CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Reactor Safeguards Materials and Metallurgy & Plant Operations Joint Subcommittee Meeting

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Heather Craycraft
Official Reporter
Neal R. Gross & Co., Inc.

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
MATERIALS & METALLURGY AND PLANT OPERATIONS SUBCOMMITTEES
VHP CRACKING AND RPV HEAD DEGRADATION
COMMISSIONERS' CONFERENCE ROOM (O-1G16)
11545 ROCKVILLE PIKE, ROCKVILLE, MARYLAND

April 23, 2003

- PROPOSED AGENDA -

	SUBJECT	PRESENTER	TIME
I.	Introductory Remarks Subcommittee Chairmen	F.P. Ford, ACRS J.D. Sieber, ACRS	8:30 -8:35 a.m.
II.	NRC Inspection Requirements and Guidance	Allen Hiser, NRR	8:35 - 10:00 a.m.
		*****BREAK*****	10:00 - 10:15 a.m.
III.	NRC Inspection Requirements and Guidance (Continued)	Allen Hiser, NRR	10:15 - 11:30 a.m.
		*****LUNCH*****	11:30 - 12:30 p.m.
IV.	LLTF Action Plans	Brendan Moroney, NRR Cayetano Santos, RES	12:30 - 2:00 p.m.
V.	General Discussion and Adjournment		2:00 - 3:00 p.m.

Note: Presentation time should not exceed 50% of the total time allocated for a specific item. Number of copies of presentation materials to be provided to the ACRS - 40.

ACRS CONTACT: Maggalean W. Weston, mww@nrc.gov or (301) 415-3151.

REACTOR VESSEL HEAD INSPECTIONS

Presented by

Dr. Allen L. Hiser, Jr.
Materials and Chemical Engineering Branch
Office of Nuclear Reactor Regulation

ACRS Materials & Metallurgy, and Plant Operations Subcommittees

April 23, 2003

OUTLINE

- Background
- Order EA-03-009 (issued February 11, 2003)
  - Inspection requirements
  - Relaxation requests
- Recent plant experience
  - North Anna Unit 2 - fall 2002
  - ANO Unit 1 - fall 2002
  - Sequoyah 1 - fall 2002
  - North Anna Unit 1 - spring 2003
  - Sequoyah 2 - spring 2003
  - South Texas Project Unit 1 - spring 2003
- Outlook

BACKGROUND

- Fall 2000
  - Oconee Unit 1 identifies deposits - axial leak

- Spring 2001
  - Oconee Unit 2 and 3 identify circumferential cracks
  - ANO Unit 1 identifies a leaking nozzle

- **NRC issues Bulletin 2001-01 - August 2001**
  - Focus is safety issue (circumferential cracks) for high susceptibility plants

- Fall 2001
  - Circumferential cracks identified - Crystal River 3 and Oconee 3
  - Leaks and repairs at Surry 1, North Anna 2 and TMI

BACKGROUND (cont.)

- Spring 2002
  - Davis-Besse identifies RPV head wastage & circumferential cracking

- **NRC issues Bulletin 2002-01 - March 2002**
  - Focus is safety issue is RPV wastage for all plants

- Spring 2002
  - Millstone identifies part through-wall cracks

- **NRC issues Bulletin 2002-02 - August 2002**
  - Focus is adequacy of inspection programs - methods (non-visual NDE for high susceptibility) and frequency
  - Licensee responses generally vague on future program, many cite MRP-75 program

BACKGROUND (cont.)

- Fall 2002
  - North Anna 2 identifies
    - ✓ Prevalent weld cracking
    - ✓ Leak from a repaired nozzle
    - ✓ Circumferential cracking at weld root without boron deposits
  - ANO Unit 1 identifies leak from a repaired nozzle
  - Oconee Unit 2 identifies possible through-wall cracking without boron deposits on the RPV head
  - Head corrosion at Sequoyah Unit 2 - above head boron source

- **NRC issues Order EA-03-009 - February 2002**
  - Mandates inspections for all PWRs

- Spring 2003
  - Sequoyah Unit 1 - boron deposit on a low susceptibility plant
  - South Texas Project Unit 1 - boron deposits on the lower head

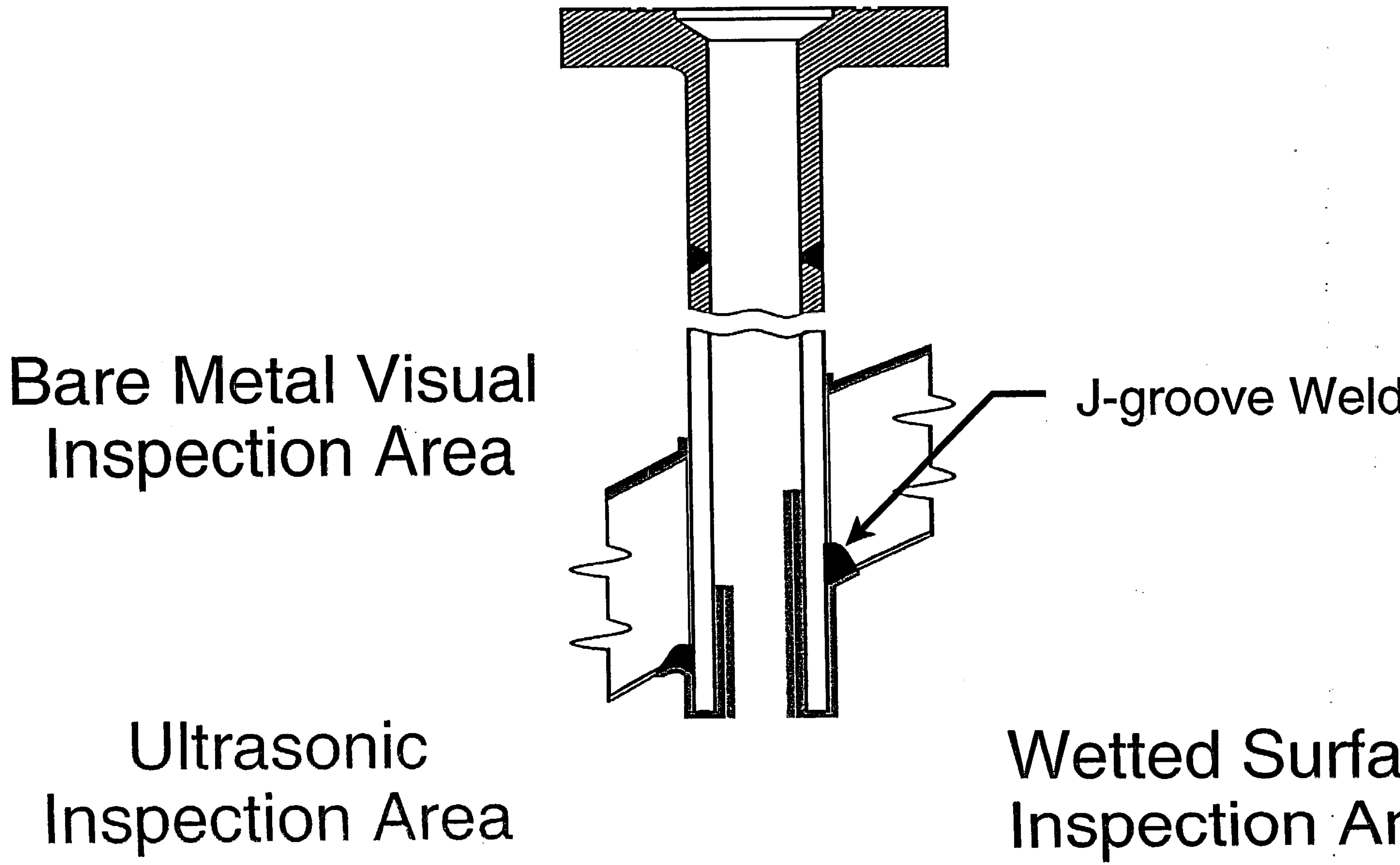
OVERVIEW OF ORDERS

- Issued February 11, 2003
- Issued to all PWRs
- Adequate protection basis
  - ASME Code inspections are inadequate
  - Revisions to inspection requirements are not imminent
  - RPV head degradation and nozzle cracking pose safety risks if not promptly identified and corrected
- Provides a clear regulatory framework pending the incorporation of revised inspection requirements into 10 CFR 50.55a

ORDER REQUIREMENTS

- Evaluate susceptibility - effective degradation years (EDY)
- High plants - bare metal visual AND non-visual NDE at EVERY RFO
- Moderate plants - BMV and non-visual NDE at alternating RFOs
- Low plants - BMV by next 2 RFOs (repeat every 3rd RFO or 5 years), non-visual by 2008 (repeat every 4th RFO or 7 years)
- Non-visual NDE is EITHER:
  - Ultrasonic with evaluation of interference fit leakage, OR
  - Wetted-surface examination

Order EA-03-009
Required Inspection Surfaces



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ORDER REQUIREMENTS

- Explicit requirements and criteria to inspect repaired nozzles/welds
- Each RFO, must perform visual inspections to identify boric acid leaks from components above the RPV head - follow-up actions include inspections of potentially-affected RPV head areas and nozzles
- Flaw evaluation per NRC guidance (Strosnider letter fall 2001)
- Orders also apply to new RPV heads, either Alloy 600 (Davis-Besse) or Alloy 690 (North Anna 2 and many others)
- Post-outage report 60 days after restart

LICENSEE OPTIONS

- Must respond within 20 days
  - May request a hearing
  - May request a time extension to respond
- Request Director of NRR to relax or rescind requirements of the order
- Requests for relaxation for specific VHP nozzles will be evaluated using procedures for proposed alternatives to the ASME Code in accordance with 10 CFR 50.55a(a)(3)

NEED FOR ORDERS

- Past process of issuing Bulletins unwieldy, inconsistent, not stable, and has no regulatory weight (licensee commitments only)
- Rulemaking would take at least 1 or 2 years
- Orders can be revised or rescinded as necessary
- Although inspection plans for the next RFOs were generally acceptable, NRC wanted to provide licensees with planning time to meet order requirements
- Concerns that above RPV head leakage could result in undetected RPV head degradation

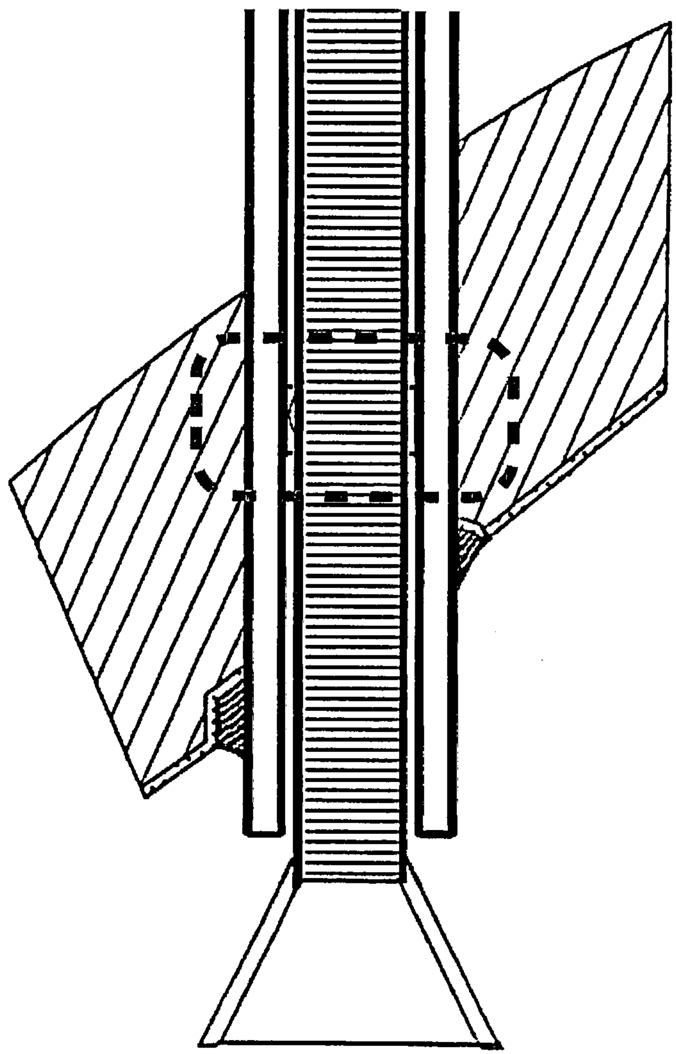
RELAXATION REQUESTS

- Limitations above the J-groove weld
  - Centering tabs & step on nozzle ID
  - Stress in non-inspected area below 28 ksi
  - Hardship - would have required guide sleeve removal and re-welding of a guide funnel onto nozzle

- Limitations below the J-groove weld
  - Guide funnel threads (ID & OD) and tapers on end of nozzles
  - Transducer coupling for time-of-flight-diffraction

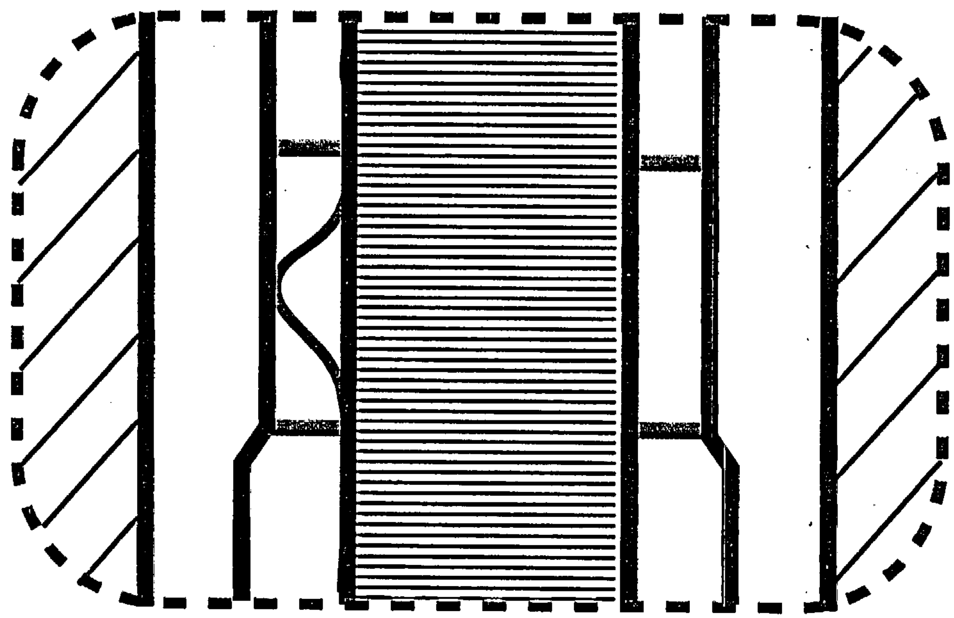
- Bare metal visual examinations
  - Localized insulation and support shroud interferences
  - Insulation prevents total access to RPV head surface
    - ✓ UT RPV head thickness measurements

Calvert Cliffs
Order Inspection Limitations

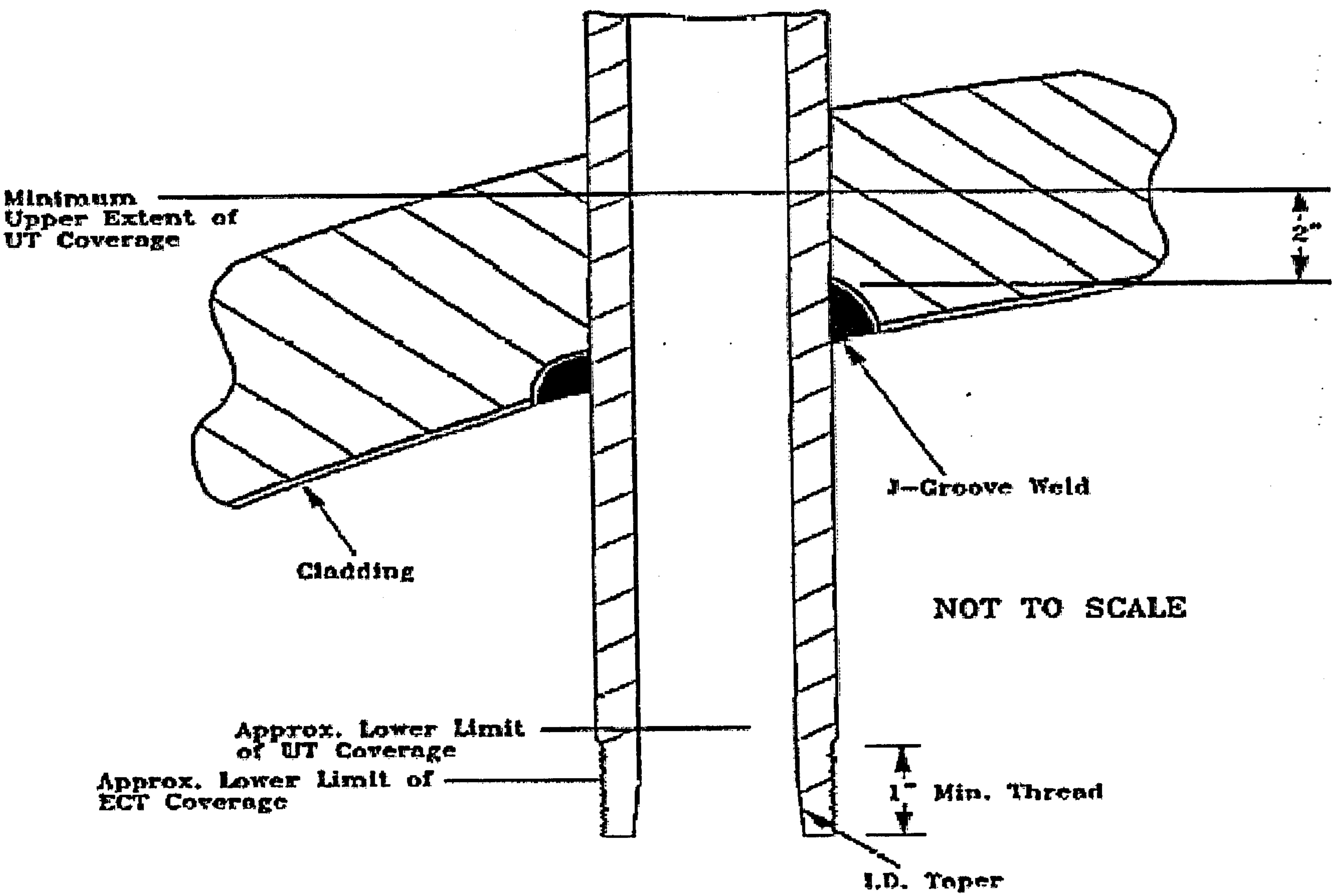


Thermal/Guide Sleeve

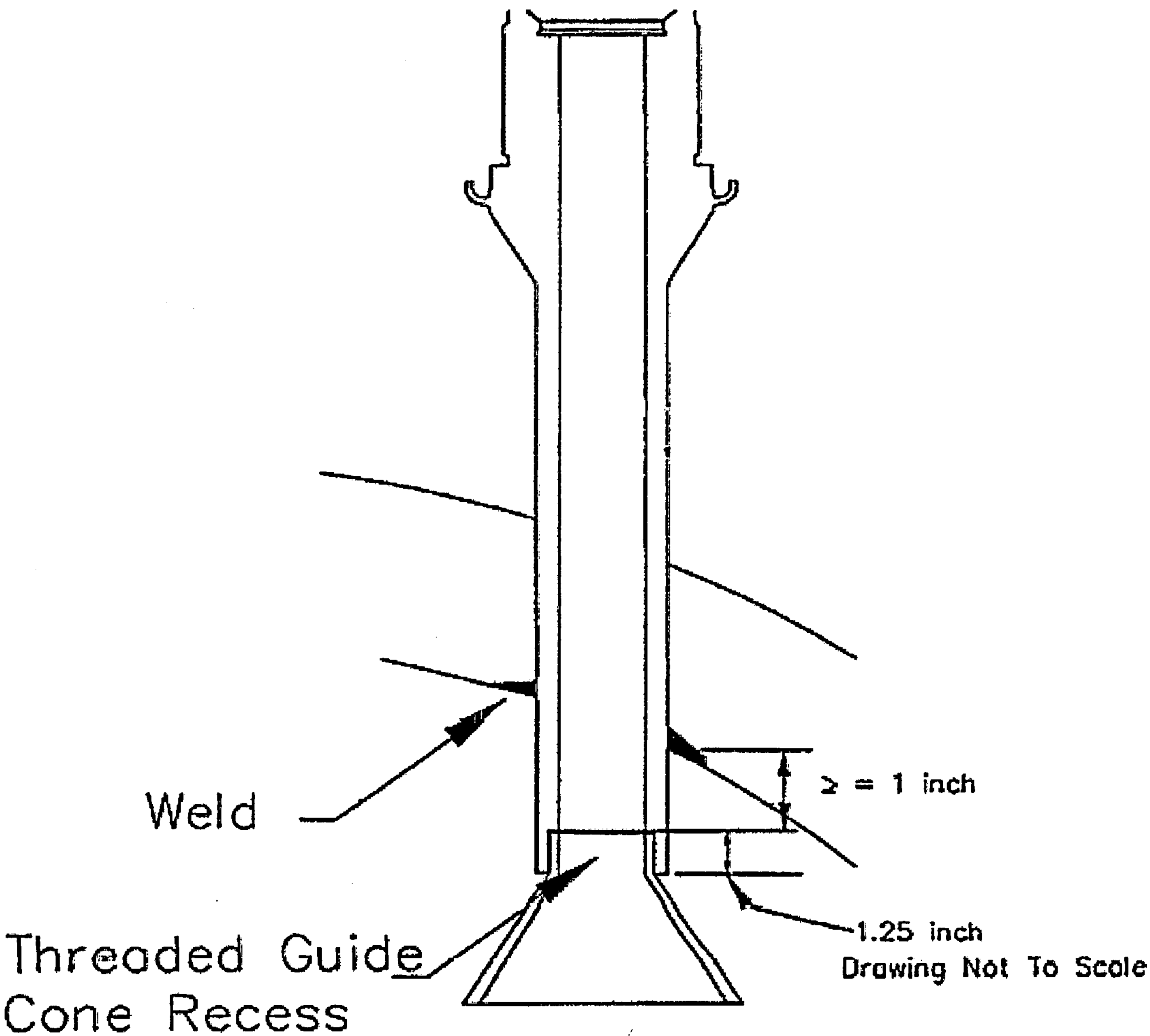
Sleeve Expansion Points



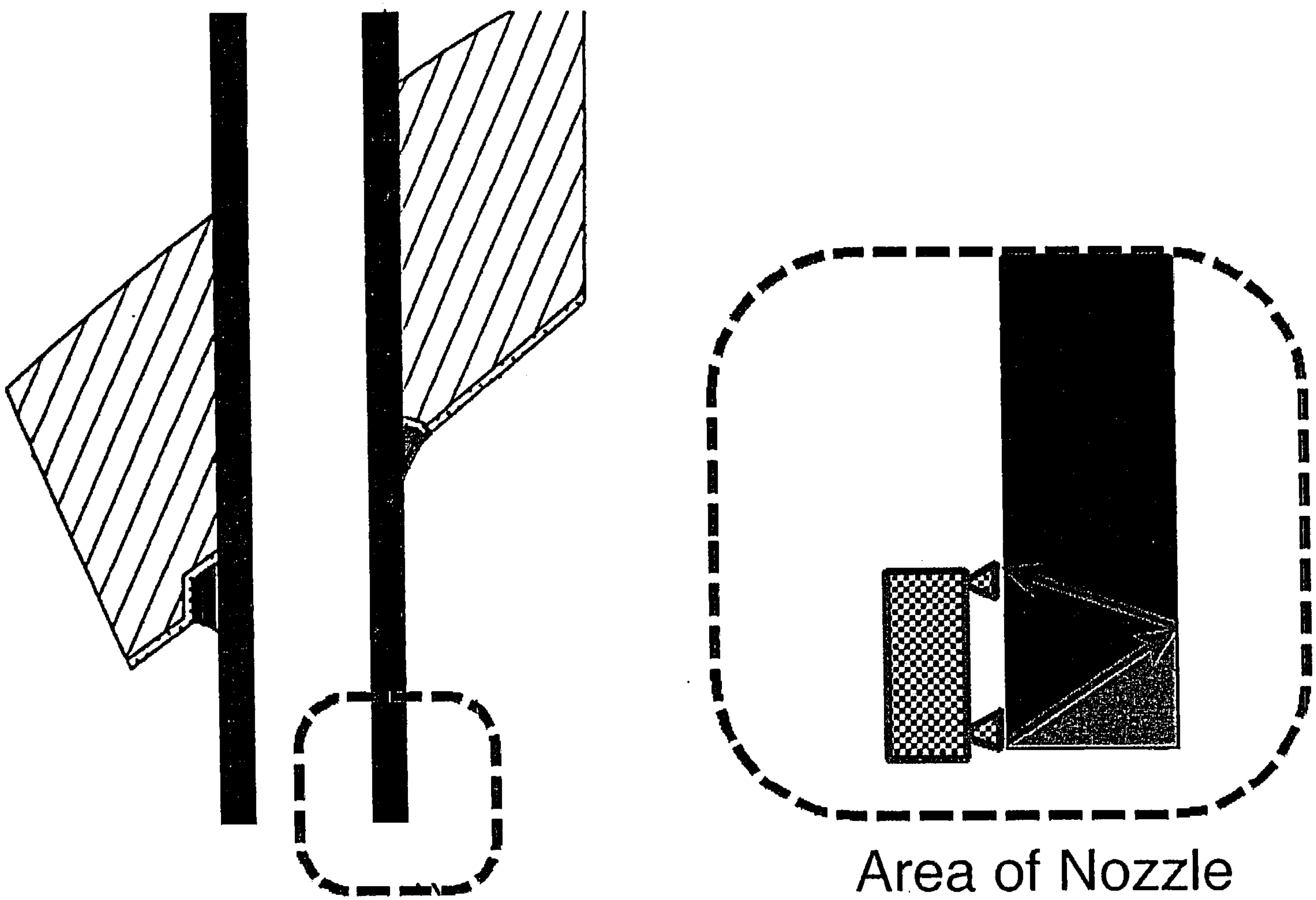
Farley Nuclear Power Plant
Cross-section of Typical 4" RPV Nozzle Penetration



St. Lucie Unit 2
Typical RPV Nozzle With Threaded Guide Funnel

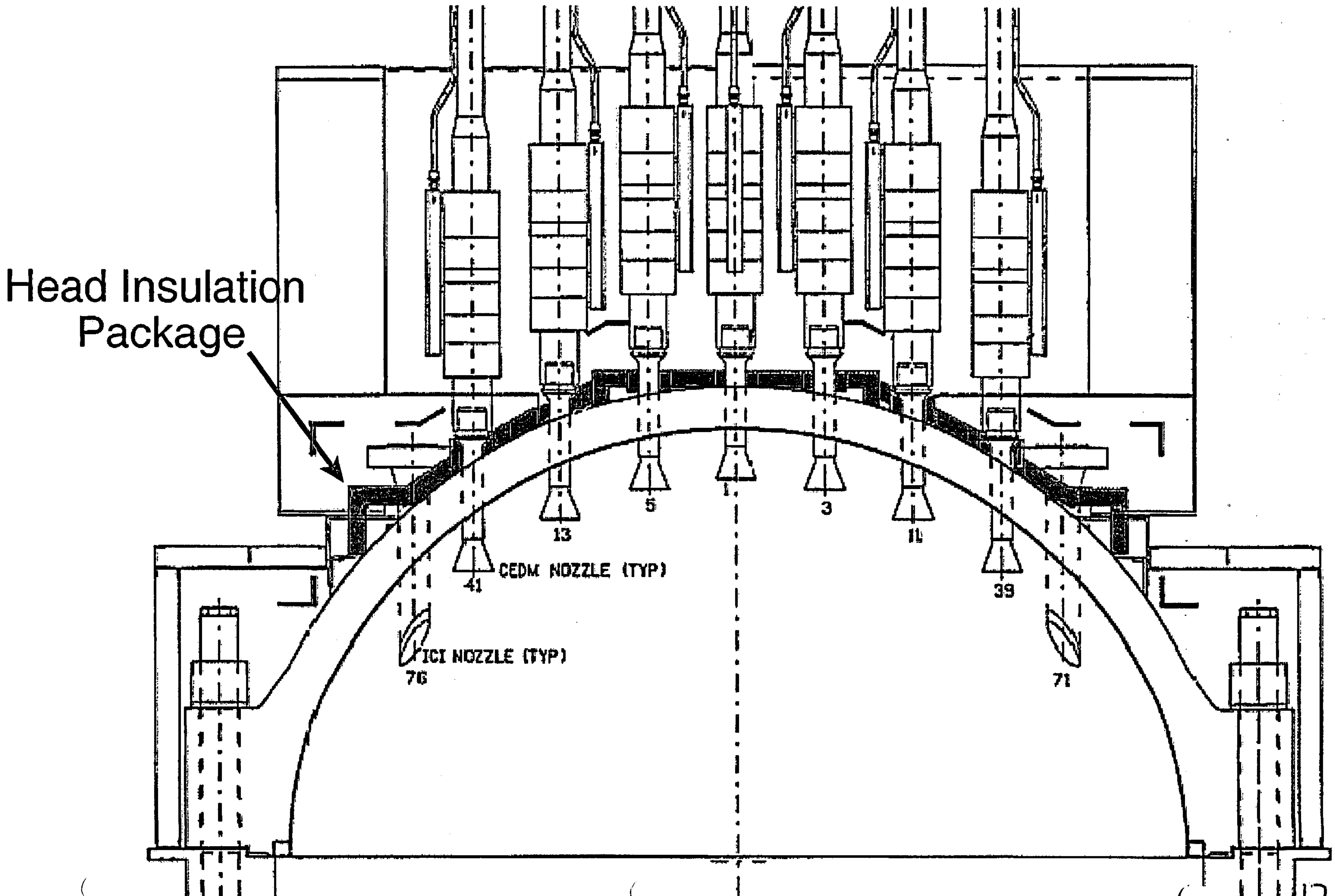


TOFD Transducer Coupling Limitations



Area of Nozzle
Inspection Limitation

Millstone Power Station
Bare Metal Visual Inspection Restraints



PLANTS WITH RELAXATION REQUESTS

- Turkey Point - High Susceptibility
  - No ID examination of 2 RVLMS nozzles
  - Limited incomplete coverage > 1 in. below the weld
- Calvert Cliffs Unit 2 - High Susceptibility
  - Centering tab above weld
  - Transducer coupling issues
- Farley Unit 1 - High Susceptibility
  - Threads on nozzle end and taper
- Millstone Unit 2 - High Susceptibility
  - Inaccessible insulation - UT measurements of RPV head thickness

PLANTS WITH RELAXATION REQUESTS

- St. Lucie - High Susceptibility
  - Threaded guide cones
  - Insulation and insulation support leg interferences

- D.C. Cook Unit 1 and 2 - Moderate and High Susceptibility, resp.
  - Threaded nozzle ends
  - Transducer coupling

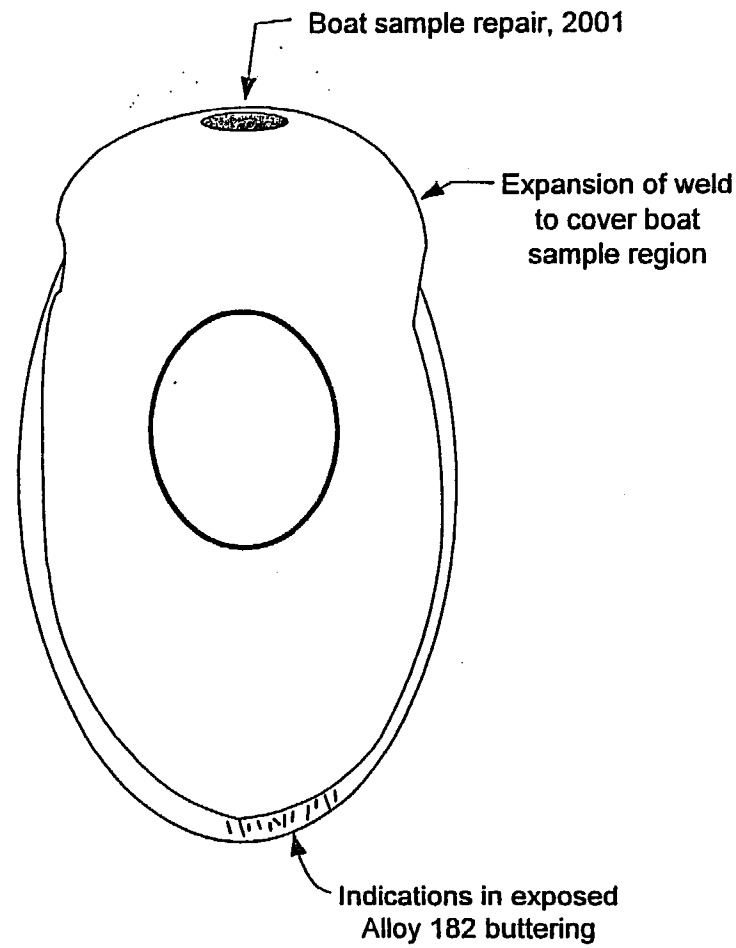
- Indian Point Unit 3- Moderate Susceptibility
  - External guide funnel threads

- Palo Verde- Moderate Susceptibility
  - External guide funnel threads
  - BMV of vent line

NORTH ANNA UNIT 2 - FALL 2002

- Several leaks identified on the RPV head
- Repairs implemented in fall 2001 did not adequately cover original Alloy 182 buttering
- Numerous welds with indications
- RPV head replaced with new head (Alloy 690 nozzles)

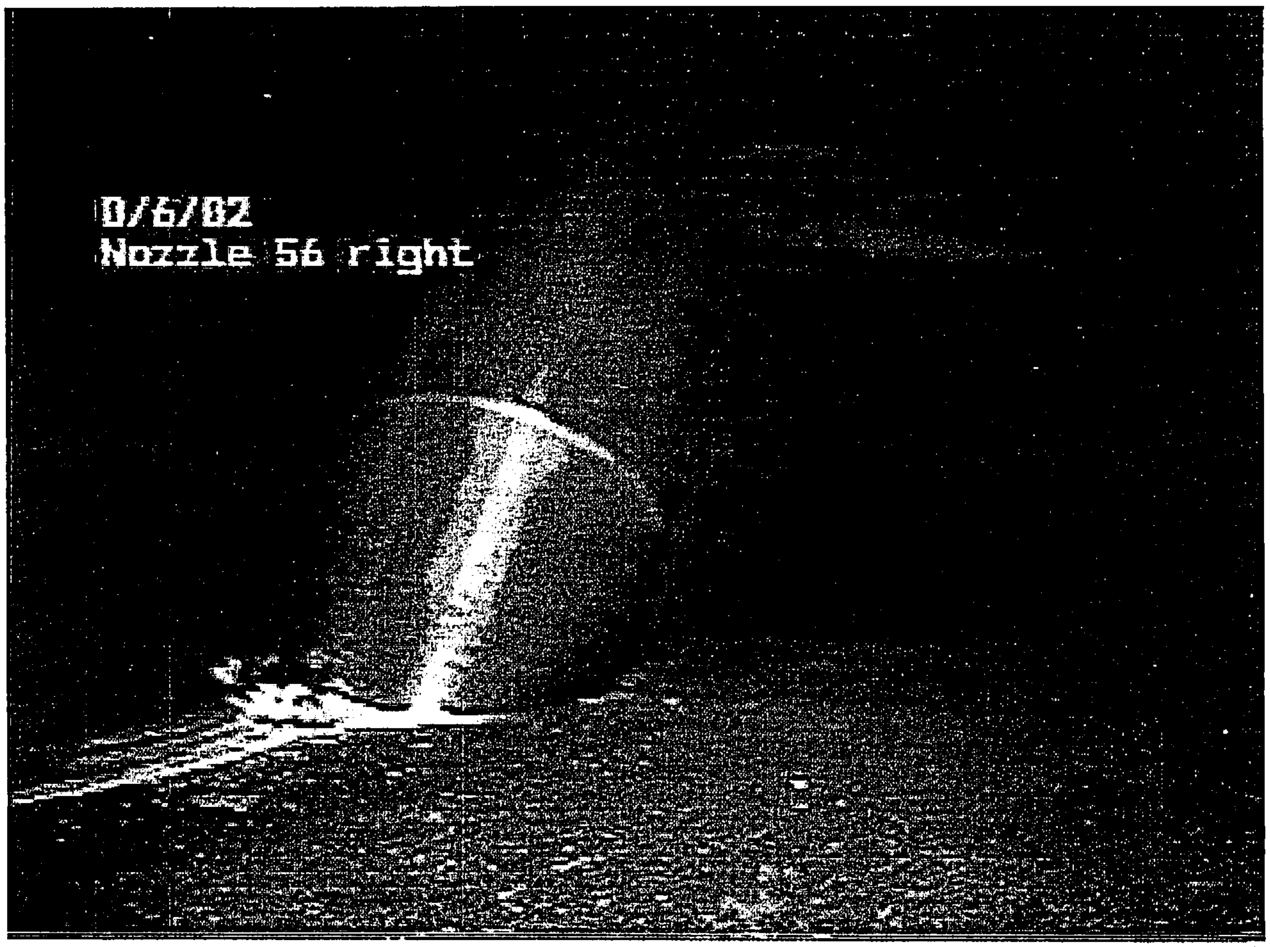
Sketch of Weld Repair, Penetration 62, Shows the Extension to Cover Buttering



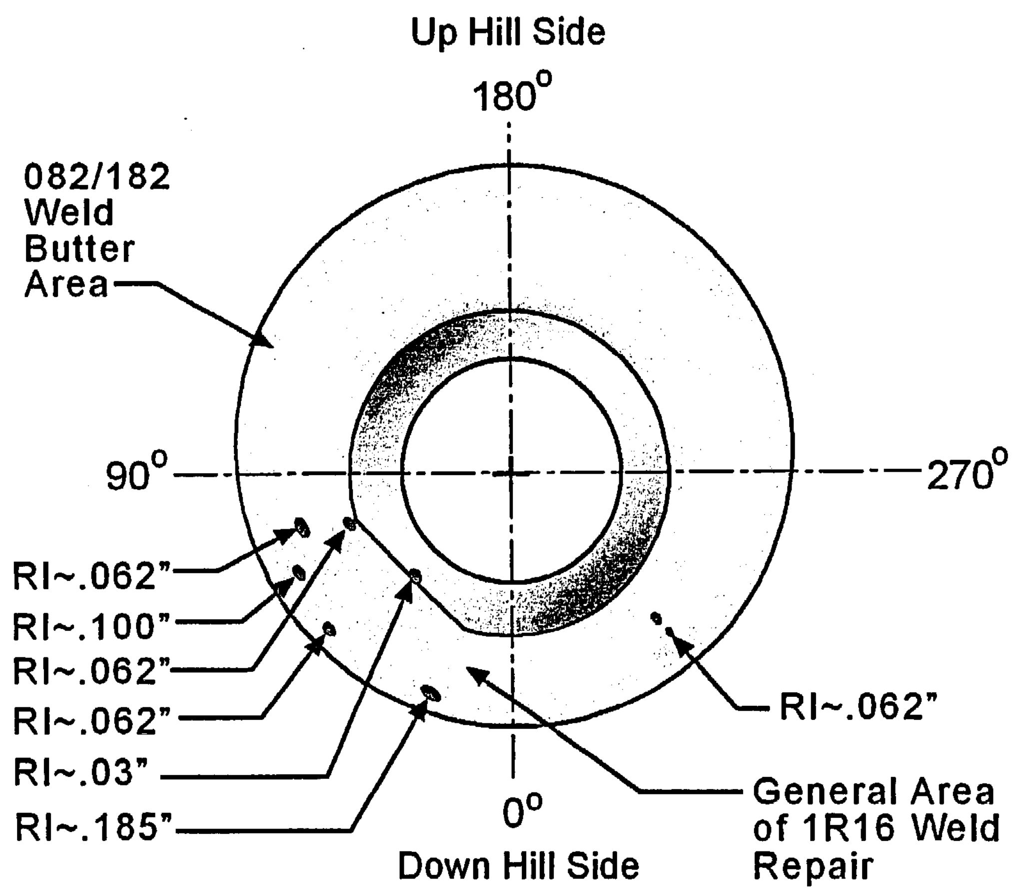
ANO UNIT 1 - FALL 2002

- Leak identified on the RPV head at repaired nozzle
- Repair implemented in spring 2001 left original Alloy 182 exposed
- Revised repair implemented

1R17 Nozzle 56 Boric Acid



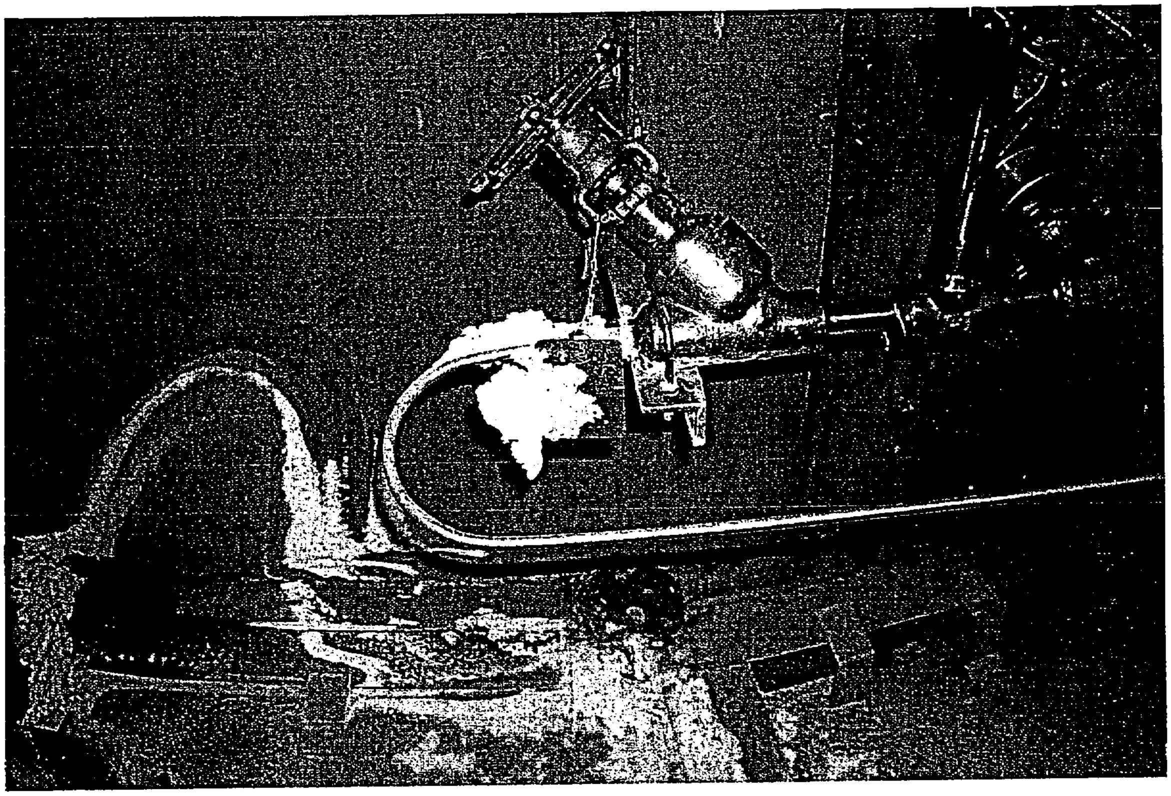
PT Layout of Nozzle 56
(General Representation)

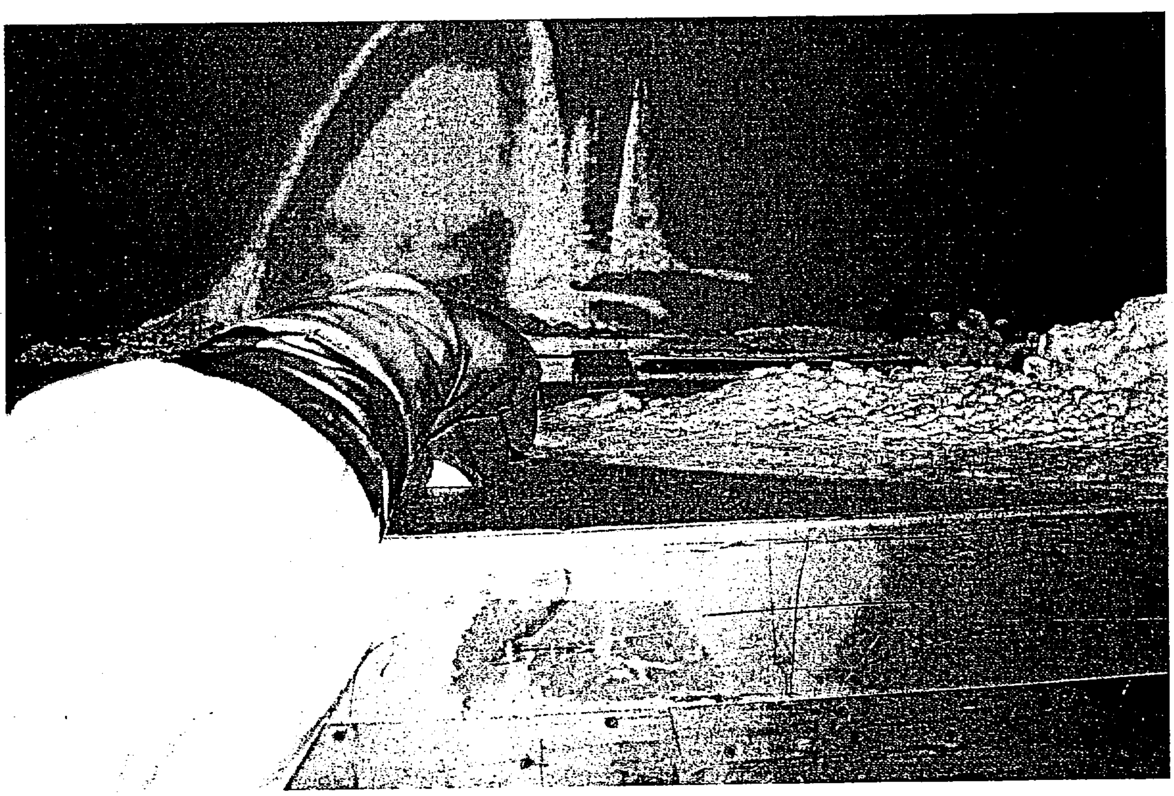


SEQUOYAH UNIT 2 - FALL 2002

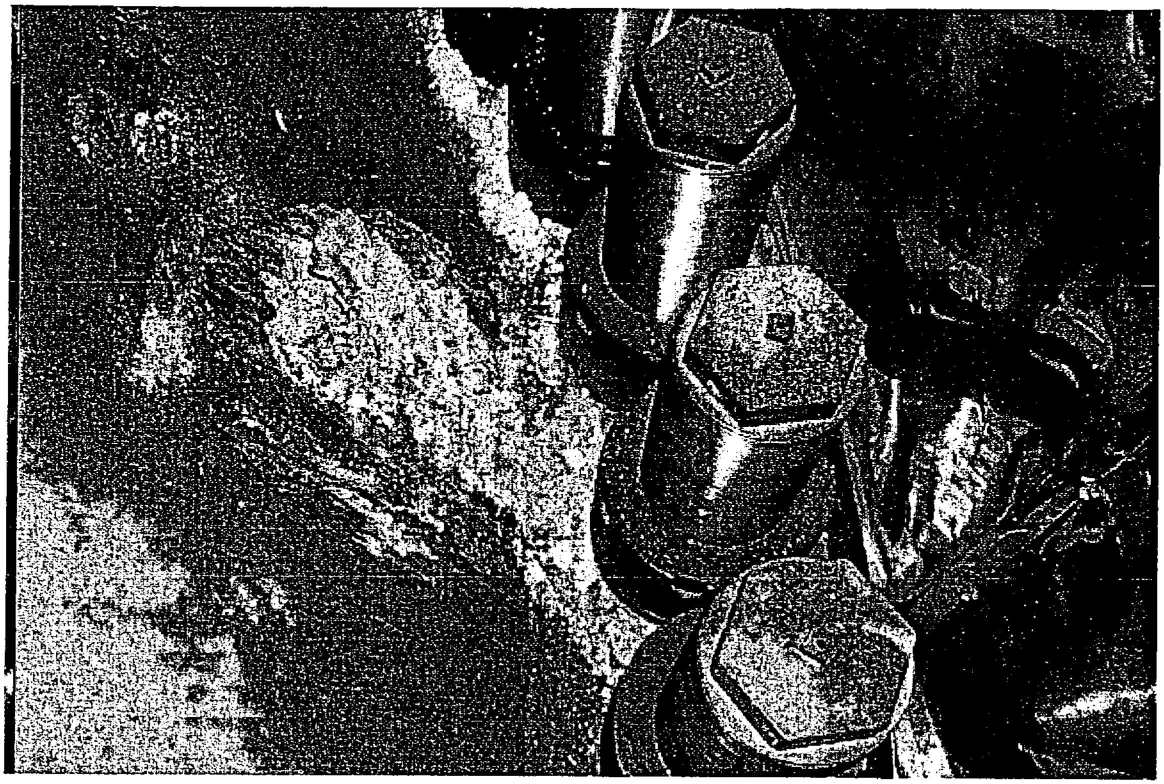
- Leak from RVLIS valve
- Impacted insulation and fell through a seam and onto the RPV head
- Area cleaned up
- Corrosion area of 5 in. long x 5/16-in. wide x 1/8-in. max depth

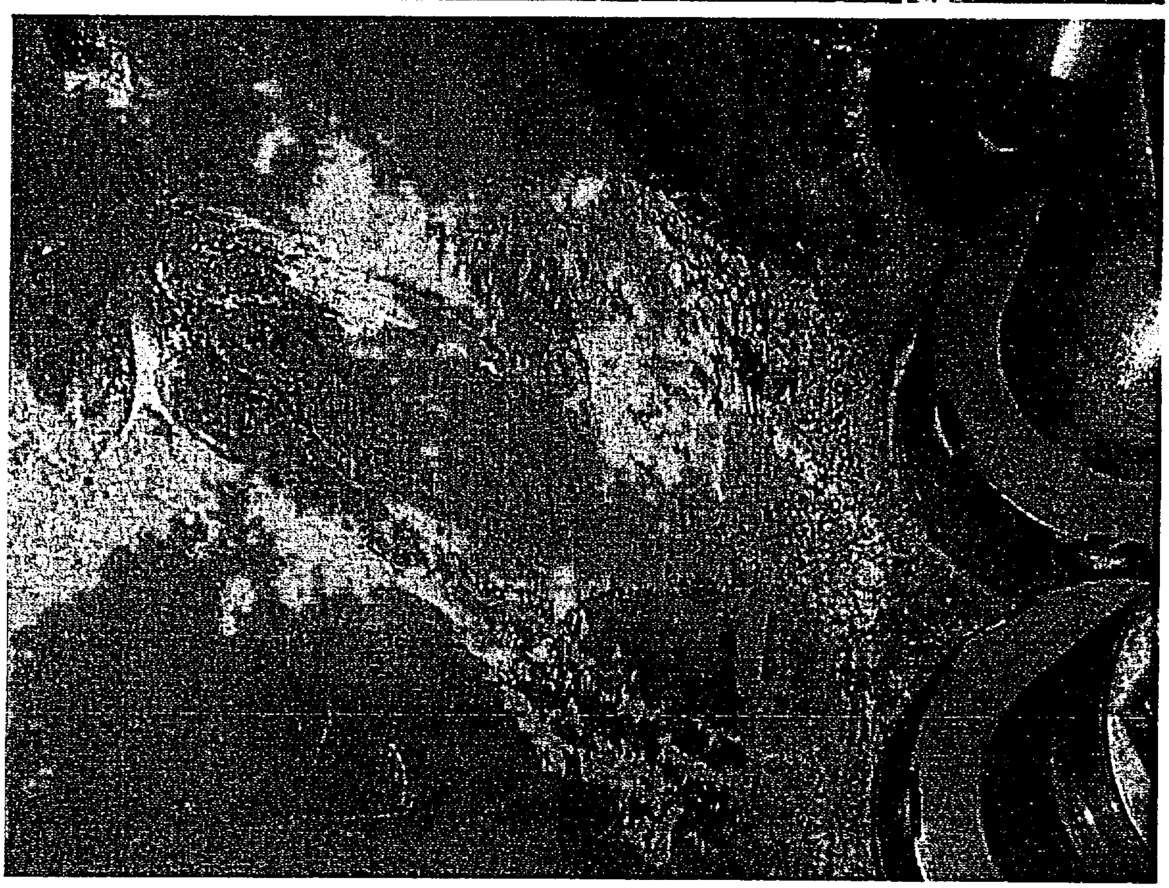
SEQUOYAH 2 - RVLIS LEAK (FALL 2002)





SEQUOYAH 2 - RVLIS LEAK (FALL 2002)





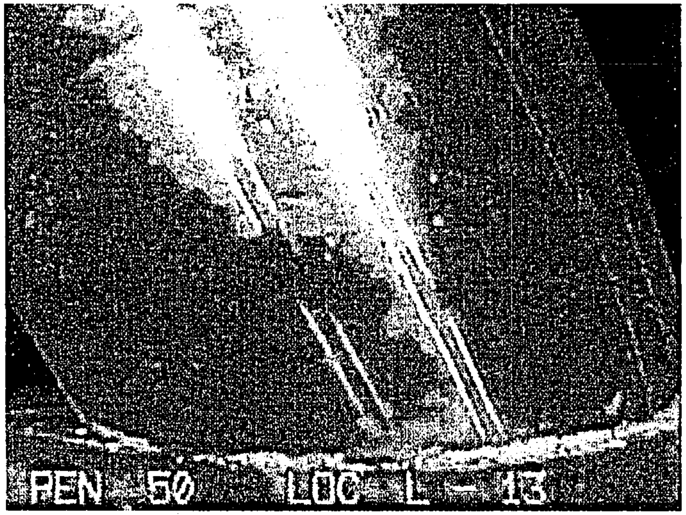
NORTH ANNA UNIT 1 - SPRING 2003

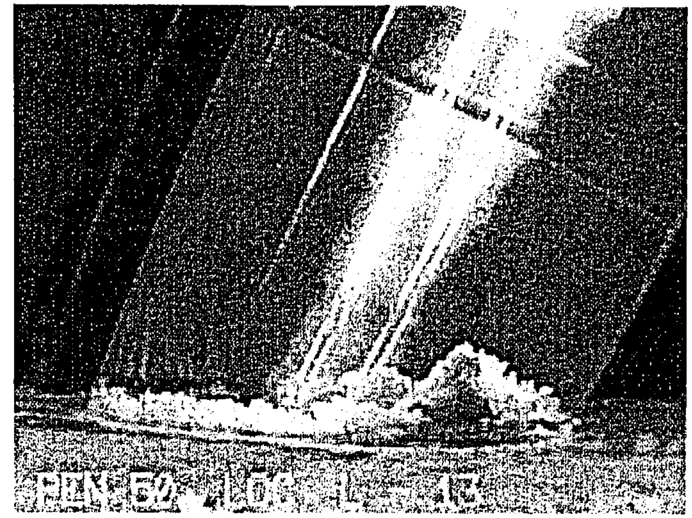
- Popcorn deposit on Nozzle #50 - only a limited bare metal visual

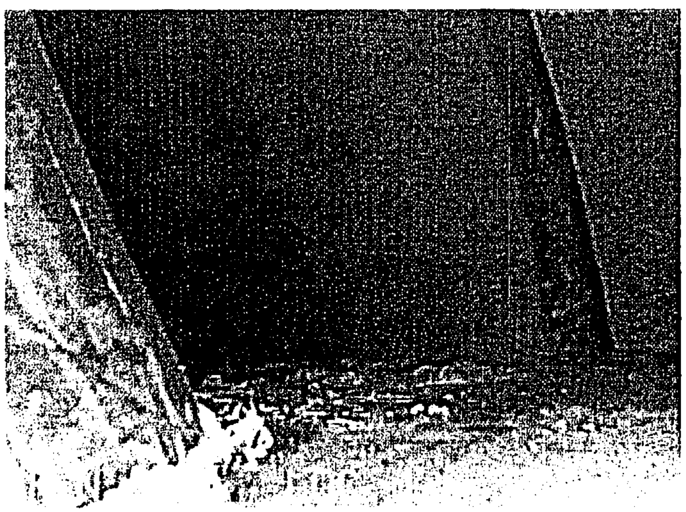
- Nozzle identified as suspect at fall 2001 outage - first plant inspected after issuance of Bulletin 2001-01
  - Clean ultrasonic record in fall 2001
  - PT indications "in the cladding"

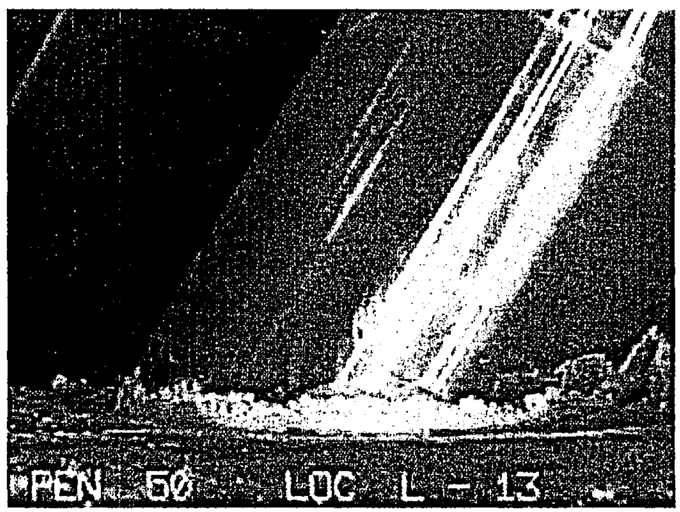
- RPV head replaced

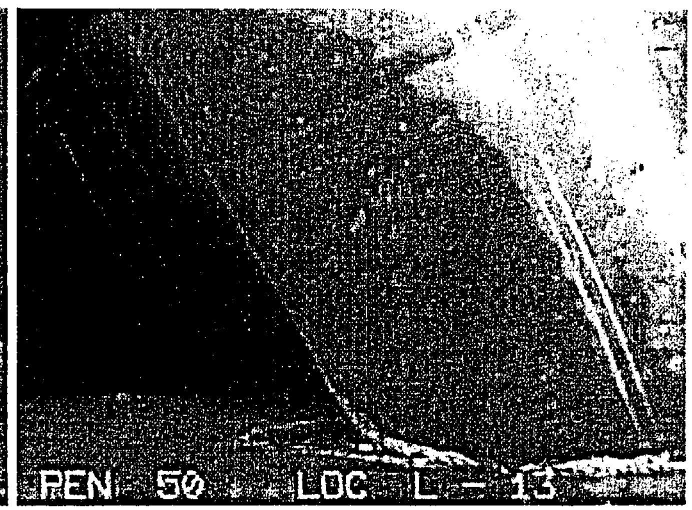
NORTH ANNA UNIT 1 - FALL 2001
(NOZZLE #50)



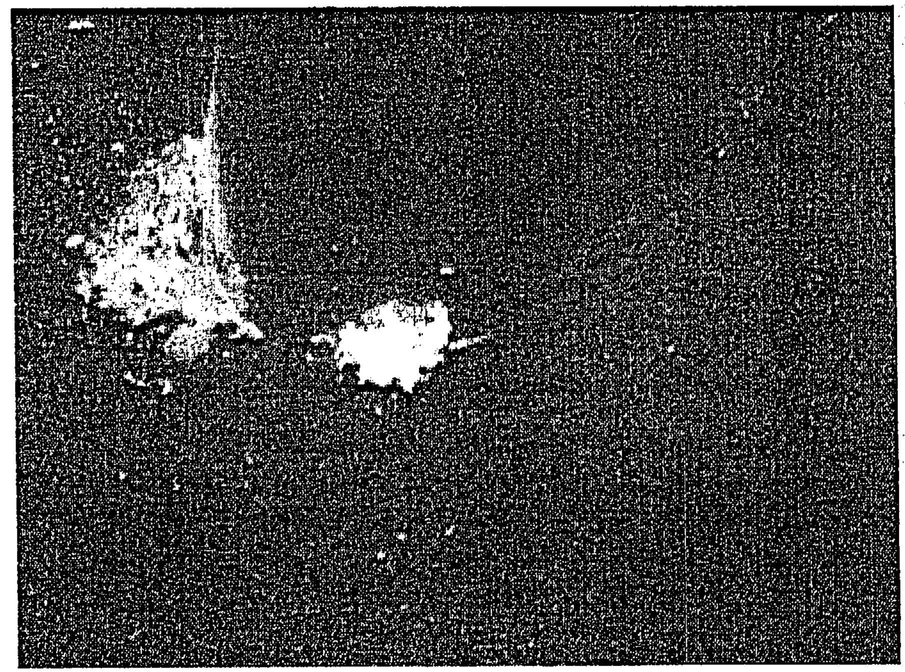








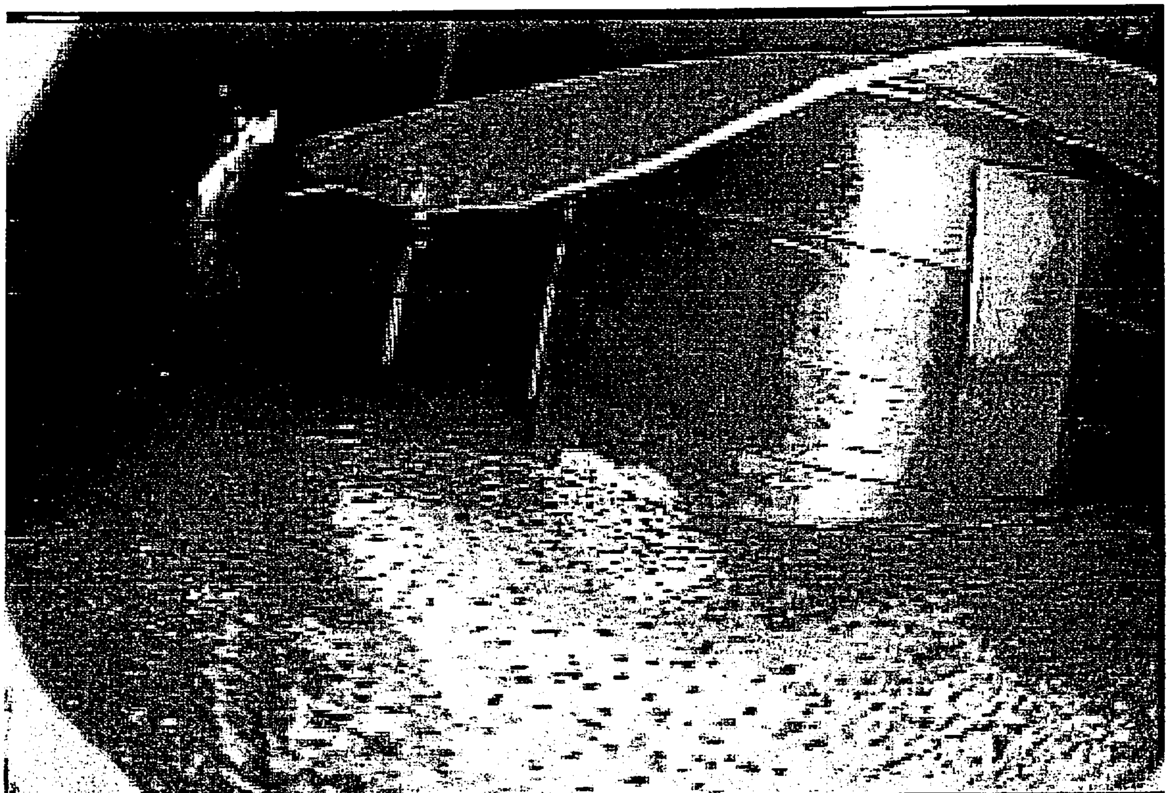
NORTH ANNA UNIT 1 - SPRING 2003
(NOZZLE #50)

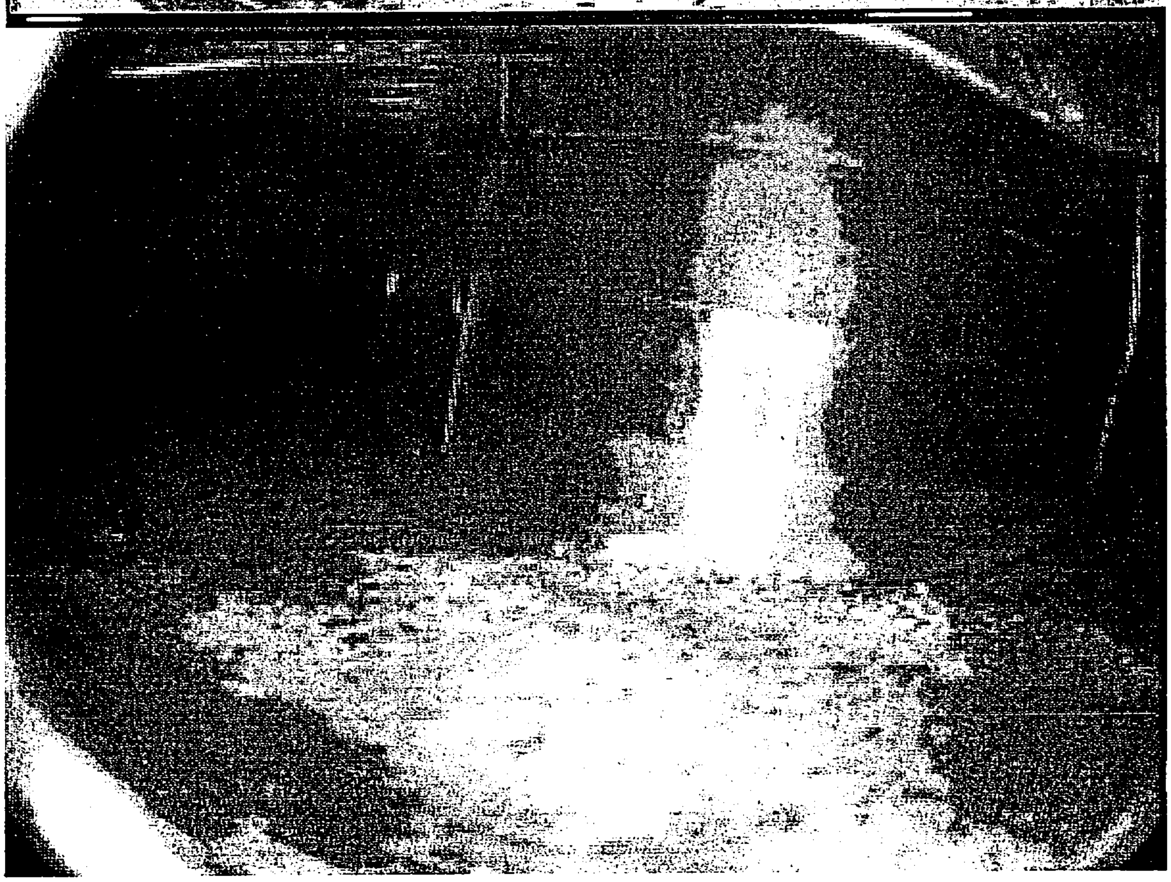


SEQUOYAH UNIT 1 - SPRING 2003

- Boron deposit identified at Nozzle #3
- Low susceptibility plant with lowest RPV head temperature (547°F) and EDY of ~ 1.5- first time RPV head examined
- UT of nozzle base material clean - no leak path indication
- PT of J-groove weld identified by the licensee as clean - concurred by NRC Region III and a "third-party independent assessment"
- Analysis identified boron as 5 to 10 years old based on ratio of Cesium-134 to Cesium-137

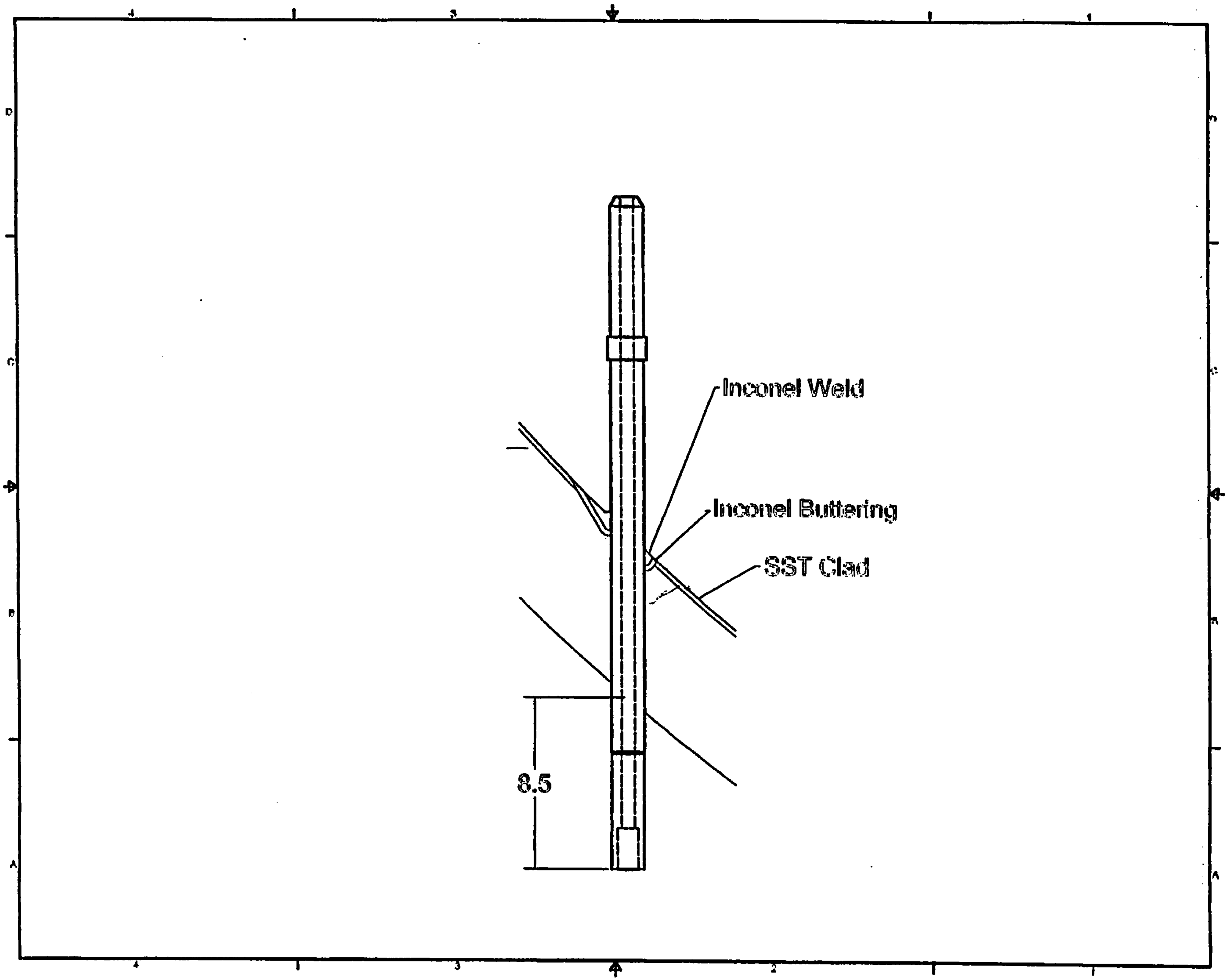
SEQUOYAH 1 - SPRING 2003

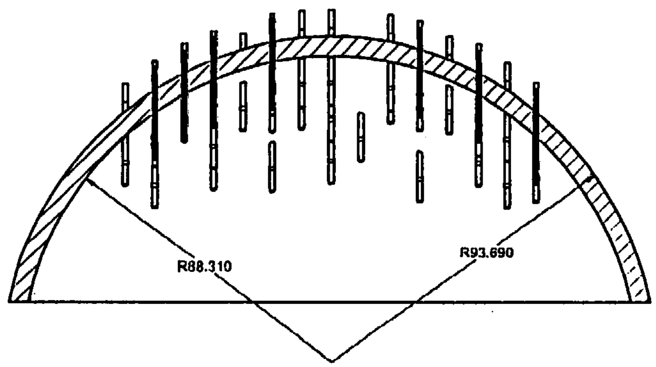




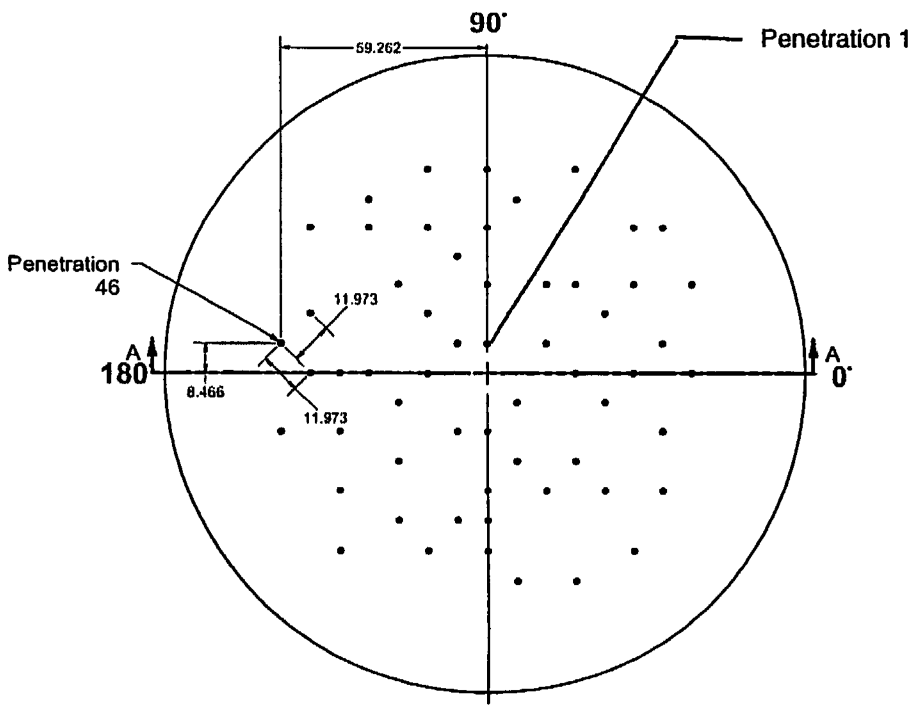
SOUTH TEXAS PROJECT UNIT 1 - SPRING 2003

- Lower head examination identifies 2 nozzles with deposits - #1 and #46 - upper head is clean
- EDY of upper head is 4.5-6.3 (recent bypass flow conversion)
- EDY of lower head ~2.1 (operating temperature 561°F)
- Licensee planning characterization activities, including flaw identification (nozzle base material or J-groove weld?), root cause (fabrication-related, fatigue or PWSCC?) and repair - restart late summer

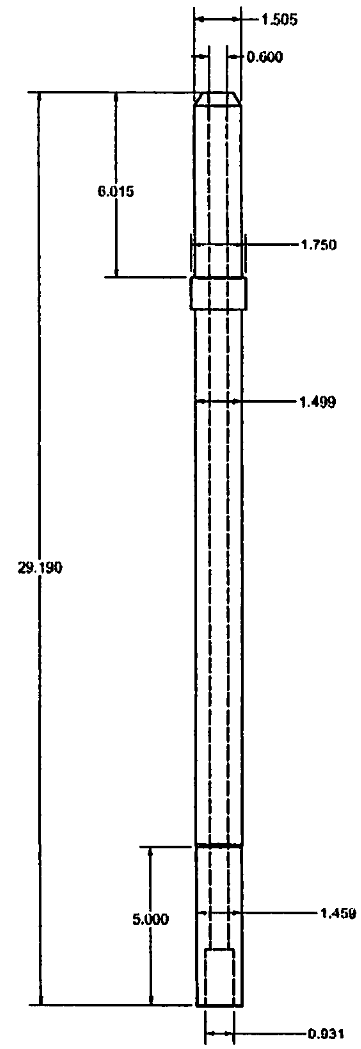

Inconel Weld
Inconel Buttering
SST Clad
8.5



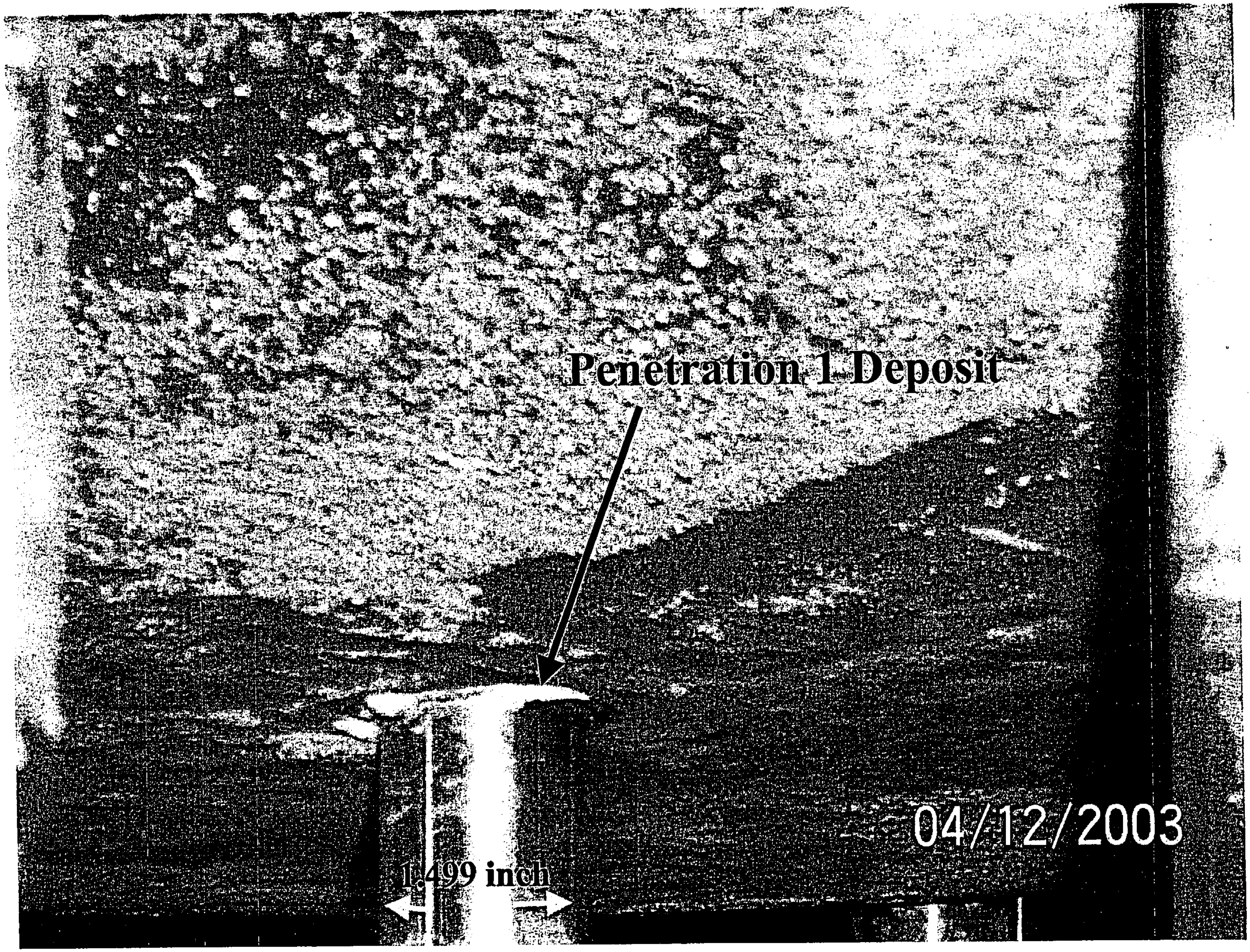
SECTION A-A
SCALE 1 / 25



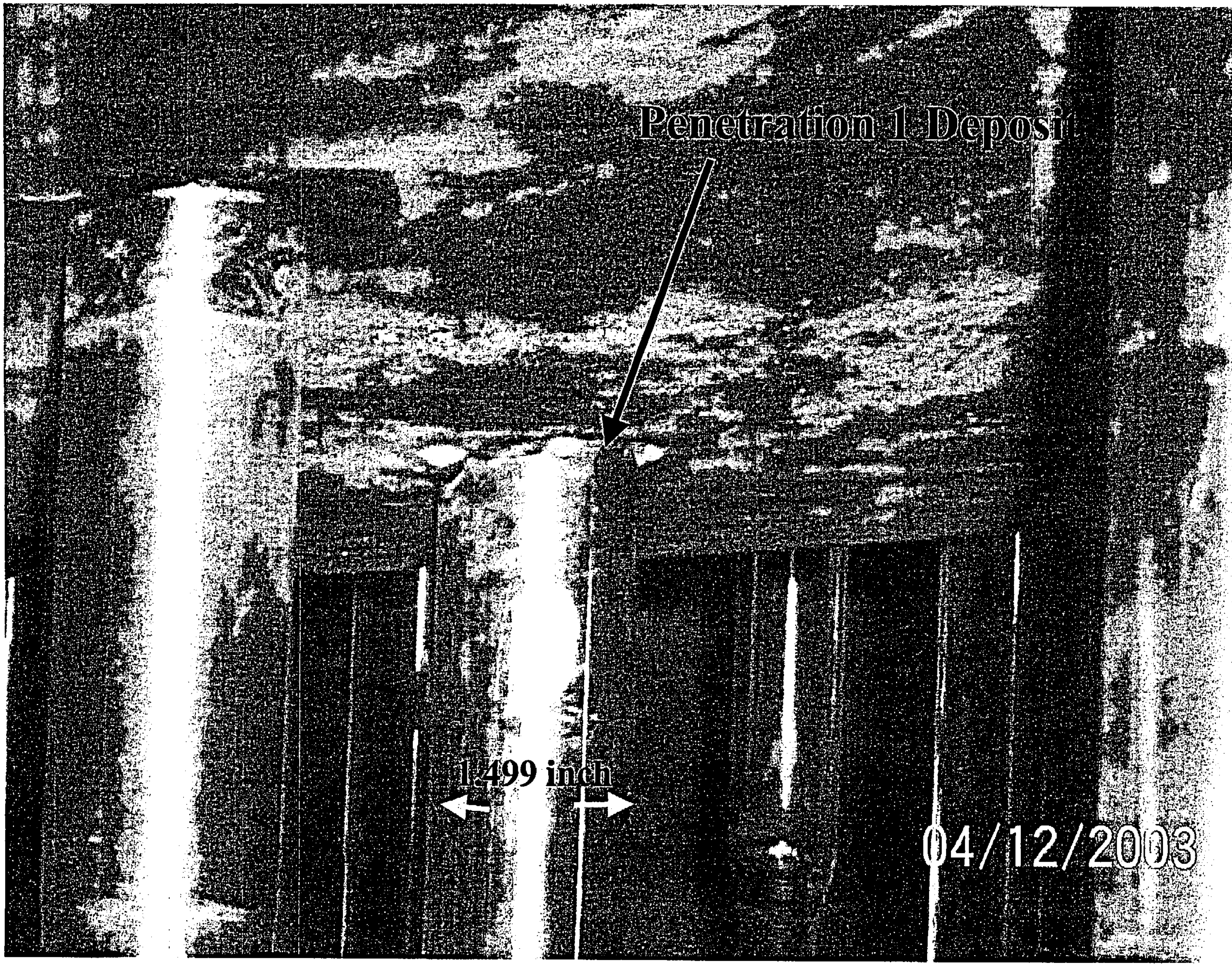
Viewed From Outside Head



Penetration 46
BMI Tube
Mtl. = SB-166



Penetration 1



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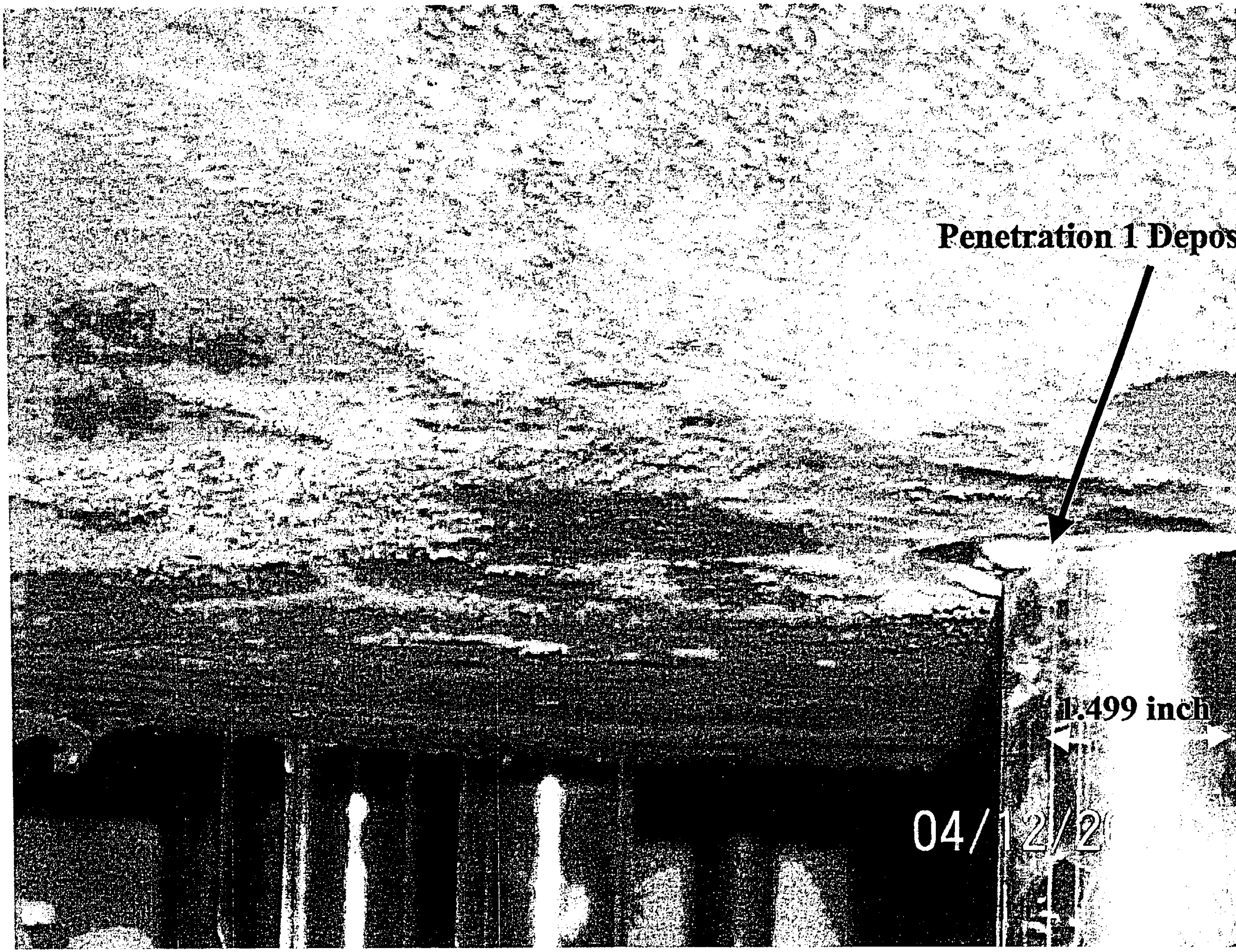
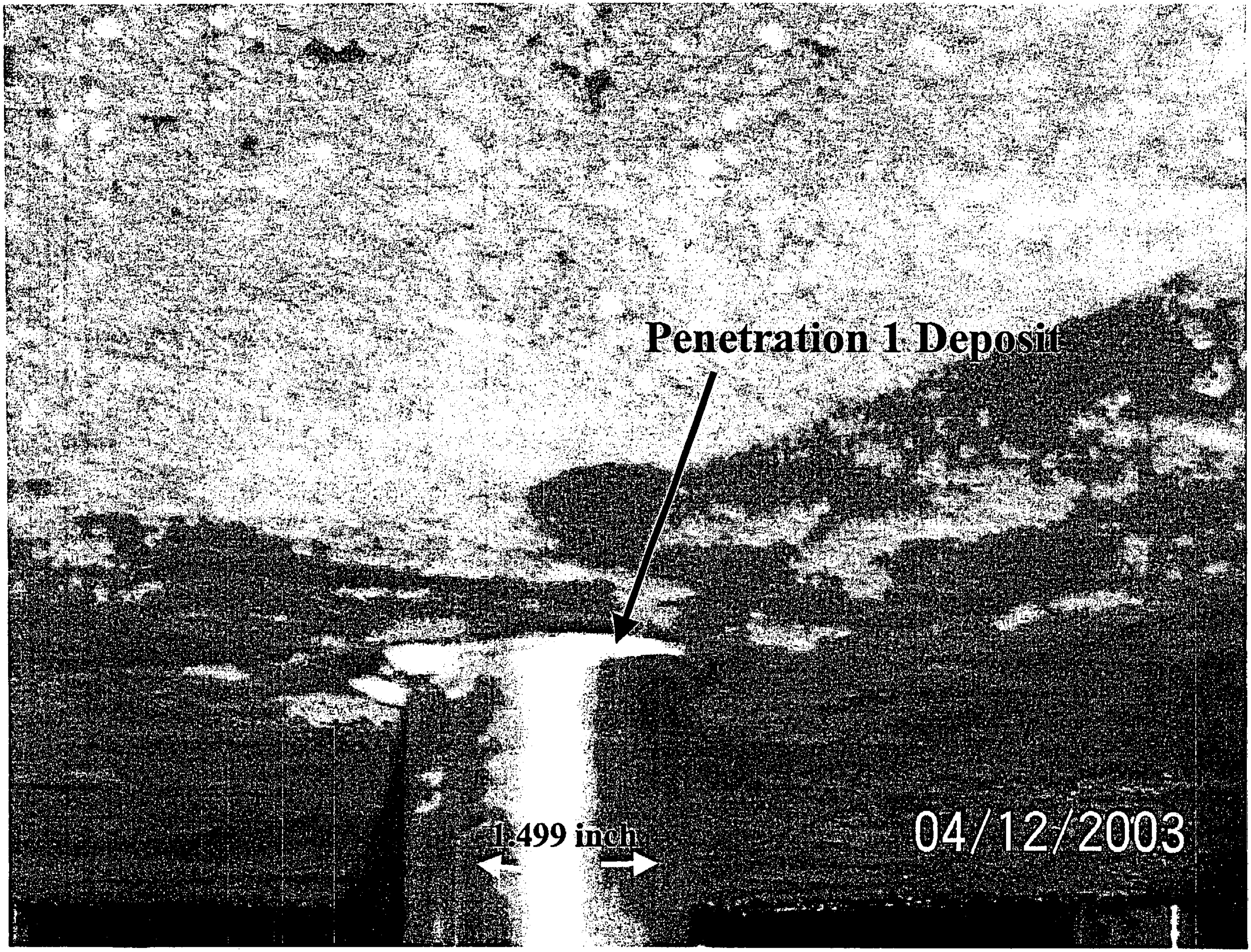
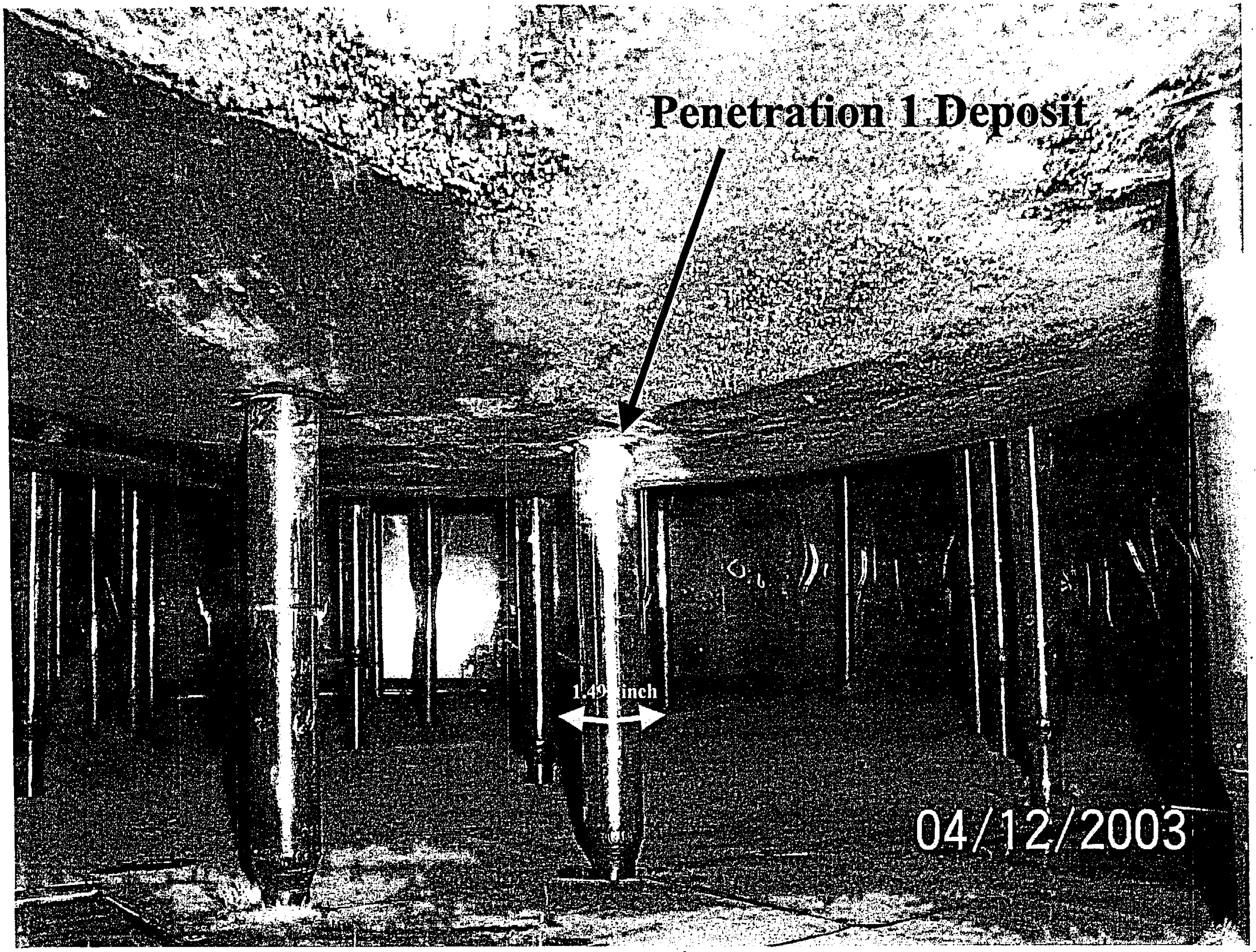


Penetration 1



Penetration 1



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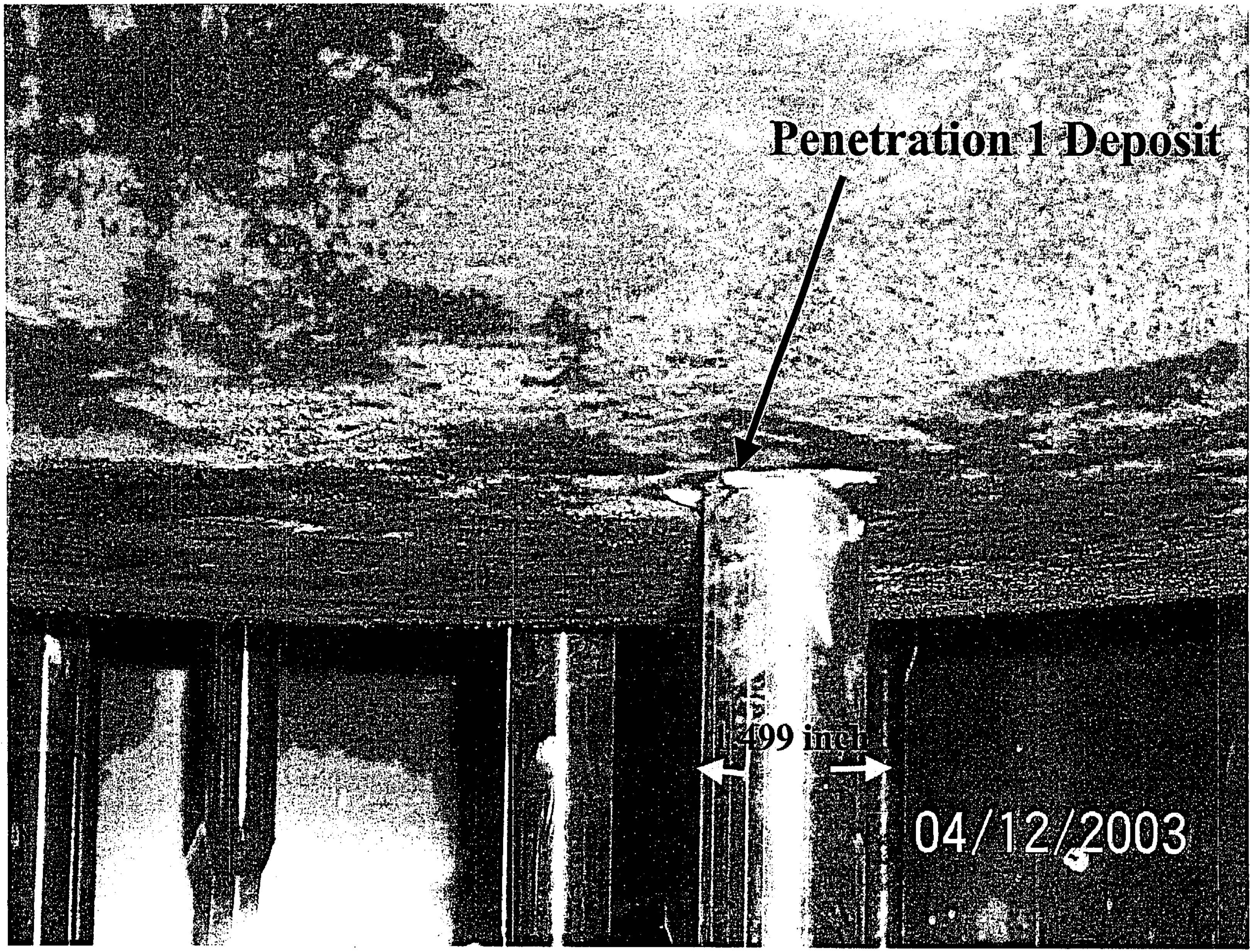
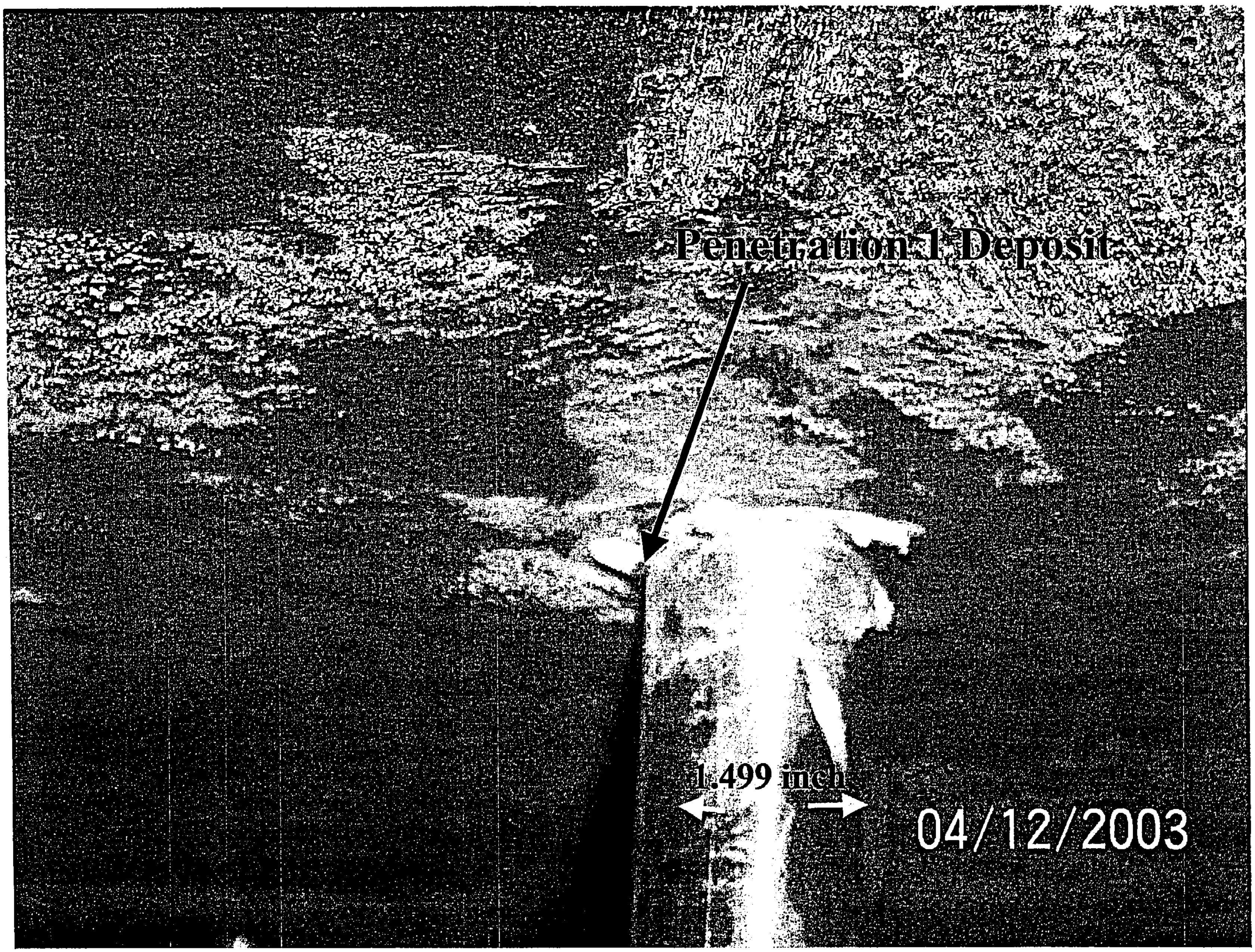
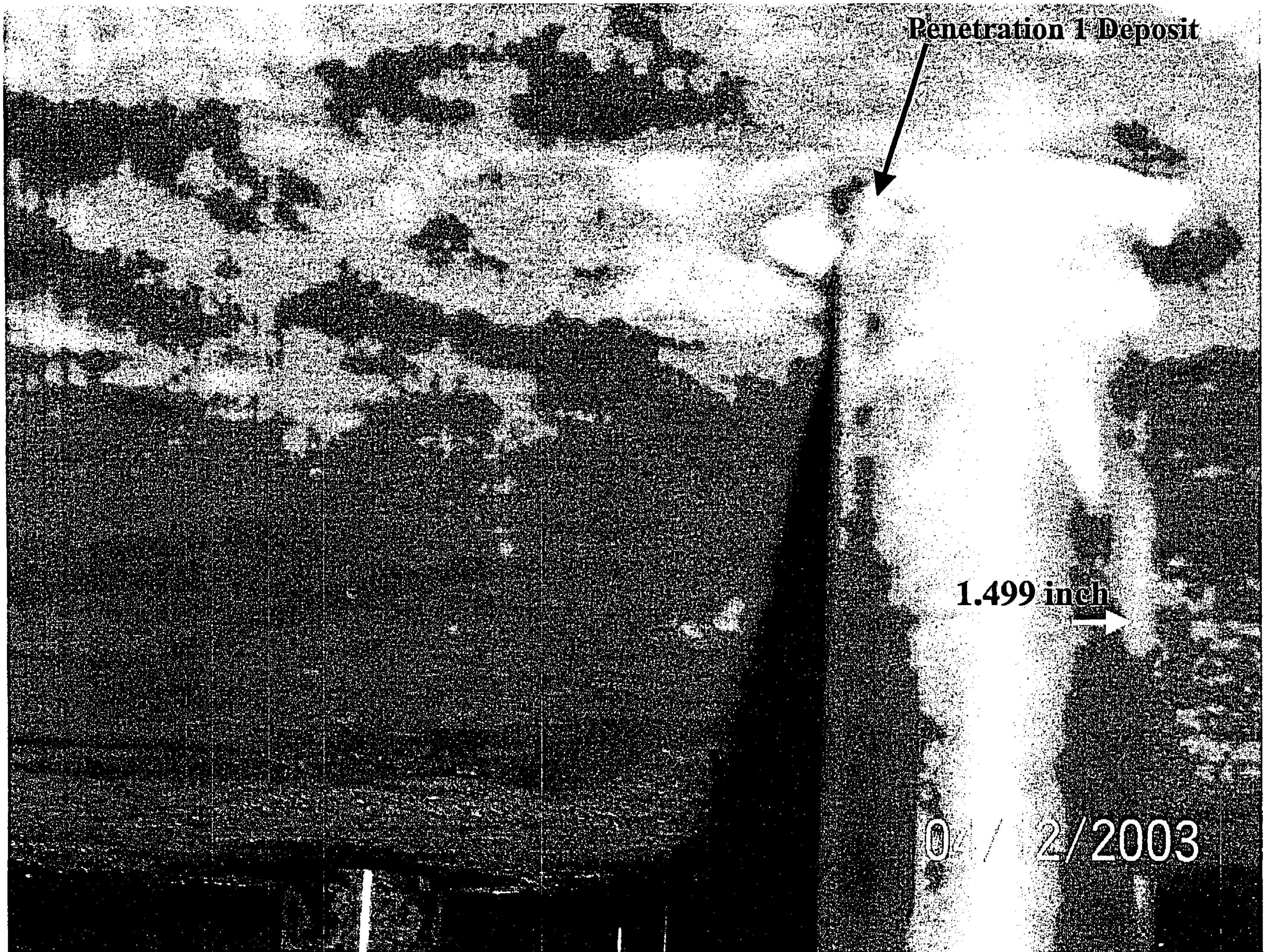


Penetration 1



Penetration 1



Penetration 1

Unit 1 BMI Penetration 46
Initial Inspection – Attachment to 03-6248

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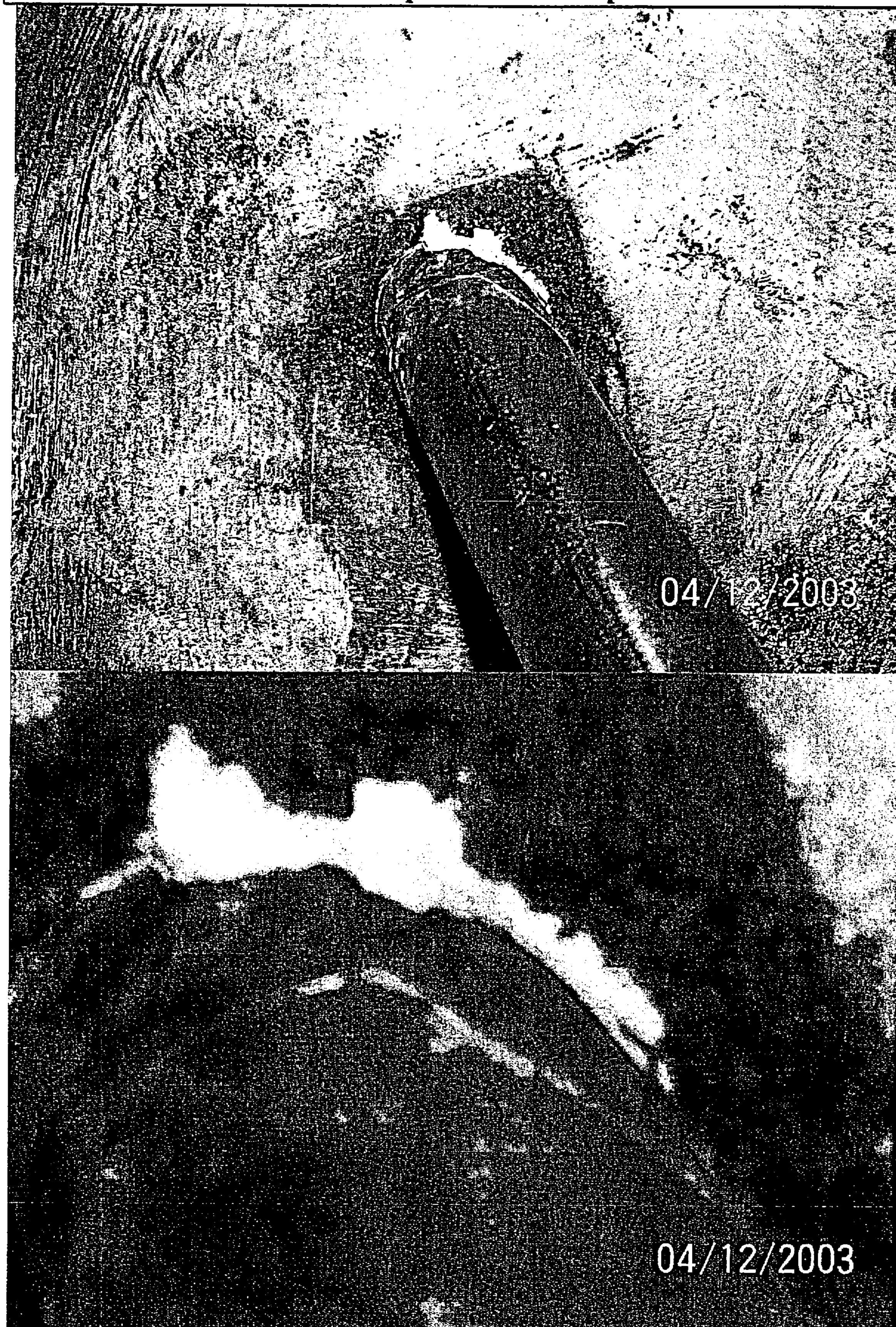
Unit 1 BMI Penetration 46
Initial Inspection – Closeups



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Unit 1 BMI Penetration 46
Initial Inspection – Closeups

45

Unit 1 BMI Penetration 46
After Obtaining Samples

46

OUTLOOK

- Goal is "permanent" requirements for inspections to ensure structural integrity of the RPV head and VHP nozzles

- ASME Code is working to develop inspection requirements
  - Has been based upon industry report (MRP-75)
  - NRC staff has provided comments - report is not acceptable as submitted, acceptability is not certain
  - NRC has suspended review pending revisions by the industry based on fall 2002 findings
  - ASME Code adoption of requirements may not be complete until 2004 or later

- Inspection requirements will be implemented in 10 CFR 50.55a
  - Endorse the new ASME Code requirements (if acceptable) under expedited implementation, OR
  - Codify alternative inspection requirements
  - Will take 1-2 years once acceptable requirements are identified

INDUSTRY'S ROLE

- Complete development of and submit revised MRP-75 in a timely manner
- Continue/renew staff level interactions with NRC on the underlying analyses to support MRP-75
- Continue development of improved inspection tools to provide more effective examinations
- Continue activities to characterize RPV heads removed from service (e.g., North Anna Unit 2, Oconee Unit 2, etc.)
- Continue boric acid corrosion research to determine the conditions that can lead to accelerated corrosion rates
- Begin consideration of other RCS areas susceptible to cracking (e.g., hot leg piping, etc.)

BWRVIP Lower Plenum Internal Components

- BWRVIP-47, "BWR Lower Plenum Inspection and Flaw Evaluation Guidelines," provides a history of inspection data and inspection guidelines for the lower plenum internal components.

- BWRVIP review of field cracking data indicated that with the exception of some unusual cases, i.e., furnace-sensitized stub tubes at Oyster Creek and NMP-2, the lower plenum components have not experienced significant field cracking.
    - Stub tube cracking in the two plants with furnace sensitized stub tubes is being repaired and monitored using well-established procedures approved by the NRC (roll expansion repair method).

Inspections

- Various visual inspections are performed on the CRD guide tubes, stub tubes, and in-core housings, in accordance with ASME Code, Section XI.

- Instument penetrations are pressure tested.

- Visual inspections are performed on the dry tubes as recommended by GE SIL 409

- Additional inspections are performed in accordance with the recommendations of BWRVIP-47.

    - CRD Guide Tube Sleeve to Alignment Lug Weld

    - CRD Guide Tube Body to Sleeve Weld and CRD Guide Tube Base to Body Weld

    - Guide Tube and Fuel Support Alignment Pin-to-Core Plate Weld and Pin

    BWRVIP-47 provides recommendations of sample size, frequency, and acceptance criteria.

BWRVIP Inspection Summary Indication Results of the Lower Plenum Components
1994 - 2002

- Dresden
  - 1994: 1 dry tube was identified to be cracked and replaced.

- Oyster Creek:
  - 2000: 2 stub tubes found leaking at bottom head. UT performed of CRD housing to stub tube welds and area of housing to be rolled. No reportable indications. Roll repaired both leaking housings.

- Browns Ferry Unit 2
  - 1994: Dry tubes inspected per GE SIL 409. Cracking found. Tubes were replaced.

Safety Consequence/Inspection Experience/Susceptibility

- The cracking at the CRD and in-core housing welds does not have a significant safety consequence since it does not affect CRD insertion. Even if extensive cracking were to occur, the potential for CRD ejection is eliminated by the shoot-out steel. Thus CRD insertability is not challenged. There is additional redundancy through the availability of boron injection if failure of CRD insertion is postulated.

- If cracking is significant and leads to leakage, it would be detected immediately and appropriate corrective action can be taken.

- As plants implement moderate HWC, the actual susceptibility is expected to drop significantly.

- In view of good field history, significant inspection experience, detectability through leaks, and minimal safety implications, no additional inspections are recommended for many of the locations in the CRD housing/stub tube/guide tube/fuel support assemblies and the in-core housing/guide tube/dry tube assemblies.

PLANS FOR ADDRESSING THE DAVIS-BESSE LESSONS LEARNED TASK FORCE RECOMMENDATIONS

Brendan Moroney, NRR

Cayetano Santos, RES

April 23, 2003

INTRODUCTION

- NRR and RES jointly developed an overall implementing plan
- Delivered to EDO on 2/28/03
- Forwarded to Commission on 3/10/03

HIGH PRIORITY ITEMS

- Overall Plan includes 4 Action Plans for High Priority items (21 items) in Davis-Besse LLTF Review Team memo

ACTION PLANS

- **Stress Corrosion Cracking**

  Lead: NRR/DLPM

- **Operating Experience**

  Lead: NRR/DRIP

- **Inspection, Assessment, and Project Management**

  Lead: NRR/DIPM

- **Barrier Integrity**

  Lead: RES/DET

MEDIUM/LOW PRIORITY ITEMS

- Lead Responsibility, Resource Allocation and Schedule to be established via the Planning, Budgeting and Project Management (PBPM) process
- Initial Screening to be completed by 8/31/03

TRACKING & REPORTING

- Action Plan status reported quarterly to Office Directors
- Status on all LLTF recommendations reported semiannually to EDO and Commission
- First Semiannual Report 8/31/03

STRESS CORROSION CRACKING ACTION PLAN

Part I **RPV Head Inspection Requirements**

Part II **Boric Acid Corrosion Control Requirements**

Part III **Inspection Program Improvements**

STRESS CORROSION CRACKING ACTION PLAN

Part I - Inspection Requirements

1. Collect world-wide information
2. Evaluate existing SCC models for use in susceptibility index
3. Evaluate results of inspections per Bulletins and Orders
4. Review and evaluate MRP and ASME efforts
5. Endorse ASME Code changes or develop alternative inspection requirements

STRESS CORROSION CRACKING ACTION PLAN

Part II - Boric Acid Corrosion Control

1. Collect world-wide information

2. Evaluate responses to Bulletin 2002-01

3. Evaluate the need for additional regulatory actions

4. Review and evaluate ASME Code revised requirements

STRESS CORROSION CRACKING ACTION PLAN

Part III - Inspection Programs

1. Guidance for periodic review of licensee ISI activities by NRC

2. Guidance for timely, periodic inspections of plant BACC programs

3. Guidance for assessing adequacy of plant BACC programs

BARRIER INTEGRITY ACTION PLAN

Part I Leakage Detection and Monitoring Requirements

Part II Improved Performance Indicators

BARRIER INTEGRITY ACTION PLAN

Part I - Leakage

1. **Develop basis for new RCS leakage requirements**
   - **Review bases for current leakage limit**
   - **Review experience/capabilities of currently used leak detection systems**
   - **Evaluate capabilities of state-of-the-art leak detection systems**
     - * **Scope of Action Plan increased to include methods which may be capable of detecting degradation before leakage**
   - **Evaluate leak rates that lead to degradation**

BARRIER INTEGRITY ACTION PLAN

Part I - Leakage (Continued)

2. Develop recommendations for improved leakage requirements
   - TS
   - Inspection Guidance
   - RG 1.45

3. Incorporate recommendations, as appropriate, into requirements
4. Examine improvements to barrier integrity requirements in addition to those which rely on leakage monitoring

BARRIER INTEGRITY ACTION PLAN

Part 2 - Performance Indicators

- **Implement improved PI based on current requirements and capabilities**
- **Develop and implement an advanced PI**
- **Re-evaluate PI based on changes to RCS leakage requirements**