

July 20, 2001

MEMORANDUM TO: James W. Clifford, Chief, Section 2
Project Directorate I
Division of Licensing Project Management

FROM: Jacob I. Zimmerman, Project Manager, Section 2 /RA/
Project Directorate I
Division of Licensing Project Management

SUBJECT: SUMMARY OF JULY 3, 2001, MEETING WITH ELECTRIC POWER
RESEARCH INSTITUTE MATERIALS RELIABILITY PROGRAM AND
NUCLEAR ENERGY INSTITUTE ON GENERIC ACTIVITIES RELATED
TO VESSEL HEAD PENETRATION NOZZLE CRACKING

On July 3, 2001, members of the U.S. Nuclear Regulatory Commission (NRC) staff participated in a public meeting held at the NRC offices in Rockville, Maryland, with representatives from the Electric Power Research Institute (EPRI) Materials Reliability Program (MRP), the Nuclear Energy Institute (NEI), various operating nuclear reactor licensees, and members of the public. In addition, the NRC established a telephone conference bridge number, to allow interested individuals to participate in the meeting via telephone. The bridge number and meeting slides were made available prior to the meeting on the NRC web site for this issue ("Generic Activities on PWR Alloy-600 Weld Cracking," at <http://www.nrc.gov/NRC/REACTOR/ALLOY-600/index.html>). Attachment 1 is the meeting agenda, Attachment 2 provides the meeting slides, and Attachment 3 lists the meeting attendees and those participating via telephone.

The purpose of the meeting was to brief the industry and external stakeholders on the status of development of a generic communication on vessel head penetration (VHP) nozzle cracking and to discuss the MRP's June 29, 2001, response to the NRC staff's June 22, 2001, request for additional information (RAI).

Mr. Jack Strosnider, the Division Director for the Division Engineering in the NRC's Office of Nuclear Reactor Regulation (NRR), discussed the staff's actions to date. This included the drafting of a proposed bulletin and meetings with NRC senior management and the Committee to Review Generic Requirements on the proposed bulletin content and requested information. In addition, Mr. Strosnider discussed the MRP's June 29, 2001, RAI response and noted that the response documented information previously discussed during the June 7, 2001, public meeting. Mr. Strosnider informed the MRP that the staff has done a cursory review of their response and it appears that several key pieces of information, such as the names of the plants with their susceptibility ranking and the applied stress intensity values profile, were not provided. Mr. Strosnider also informed the industry that the staff is trying to obtain a better understanding of the design and configuration of the components above the reactor vessel head and that a supplemental RAI may be forthcoming.

Mr. Allen Hiser, the lead technical reviewer, from the Materials and Chemical Engineering Branch of the Division of Engineering, presented background information on control rod drive mechanism nozzle cracking and discussed an overview of the staff's approach for the proposed bulletin. Mr. Hiser discussed the purpose of the proposed bulletin, which are: 1) to assess compliance with regulations, and licensee actions; 2) to determine the prevalence and severity of primary water stress corrosion cracking; and 3) to determine the need for future NRC action. In addition, Mr. Hiser discussed staff concerns with uncertainty of the industry susceptibility model, the adequacy of visual examinations for detection of boric acid deposits, the potential for reaching critical crack size before detecting leakage, postulated risk analysis/risk insights, and compliance with regulatory requirements. Finally, Mr. Hiser discussed the proposed information request and required response in the proposed bulletin.

I gave a brief discussion on the schedule for issuance of the proposed bulletin. The schedule includes briefings of the Advisory Committee on Reactor Safeguards (ACRS) Materials and Metallurgy subcommittee on July 10, 2001; the ACRS Full Committee on July 11, 2001; the Committee to Review Generic Requirements on July 12, 2001; issuance of the Commission Information Paper on July 18, 2001; and, issuance of the final bulletin by August 1, 2001.

Dr. Edwin Hackett, the Assistant Chief of the Materials Engineering Branch, from the Division of Engineering Technology in the Office of Nuclear Regulatory Research (RES), presented a status of RES initiatives on this issue. One of these initiatives includes the formation of an independent group of experts to review the technical aspects of the recent reactor vessel head penetration cracking occurrences at Oconee and Arkansas Nuclear One, Unit 1. The charter for the expert group includes an evaluation of the technical/safety bases for continued operation and an evaluation of the technical issues, with conclusions and recommendations relevant to the contents of the proposed bulletin and guidance for inspection activities for fall 2001 outages. In addition, RES staff and contractors have continued to provide technical support to NRR for ongoing programs in the areas of: environmentally assisted cracking; non-destructive evaluation; structural integrity/fracture mechanics; and probabilistic risk assessment.

The staff will schedule further meetings with industry, as necessary, to facilitate the timely exchange of technical information and to assure that stakeholders are kept informed of the status of the issue in the regulatory process.

Attachments: As stated

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Attachments: As stated

Distribution:

PUBLIC	PDI-2 R/F	JStrosnider	WBateman	AHiser
KWichman	AHowell, RIV	CECarpenter	JClifford	ACRS
MMayfield, RES	NChokshi, RES	EHackett, RES	MReinhart	TClark
EAdensam	JZwolinski	WLanning, RI	CCasto, RII	OGC
JGrobe, RIII	JZimmerman	WNorris	RCaldwell	TTate
DStarkey	JShapaker	BJain	DJackson	RAssa
SRosenberg	FJaxheimer, RI	JChung	SCollins	JDavis
BBorchardt	JBlake, RI	LMarsh	FEItawila	MSnell
SMalik				

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NAME	JZimmerman	TClark	CGratton for JClifford
DATE	7/20/2001	7/20/2001	7/20/2001

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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

Attachment 2

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

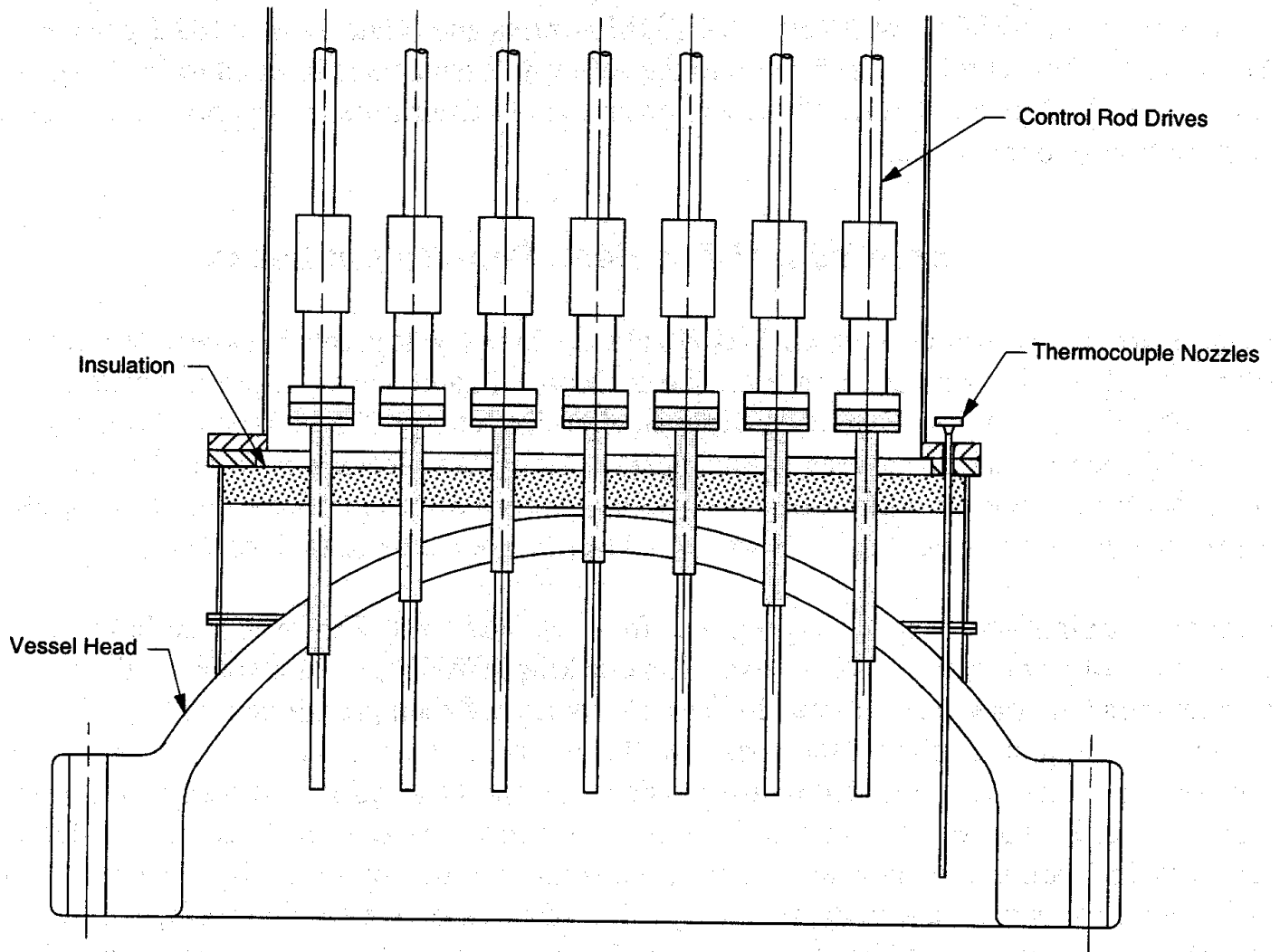
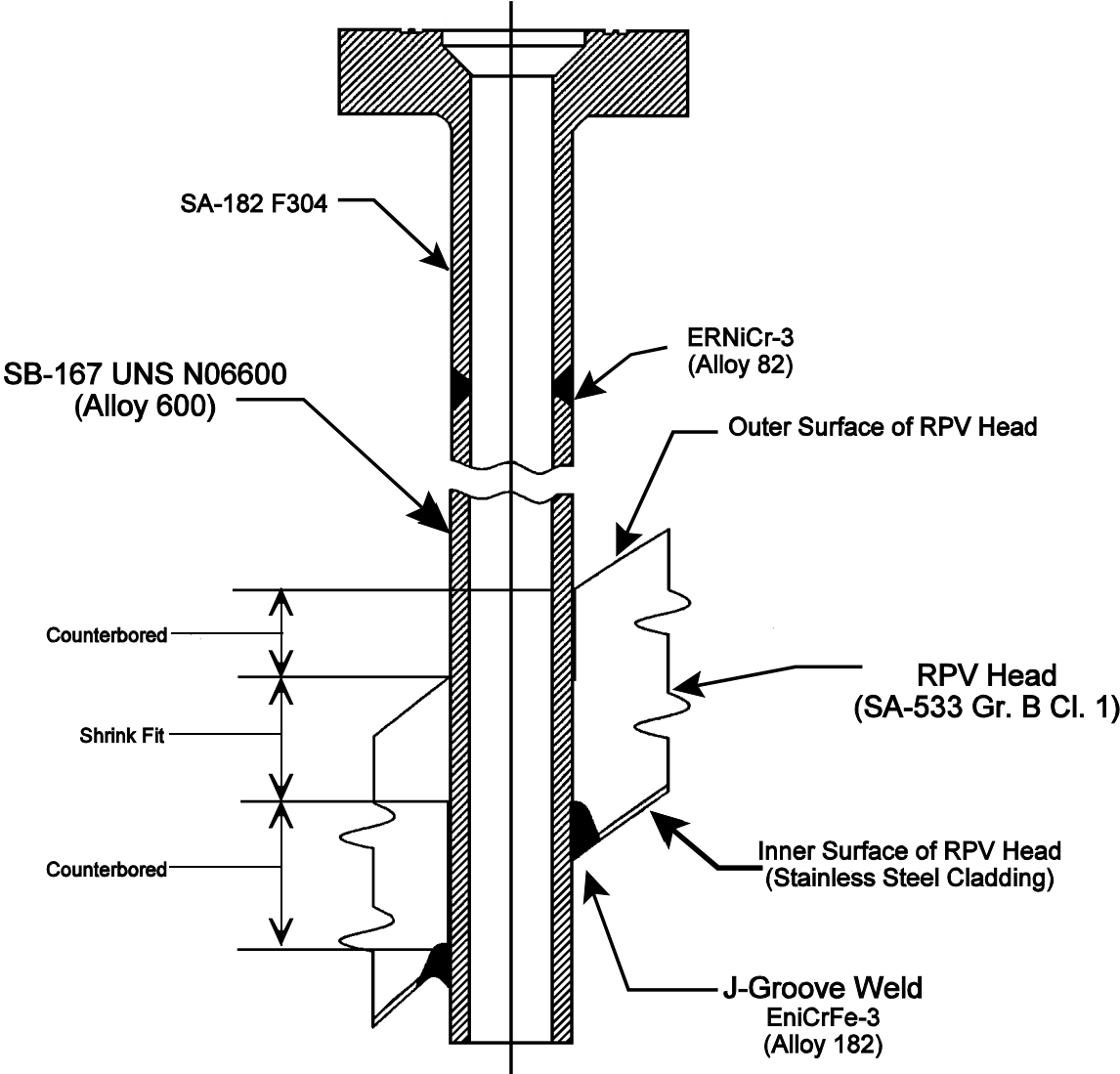


Figure 2 Typical Reactor Vessel Head - Oconee Unit 1 (Babcock & Wilcox)

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

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

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
 - ▶ Appropriate for Moderate Susceptibility Plants (31 total) - PWSCC of nozzles not likely in short term, but could occur

- Plant-Specific Visual Examination Qualification
 - ▶ Plant-specific demonstration that VHP nozzle cracks will lead to deposits on the RPV head (interference fit measurements, etc.)
 - ▶ Must be capable of reliable detection and source identification of leakage (insulation, pre-existing deposits, other impediments)
 - ▶ Appropriate for High Susceptibility Plants (10 total) - PWSCC of nozzles likely to occur in the near term

- Volumetric Examination Qualification
 - ▶ Demonstrated capability to reliably detect cracking on the OD of VHP nozzles
 - ▶ Appropriate for plants that have identified cracking (4 total) - PWSCC of nozzles is a documented occurrence
 - ▶ Default if Visual Examination cannot be Qualified
 - ▶ Applies for any plant finding leakage

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

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



**NRC Meeting with Nuclear Energy Institute and Material Reliability Program on
Vessel Head Penetration Nozzle Cracking**

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

Name	Organization/Title	Phone Number/Email
Jake Zimmerman	NRC/NRR/DLPM - Lead Project Manager	(301) 415-2426, jiz@nrc.gov
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Sherry Bernhoft	FPC	(352) 563-4566
Vaughn Wagoner	CPL	(919) 546-7959
Mike Tuckman	Duke	(704) 382-2200
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Frank Ammirato	EPRI	(704) 547-6129
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Kurt Cozens	NEI	(202) 739-8085
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E.G. Adensam	NRC/NRR/DLPM/LPDI	(301) 415-1353
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A. Hiser	NRC/NRR/DE/EMCB	(301) 415-1034
S. Collins	NRC/NRR	(301) 415-1270



**NRC Meeting with Nuclear Energy Institute and Material Reliability Program on
Vessel Head Penetration Nozzle Cracking**

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

- Phone Participants -

Name	Organization/Title	Phone Number/Email
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D. Bryan Miller	Entergy - Corporate Licensing	(504) 739-6692
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Jim Bennetch	Virginia Electric & Power Co. (Dominion)	
Dean Price	Virginia Electric & Power Co. (Dominion)	
Dave Sommers	Virginia Electric & Power Co. (Dominion)	
Margaret Earle	Virginia Electric & Power Co. (Dominion)	
Tom Shaub	Virginia Electric & Power Co. (Dominion)	
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Bruce Hinton	Westinghouse	(860) 285-3106
Robert Phillips	TVA	
Fred Jaxheimer	USNRC/Region I/DRS	
Jerry Blake	USNRC/Region II/DRS	