U.S. Nuclear Regulatory Commission Meeting
with Nuclear Energy Institute and Material Reliability Program

Tuesday, July 3, 2001
10:00 a.m. - 12:30 p.m.
Room: T-2B3

Purpose: To brief the industry on the status of development for the generic communication on Vessel Head Penetration Nozzle Cracking and to discuss the Material Reliability Program's June 29, 2001, response to NRC's June 22, 2001, Request for Additional Information (RAI).

Success: Industry and external stakeholders have a clear understanding of the NRC's generic communication approach and current schedule.

Introduction:	Jake Zimmerman, NRC	10:00 a.m. - 10:15 a.m.
Opening Remarks:	Jack Strosnider, NRC	10:15 a.m. - 10:25 a.m.
Discussion of Generic Communication:	Allen Hiser, NRC	10:25 a.m. - 11:15 a.m.
Discussion of Schedule:	Jake Zimmerman, NRC	11:15 a.m. - 11:30 a.m.
Discussion of Office of Research Activities:	Ed Hackett, NRC	11:30 a.m. - 11:45 a.m.
Closing Comments:	NRC/MRP/NEI	11:45 p.m. - 12:00 p.m.
Comments/Questions from External Stakeholders:		12:00 p.m. - 12:30 p.m.

Additional information on Generic Activities on PWR Alloy-600 Weld Cracking may be found on the NRC web site at http://www.nrc.gov/NRC/REACTOR/ALLOY-600/index.html.

The NRC staff will be available immediately following the meeting to speak with members of the public.

CIRCUMFERENTIAL CRACKING OF REACTOR PRESSURE VESSEL HEAD PENETRATION NOZZLES

Allen Hiser

US Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Division of Engineering
Materials and Chemical Engineering Branch

Public Meeting

July 3, 2001

BACKGROUND ON CRDM CRACKING HISTORY

- First cracking of CRDM nozzles identified in France in 1989
  - Predominantly axial cracks -- minor circumferential tips
  - Axial flaws will cause leaks, circumferential can cause rod ejection/LOCA

- NRC issued Generic Letter 97-01
  - Integrated industry resolution
  - Used susceptibility models to rank plants
  - Voluntary volumetric examinations at highest ranked plants
  - Boric acid walkdowns to detect throughwall leakage

- Spring 2001 Outages -- Circumferential flaws detected (boric acid deposits)
  - Oconee Unit 3
    - ➜ 2 nozzles, 165° around circumference (throughwall & pin-hole ID indications)
    - ➜ Circumferential flaws detected when repairing axial indications
  - Oconee Unit 2
    - ➜ 1 nozzle, 45° around circumference (0.1 inch in throughwall extent)
  - Chronology of circumferential cracks
    - ➜ Axial cracks in J-groove welds or HAZ allow leakage into annular region
    - ➜ Leakage to vessel head OD may be restricted by interference fit of nozzles
    - ➜ Circumferential cracks initiate on OD and grow in aggressive environment

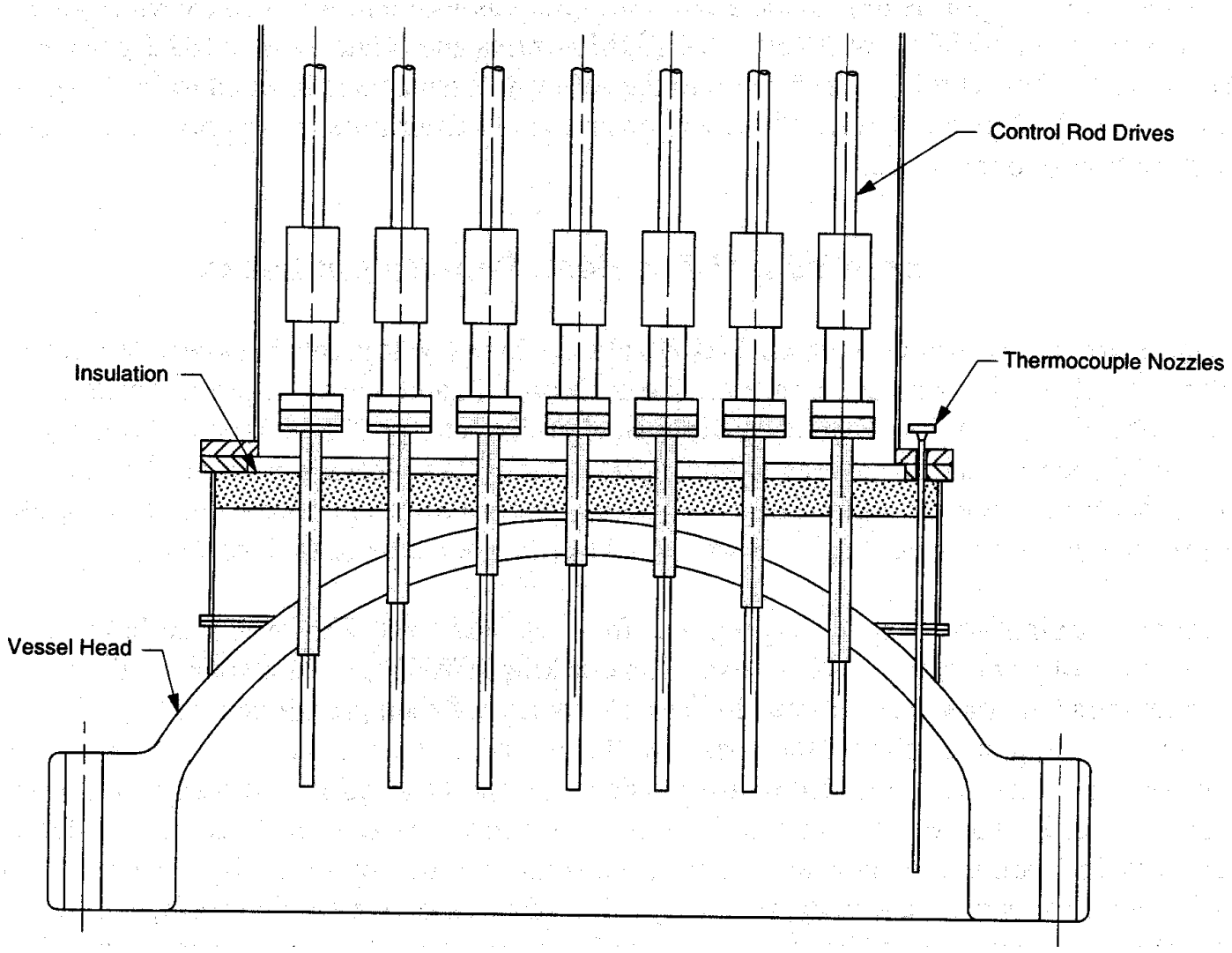
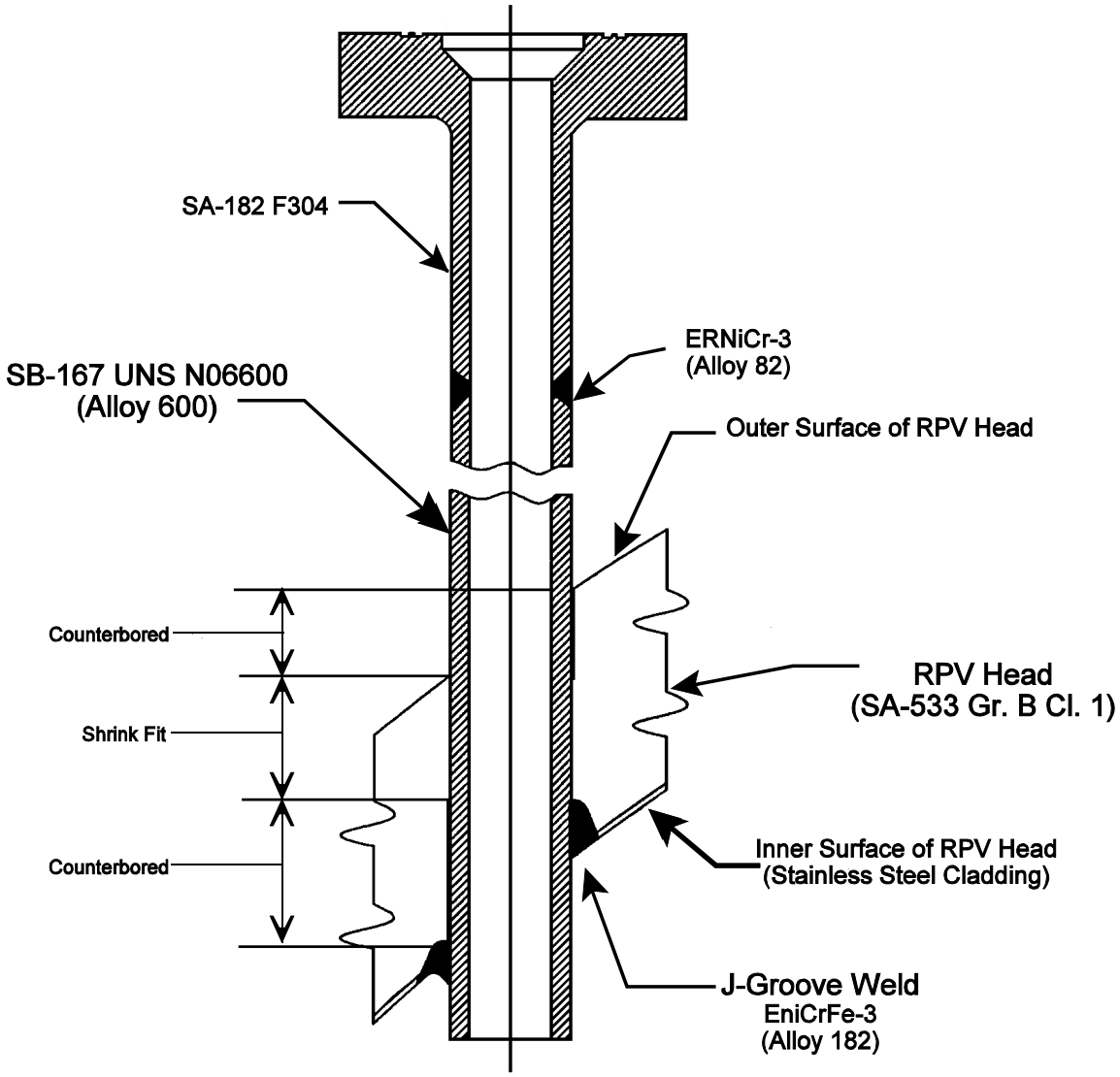


Figure 2 Typical Reactor Vessel Head - Oconee Unit 1 (Babcock & Wilcox)

Schematic View of B&W Design CRDM Nozzle Area



SAFETY PERSPECTIVE

- Failure of a CRDM nozzle constitutes a LOCA and control rod ejection which are analyzed events
- Existing PRAs indicate a level of risk requiring increased attention
- Worst case crack found at a high susceptibility plant had a remaining ligament safety margin of ≈6 to failure
- No reason to conclude that cracking won't affect additional units
- Timely, effective inspections should provide additional information on extent of the problem and provide confidence that safety is maintained and regulatory requirements are satisfied

OVERVIEW OF STAFF APPROACH

- Public meeting with industry -- April 12, 2001

- Industry report (MRP-44, Part 2) -- May 18, 2001

  - Staff review highlighted technical issues - questions to MRP (June 22, 2001)
  - Public meeting on June 7, 2001

- Proposed Generic Communication

  - Assess compliance with regulations and licensee actions
  - Determine prevalence and severity of PWSCC
  - Formulate future actions

INDUSTRY JUSTIFICATION FOR CONTINUED OPERATION (MRP-44, Part 2)

- Staff requested industry submittal (received May 18)

- Uses susceptibility ranking to assess entire industry (effective time at temperature)
  - 14 plants within 4 EFPY of Oconee Unit 3
  - 25 plants within 10 EFPY of Oconee Unit 3
  - 33 plants within 15 EFPY of Oconee Unit 3
  - 24 plants greater than 30 EFPY of Oconee Unit 3

- Uses Oconee Unit 3 as the benchmark case (cracking and leakage detection)

- Finds that nozzle leaks are detectable in all vessel heads

- Critical remaining ligament is 87° of the circumference (using ASME Code margins)

- Recommendations in industry report
  - Continue inspections for boric acid deposits
  - For plants within 10 EFPY of Oconee Unit 3 and having Fall 2001 outages, perform visual inspection of top head capable of detecting small amounts of leakage

STAFF CONCERNS

- Susceptibility model only provides plant ranking relative to Oconee Unit 3 (not predictive capability) - large uncertainties

- 10 EFPY threshold is not supported by operating experience
  - ANO-1 with axial cracks was > 11 EFPY “behind” according to GL 97-01 modeling
  - 33 out of 69 PWRs are within 15 EFPY of Oconee Unit 3

- Questions regarding adequacy of visual examinations for detection of boron
  - Small quantities of boric acid deposits (< 1 $in.^3$ at Oconee Unit 3)
    - ➜ Variability in interference fits
    - ➜ Tightness of PWSCC cracks
  - Difficulty in identifying leakage from CRDM nozzle cracking
    - ➜ Leakage from Conoseals®, etc. - has head been cleaned ?
    - ➜ Insulation on head -- cannot readily inspect bare metal of RPV head

- Remaining ligament margins do not incorporate time margin and crack growth rate

- Potential for reaching critical crack size before detecting leakage
  - Periodic examination -- no continuous monitoring
  - Inspection under insulation is not adequately addressed

- Postulated accident analysis/risk insights

- Compliance with regulatory requirements

APPLICABLE REGULATORY REQUIREMENTS

- 10 CFR 50.55a
  - References Section XI of ASME B&PV Code
  - Does not permit through-wall cracking

- GDC 14 - Reactor Coolant Pressure Boundary (Appendix A to 10 CFR Part 50)
  - RCPB shall have extremely low probability of abnormal leakage, or rapidly propagating failure and of gross rupture

- GDC 31 - Fracture Prevention of Reactor Coolant Pressure Boundary (Appendix A)
  - RCPB must minimize the probability of rapidly propagating fracture

- GDC 32 - Inspection of Reactor Coolant Pressure Boundary (Appendix A)
  - RCPB shall be designed to permit periodic inspection and testing to assess their structural and leaktight integrity

- Criterion IX - Control of Special Processes (Appendix B to 10 CFR Part 50)
  - Special processes such as non-destructive testing shall be controlled and accomplished by qualified personnel using qualified procedures in accordance with codes/standards/specifications/criteria & other special requirements

- Criterion V - Instructions, Procedures, and Drawings (Appendix B to 10 CFR Part 50)
  - Activities affecting quality shall be prescribed by documented instructions, procedures, or drawings, including appropriate acceptance criteria

- Criterion XVI - Corrective Action (Appendix B to 10 CFR Part 50)
  - Conditions adverse to quality are promptly identified and corrected
  - Determine cause of condition and corrective action to preclude repetition

QUALIFICATION OF EXAMINATION METHODS

- VT-2 Visual Examination Qualification
  - Capable of detecting small amounts of boric acid deposits and discriminating deposits from VHP nozzle and other sources

- Plant-Specific Visual Examination Qualification
  - Plant-specific demonstration that VHP nozzle cracks will lead to deposits on the RPV head (interference fit measurements, etc.)
  - Capable of reliable detection and source identification of leakage (insulation, pre-existing deposits, other impediments)

- Volumetric Examination Qualification
  - Demonstrated capability to reliably detect cracking on the OD of VHP nozzles

STAFF ASSESSMENT OF SUSCEPTIBILITY

! Subpopulations of PWRs based on PWSCC susceptibility ranking

- Plants that have identified cracking
  - ➜ PWSCC of nozzles is a documented occurrence
  - ➜ 4 plants total (Oconee 1,2,3 and ANO-1)
- Plants with HIGH susceptibility to PWSCC (<4 EFPY from the ONS3 condition)
  - ➜ PWSCC of nozzles likely to occur in the near term
  - ➜ 10 plants total
- Plants with MODERATE susceptibility to PWSCC (from 4 to 30 EFPY of ONS3)
  - ➜ PWSCC of nozzles not likely in short term, but could occur
  - ➜ 31 plants total
- Plants with LOW susceptibility (balance of plants)
  - ➜ PWSCC of nozzles not likely throughout current license period
  - ➜ 24 plants total

! Verify compliance with regulatory requirements through QUALIFIED examinations

- Graded approach depending on PWSCC likelihood
- Examinations of 100% of all VHP nozzles
  - ➜ Based on statistics and no identified preferential cracking tendencies
  - ➜ All VHPs - similar materials, etc., only failure consequences vary

PROPOSED INFORMATION REQUEST

Within 30 days of issue date:

- Provide plant-specific susceptibility ranking (data used to determine ranking) and description of VHP nozzles (number, type and materials of construction)

- For plants that have identified leakage or cracking in VHP nozzles

  a. Describe the extent of VHP nozzle leakage and cracking (number, location, size, and nature of each crack detected)

  b. Describe the inspections (type, scope, qualification requirements and acceptance criteria), repairs, and other corrective actions taken

  c. Discuss plans and schedule for future inspections (type, scope, qualification requirements and acceptance criteria)

  d. Discuss how the planned inspections will meet regulatory requirements

     (1) If inspection plans do not include inspections before end of 2001, provide the basis for concluding that the regulatory requirements will continue to be met until the inspections are performed

     (2) If inspection plans do not include volumetric examination of all VHPs, provide basis for concluding that the regulatory requirements will be satisfied

PROPOSED INFORMATION REQUEST

! For plants with susceptibility rankings within 4 EFPY of Oconee Unit 3

a. Describe the VHP nozzle inspections (type, scope, qualification requirements and acceptance criteria) performed in the past 5 years

b. Discuss plans and schedule for future inspections (type, scope, qualification requirements and acceptance criteria)

c. Discuss how the planned inspections will meet regulatory requirements

(1) If inspection plans do not include inspections before end of 2001, provide the basis for concluding that the regulatory requirements will continue to be met until the inspections are performed

(2) If inspection plans include only visual inspections, discuss corrective actions, including alternative inspection methods (for example, volumetric examination), if leakage is detected

PROPOSED INFORMATION REQUEST

! For plants with susceptibility rankings within between 4 and 30 EFPY of Oconee 3

a. Discuss plans and schedule for future inspections (type, scope, qualification requirements and acceptance criteria)

b. Discuss how the planned inspections will meet regulatory requirements

(1) If inspection plans do not include a visual examination at the next scheduled refueling outage, provide the basis for concluding that the regulatory requirements will continue to be met until the inspections are performed

! For plants with refueling or scheduled maintenance outages, provide within 30 days after restart

a. Describe the extent of VHP nozzle leakage and cracking (number, location, size, and nature of each crack detected)

b. Describe the inspections (type, scope, qualification requirements and acceptance criteria), repairs, and other corrective actions taken

PROPOSED REQUIRED RESPONSE

Within 30 days of issue date, submit a written response indicating:

(1) whether the requested information will be submitted

(2) whether the requested information will be submitted within the requested time period

Addressees who choose not to submit the requested information, or are unable to satisfy the requested completion date, must describe in their response any alternative course of action that is proposed to be taken, including the basis for the acceptability of the proposed alternative course of action.

STATUS OF OFFICE OF NUCLEAR REGULATORY RESEARCH (RES) INITIATIVES ON REACTOR VESSEL HEAD PENETRATION (VHP) CRACKING

Briefing for Public Meeting with NEI/MRP

Ed Hackett
Assistant Chief, RES/DET/MEB

July 3, 2001

Status of RES Initiatives on
Reactor Vessel Head Penetrations (VHPs)

- ➜ At the request of NRR (June 11, 2001), RES formed an independent group of experts to review technical aspects of the recent VHP cracking occurrences at Oconee and ANO:
  - ➜ The group has completed their initial review as of June 29, 2001
  - ➜ RES is currently developing an integrated perspective based on the initial expert review and consideration of other information sources
- ➜ RES staff and contractors have continued to provide technical support to NRR through on-going programs:
  - ➜ Environmentally Assisted Cracking
  - ➜ Non-destructive Evaluation
  - ➜ Structural Integrity/Fracture Mechanics
  - ➜ Probabilistic Risk Assessment
- " RES is planning on support of NRR for any VHP inspection oversight activities for Fall/01' outages

Status of RES Initiatives on
Reactor Vessel Top Head Penetrations
Independent Group of Experts

" Expert Group Members:

- S Dr. William Shack (ANL) - Environmentally Assisted Cracking
- S Dr. Steven Doctor (PNNL) - Non-destructive Evaluation
- S Dr. Gery Wilkowski (EMC) - Leakage Integrity
- S Dr. Richard Bass (ORNL) - Structural Integrity
- S Mr. Mark Cunningham (RES/PRAB) - Probabilistic Risk Assessment

" Expert Group Charter

- S Evaluate technical/safety bases for continued operation;
- S Evaluate technical issues and provide conclusions/recommendations relevant to:
  - # Contents of proposed generic communication
  - # Guidance for inspection activities for Fall/01' outages
- S Provide written inputs to RES by June 29, 2001
- S Provide technical support for ACRS meetings (July 10&11, 2001)