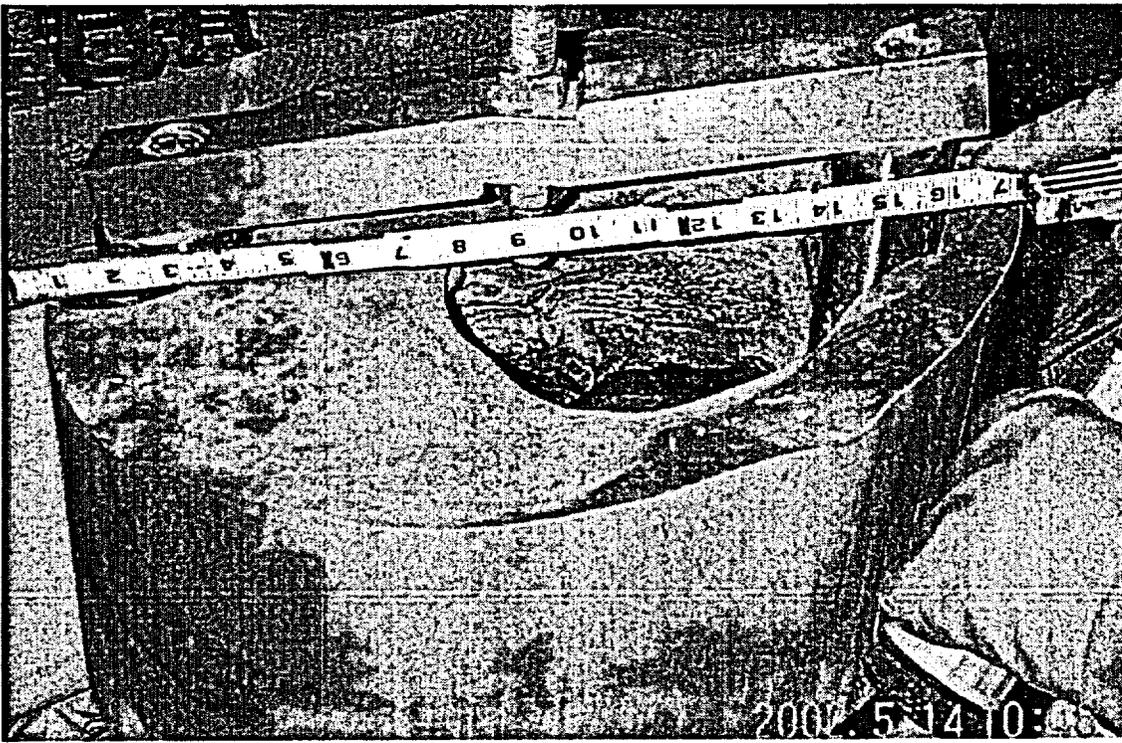
Licensee's Investigation



September 2002



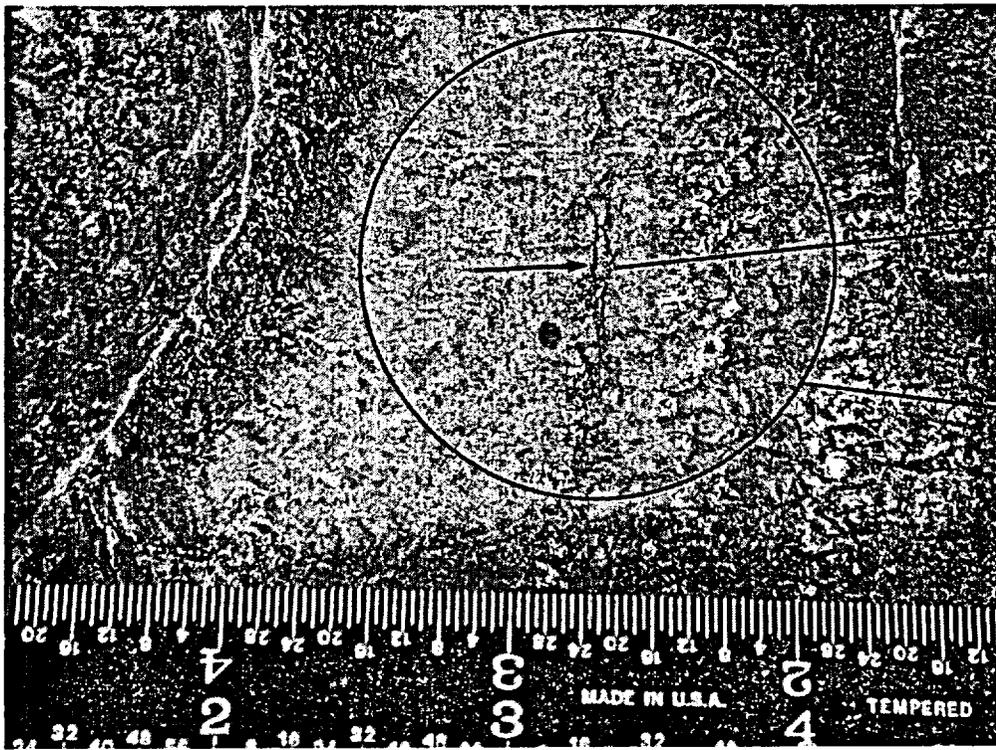
Licensee's Investigation



September 2002



Licensee's Investigation



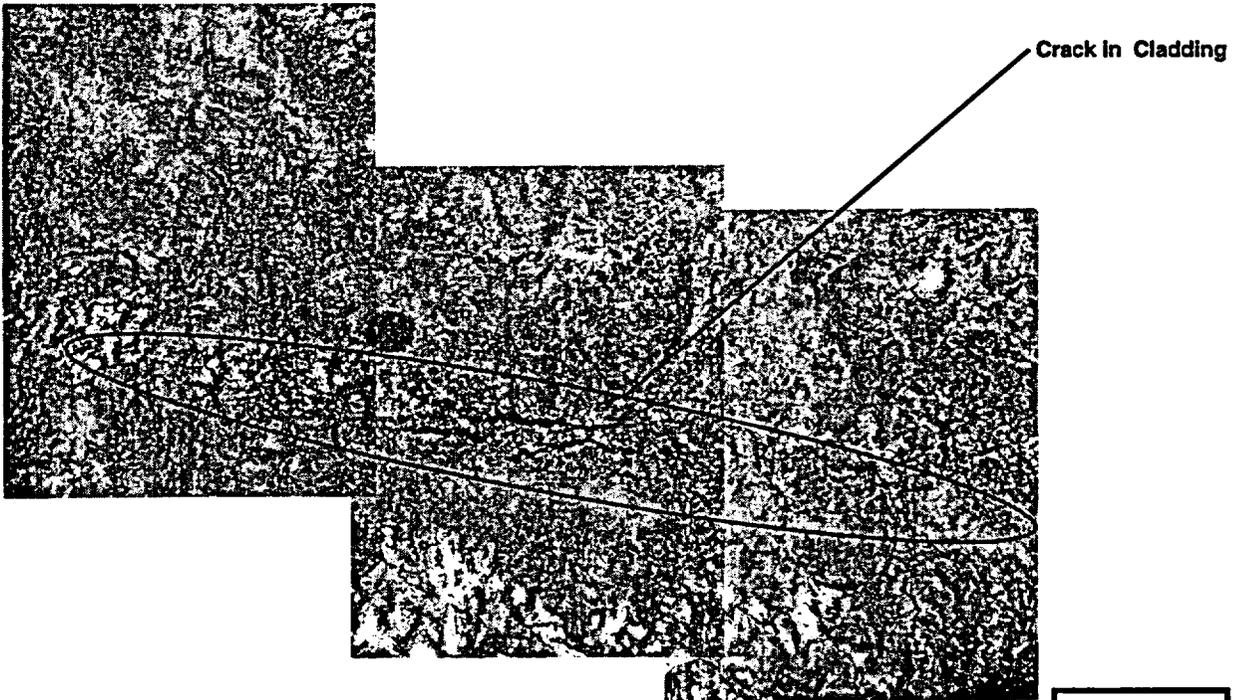
Crack In
Cladding

"Bulged"
Area

September 2002



Licensee's Investigation

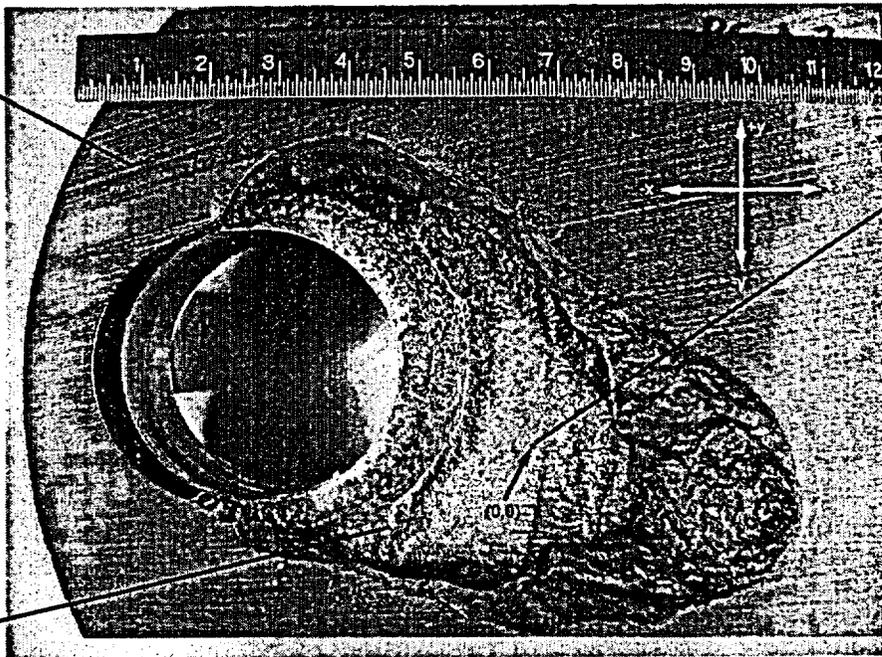


September 2002



Licensee's Investigation

Carbon Steel
RPV Head



Crack in
Cladding

Stainless Steel
Cladding

September 2002



Davis-Besse Actions - Root Cause

- Pressurized Water Stress Corrosion Cracking of Control Rod Drive Mechanism Nozzle
 - Leakage Onto Head
- Licensee's Inspection Program Inadequate and Not implemented Properly
- Changes in Plant Conditions Inadequately Investigated
 - Amount and Color of Deposits on RPV Head
 - Clogging of Air Coolers
 - Fouling of Radiation Monitor Filters

September 2002



Davis-Besse Actions - Repairs & Corrective Actions

- **RPV Head Being Replaced**
 - **Management Team Has Been Replaced**
 - **Procedures for Detecting and Correcting Problems Is Being Enhanced**
 - **Safety Focus of Plant Personnel and Managers Is Being Addressed**
 - **Plant Safety Systems Being Inspected and Repaired, If Needed**
-

September 2002



Davis-Besse Actions

**Licensee has to demonstrate its
readiness to operate the plant safely.**

September 2002



Additional Information

<http://www.nrc.gov/reactors/operating/ops-experience/vessel-head-degradation.html>

September 2002

