Session 3
February 27, 2001

Analyst Guidelines

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US-NRC

Public Workshop to Discuss Nuclear Power Reactor Steam Generator Tube Issues

February 27-28, 2001

Holiday Inn, Bethesda

Good analyst guidelines are essential for a good inspection

- Utilities spend a lot of money for the training and use of analysts.
- There is a severe shortage of good QDA's during the peak outage seasons.
- Analysts may make mistakes form using poor guidelines.
- Writing the best guidelines possible will save the utilities money.

The purpose of the Data Analyst's guidelines is to inform the analyst:

- With the type of plant you have.
- How data should be analyzed at your plant.
- The prior history of your plant.
- The expected present conditions at this outage.
- The prior history of similar plants.

The purpose of the Data Analyst's guidelines is to provide:

- A training and reference tool for the analyst.
- A training and reference tool for the analyst.
- A valuable reference about how the data were analyzed.

Good analyst guidelines:

- Are easy to read.
- Are complete without being too long.
- Are plant and unit specific.
- Follow the same general EPRI format.
- Have a separate section for each type of probe.
- Make liberal use of high quality graphics, preferably in color.

Good analyst guidelines:

- Do not require the level IIA analysts to know all the details of data management.
- Have tabs in the analyst guidelines for quick reference.
- Contain the ETSS sheets in an appendix.
- Contain a table summarizing the standards used for each probe type.

At present, eddy-current analysis of steam generator tubing is very graphic oriented and the guidelines should also be. Each figure should be self-contained. The text accompanying the figure should be next to the figure.

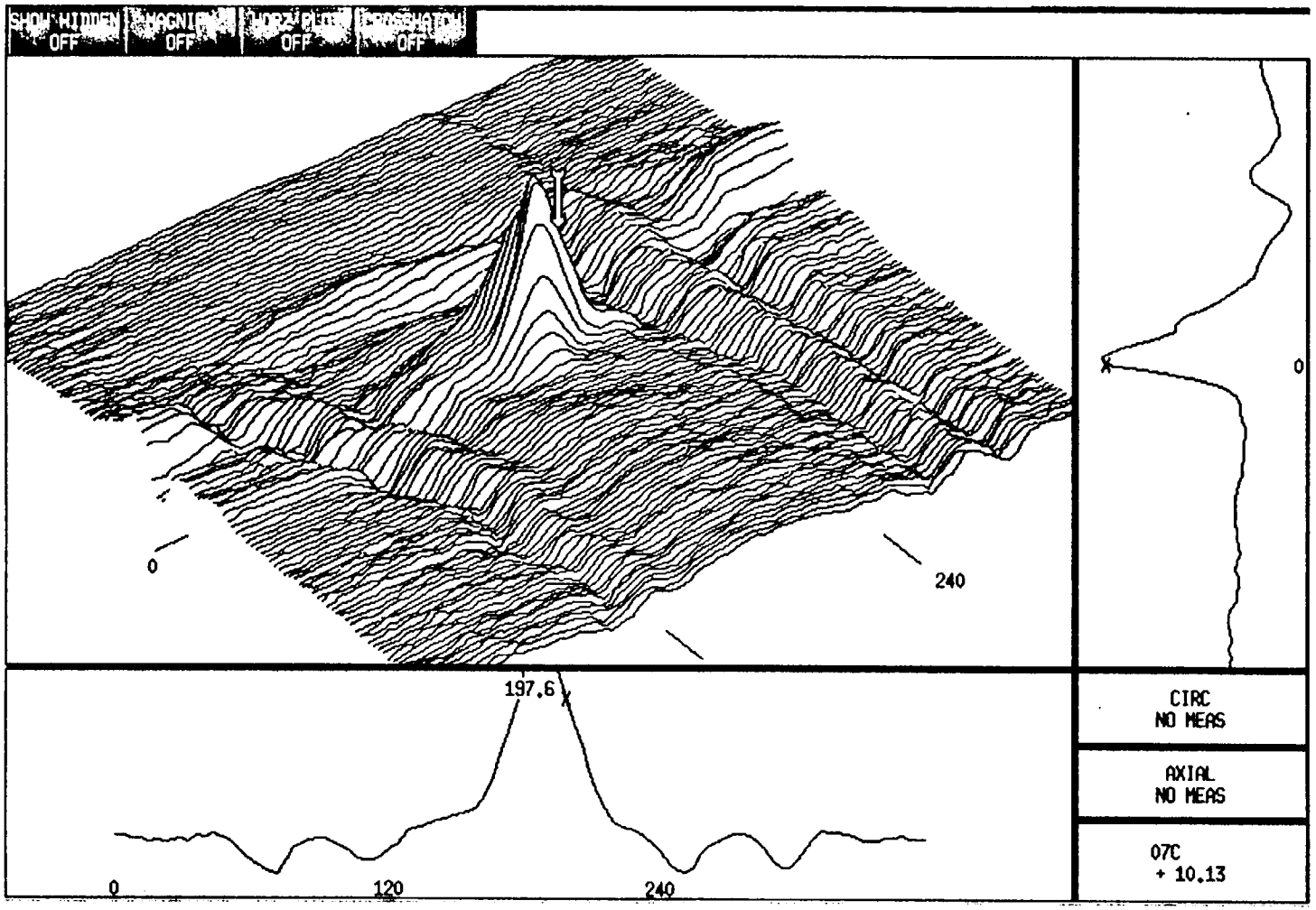


Figure 1 Plus point scan of a circumferential id defect at 300 kHz with the midrange probe before pressurization. This is the P2-process channel with the circumferential defects in the vertical direction. This tube leaked at 0.005 gpm at 5500 psig. Note the axial ridges of noise on the tube.

The figures can be created from the Hewlett Packard computer screen using the XV program

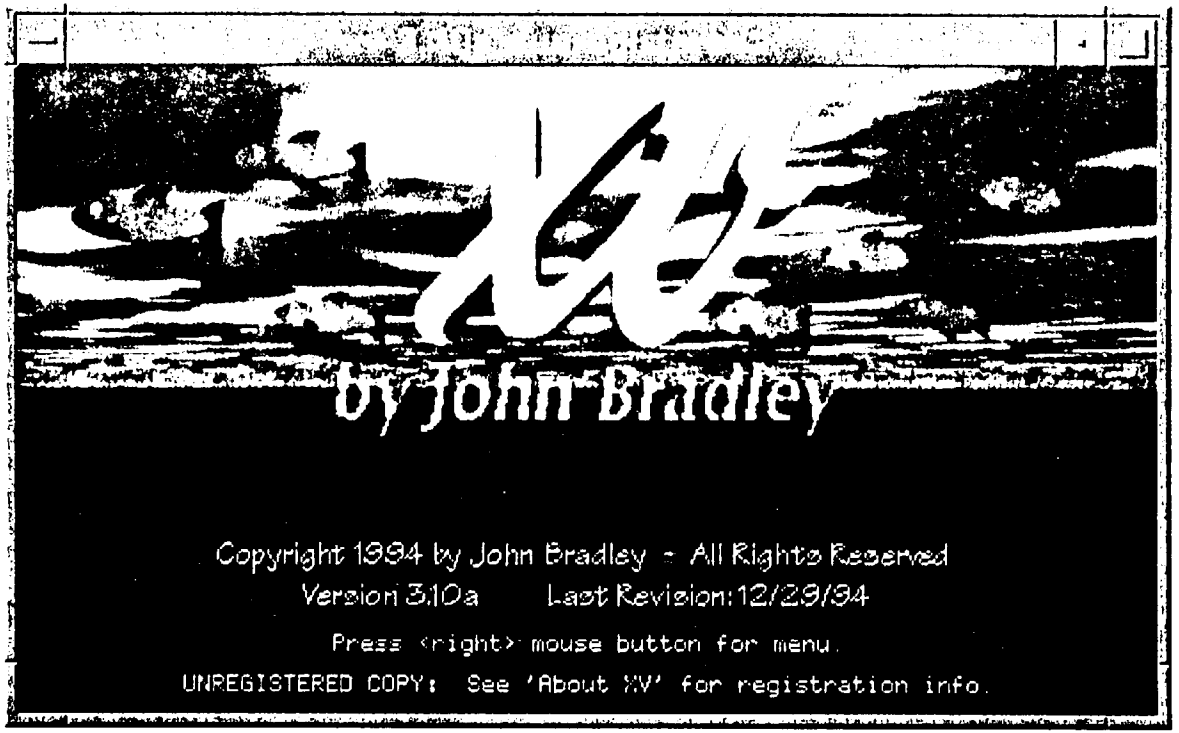


Figure 2 The XV program is a shareware program that operates under Hewlett Packard HP-US software, and costs $25 to register. The program can be run by selecting it from the Eddynet Utilities list or by typing xv in a command window. The above logo will appear on the screen. Right click on the mouse on this logo to bring up the next capture screen, shown in the next figure.

Grab the desired graphic screen and save it to a file in the appropriate format

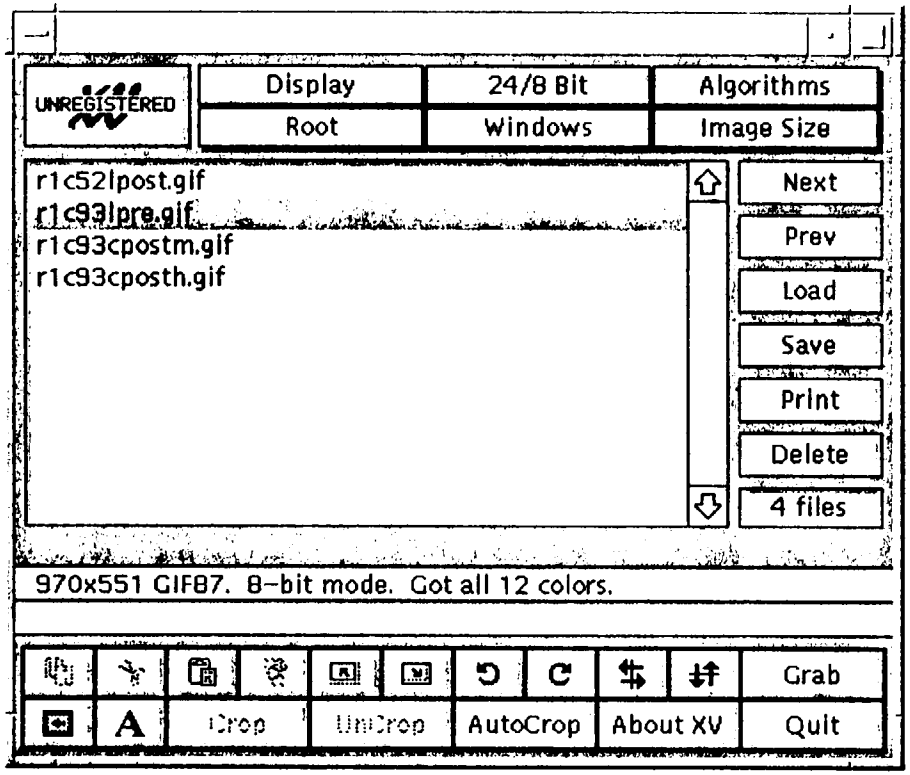
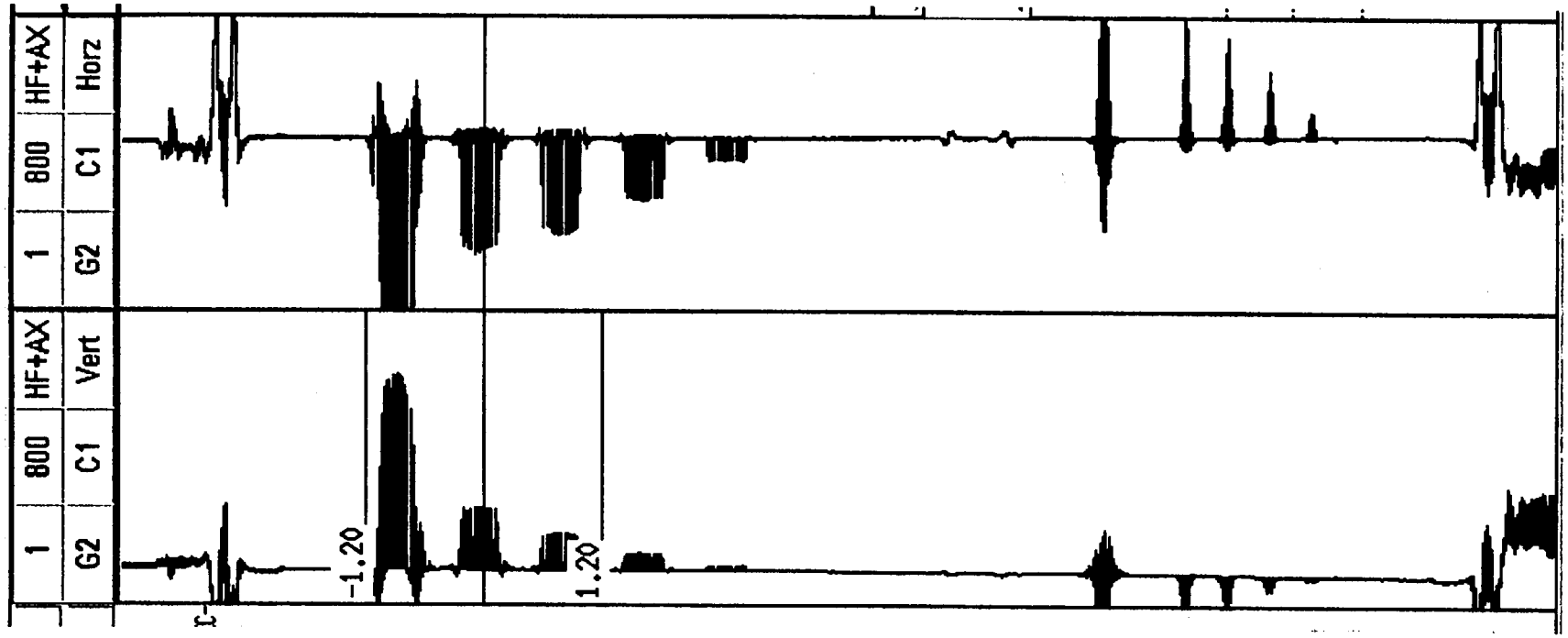


Figure 3 Click on the grab of this screen, the grab of the next screen that appears, and then the graphic that you wish to grab. Then click on save. A screen then appears that allows you to type in the file name (with the extension), which defaults to the last one you used. You can select a new format by holding the mouse on the default extension and dragging it down to the new one you want. The preferred format is Compuserve's .gif format. This is a vector graphics format, as are most of the screens in the eddy-current software. The files take up much less storage and can be magnified much more without losing resolution. Also, this format is used for graphics on the web if you wish to post your guidelines there.

Standards used for each probe type should be summarized in a table.



Dist (in.)	2.0	3.0	4.0	5.0	6.0	7.5	9.0	10.5	11.5	12.5
Id Depth (%)	100	79	61	41	22			100	83	39
Type	Ax	Ax	Ax	Ax	Ax	Ring	Dent	Cir	Cir	Cir
Od Depth (%)		80	58	40	20			100	79	41
Type		Ax	Ax	Ax	Ax			Hole	Cir	Cir

Summary

A well-written set of guidelines will help in the training of the analysts, provide a valuable reference to the analyst while the test is being performed, and document how the inspection was performed when questions arise in the future. While the initial cost may be higher, it will improve the inspection and save money in the long run.

PWR SG EXAMINATION GUIDELINES
Revision 5

NRC S/G Workshop

February 27-28, 2001

Washington, DC

Scott Redner

Xcel Energy

Guidelines
Purpose and Scope

- Purpose
  - Provide inspection requirements that:
    - identifies degradation,
    - applies valid inspection techniques,
    - and assures tube integrity
- Scope
  - Provide requirements for:
    - performing S/G assessments,
    - selecting an inspection sample,
    - validating NDE systems to detect and size flaws,
    - and qualification of techniques and data analysts

Background

- PWR Steam Generator Examination Guidelines is an industry developed document based on:
  - Plant operating experience and lessons learned
  - Current technology and practices
  - Available resources - What's practical
- Recent revisions have been developed by utility representatives with input from NSSS and ISI vendors

Guideline Revisions

- First edition developed in 1981 by the EPRI NDE Center
- Rev. 1 was formally published as an EPRI report in 1984
- Rev. 2 published in 1988 benefited from input from Utilities, NSSS vendors and ISI vendors
- Rev. 3 published in 1992 introduced the protocol for performance demonstration through Appendices G & H
- Rev. 4 published in 1996 introduced specific guidance on sampling for various degradation modes
- Rev. 5 published in 1997 transferred prior guidance into specific requirements
- Rev. 6 is under development for 2001 publication

Revision 5 Organization

- 1 - Introduction and Background
- 2 - Compliance Responsibilities
- 3 - Sampling Requirements for Technical Specification Type Examinations
- 4 - Sampling Requirements for Performance Based Examinations
- 5 - Steam Generator Assessments
- 6 - System Performance
- 7 - Summary of Requirements
- Appendices - A through K

Revision 5 Highlights

- **Performance Demonstration**
  - Appendix G - Analyst Qualification
  - Appendix H - Technique Qualification
- **System Performance**
  - Section 6
- **Summary of Requirements**
  - Section 7
- **Inspection Requirements Due To Leakage Forced Outages**
  - Appendix K

Appendix G
Analyst Qualification

- Establishes an industry standard for the qualification of S/G data analysts
  - Requires a written program for control and administration
  - Requires a minimum of 40 hours training
  - Requires both a written and a practical examination
  - Requires 8 hours of annual training and re-qualification every 3-5 years

Appendix G
Written Examination

- Written examination based on:
  - Known tube degradation
  - Babcock & Wilcox OTSG operating experience
  - Combustion Engineering operating experience
  - Westinghouse operating experience
  - Tube examination techniques
- A passing grade of 80% is required to proceed with the practical examination

Appendix G
Practical Examination

- Practical examination based on:
  - All damage mechanisms
    - Thinning
    - Pitting
    - Wear
    - ODSCC
    - PWSCC
    - Impingement
  - Test data is from actual S/G's using data acquired with Appendix H techniques

Appendix G
Practical Examination

- The practical examination requires evaluation of approximately 5000 intersections
- The correct answer is based on expert opinion (similar to the NRC Program at Argonne)
- A passing grade on each mechanism is required to be considered a Qualified Data Analyst (QDA)
  - 80% POD @ 90% CL on repairable indications, $\geq$80% detection of non-repairable indications, $\leq$10% RMS sizing error, $\geq$80% on RPC orientation and <10% overcall rate

Appendix H
Technique Qualification

- Establishes an industry standard for the qualification of S/G ET techniques
  - Provides Performance Demonstration Qualification Requirements for:
    - documenting essential variables
    - the detection and sizing sample set
    - the detection and sizing performance measurers
    - equipment characterization and equivalency
    - technique inclusion in the QDA
    - peer review and acceptance criteria

Appendix H
Technique Qualification

- Sample Set
  - Samples may be fabricated using mechanical or chemical methods as long as they produce signals similar to those observed in the field
    - However, we prefer tube pulls when available
    - EDM notch samples are replaced with crack samples as they become available
  - Flaw dimensions for samples shall be verified
    - Expert opinion is not acceptable
    - Metallurgical depth is averaged over the coil width

Appendix H
Technique Qualification

- Detection sample set
  - Minimum of 11 flawed grading units $\geq$ 60% TW
    - Provides 80% POD @ 90% CL $\geq$60% TW
- Sizing sample set
  - Minimum of 5 additional flaws 20-59% TW
- Peer Review and Acceptance Criteria
  - A minimum of 5 QDA's review the technique documentation and based on a majority either accept or reject the technique

Section 6
System Performance

- Site-Qualified Techniques
  - Site validation process that compares site data and variables to a qualified technique
- Analyst Performance Tracking
  - Feedback loop to increase consistency
- Site Specific Performance Demonstration
  - Miniature QDA examination that orientates data analysts to site specific conditions
  - Provides performance measures on utility techniques not covered by the QDA

Section 7
Summary of Requirements

- Section 7 compiles the 168 requirements (SHALL) found in Sections 1 through 6
- Prairie Island developed a conformance matrix with Section 7 when Rev. 5 was first issued as part of a Self Assessment
  - We found we were not in conformance
  - A Condition Report with 10 Corrective Actions was issued
  - We are now in conformance w/o deviation

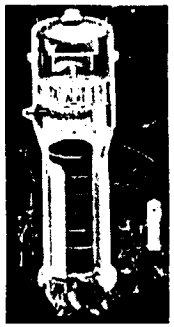
Appendix K
Leakage Forced Outages

- Summary of engineering and inspection aspects to be considered
  - Guides Utility to find and understand source of leakage
  - Identifies program deficiencies
  - Proposes corrective actions and mitigation
  - Assures continued tube integrity

Guidelines Implementation

- Rev. 5 of the SG Examination Guidelines is used by all US PWR utilities in developing plant specific SG inspection programs
- Rev. 5 is also used by INPO in its periodic review visits of SG inspection programs at US PWRs

EPRI



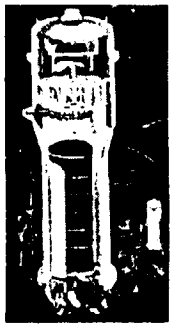
SG Examination Guidelines Revision 6

NRC Workshop
February 27-28, 2001
Washington, DC

Dan Mayes

Duke Power

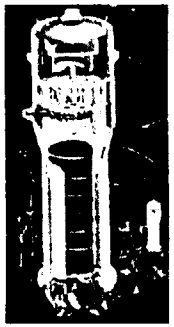
EPRI



Background

- Revision 5 of the NDE G/L requires that the need for G/L revision be assessed at least once every two years
- Revision 5 was issued in November 1997. A utility group met in April 1999 and decided that no revision was needed as of that date
- With NEI 97-06 initiative and increasing number of 2nd generation steam generators, there was a need to address G/L revision again in 2000

EPRI

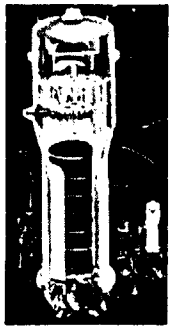


Background, Cont..

NDE Guidelines Workshop

- A workshop was conducted on February 3-4, 2000 in Orlando, FL.
- 45 participants representing utilities and all of the major ISI vendors
- Background presentation on:
  - Risk-based ISI
  - Data quality standards
- Utility and vendor presentations on:
  - Implementation Experience
  - Strengths and weaknesses of the Guidelines
  - Suggested revisions

EPRI

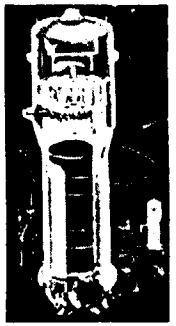


Background, continued

Summary of suggested changes

- Clarifications and editorials
- Allow dual automated analysis
- Update and refine Appendices G and H
- Relaxation of requirements for replacement S/G
  - 100% ISI within 60 EFPM
  - No S/G can go longer than 2 cycles without ISI
- Inclusion of new topics in new revision:
  - Risk-based considerations
  - Data quality standards

EPRI



Background, continued

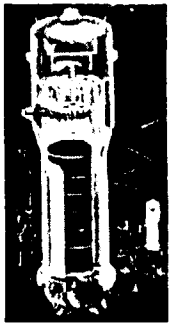
Workshop Conclusions

- The ISI Guidelines has served the industry well
- Unanimous recommendation to produce Revision 6 to incorporate the suggested changes

Actions

- Take workshop recommendations to the NDE IRG and SGMP IIG for approval to proceed
- Form a utility group to produce Revision 6

EPRI

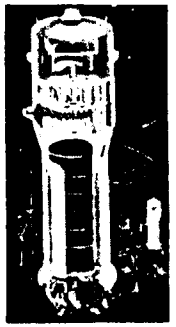


Development of Rev. 6

- EPRI solicited utility participation and the following responded by participating in one or more working meetings:

Ed Addison / EOI	Tom Bipes / CP&L
Al Matheney / SCE	Ian Mew / Entergy
Scott Redner / Xcel	Steve Swilley / TXU
Clayton Webber / TVA	Dan Mayes / Duke
CJ Conner / PSE&G	Doug Hansen / APS
John Smith / RG&E	M. Behravesh / EPRI
Gary Henry / EPRI	

EPRI

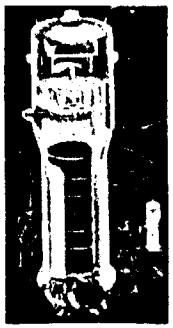


Approach to Revision 6

General and up front resolutions

- Use comments on Revision 5 as general guidance in developing Revision 6
- Produce Revision 6 in a single volume and include justifications where needed
- Maintain Revision 5 organization in Revision 6. -- Seven sections with similar headings and retain appendices

EPRI

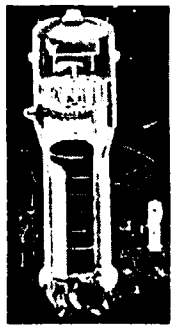


Approach to Revision 6

General and up front resolutions

- Include new and updated material on data quality, risk-informed considerations, and visual inspections
- Modify existing guidance and provide new guidance to better accommodate the needs of improved-material and replacement SGs
- Modify guidance on auto analysis to better reflect current technology and experience
- Track and respond to all comments on Revision 6

EPRI

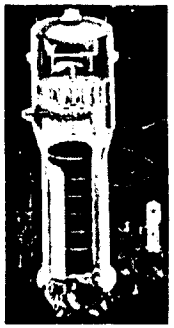


Migration From Revision 5 to Revision 6 and Ownership of Various Sections

The following have assumed the lead role and primary responsibility for development of each of the following sections:

- Al Matheney -- Sec.1, Introduction and Background
- Steve Swilley -- Sec.2, Compliance Responsibilities
- Redner/Henry -- Sec.3, Sampling for Tech. Spec. Exams
- Dan Mayes -- Sec. 4, Sampling for Perfor.-Based Exams
- Dan Mayes -- Sec. 5, SG Assessments
- Scott Redner -- Sec. 6, System performance
- Matheney / Henry -- Appendices G and H
- Sears / Exner -- Appendix K

EPRI



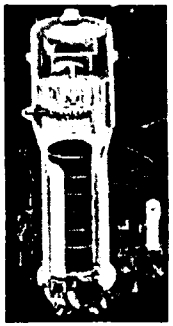
Important Changes Underway

Separate sampling requirements in Section 3 for 600 MA, 600TT, and 690TT materials

600 MA:

- Inspect 100% of tubes in each SG every 60 EFPM
- No SG may go more than 2 cycles without inspection

EPRI



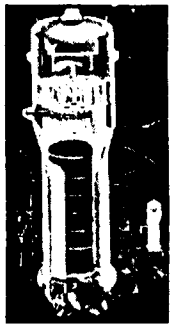
Important Changes Underway

600 TT:

Inspect 100% of tubes in each SG in 120, 90, and 60 EFPMs and with the following conditions:

- Examine at least 50% of tubes in each SG by 1/2 way through each period and the remaining 50% by the end of the period and
- Examinations are to be performed at the nearest refueling cycle provided that no more than 12 months will be added to the inspection cycle.

EPRI



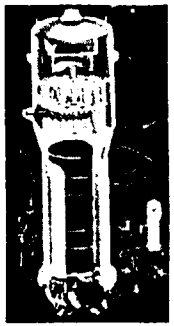
Important Changes Underway

690 Alloy:

Inspect 100% of tubes in each SG in 144, 108, 72, and 60 EFPMs with the following conditions:

- Examine at least 50% of tubes in each SG by 1/2 way through each period and the remaining 50% by the end of the period and
- Examinations are to be performed at the nearest refueling cycle provided that no more than 12 months will be added to the inspection cycle.

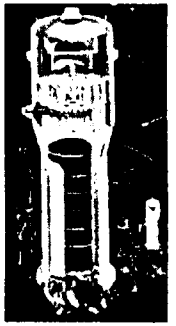
EPRI



Important Changes Underway

- Data Quality requirements
  - Generic, bobbin, rotating +Point, rotating pancake and array probes.
  - The tables provide a frequency, location, acceptance criteria, and corrective action for each of the listed quality parameters.
- Probe Manufacturing Quality requirements
  - Coil type
  - Acceptance criterion for each of the quality parameters

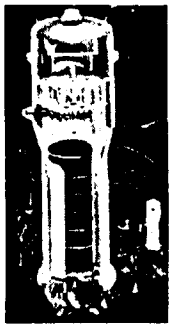
EPRI



Progress to Date

- Monthly working meetings have been held since March 2000.
- Drafts of all sections have been completed and reviewed by the group
- Extensive effort has been devoted to the development of data quality parameters. Draft quality parameters for commonly used probes have been developed and reviewed by vendors.

EPRI



Schedule

- Draft Revision 6 is currently expected to be ready for its industry review cycle by April and publication in the 2nd half of 2001

Steam Generator Eddy Current Inspection Challenges

Steam Generator Workshop
February 27-28, 2001

Session on Steam Generator Inspection Technical Issues

Stephanie Coffin
NRR/DE/EMCB

SG Eddy Current Inspections

- What is success?
  - Defective tubes removed from service prior to exceeding performance criteria
- How are defective tubes identified?
  - Eddy current testing
- When are defective tubes repaired?
  - "Upon detection" for most cracklike indications

SG Eddy Current Inspections

- Three challenges:
  - Data quality
  - Flaw detection performance (POD)
  - Flaw sizing performance

SG Eddy Current Inspections

- Lack of rigorous treatment of data quality during inspections
  - Limits ET inspection capabilities
- Lack of rigorous treatment of POD and flaw sizing performance during condition monitoring and operational assessment
  - Limits tube repair options

Data Quality

- Recognition that noise cannot be eliminated completely but ET inspections can sometimes be improved
  - Particularly vulnerable areas include U-bend and sludge pile regions
- Ability to detect flaws that could potentially impact performance criteria over the next operating cycle
  - The signals of such flaws may be small in size relative to the noise
- Supplemental information can provide additional assurance
  - In situ pressure testing
  - Historical reviews

Data Quality

- Data quality needs to be explicitly considered and addressed
  - Simple comparisons to the Appendix H qualification data set may not be sufficient
    - There are limits to these techniques' applicability to specific defect types and associated plant-specific extraneous test variables (e.g., denting signals, noise, S/N ratios, tube geometry, etc.)
  - Noise levels should be sufficiently low such that flaws of potential tube integrity significance are detectable

Data Quality

- Recent Example: IP2
  - Hindsight analysis of 1997 inspection revealed four missed indications.
  - One of the missed indications was in the tube that failed on February 15, 2000
  - Detection difficult because of poor quality ET inspection data

POD

- POD is a key input parameter for operational assessments
- Results of operational assessments are typically very sensitive to this specific input
- Rigorous performance demonstration can be used to justify less conservative, more realistic POD assumptions (e.g., varying POD as a function of indication size)

POD

- Recent Example: IP2
  - Absence of directly applicable POD data for PWSCC at low row U-bends
  - EPRI qualifiation set primarily EDM notches
  - Licensee used POD from a formal performance demonstration program for PWSCC at dented TSPs
    - Staff found lack of justification for applying to IP-2 U-bends. Comparative noise levels were an important consideration.
  - OA results very sensitive to POD assumptions

Flaw Sizing Performance

Condition Monitoring

- Sizing uncertainties must be considered when choosing in situ pressure test candidates
  - Recent experiences emphasize the importance of explicitly considering flaw sizing uncertainties and conservatively choosing candidates to reflect those uncertainties
  - Completed in situ pressure test results often provide a more reliable indication that tubes retain adequate integrity than engineering analysis

Flaw Sizing Performance

Condition Monitoring

- Recent Example: ANO-2, November 1999
  - Six tubes found to exceed in situ pressure test screening criteria
  - The NDE measured size of the respective flaws in four of the six tubes were bounded by the size of flaws successfully in situ pressure tested during a previous inspection outage
  - Testing on one of the four tubes was terminated at a pressure below $3\Delta P$ criterion when leakage through the flaw exceed the capacity of the system
  - Staff concluded that the tube was about to burst when the test was terminated
  - Underscores the importance of allowing for flaw size measurement errors when selecting in situ pressure test candidates

Flaw Sizing Performance

Operational Assessments

- Flaw sizing error uncertainty distributions are another key input parameter for operational assessments
- Results of operational assessments are typically sensitive to this specific input
- Availability of a rigorous performance demonstration enables the direct consideration of the ET inspection results

Flaw Sizing Performance

Operational Assessments

- Recent example: Sequoyah PWSCC ARC
  - Performance demonstration supported flaw sizing error uncertainty distributions for average depth, maximum depth, and length
  - Repair criteria no longer "upon detection" for PWSCC located within the TSPs

Performance Demonstrations

Quantifies performance of the total system (personnel and technique) relative to ground truth

- Major components of a performance demonstration include:
  - Data sets include representative flaw morphology(ies) as well as extraneous signals representative of those experienced in the field (e.g., similar voltage amplitude, complexity, and S/N ratios)
  - Blind data acquisition and analysis
  - Statistically valid sample set of flawed and unflawed grading units with a range of defect sizes

Conclusions

Performance Demonstrations

- Reduce/quantify POD uncertainties
- Reduce/quantify NDE sizing uncertainties
- Lead to enhanced ET inspection capabilities
- Support expanded tube repair options

NRC Steam Generator Workshop

NDE Issues

D. S. Kupperman
Argonne National Laboratory
February 27-28, 2001
Bethesda, Maryland

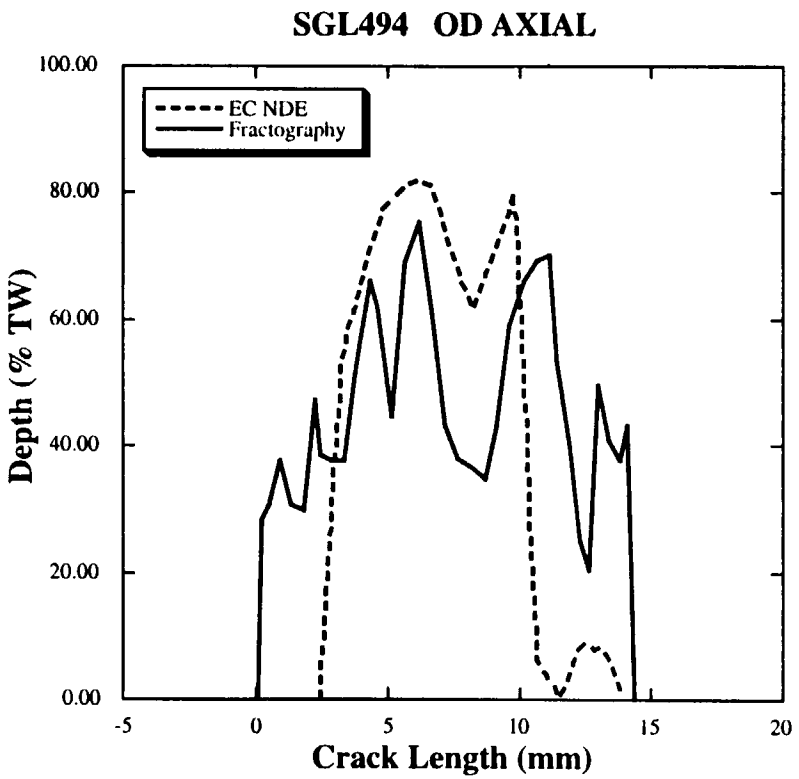
Performance Demonstrations

- Need more representative data set for testing personnel
  - Realistic samples with true state
  - Higher passing criteria: better than 80% for >60%TW
  - Test analysts with high noise situations (deposits, RTZ etc.)
  - Demonstrate ability to judge data quality

Rotating Coil Data Does Not Always Lead to Better Characterization

- MRPC Signal may be to complex
- MRPC may be less sensitive to volumetric flaws (I.e IGA)
- BC "I" code call with no MRPC flaw call possible
  - For Argonne Mock-up RR about 10% of the time flaws >40%TW with BC "I"code calls and BC voltage in 2.0-5.6 v range were dismissed with MRPC +Point analysis

Flaws Detectable by MRPC could be missed by BC screening



- No detectable BC flaw signal above few tenths background level
- Low level but detectable +Point indication
- Crack 75%TW and 1/2 inch long

Data Quality

- Noise Levels
  - Use improved data acquisition systems to filter out noise
- Increase number of flaws in standards to better quantify quality of data
- Quantify quality of data needed for sizing which is different for detection

Data Screening

- Log scale or two traces to cover wide dynamic range in EC signal voltage
  - Help avoid missing large signals
- Development of array probes may improve screening
  - Axial and circumferential flaws detectable and distiguishable

Argonne SG Mock-up NDE Round Robin

J. Muscara

U. S. Nuclear Regulatory Commission

NRC Steam Generator Workshop

Bethesda, Maryland
February 27-28, 2001

Introduction

- NRC has been developing new regulatory guidance for SG tube integrity
  - Condition monitoring (evaluate as-found condition of tubes)
  - Operational assessment (demonstrate that performance criteria for SG tube integrity will continue to be met)

- Quantitative information is needed to estimate true state of the SG after ISI
  - POD
  - Sizing accuracy

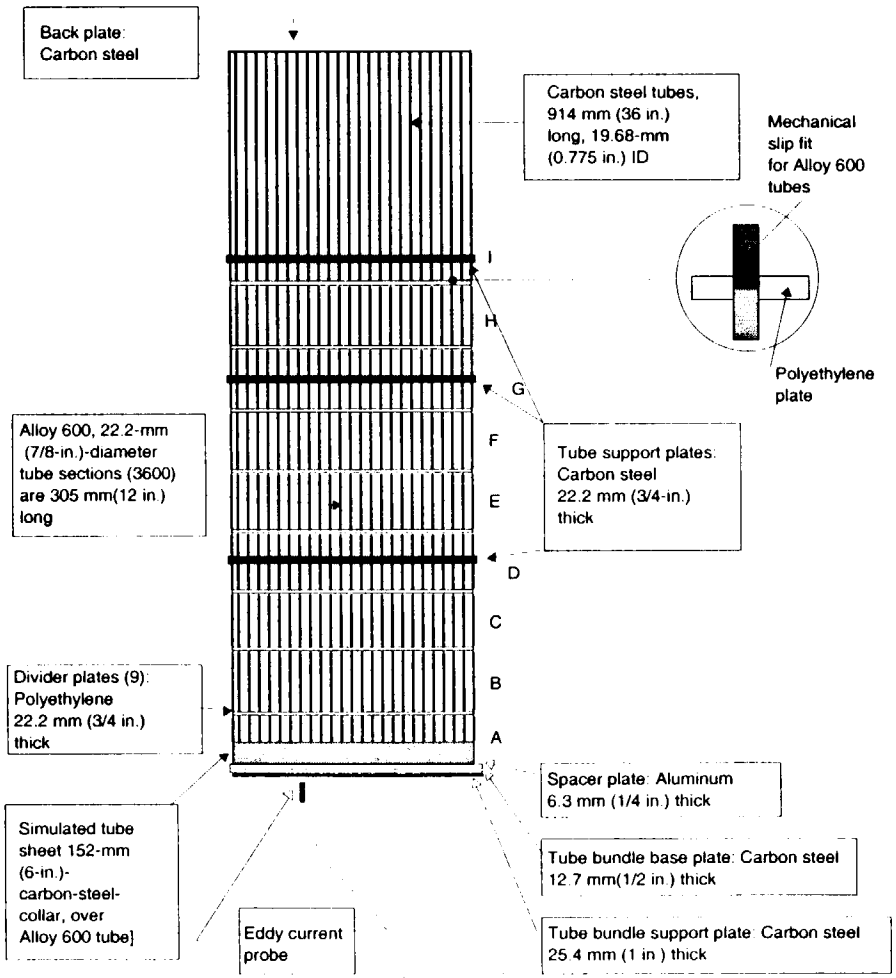
Introduction (cont.)

- One task of the NRC-sponsored SG TIP at ANL is to evaluate and quantify reliability of current, advanced and emerging technology used for ISI
- Approach to establishing ISI reliability is to carry out RR exercises on SG mock-up with flaws and conditions representative of SGs in service
- Data acquisition and analysis for the RR was performed by qualified commercial teams

Mock-up Design

- Tube bundle consists of aproximately 300 flaws in 12-in. long, 7/8-in.diameter Alloy 600 test sections with various forms of degradation (mainly ANL produced but some from Westinghouse, PNNL, ENSA and PISC)
  - Circumferential and axial ID and OD in roll transition
  - Axial ODSCC (planar and segmented) in TSP
  - Axial IDSCC in dents at TSP
  - ODSCC (planar and segmented) in free span
  - IGA and wear in small numbers at different locations
- The tube bundle consists of 400 tube openings, each with 9 levels, for a total of 3600 test sections.
  - One tube sheet simulation.
  - Three drilled hole TSP simulations
  - Five free-span levels

Mock-up Schematic



Mock-up Degradation

Location	EDM & Laser Cut Slots	IGA	ODSCC	PWSCC	Wear/ Wastage	Fatigue
Top of Tube sheet			21	47		
Free Span	14	8	95	4	3	
TSPs	7	5	65	31	9	3

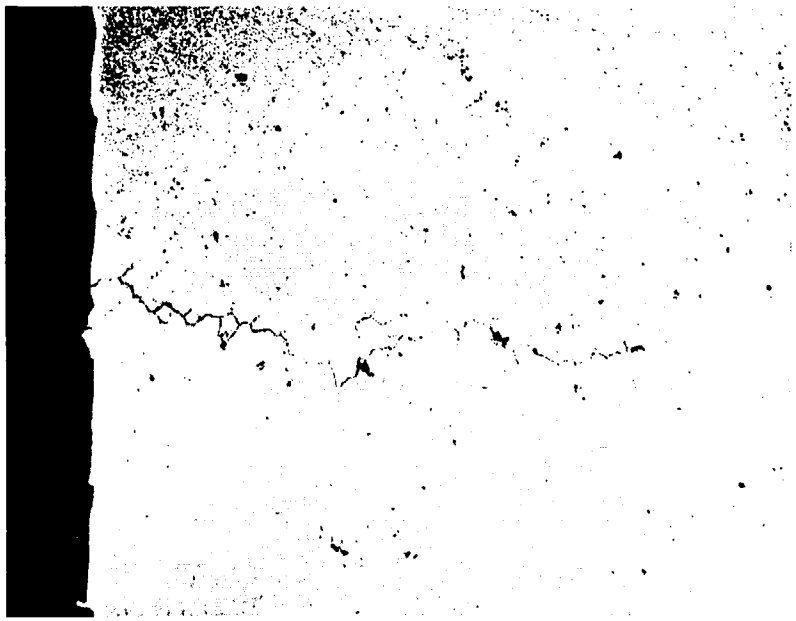
Artifacts

- **Other conditions and artifacts that can produce or distort EC signals in actual SGs are simulated in the mock-up**
  - **Roll transitions at TS level**
  - **Magnetite has been applied to the TSP region**
  - **Sludge has been incorporated above the TS and some TSP**
  - **Dented tubes (with and without SCC) were made with a device provided by FTI have been installed at TSP locations (elliptical and circular)**

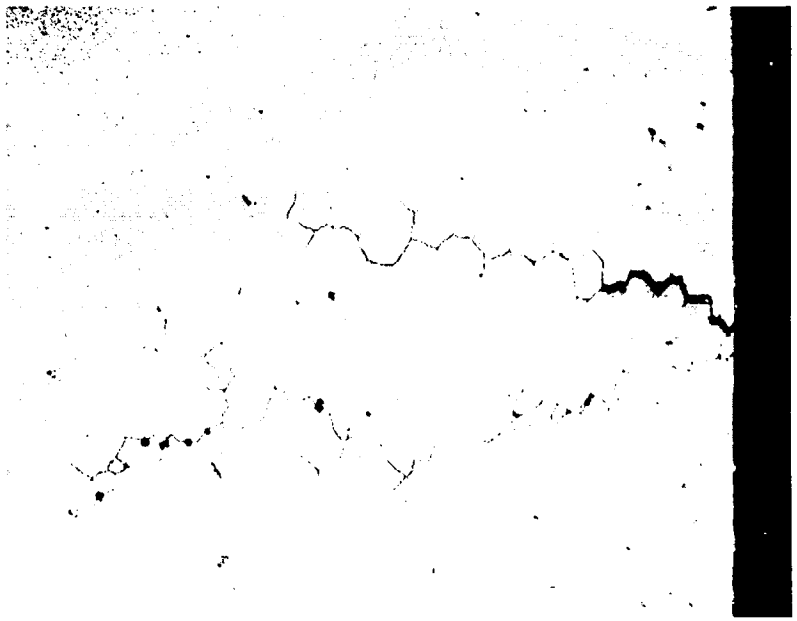
Cracks are Realistic

- SCC grown by aqueous solution of sodium tetrathionate at RT and ATM pressure
- Examination techniques used to evaluate nature of flaws
  - EC NDE
  - Dye penetrant examination
  - fractography
  - Optical microscopy
  - Scanning electron microscopy

Optical Metallography



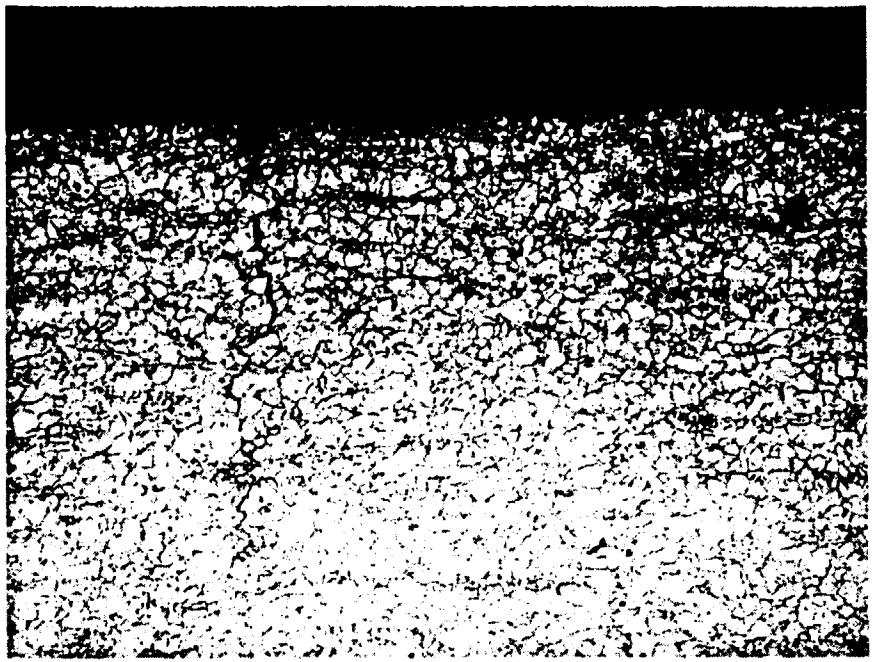
Axial ODSCC



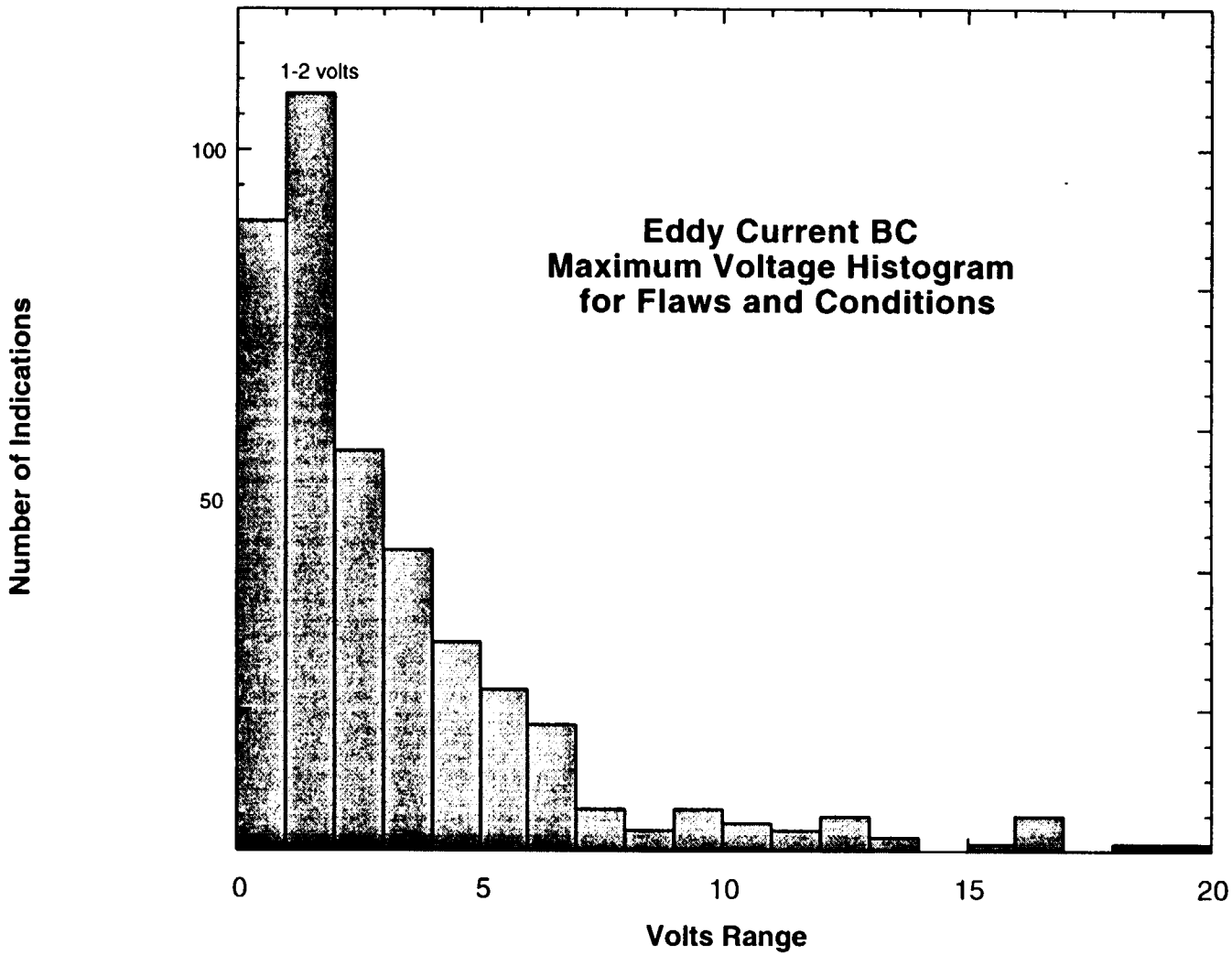
Branched Axial ODSCC

Figure A1. Cross Sectional Optical Metallography

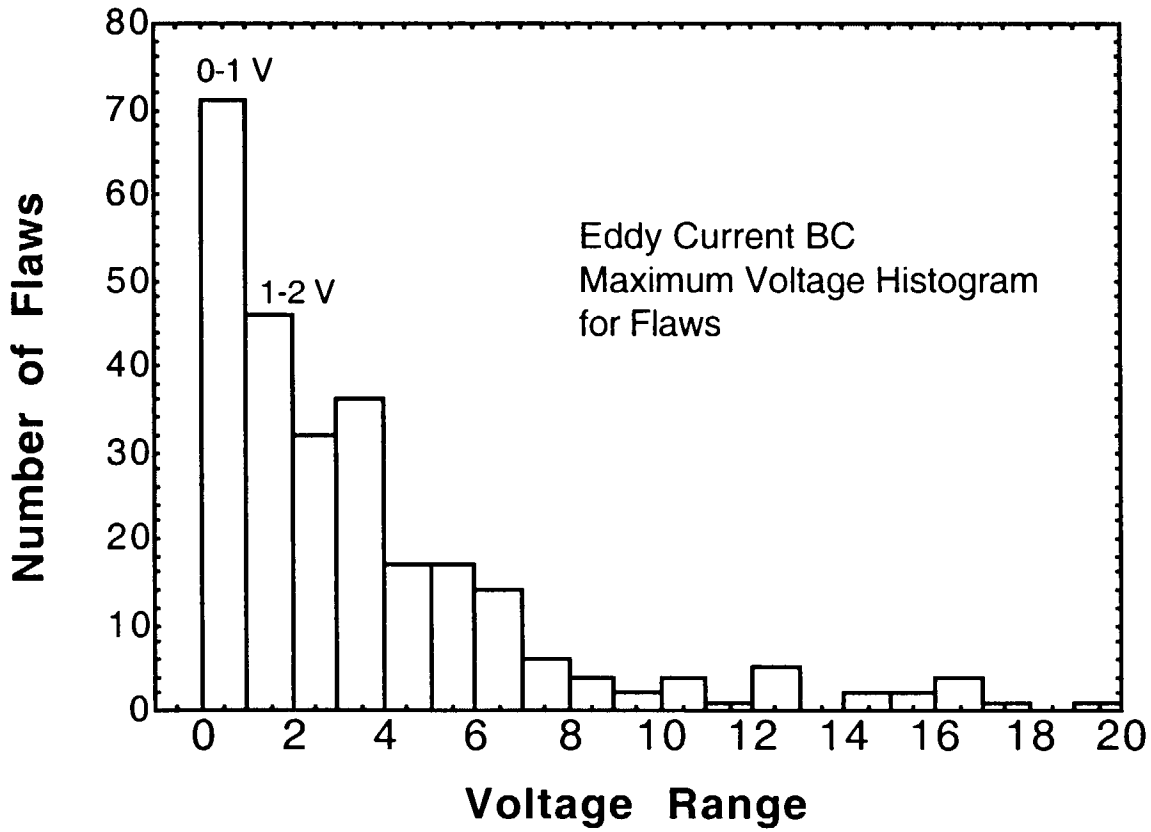
Optical Metallography



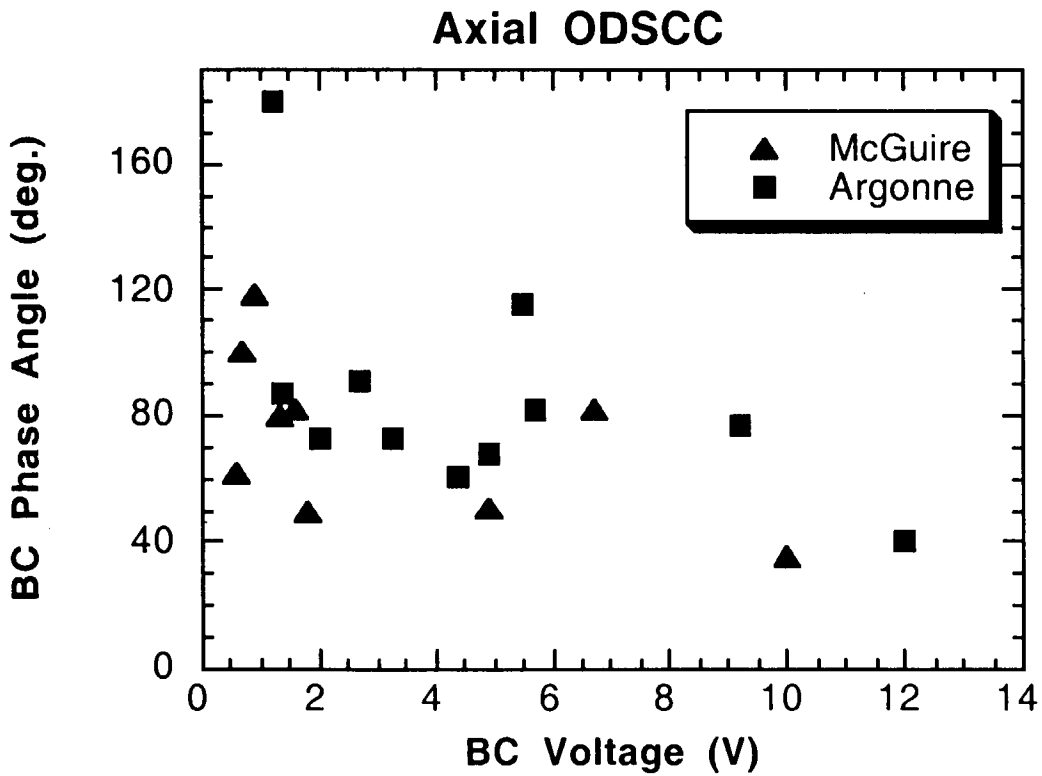
BC Voltage Histogram for Mock-up Flaws and Conditions



BC Voltage Histogram for Mock-up Flaws



McGuire vs. Mock-up



Evaluation of NDE Techniques for Characterization of Mock-up Flaws

- True state of mock-up flaws is needed to estimate POD and sizing accuracy from the inspection results without destroying the mock-up samples

- Effort undertaken to identify laboratory techniques for accurate characterization of the mock-up flaws

Evaluation of NDE Techniques for Characterization of Mock-up Flaws (Cont.)

- A subset of twenty specimens from the mock-up test sections was inspected using several NDE techniques:
  - Phase analysis of EC +Point data
  - Multivariate regression analysis of EC data
  - Multiparameter analysis of EC data with neural networks
  - High-frequency UT from the OD
  - Ultrasonic Lamb waves
  - Acoustic microscopy
  - Combination of UT and EC data (from the ID)
  - Dye penetrants

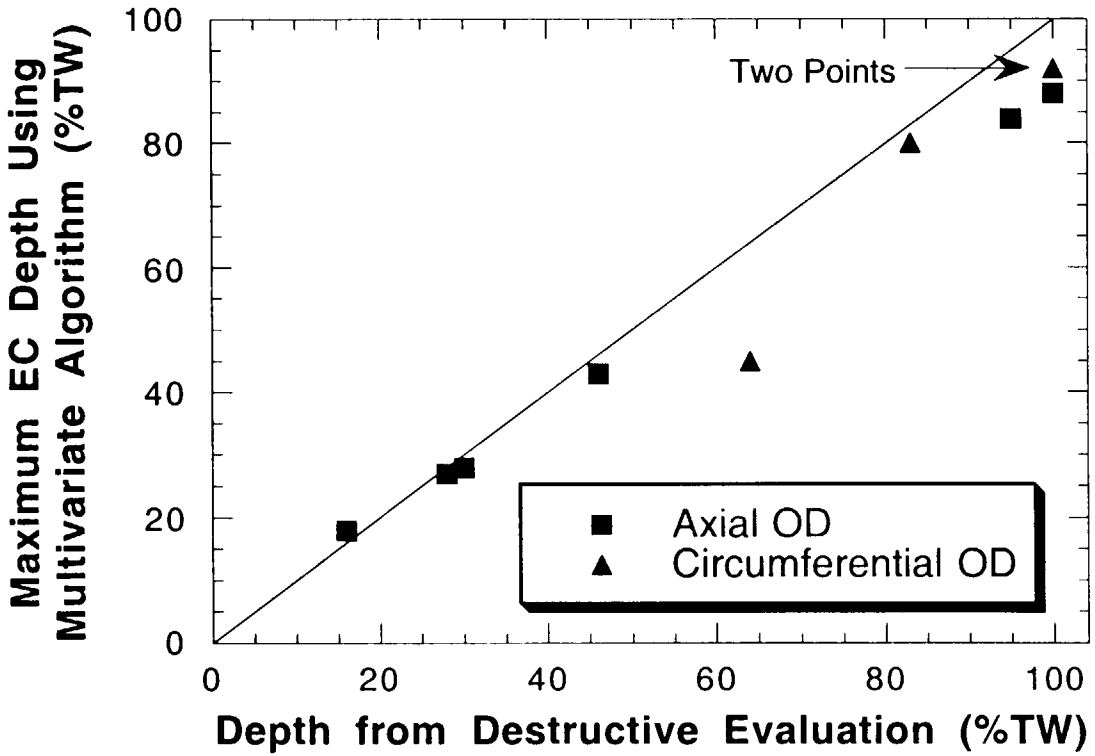
Evaluation of NDE Techniques for Characterization of Mock-up Flaws (Cont.)

- Conducted metallographic examinations to evaluate the sizing accuracy of the different methods and analysis techniques

- Analysis of the results indicated that most of the techniques did not provide desired accuracy for sizing the various flaws

- Multivariate regression techniques of EC data provided the best accuracy for sizing the cracks

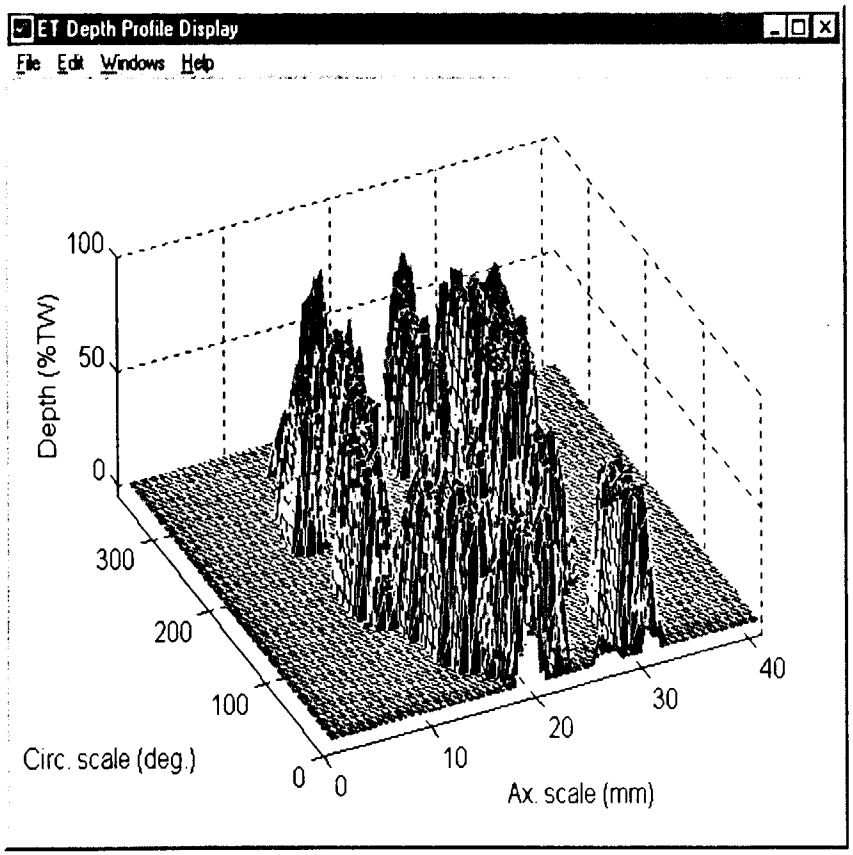
Maximum Depth as %TW Using Multiparameter Algorithm



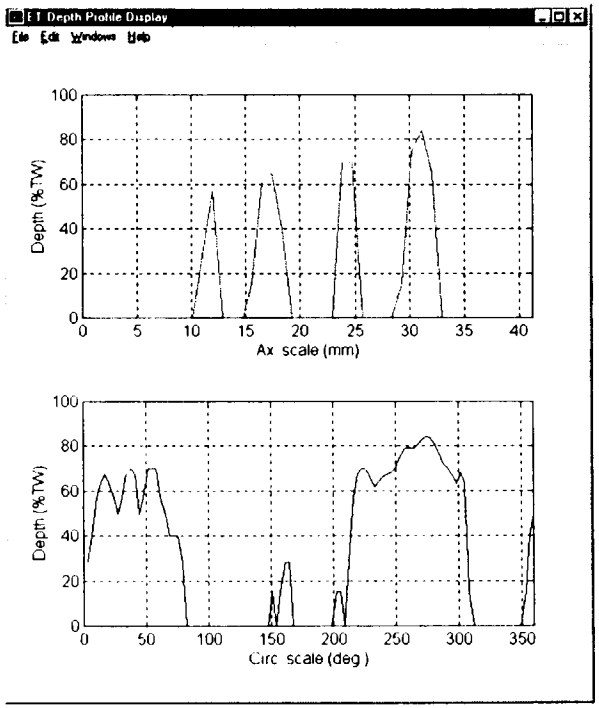
Evaluation of NDE Techniques for Characterization of Mock-up Flaws (Cont.)

- Development of an automated imaging and analysis algorithm for the analysis of RPC data.
  - Automated calibration
  - Filtering and deconvolution for improved S/N
  - Rule-based expert system
  - Multifrequency, multiparameter correlations for flaw size
  - Method provides graphical display which helps visualize cracking especially in cases like the roll transition where geometry greatly complicates analysis

Isometric and Cross Sections of Lab Grown ODSCC Using Advanced EC Analysis

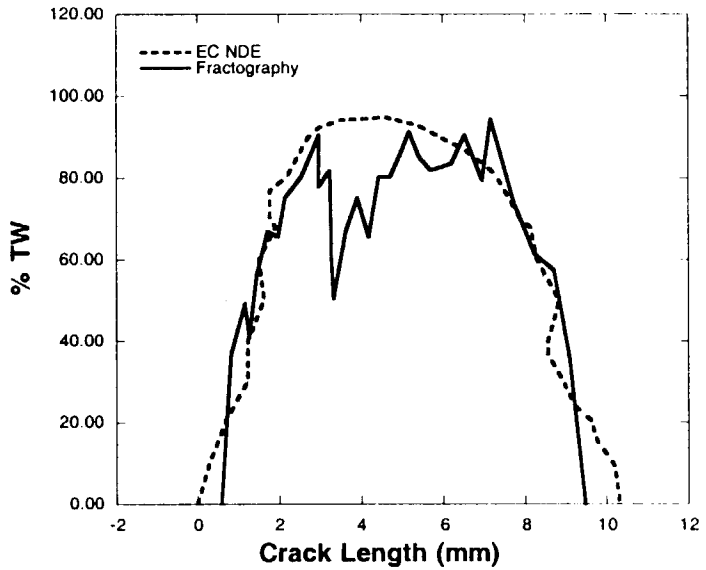


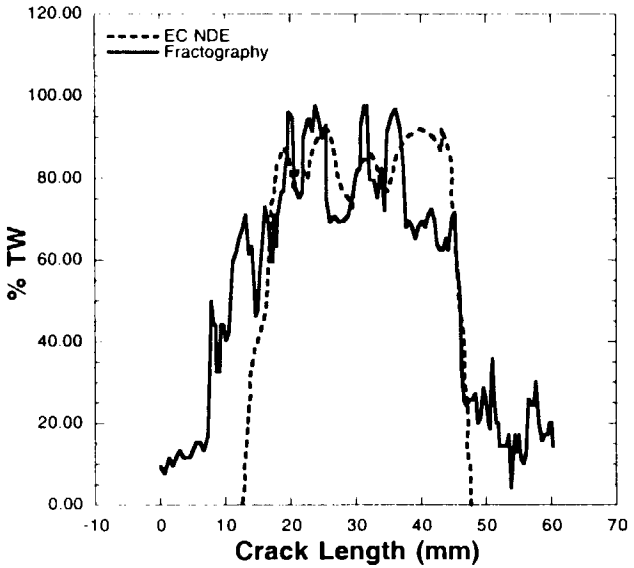
Lab-grown circumferential ODSCC ≈360° staggered cracking with maximum depth >80% TW.

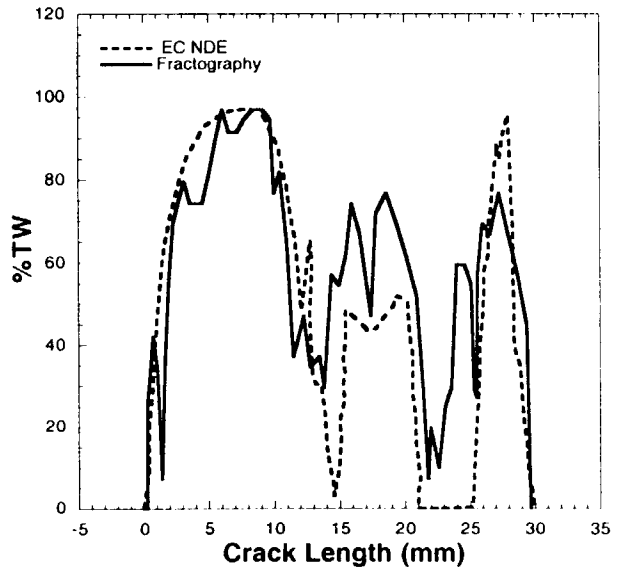


Axial or circumferential cross-sections can be taken to get profiles of the crack

Validation of Multiparameter Eddy Current Profiles vs. Destructive Analysis

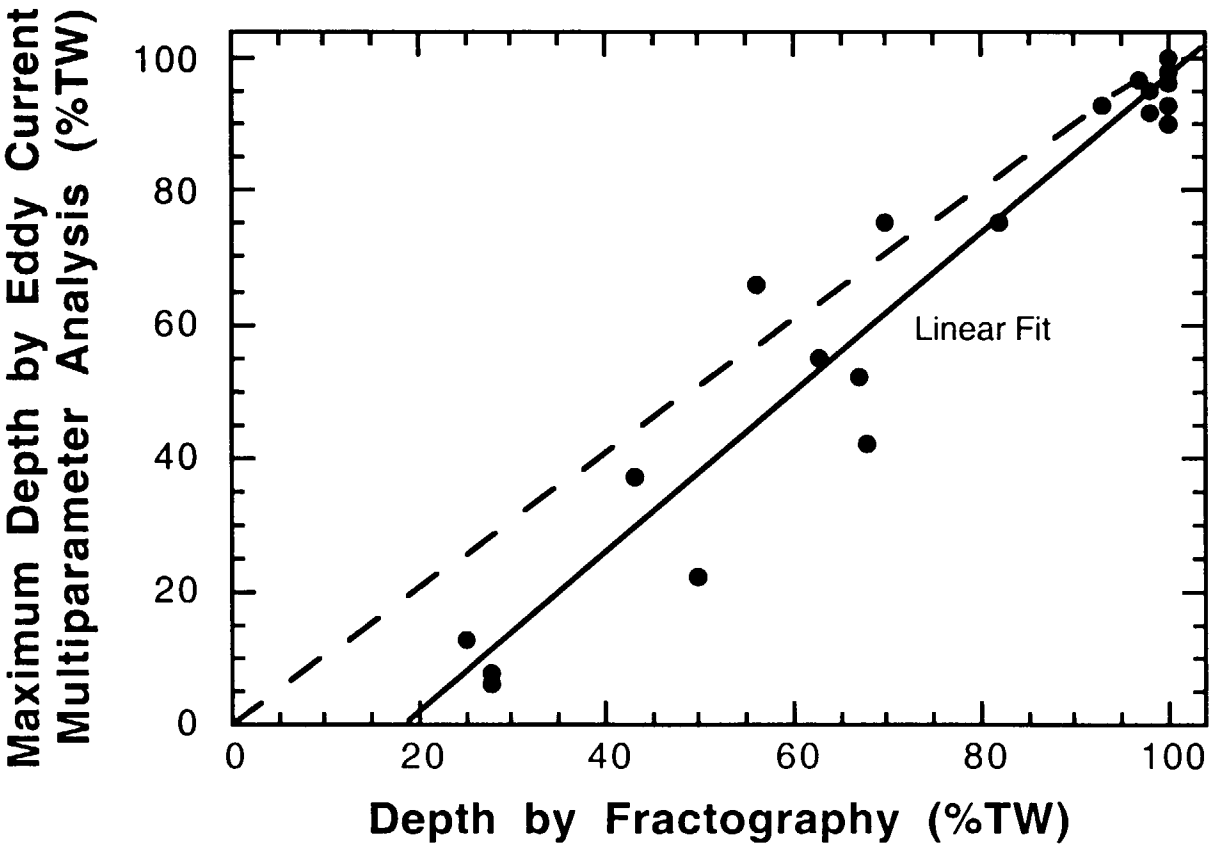




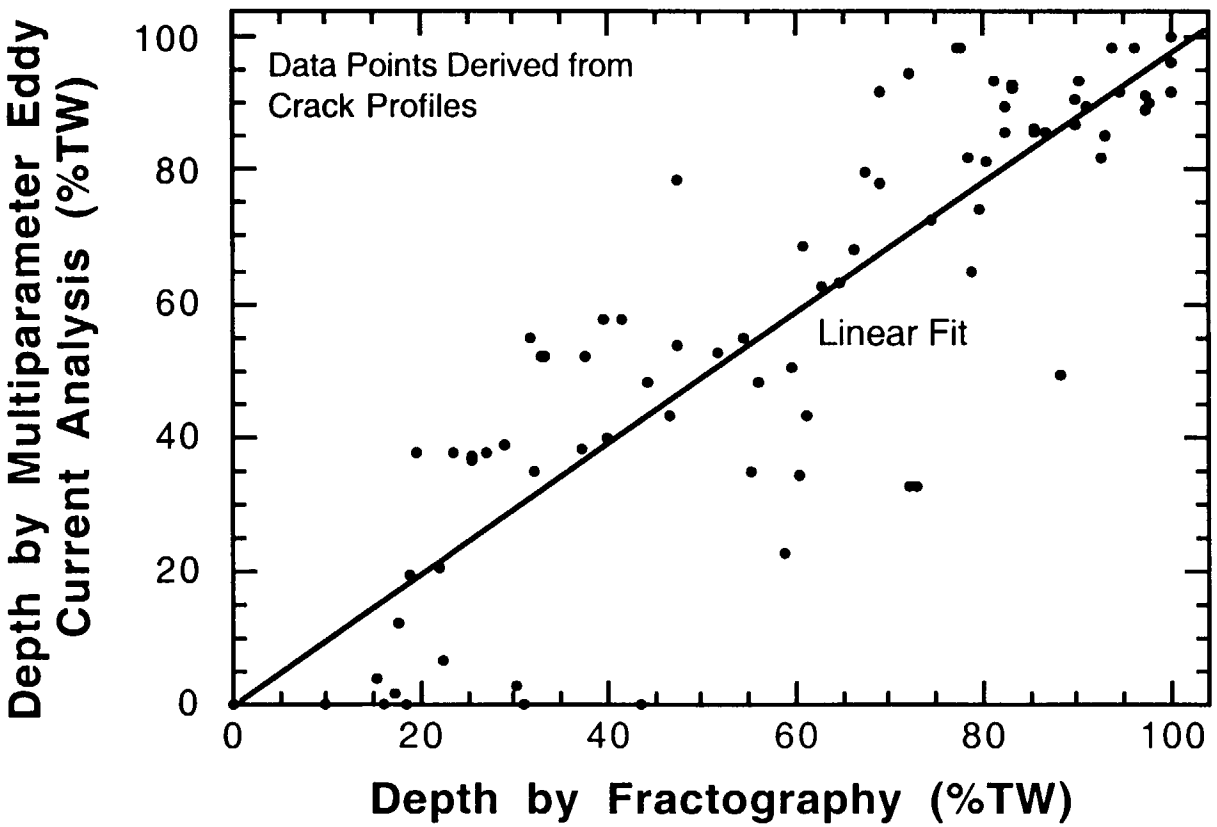


Destructive analysis of 29 tube set performed to validate capability of multiparameter analysis to better size and characterize a variety of flaws

Multiparameter Eddy Current Maximum Depth vs. Destructive Analysis



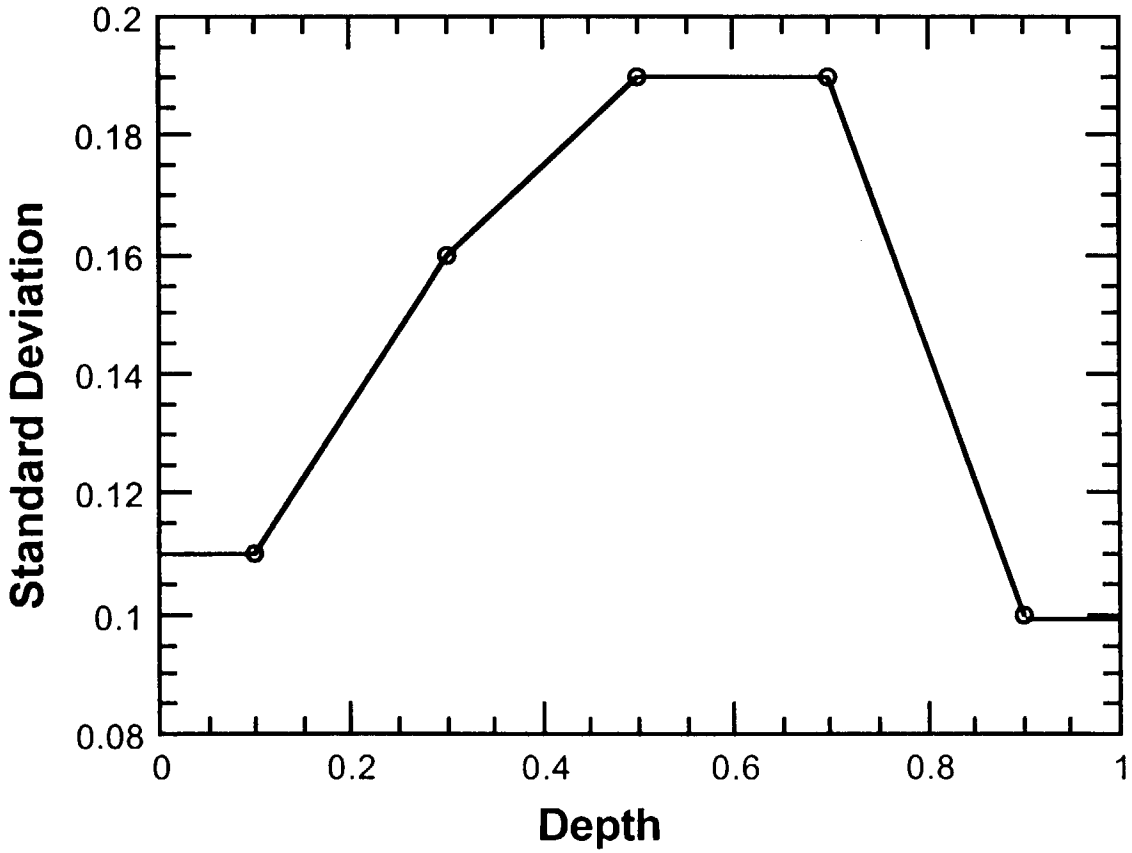
Multiparameter Eddy Current Point-by-Point Depth vs. Destructive Analysis



Depth Estimates by Multiparameter Algorithm as Function of Metallographic Crack Depth

Depth Range (%TW)	RMSE Max Crack Depth (%TW)
0-100	13.7
80-100	9.7

Standard Deviation Determined from Comparisons with Fractography



NDE Round Robin Objectives

- Establish POD for current day flaws as a function of size, type and location using the types of equipment, procedures and personnel qualified to conduct ISIs of SG tubes in the USA

- Quantify the accuracy of different methods and procedures for sizing the different flaw types

NDE Round Robin(cont.)

- Inspection of the mock-up and data analysis mimics the inspection process conducted on operating SGs
- NDE Task Group was formed to provide input to RR protocol and inspection procedures
  - Members are industry experts and practitioners were nominated by the program participants
- Using input from the Task Group, ANL developed protocol, documentation and requirements for "ISI of the mock-up"

Active Task Group Members (other than ANL and NRC)

- EPRI: G. Henry, J. Benson
- XCEL Energy (NSP): S. Redner
- Westinghouse: D. Adamonis, R. Maurer (ABB-CE)
- FTI: T. Richards, R. Miranda
- Zetec: N. Farenbaugh
- Duke Power: D. Mayes

NDE Round Robin (cont.)

- Degradation assessment for mock-up was carried out and qualified techniques selected
  - Examination Technique Specification Sheets for the inspection have been documented
- NDE Task Group members reviewed EC signals to ensure signals are realistic
- Metallographic examination results of cracks in the mock-up tubes showed that they were similar to cracks removed from service
- Comparison of signals from mock-up flaws with those from McGuire shows flaw responses are comparable

NDE Round Robin (cont.)

- Site specific essential variables for the mock-up were reviewed to ensure consistentcy with those of the qualified techniques
- Data was collected with a MIZ30 instrument and analyzed with Eddynet 98 software
- Data analysis RR carried out by 11 qualified teams from various ISI vendors

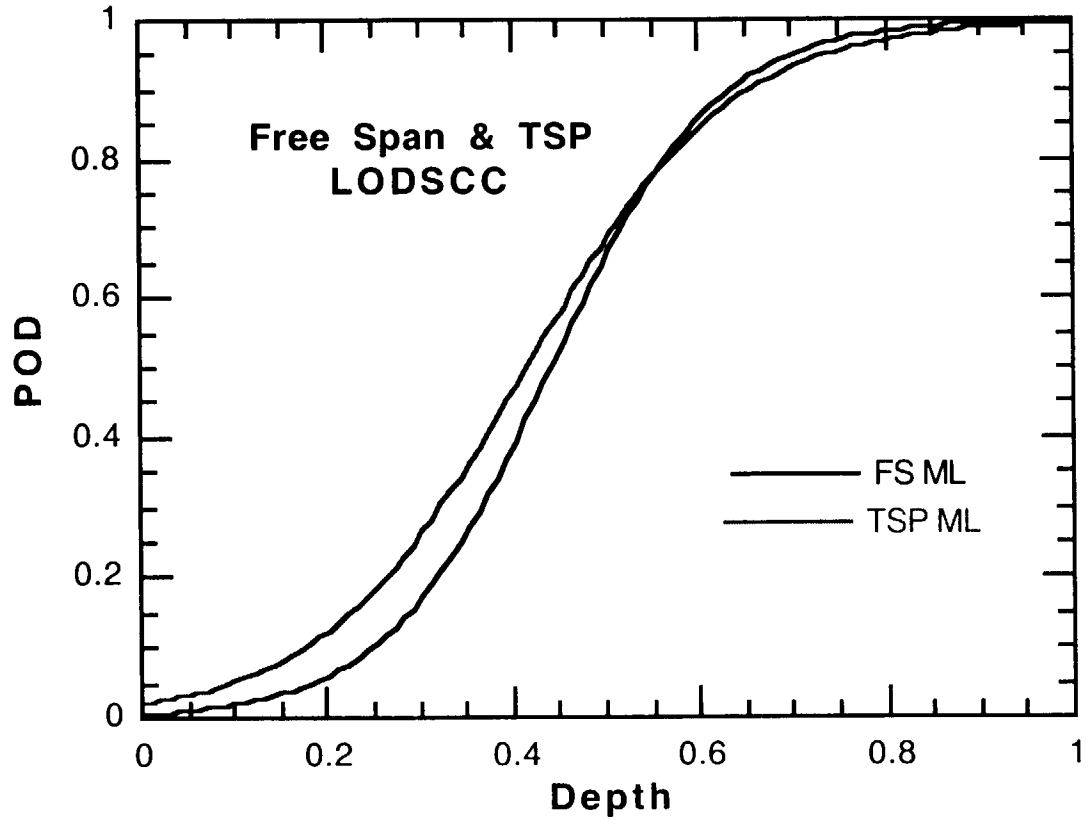
NDE Round Robin (Cont.)

- Each team consisted of a primary, secondary, two resolution analysts and a QDA
- Analysts were subjected to site specific training and performance demonstrations
- Inspection of the mock-up was carried out June and August 1999 with analysis completed Dec 2000.

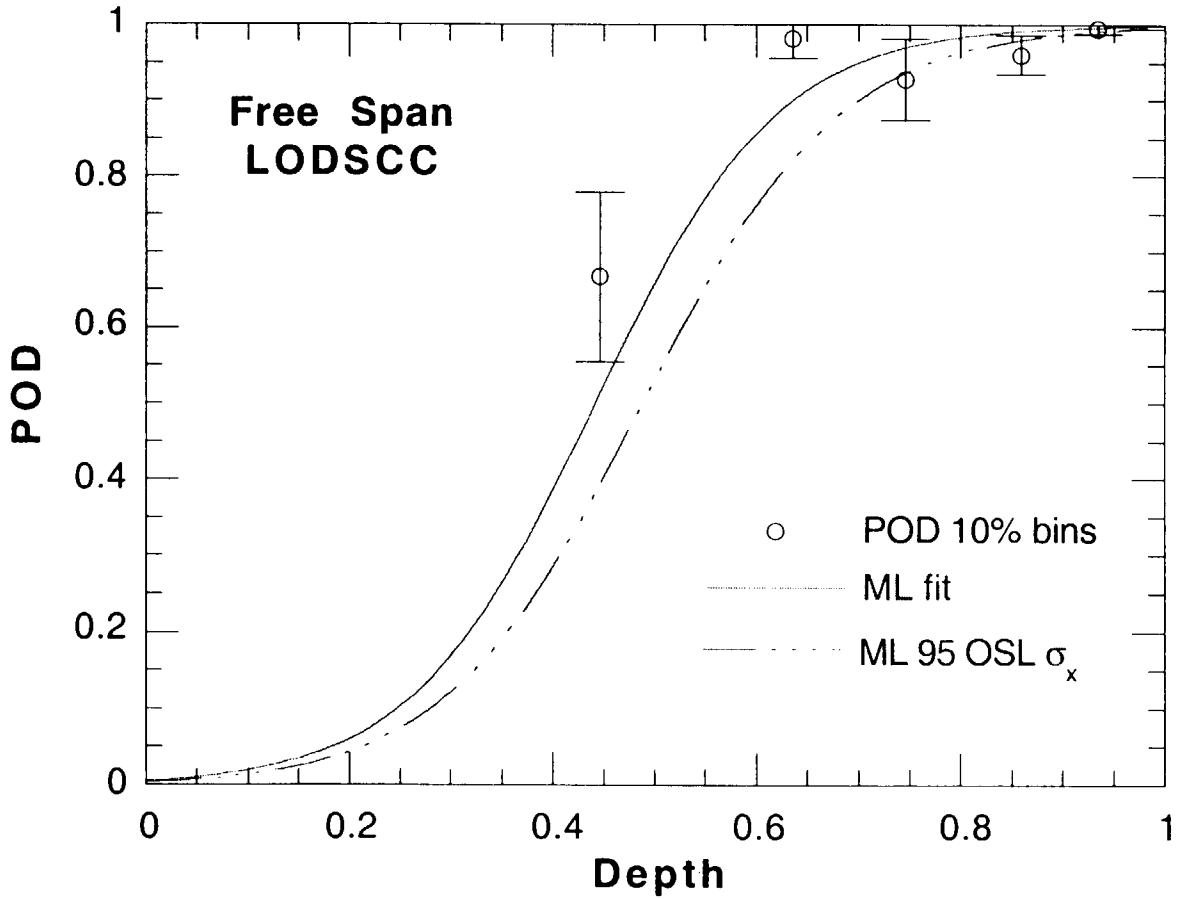
NDE Round Robin (cont.)

- Eleven teams have participated in the round robin exercise:
  - FTI (2),
  - ABB-CE,
  - Anatec,
  - Zetec (2),
  - Kaitec,
  - Duke Engineering and Services
  - Ontario Power Generation
  - Westinghouse (2).
- Analysis took 6-8 working days to complete

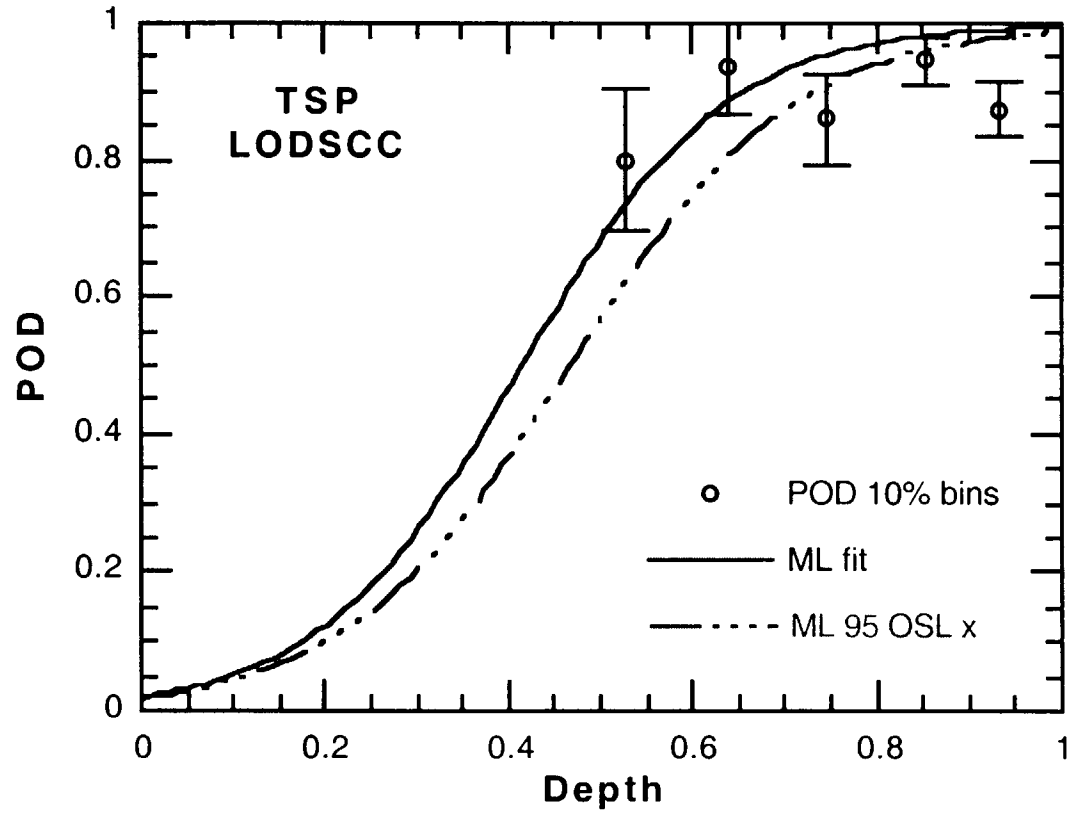
Preliminary Example Results: TSP and Free Span POD Fits for LODSCC >40%TW



Preliminary Example Results Including Error in Depth: Free Span LODSCC >40%TW



Preliminary Example Results: Including Error in Depth: TSP LODSCC >40%TW



Summary

- A SG tube bundle mock-up was assembled for evaluation of ISI reliability
- Inspection of the mock-up and analysis of the data mimics industry ISI practices conducted on operating SGs
- All documentation for conducting the inspections was prepared and the realism of the mock-up was established
- Data was acquired in June and August of 1999 and analysis of this data by 11 commercial teams was completed in December 2000
- Preliminary results indicate that good POD can be achieved for deep flaws when commercial techniques are used in a similar manner to that of the RR exercise
- Evaluation of results is continuing