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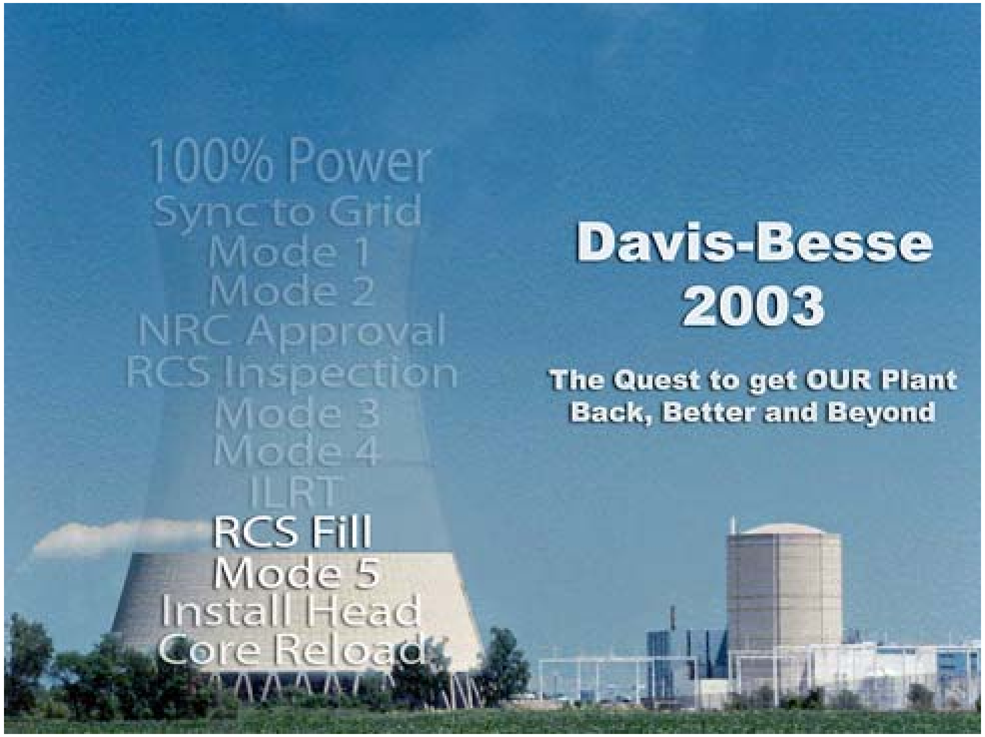
Davis-Besse Nuclear Power Station



Reactor Vessel
Incore Monitoring Instrumentation Nozzle
Leakage Simulation Results

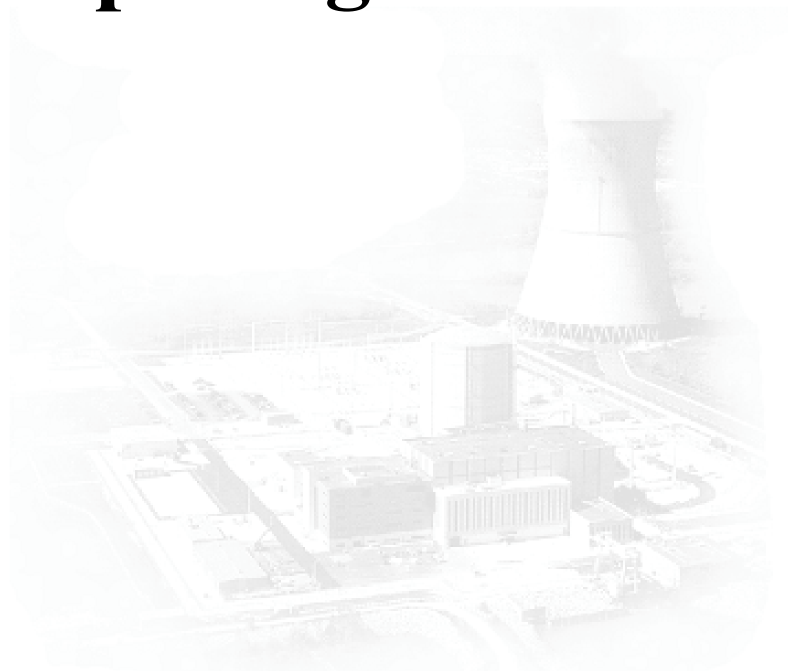
Agenda

Opening Remarks . . . . …………………. Gary Leidich

- Background on Reactor Vessel IMI Nozzles….. Jim Powers
- Simulation of Reactor Vessel IMI Nozzle Leakage…………………………………Craig Hengge

Closing Comments………………………….... Gary Leidich

Opening Remarks

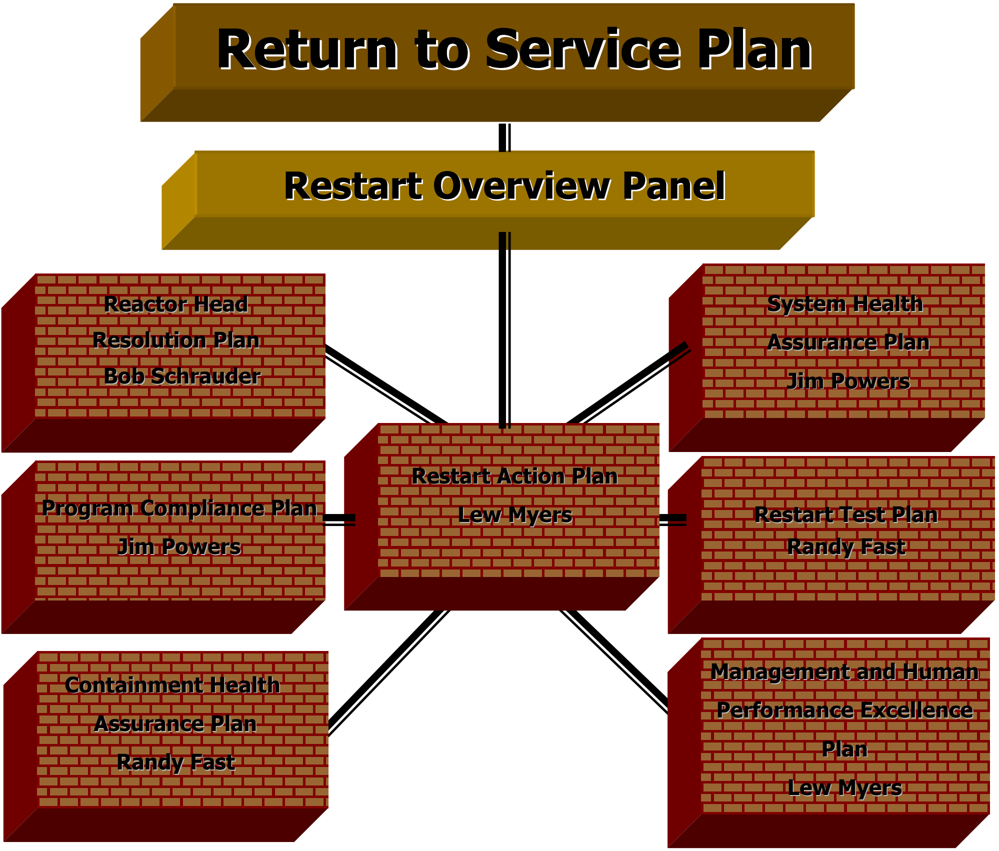


Gary Leidich
Executive Vice President - FENOC

Desired Outcome

- Brief the NRC Staff on the Incore Monitoring Instrumentation (IMI) Nozzle Leakage Simulation Configuration and the Test Results
- Address the Plant Normal Operating Pressure Inspection Plan

Return to Service Plan



- Inspection of the IMI Nozzles is part of the Containment Health Assurance Building Block in the Davis-Besse Return to Service Plan

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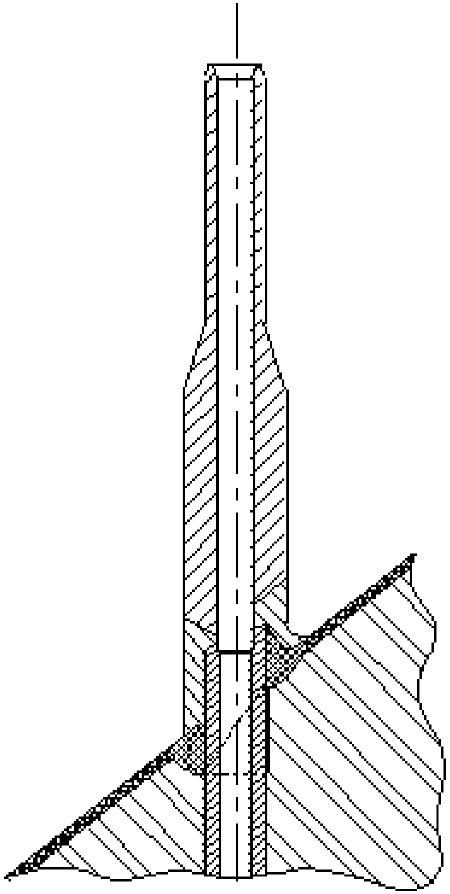
Background on Reactor Vessel Incore Monitoring Instrumentation (IMI) Nozzles

Jim Powers
Director - Davis-Besse Engineering

IMI Nozzles
Configuration

Modified IMI nozzle (inside of reactor vessel)

- Babcock & Wilcox reactor vessel has 52 IMI nozzles
- IMI nozzles are ~ 1 inch in diameter
- Original IMI nozzles fabricated from Alloy 600 material
- J-Groove welds - Alloy 182 (stress relieved)
- IMI nozzles modified (not stressed relieved) following Oconee 1-1972 Hot Functional Testing Failure

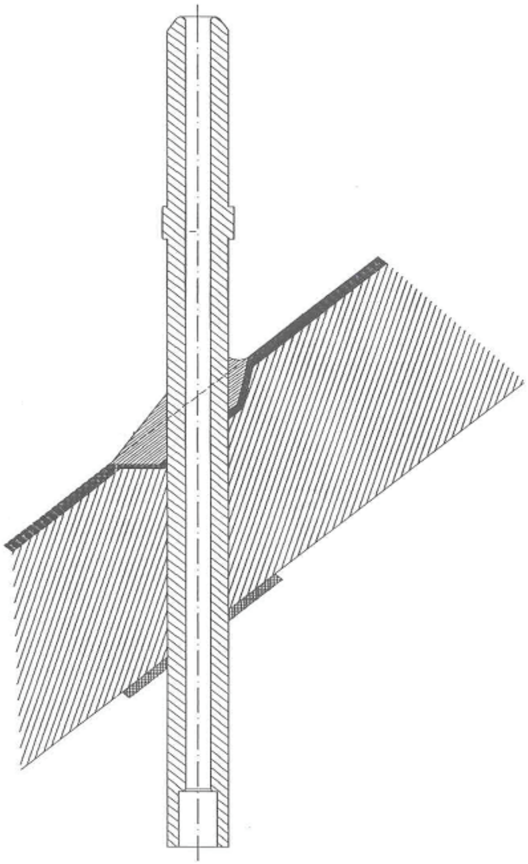


B&W Nozzle Configuration

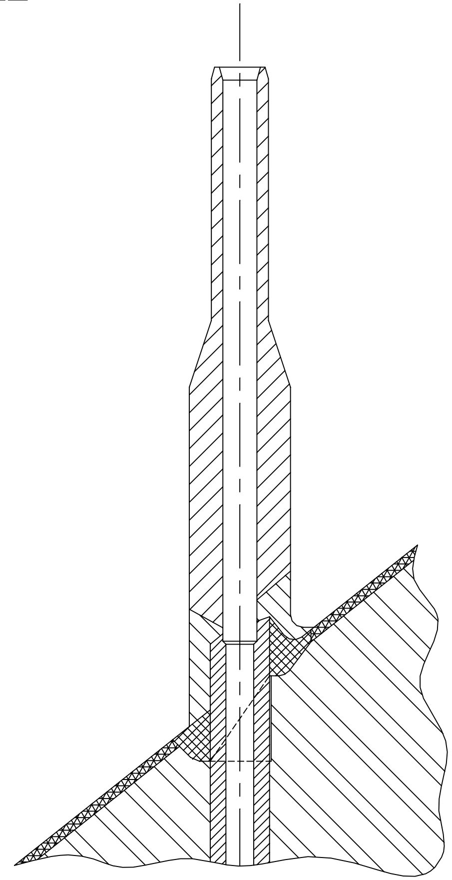
IMI Nozzles
Industry Experience

- IMI nozzles are exposed to lower temperatures (558^{o}F) than Control Rod Drive Mechanism (CRDM) nozzles (605^{o}F)
- Alloy 600 material is generally less susceptible to stress corrosion cracking at lower temperatures
- Visual inspections of the IMI nozzles have not been routinely conducted in United States plants
- Inspections of IMI nozzles at thirteen French plants have not discovered cracking or leaking

EDF vs. B&W Nozzle Configuration



EDF Nozzle Configuration



B&W Current Nozzle Configuration

Inspection Results
Summer 2002

IMI Nozzles
at Bottom of Reactor Vessel
(Post-cleaning)

- Boron and rust deposit trails were observed on the sides and bottom of the reactor vessel
- No build-up of boric acid deposits or corrosion products on top of insulation
- No evidence of wastage on bottom of reactor vessel

Deposit Characterization
Summary

- Boron and Lithium were higher at several IMI nozzle locations than in flow trails and more comparable with previously analyzed upper head deposit samples
- Cobalt (Co^{60}) and Iron (Fe^{59}) were higher in the flow trails than at the IMI nozzle locations
- Minor species (Uranium, Barium, Thorium, Strontium, & Zirconium) were higher at several IMI nozzle locations than in the flow trails. However, the lack of activity associated with these species did not support reactor coolant as the source
- Inconsistent concentration gradients along possible flow trail paths

Deposit Characterization
Conclusion

- From the results of the analysis, it was inconclusive whether the flow trails at the bottom of the reactor head and IMI nozzle deposits had a common source

- Framatome ANP was tasked to conduct simulation testing to determine the ability to visually detect the presence of very small leaks that would be associated with a cracked weld or IMI nozzle

Simulation of IMI Nozzle Leakage

Craig Hengge
Engineer - Plant Engineering

Leakage Simulation Test
Program Objectives

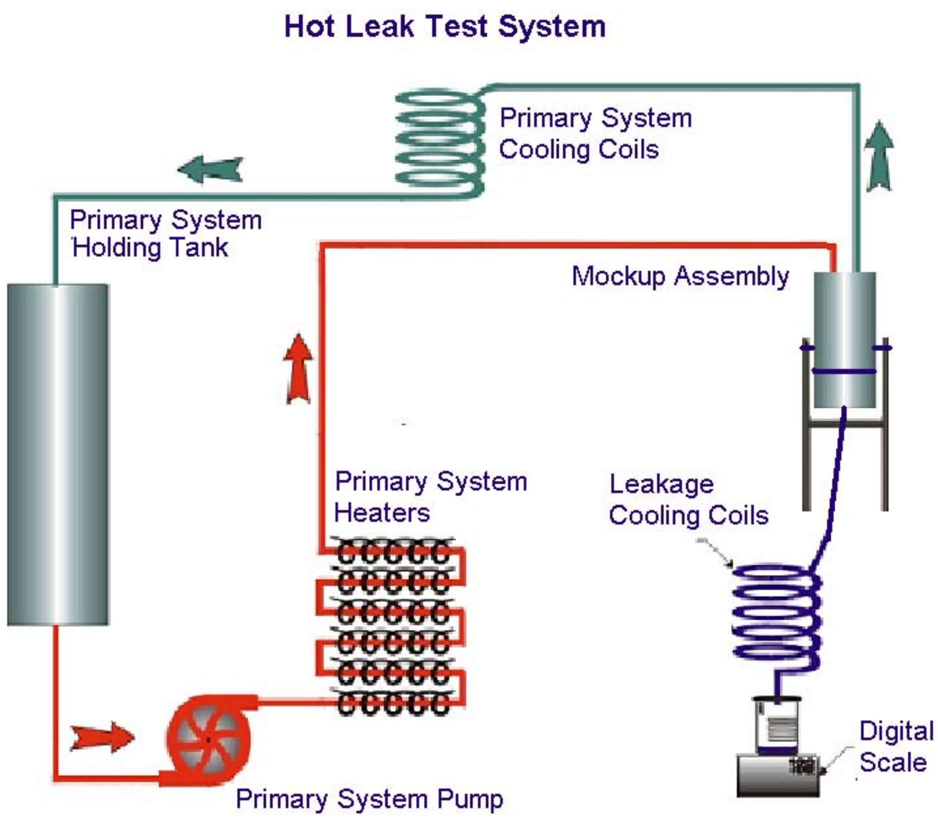
- Confirm that very small leak rates would result in visible boric acid crystals at the exit of the annulus between the nozzle and reactor vessel
- Characterize the residue deposit chemistry that exits the annulus

Leakage Simulation Test
Facility

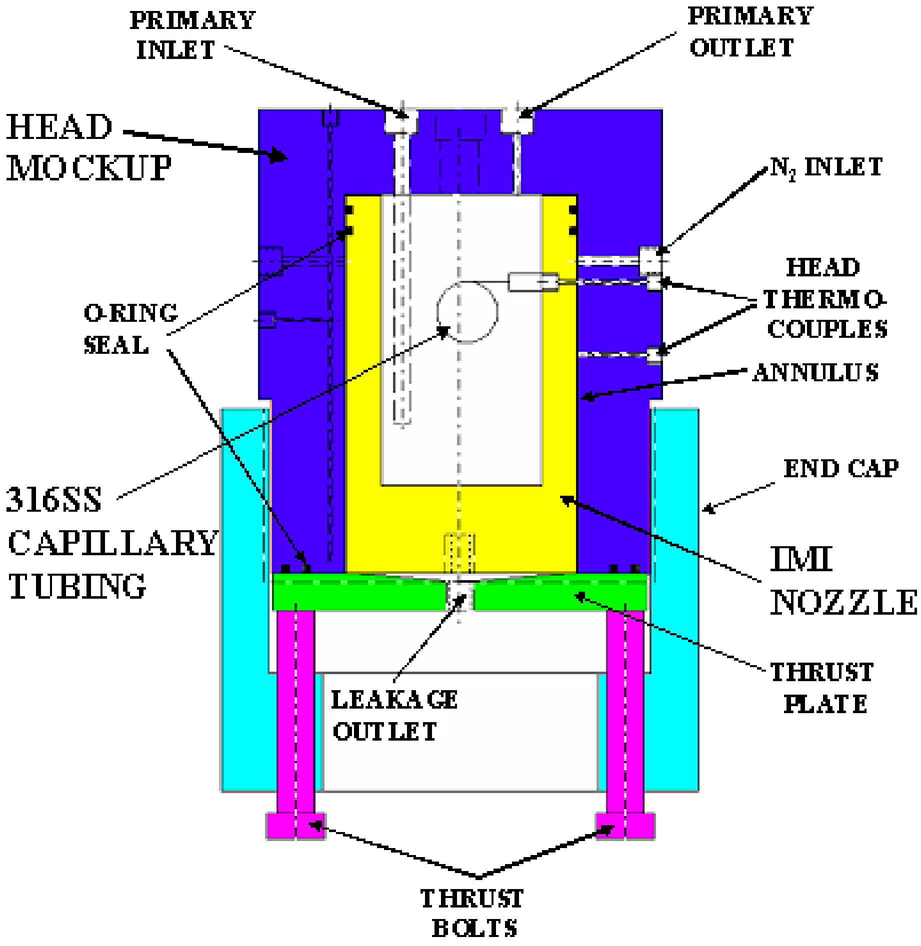
- Conducted at Framatome ANP's Hot Leak Test Facility in Lynchburg, Virginia
- Facility designed/built to achieve the primary and secondary side temperature and pressure conditions for Babcock and Wilcox pressurized water reactor systems
- Project performed in accordance with Framatome ANP Quality Assurance Program
  - Mockup design and fabrication controlled
  - Material traceability maintained during fabrication
  - Test procedures written and approved
  - Calibrated instruments used for all measurements (leak rates measured on best-effort basis)

Leakage Simulation Test
Basic Description of Test

- Demineralized water containing Boric Acid and Lithium in the primary system holding tank was pumped through a series of electric heaters to achieve desired test temperature
- Water entered nozzle mockup assembly, heated up the mockup to primary side temperature and was free to leak through capillary tubing into annulus
- Pressure was monitored by transducers and temperatures by thermocouples (data recorded)



Leakage Simulation Test Mockup



- Test Assemblies consisted of an Alloy 600 nozzle (3.990 inch outer diameter) inserted into an AISI 8620 carbon steel head with a 0.010-inch annulus
- Various lengths of 0.005-inch and 0.010-inch inner diameter stainless steel capillary tubes were tested to simulate a range of potential leak rates

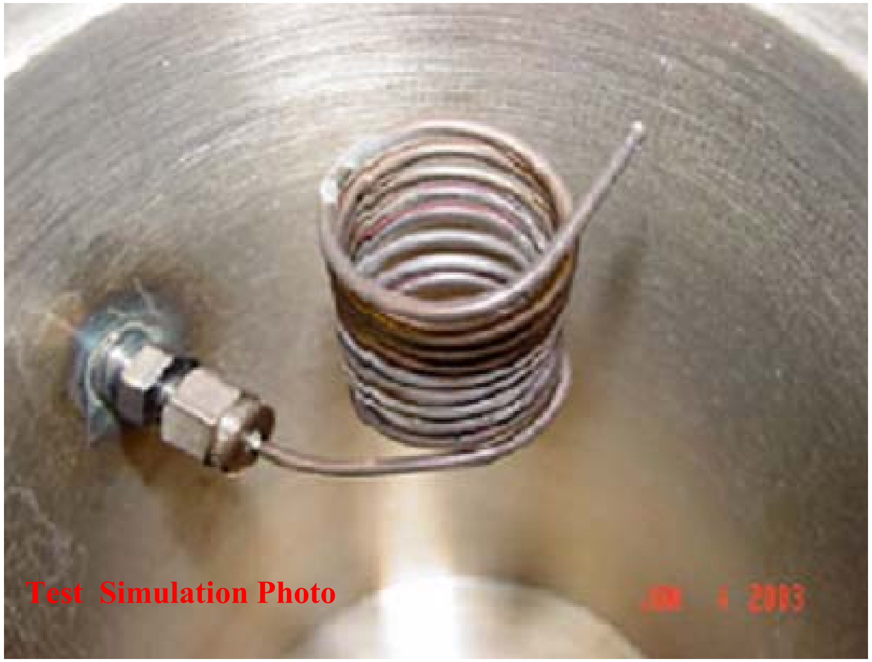
Leakage Simulation Test
Collection of Deposits

- Test leakage was condensed, collected as liquid, and weighed at discrete time intervals
- Mockup was disassembled and inspected to determine the distribution and quantity of residue deposits, and for evidence of flow assisted corrosion (FAC)
- Nozzle was removed and visually examined
- Photographs of observed deposits were taken prior to collecting the deposit samples

Test #5 (leak rate: 0.0006 gpm)
Crusty yellow deposit buildup on nozzle wall at annulus discharge

Test #1
(leak rate: 0.015 gpm)
Nozzle OD showing leak path

Leakage Simulation Test Parameters



Test #2 (leak rate: 0.0017 gpm)
Inside of nozzle showing capillary tube arrangement

- Five tests conducted at varying leak rates
  - Primary water leaked at controlled rates (0.0004 to 0.015 gpm) into an annulus
  - Capillary tubing was used to achieve low leak rates
  - Tests were conducted at both Mode 1 and 3 plant operating temperatures and pressures
  - Leakage was collected for analysis
  - Test mockup was inspected after each test

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Leakage Simulation Test
Test Matrix

TEST #	DURATION	BORON	LEAK RATE
1	6.3 Hours	2680 ppm	0.015 gpm
2	8 Hours	2680 ppm	0.0017 gpm
3	8 Hours	2680 ppm	0.0004 gpm
4	8 Hours	1134 ppm	0.0012 gpm
5	55 Hours	2680 ppm	0.0006 gpm (0 gpm after 47 hr)

- All tests resulted in visible residue on nozzle and vessel surface
- Significant Lithium deposits left at nozzle/vessel surface

Leakage Simulation Test

Before cleaning

Test #1 (leak rate: 0.015 gpm)
Inside of vessel head after removal of nozzle, showing eroded leak path

Test #1 (leak rate: 0.015 gpm)
Post test view of nozzle/vessel head assembly

Leakage Simulation Test

Test #2 (leak rate: 0.0017 gpm)
Nozzle OD showing buildup
of white deposits

Test #2 (leak rate: 0.0017 gpm)
Close-up view of head-to-nozzle
annulus showing buildup of white deposits at
exit of annulus

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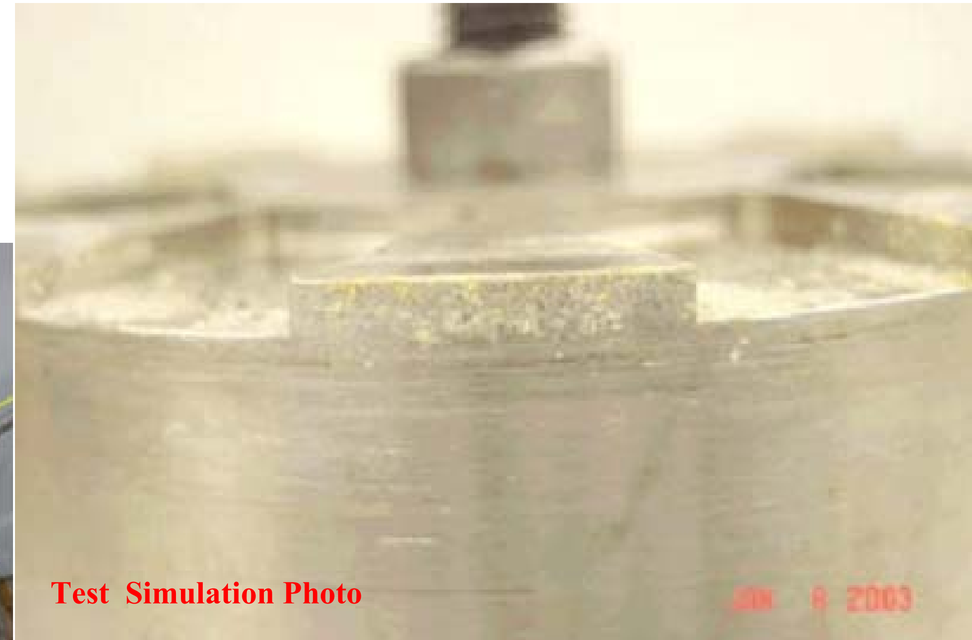
Leakage Simulation Test



Test #3 (leak rate: 0.0004 gpm)
Nozzle surface deposits

Test #3 (leak rate: 0.0004 gpm)
Post test view of nozzle/head assembly & thrust plate

Leakage Simulation Test

Test #4 (leak rate: 0.0012 gpm)
Nozzle outer diameter showing buildup of white deposits at discharge of annulus

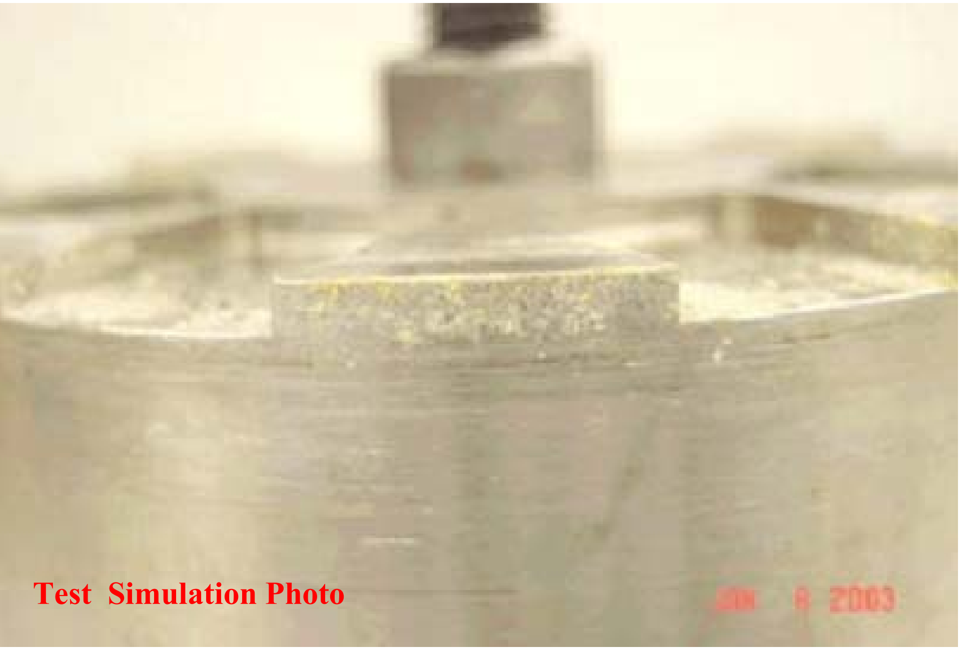
Test #4 (leak rate: 0.0012 gpm)
Close-up of head-to-nozzle annulus showing buildup of white deposit at exit of annulus

Leakage Simulation Test Results

- Small leak rates (equivalent to 0.0004 gpm in mockup) were detected by the presence of a small amount of material at the annulus exit
- Large leak rates (equivalent to 0.015 gpm in the mockup) were easily detected by presence of a considerable amount of rust-colored material extending down the nozzle outer diameter
- All leak rates were detected by both Boron and Lithium concentrations in the deposits

Test #5 (leak rate: 0.0006 gpm)
Crusty yellow deposit buildup on nozzle wall at annulus discharge

Leakage Simulation Test
Conclusions



Test #3 (leak rate: 0.0004 gpm)
Nozzle surface deposits

- Visible evidence of small leakage would be present on the IMI nozzle even for very small leaks
- Deposits may appear crusty with light yellow coloration
- Significant levels of Lithium (concentrations could reach levels of 15,000 ppm or higher) would be present in the deposit in addition to high Boron levels

Leakage Simulation Test
Conclusion

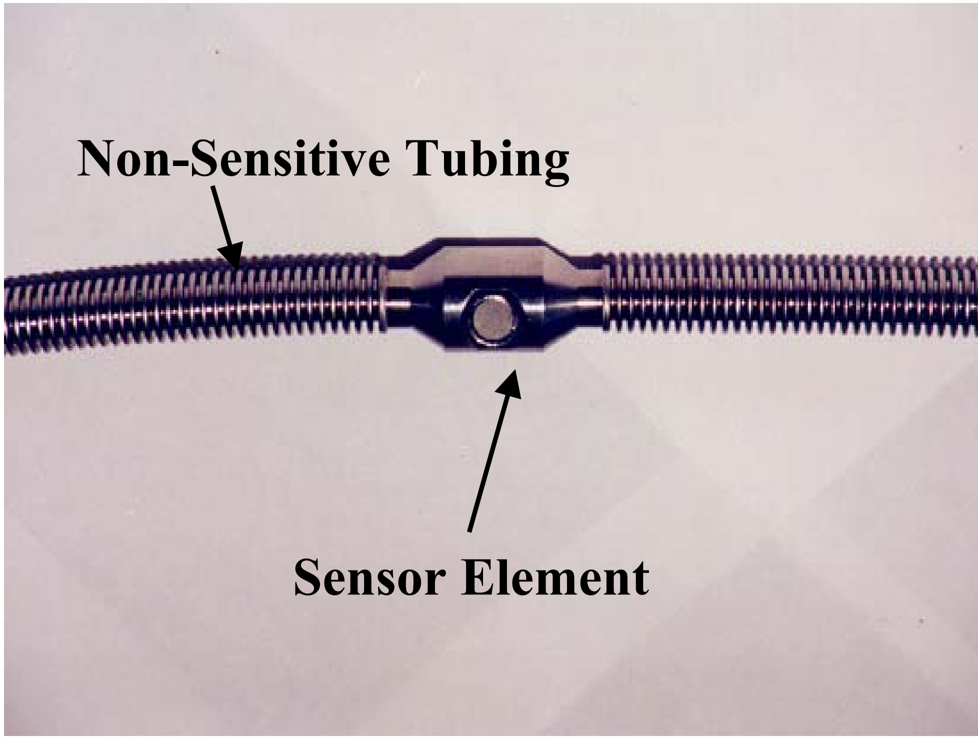
- Based on the results of test, there is confidence that leakage would be visually discernable at an IMI nozzle

Reactor Vessel IMI Nozzles
Inspection Plan

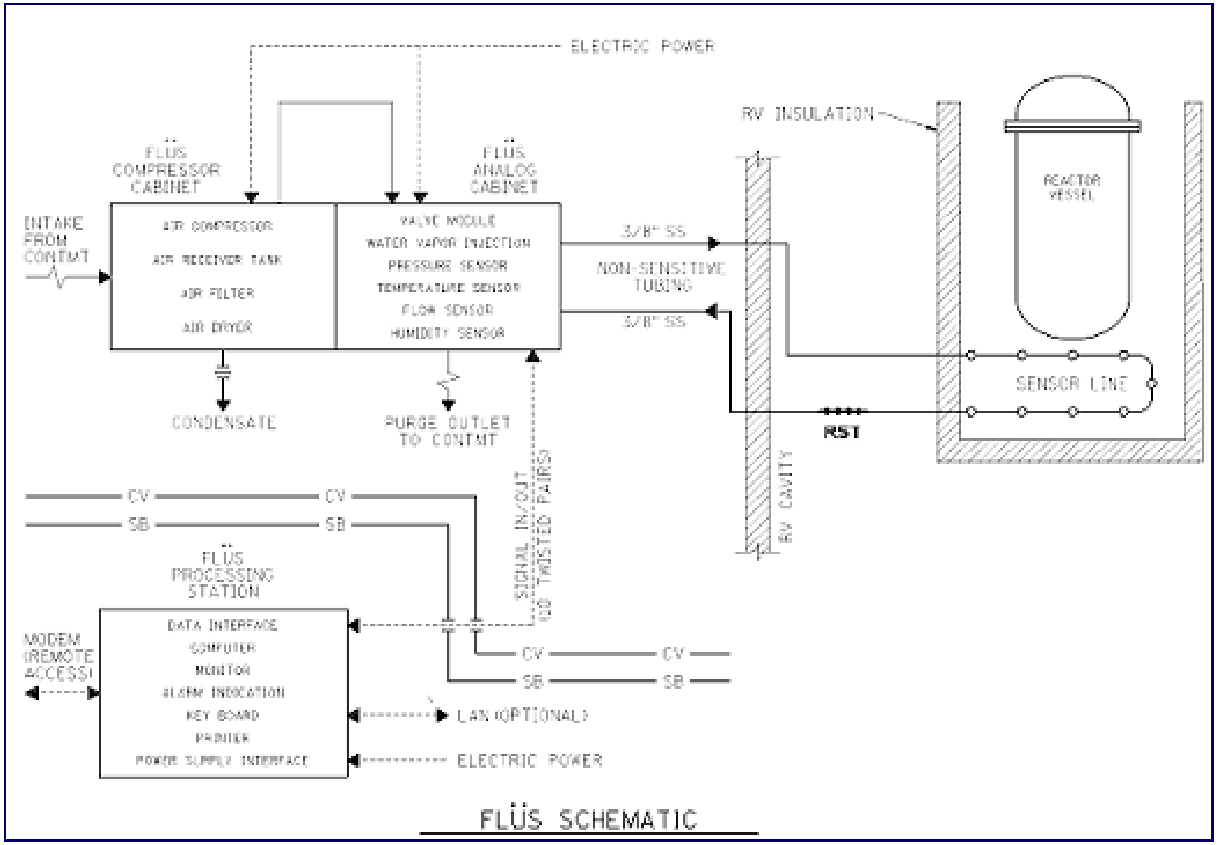
- Planned visual inspections prior to startup:
  - Obtain wipe samples from selected IMI nozzles to establish baseline chemistry
  - Perform video inspection of IMI nozzles
  - Perform visual inspection of IMI nozzles with Reactor Coolant System (RCS) pressure at 250 psig
  - Raise RCS to Mode 3 operating pressure and hold
  - Lower the RCS pressure
  - Re-perform video inspection of IMI nozzles
  - If required, obtain additional wipe samples for chemical analysis

FLÜS Online Leak Monitoring

- Davis-Besse is installing a FLÜS Online Leak Monitoring System to detect/locate under vessel leakage
- Leak detection system measures the moisture penetrating a sensor tube
- Installed or being installed in 12 units in a variety of European countries and Canada
- Operational history of 10 years



FLÜS Installation



- Install sensor tube between the reactor vessel insulation and reactor vessel
- Expected sensitivity of approximately 0.004 to 0.02 gpm (sensitivity test during Mode 3)
- System sensitivity is dependent on the air tightness of reactor vessel insulation

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Closing Comments

Gary Leidich
Executive Vice President - FENOC