BAW-10204
REVISION 03
MAY 1996

SOUTH TEXAS PROJECT - UNIT 1 TUBE REPAIR CRITERIA FOR ODSCC AT TUBE SUPPORT PLATES

FTI Non-Proprietary

FRAMATOME TECHNOLOGIES, INC.
P.O. BOX 10935
LYNCHBURG, VA 24506-0935

This document is the non-proprietary version of the proprietary document BAW-10204P-03. In order for this document to meet the non-proprietary criteria, certain blocks of information were withheld. The basis for determining what information to withhold was based on the criteria listed below. Depending upon the application criteria, the criteria codes below represent the withheld information.

(c) The use of the information by a competitor would decrease his expenditures, in time or resources, in designing, producing or marketing a similar product.

(d) The information consists of test data or other similar data concerning a process, method or component, the application of which results in a competitive advantage to FTI.

(e) The information reveals special aspects of a process, method, component or the like, the exclusive use of which results in a competitive advantage to FTI.

[]^{FP} The information contains data that is directly proprietary to FTI and the corresponding code from above is applied to the information as needed between the brackets.

[]^{EP} The information contains data that is directly proprietary to EPRI and HL&P, as a member of EPRI has declared that this information is proprietary to EPRI and therefore was removed.

TABLE OF CONTENTS

	Page
LIST OF TABLES	ii
LIST OF FIGURES	iii
LIST OF ABBREVIATIONS	vi
RECORD OF REVISIONS	viii
1.0 INTRODUCTION	1-1
2.0 EXECUTIVE SUMMARY	2-1
3.0 GENERIC LETTER APPLICABILITY TO STP-1	3-1
4.0 GENERIC LETTER EXCEPTIONS FOR STP-1	4-1
5.0 STP-1 STEAM GENERATOR DESIGN INFORMATION	5-1
6.0 REPAIR LIMITS	6-1
7.0 NDE INSPECTION CRITERIA	7-1
8.0 TUBE REMOVAL AND EXAMINATION/TESTING	8-1
9.0 VOLTAGE DISTRIBUTIONS AND PROJECTIONS	9-1
10.0 PROBABILITY OF BURST	10-1
11.0 EVALUATION OF LEAKAGE	11-1
12.0 OPERATIONAL LEAKAGE LIMITS	12-1
13.0 REPORTING REQUIREMENTS	13-1
14.0 EXCLUSION OF INTERSECTIONS	14-1
15.0 CONCLUSIONS	15-1
16.0 REFERENCES	16-1
APPENDIX A - NDE DATA ACQUISITION AND ANALYSIS REQUIREMENTS FOR ODSCC AT TSP ARC	A-1

LIST OF TABLES

		Page
TABLE 5-1	W-E DESIGN AND OPERATING CHARACTERISTICS	5-3
TABLE 6-1	STP-1 ARC REPAIR LIMITS TO SATISFY STRUCTURAL REQUIREMENTS	6-5
TABLE 8-1 (A-D)	RESULTS OF TUBE PULL EXAMINATIONS ON STP-1 1993 H/L TSP INTERSECTIONS	8-6
TABLE 8-2 (A,B)	RESULTS OF TUBE PULL EXAMINATIONS ON STP-1 1995 H/L TSP INTERSECTIONS	8-10
TABLE 9-1	STP-1 FIELD BOBBIN CALLS AND RE-SIZED CALLS FOR DSIs AT H/L TSPs 1995 INSPECTION	9-9
TABLE 9-2	BOUNDING VOLTAGE GROWTH DISTRIBUTION FOR STP-1	9-39
TABLE 10-1	MATERIAL PROPERTIES FOR WESTINGHOUSE ALLOY 600 MILL ANNEALED 3/4" x 0.043" TUBING	10-6
TABLE 10-2	STP-1 EOC-5 PROBABILITY OF BURST RESULTS	10-8
TABLE 10-3	VOLTAGE-BURST-LEAK RATE PROBABILITY OF LEAK DATA TABLE	10-13
TABLE 10-4	BASIS FOR EXCLUDING DATA FROM THE 3/4 INCH BURST CORRELATION	10-19
TABLE 11-1	PROJECTED EOC-6 LEAK RATES	11-7
TABLE 11-2	PROBABILITY OF LEAKAGE PARAMETERS	11-9
TABLE 11-3	BASIS FOR EXCLUDING INDICATIONS FROM 3/4" PROBABILITY OF LEAK CORRELATION	11-15
TABLE 11-4	BASIS FOR EXCLUDING INDICATIONS FROM 3/4" LEAK RATE CORRELATION	11-16
TABLE 14-1	SUMMARY OF TUBES TO BE EXCLUDED FROM ARC	14-17

LIST OF FIGURES

		Page
FIGURE 1-1	SUMMARY OF THE MAJOR ASPECTS OF THE STP-1 ALTERNATE REPAIR CRITERIA	1-3
FIGURE 5-1	W-E RSG GENERAL ARRANGEMENT	5-4
FIGURE 9-1	STP-1 C S/G BOC 6 VOLTAGE DISTRIBUTION	9-40
FIGURE 9-2	STP-1 BOUNDING VOLTAGE GROWTH DISTRIBUTION (FROM TABLE 9-2)	9-41
FIGURE 9-3	STP-1 C S/G EOC 6 PREDICTED VOLTAGE DISTRIBUTION	9-42
FIGURE 10-1	BURST PRESSURE vs. BOBBIN AMPLITUDE FOR 3/4 INCH ALLOY 600 S/G TUBE MODEL BOILER AND FIELD DATA	10-20
FIGURE 10-2	BURST PRESSURE vs. BOBBIN AMPLITUDE RESIDUALS vs. PREDICTED VALUES	10-21
FIGURE 10-3	BURST PRESSURE vs. BOBBIN AMPLITUDE ACTUAL vs. EXPECTED CUMULATIVE PROBABILITY	10-22
FIGURE 11-1	2560 PSI MSLB LEAK RATE vs. BOBBIN AMPLITUDE 3/4" TUBES, MODEL BOILER AND FIELD DATA	11-17
FIGURE 11-2	RESIDUALS vs. PREDICTED LOG OF LEAK RATES 3/4" TUBES, MODEL BOILER AND FIELD DATA	11-18
FIGURE 11-3	CUMULATIVE PROBABILITY OF RESIDUAL LEAK RATES	11-19
FIGURE 14-1	TSP MODEL	14-7
FIGURE 14-2	MODEL ELEMENTS 32 DEGREE WEDGE LOCATION	14-8
FIGURE 14-3	MODEL ELEMENTS 16 DEGREE WEDGE LOCATION	14-9
FIGURE 14-4	TUBE BUNDLE SHOWING TSP ELEVATIONS FOR IDENTIFYING WEDGE GROUPS	14-10
FIGURE 14-5	WEDGE GROUP LOCATIONS: TSPs 1-11	14-11
FIGURE 14-6	WEDGE GROUP LOCATIONS: TSP 12	14-12
FIGURE 14-7	EXCLUDED TUBE REGION: TSPs 1-11(NOZZLE SIDE)	14-13
FIGURE 14-8	EXCLUDED TUBE REGION: TSPs 1-11(MANWAY SIDE)	14-14

LIST OF FIGURES (CONT.)

		Page
FIGURE 14-9	EXCLUDED TUBE REGION: TSP 12(NOZZLE SIDE)	14-15
FIGURE 14-10	EXCLUDED TUBE REGION: TSP 12(MANWAY SIDE)	14-16
FIGURE A-1	PROBE WEAR STANDARD SCHEMATIC	A-31
FIGURE A-2	BOBBIN COIL AMPLITUDE ANALYSIS OF ODSCC AT TSP	A-32
FIGURE A-3	BOBBIN COIL AMPLITUDE ANALYSIS OF ODSCC INDICATION AT TSP-IMPROPER IDENTIFICATION OF FULL FLAW SEGMENT RESULTING IN REDUCED VOLTAGE MEASUREMENT WHEN COMPARED WITH FIGURE A-2	A-33
FIGURE A-4	BOBBIN COIL AMPLITUDE ANALYSIS OF ODSCC INDICATION AT TSP-IMPROPER IDENTIFICATION OF FULL FLAW SEGMENT RESULTING IN REDUCED VOLTAGE MEASUREMENT WHEN COMPARED TO FIGURE A-2	A-34
FIGURE A-5	CORRECT PLACEMENT OF VOLTAGE SET POINTS ON MIX 1 LISSAJOUS TRACES FOR R18C103	A-35
FIGURE A-6	CORRECT PLACEMENT OF VECTOR DOTS ON MIX 1 LISSAJOUS TRACES FOR R22C40	A-36
FIGURE A-7	INCORRECT PLACEMENT OF VECTOR DOTS ON MIX 1 LISSAJOUS TRACES FOR R18C103	A-37
FIGURE A-8	INCORRECT PLACEMENT OF VECTOR DOTS ON MIX 1 LISSAJOUS TRACES FOR R22C40	A-38
FIGURE A-9	INCORRECT MAXIMUM VOLTAGE DERIVED FROM PLACEMENT OF VECTOR DOTS ON TRANSITION REGION OF 550 kHz RAW FREQUENCY DATA LISSAJOUS TRACE FOR R42C44	A-39
FIGURE A-10	CORRECT PLACEMENT OF VECTOR DOTS ON MIX 1 LISSAJOUS FIGURE FOR R42C44	A-40
FIGURE A-11	PLACEMENT OF VECTOR DOTS BASED SOLELY ON MIX 1 LISSAJOUS FIGURE (NO SIGNIFICANT SHARP TRANSITIONS IN ANY OF THE RAW FREQUENCIES) - R10C44	A-41
FIGURE A-12	PLACEMENT OF DOTS MARKING MIX 1 LISSAJOUS FIGURE FOR R16C26	A-42

LIST OF FIGURES (CONT.)

		Page
FIGURE A-13	INCORRECT PLACEMENT OF VECTOR DOTS MARKING MIX 1 LISSAJOUS FIGURE FOR R30C74	A-43
FIGURE A-14	CORRECT PLACEMENT OF DOTS TO EFFECT MAXIMUM VOLTAGE - R30C74	A-44
FIGURE A-15	EXAMPLE OF BOBBIN COIL FIELD DATA - MIX RESIDUAL DUE TO ALLOY CHANGE	A-45
FIGURE A-16	EXAMPLE OF MRPC DATA FOR SINGLE AXIAL INDICATION (SAI) ATTRIBUTED TO ODSCC PLANT S	A-46
FIGURE A-17	MRPC DATA FOR SINGLE AXIAL ODSCC INDICATION(SAI) - PLANT S	A-47
FIGURE A-18	MRPC DATA FOR MULTIPLE AXIAL ODSCC INDICATIONS (MAI) - PLANT S	A-48
FIGURE A-19	MRPC DATA FOR CIRCUMFERENTIAL ODSCC INDICATIONS AT DENTED UPPER AND LOWER TSP EDGES	A-49
FIGURE A-20	EXAMPLE OF BOBBIN COIL FIELD DATA- FLAW SIGNALS FOR ODSCC AT DENTED TSP INTERSECTION FROM PLANT A	A-50
FIGURE A-21	EXAMPLE OF BOBBIN COIL FIELD DATA - FLAW SIGNALS FOR ODSCC AT DENTED TSP INTERSECTION FROM PLANT A	A-51
FIGURE A-22	EXAMPLE OF BOBBIN COIL FIELD DATA - FLAW SIGNALS FOR ODSCC AT DENTED TSP INTERSECTION FROM PLANT A	A-52
FIGURE A-23	EXAMPLE OF BOBBIN COIL FIELD DATA - FLAW SIGNALS FOR ODSCC AT DENTED TSP INTERSECTION FROM PLANT A	A-53
FIGURE A-24	EXAMPLE OF BOBBIN COIL FIELD DATA - FLAW SIGNALS FOR ODSCC AT DENTED TSP INTERSECTION FROM PLANT A	A-54
FIGURE A-25	EXAMPLE OF BOBBIN COIL FIELD DATA - FLAW SIGNALS FOR ODSCC AT DENTED TSP INTERSECTION FROM PLANT A	A-55
FIGURE A-26	LOCATION OF ONE END OF AN INDICATION USING AN RPC PROBE	A-56

LIST OF ABBREVIATIONS

ARC	Alternate Repair Criteria
ASME	American Society of Mechanical Engineers
BC	Bobbin Coil
BOC	Beginning of Cycle
BWNT	B&W Nuclear Technologies
C/L	Cold Leg
EC	Eddy Current
ECT	Eddy Current Testing
EDM	Electric Discharge Machining
EFPM	Effective Full Power Month
EFPY	Effective Full Power Year
EOC	End of Cycle
EPRI	Electric Power Research Institute
F	Fahrenheit
FSAR	Final Safety Analysis Report
GDC	General Design Criteria
GL	Generic Letter
GPD	Gallons per Day
GPM	Gallons per Minute
H/L	Hot Leg
HL&P	Houston Lighting and Power Company
ID	Inside Diameter
IGA	Intergranular Attack
IN/SEC	Inch per Second
kHz	Kilo-Hertz
LBB	Leak Before Break
LB/HR	Pounds per Hour
L/HR	Liter per Hour
LOCA	Loss-of-Coolant Accident
LTL	Lower Tolerance Limit
MB	Model Boiler
MRPC	Motorized Rotating Pancake Coil
MSLB	Main Steam Line Break
NDD	No Detectable Degradation
NDE	Non-Destructive Examination
NRC	Nuclear Regulatory Commission
OD	Outside Diameter
ODSCC	Outside Diameter Stress Corrosion Cracking
PCT	Peak Clad Temperature
POD	Probability of Detection
POL	Probability of Leakage
PPM	Parts per Million
PSI	Pounds per Square Inch
PSIA	Pounds per Square Inch Atmospheric
PSID	Pounds per Square Inch Differential
PWR	Pressurized Water Reactor
RCS	Reactor Coolant System
RG	Regulatory Guide
RHR	Residual Heat Removal
RL	Repair Limit

LIST OF ABBREVIATIONS (CONT.)

RSG	Recirculating Steam Generator
S/G	Steam Generator
SG	Steam Generator
SRSS	Square Root of the Sum of the Squares
SSE	Safe Shutdown Earthquake
STP	South Texas Project
STP-1	South Texas Project Unit 1
STP-2	South Texas Project Unit 2
SU	Ultimate Tensile Stress
SY	Yield Stress
TS	Technical Specifications
TSP	Tube Support Plate
TYP	Typical
UT	Ultrasonic Testing
V_{SL}	Voltage Structural Limit
V_{RL}	Voltage Repair Limit
V_{NDE}	NDE Voltage Measurement Error
V_{CG}	Voltage Growth Anticipated Between Cycles
1RE04	Refueling Outage 4
1RE05	Refueling Outage 5
1REO6	Refueling Outage 6

RECORD OF REVISIONS

		Page
	REVISION 02	
All Sections	Changed all BWNT to Framatome Technologies, Inc.	All
All Sections	Removed all references to STP Unit 2.	All
Table of Contents	Added, deleted and renumbered Tables, where applicable.	ii
1.1	Revised paragraph to reflect the changes from Generic Letter 95-05.	1-1
2.2	Revised bullet items to reflect changes from GL 95-05.	2-1,2
3.1	Reworded phrasing of third paragraph.	3-1
3.2 (2)	Revised section to reflect changes from GL 95-05.	3-2
3.2.1	Changed number of ODSCC TSP flaws to 602 from 1RE05.	3-3
4.1	Revised section to reflect changes from GL 95-05.	4-1,-2
5.2	Renamed section and added 'Enclosure 1'. Removed reference to Unit 2 TSP.	5-1,-2
Table 5-1	Changed MSLB pressure to 2560 psid.	5-3
6.2	Revised section to reflect changes from GL 95-05.	6-1
6.2.1	Added reference 27, added 2560 psid, changed faulted pressure to 3661 psid, and changed $\%V_{NDE}$ and $\%V_{CG}$ to reflect values in GL 95-05.	6-2,-3
Table 6-1	Revised STP-1 ARC Repair limit to 2.85 volts and Structural limit to 4.70 volts based on the new Burst Pressure Correlation and GL 95-05 requirements.	6-4
7.3.2 7.3.3 7.3.4	Revised sections to reflect changes from GL 95-05.	7-2

RECORD OF REVISIONS

		Page
7.4.2 7.4.3 7.4.4 7.4.5 7.4.6 7.4.7	Revised sections to reflect changes from GL 95-05.	7-3,-4
8.2 8.3 8.4	Updated sections to reflect GL 95-05 requirements and to discuss tube pulls performed at STP-1 during 1RE05.	8-1,-2,-3
8.5	Revised database reference to incorporate Westinghouse pulled tube data	8-4
Table 8-2	Added new Table showing the results of tube pull examinations performed during 1RE05.	8-10,-11
9.2	Revised section to reflect changes from GL 95-05.	9-1,-2
9.3	Revised section to reflect that an STP-1 specific growth rate is being utilized, in lieu of the EPRI generic growth rate.	9-3,-4
9.4	Reworded discussion on Analyst and Acquisition Errors.	9-4,-5
9.5	Reworded entire section to better explain the Monte Carlo process of determining the Projected EOC Voltage Distribution.	9-5 to 9-7
Table 9-1	Revised to include the DSI population from 1995 Bobbin Coil inspection.	9-9 to -39
Table 9-2	Deleted STP-2 Data and replaced with STP-1 bounding Voltage Growth Distribution.	9-40
Table 9-3	Deleted EPRI Growth Distribution Table; Replaced with Table 9-2.	9-41
Figure 9-1 Figure 9-2 Figure 9-3	Updated to reflect changes from STP-1 DSI voltage distribution BOC 6.	9-41 9-42 9-43
10	Revised entire section to include more details on the IOB model, statistical methods utilized, equations used in the Monte Carlo simulation and updated correlations and figures based on new Industry Database.	10-1 thru 10-22

RECORD OF REVISIONS

		Page
Table 10-3 Table 10-4	Updated to correspond with new Industry database.	10-13,-19
11	Revised entire section to include more details on the POL and leak rate models, statistical methods utilized,equations used in the Monte Carlo simulation, and updated correlations and figures based on new Industry Database	11-1 thru 11-19
13.2	Revised section to incorporate changes from GL 95-05.	13-1,-2
13.3	Revised section to incorporate changes from GL 95-05.	13-3,-4
13.3.1	Revised section to incorporate changes from GL 95-05.	13-4
14.0	Revised section to incorporate changes from GL 95-05.	14-1
15	Revised section to include updated results from the simulations.	15-1 to -3
16.0	Changed Reference 1 to GL 95-05. Added References 26, 27, 28, 29, 30, 31,32.	16-1,-3 -4

RECORD OF REVISIONS

Page

REVISION 03

2.2	Revised third bullet under Inspection Requirements to include all > 1.0 volts	2-2
6.2.1	Added that STP-1 would utilize the most conservative growth rate, EPRI of 30%/EFPY or plant specific.	6-3
6.2.2	Added that STP-1 would re-calculate the upper voltage repair limit prior to each ARC inspection based upon changes in the database, plant growth rates, or ECT uncertainties.	6-4
7.2	Changed to "for each inspection when ARC will be implemented".	7-1
8.2	Added that HL&P will continue to provide information to the pulled tube database via STP-1 pulled tubes or by participating in an NRC approved industry program.	8-2
8.4	Reworded to state that axially oriented ODSCC was the predominate degradation mechanism at the TSP intersections. Also added that STP-1 will follow the guidance for the testing of the pulled tube samples.	8-3
9.3	Added "except where an indication changes from NDD to a relatively high voltage (i.e. 2.0 volts)". Also added "provided that the model accounts for the tail of the distribution.", and that for the purposes of calculating the UVRL that negative growth rates can be utilized.	9-3
10.1	Added "The Monte Carlo method will be utilized in the determination of the tube burst probabilities for future inspection outages."	10-2
10.2	Added explanation on how the tails of the EOC voltage distribution are treated in the tube burst probability calculation.	10-7
Table 10-3	Updated table to include revised data points and fix erroneous entries.	10-13 to -18
13.2.1	Added "if PWSCC indications,".	13-2

RECORD OF REVISIONS

		Page
13.3.1	Added that the cycle growth rate distribution would be supplied in the 90-day report as well as the planned cycle length in EFPY. Also that the NDE uncertainties would be included in the report.	13-5
14.0	Clarified all of the intersections where the ARC would not be applied.	14-1
Appendix A	Reworded various sections to make consistent with VC Summer Appendix A, all requirements in GL 95-05, and adopt NEI probe wear criteria.	

1.0 INTRODUCTION

1.1 Purpose

The purpose of this document is to provide a technical justification to implement an alternate steam generator tube repair criteria for outer diameter stress corrosion cracking (ODSCC) at the tube-to-tube support plate intersections in the South Texas Project Unit 1 steam generators.

This justification addresses the criteria and guidance contained in NRC Generic Letter 95-05: Voltage-Based Repair Criteria for the Repair of Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking(August 1995)[1].

This justification relies on the industry's recommended approach and methodologies, as developed by the Committee for Alternate Repair Limits for ODSCC at TSPs through the Electric Power Research Institute (EPRI). This recommended approach is defined in EPRI Technical Reports TR-100407, Revision 2A, "PWR Steam Generator Tube Repair Limits - Technical Support Document for Outside Diameter Stress Corrosion Cracking at Tube Support Plates [6], NP-7480-L "Steam Generator Tubing Outside Diameter Stress Corrosion Cracking at Tube Support Plates - Database for Alternate Repair Criteria, Volume 2: 3/4 Inch Diameter Tubing" [3] and WCAP-14277 NON-PROPRIETARY CLASS 3 (SG-95-01-007), SLB Leak Rate and Tube Burst Probability Analysis Methods for ODSCC at TSP Intersections [26].

1.2 Background

Stress corrosion cracking initiating on the outer diameter of Alloy 600 steam generator tubes has been diagnosed in the tube support plate (TSP) region of the South Texas Project Unit 1 steam generators, as well as at many other pressurized water reactor (PWR) steam generators throughout the world. If existing tube plugging limits based on crack depth were applied, many tubes would require repair that is unnecessary from either a safety or reliability standpoint.

To address this issue, the PWR industry, working through EPRI, has developed an approach to define an alternate repair criterion (ARC) that does not set limits on depth of cracks to ensure tube integrity. Instead, this criterion relies on correlating the eddy current voltage amplitude from a bobbin coil probe with the more specific measurement of burst pressure and leak rate. In turn, these items are related to assuring the structural integrity of the tubes and the safe operation of the plant.

Allowing tubes with axial ODSCC to remain in service can be justified based on a combination of enhanced in-service inspection, a repair limit based on eddy current testing voltage, a limit on the number of ARC tubes remaining in service (determined by leakage limits for faulted loads), and a reduced primary-to-secondary allowable leak rate at normal operating conditions.

1.3 Organization of Report

Each section of this report addresses a different NRC Generic Letter requirement as specified in Reference 1. The requirements are listed and then STP-1's compliance with that particular requirement is presented in a manner as to justify the STP results and position on the requirement. Section 4 contains a Table that summarizes STP-1's differences with the requirements specified in Reference 1.

Figure 1-1 depicts the major steps involved in developing the ARC for the South Texas Project Unit 1. The major requirements for the implementation of the voltage-based repair criteria are shown in this figure and the related section of this report is referenced for each.

FIGURE 1-1

SUMMARY OF THE MAJOR ASPECTS OF THE STP-1 ALTERNATE REPAIR CRITERIA

[

] c^{FP}

This Page Left Blank

2.0 EXECUTIVE SUMMARY

This report documents the technical justification for an Alternate Repair Criteria (ARC) for Outer Diameter Stress Corrosion Cracking (ODSCC) indications at Tube Support Plates (TSP) for South Texas Project Unit 1 steam generators. This assessment demonstrates that a correlation relating tube burst pressure to bobbin voltage and main steam line break (MSLB) leakage to bobbin voltage can be used to conservatively satisfy the Reg Guide 1.121 guidelines for tube integrity at South Texas Project Unit 1.

2.1 Overall Conclusions

The South Texas Project Unit 1 pulled tubes (1993 and 1995 outage) show that the degradation morphology for indications at TSPs can be described as axial ODSCC within the TSP length. The burst test behavior of these indications is consistent with the data base supporting the repair limits of this report. Application of the generic ODSCC ARC methodology developed through EPRI is appropriate for South Texas Unit 1 ODSCC flaws, satisfies the NRC Generic Letter on ODSCC ARC, and is consistent with other approved ODSCC ARC methodologies.

2.2 Requirements for Implementation of ARC

The following requirements for South Texas Project ARC conservatively satisfy Reg Guide 1.121 guidelines for tube integrity:

- Indications less than the lower voltage repair limit (1 volt), as measured by bobbin coil, may remain in service.
- Indications greater than the lower limit (1 volt) and less than or equal to the upper voltage repair limit as measured by bobbin coil, can remain in service if RPC inspection does not confirm the indications.

- o Indications greater than the lower limit (1 volt) and less than or equal to the upper voltage repair limit, as measured by bobbin coil, that are confirmed by RPC, and all indications greater than the upper voltage repair limit, as measured by bobbin coil must be repaired.

- o Projected leakage for a postulated steam line break event at end of cycle (EOC) conditions shall be less than the bounding leakage necessary to remain within applicable dose limits (10 CFR 100, NUREG 0800, and GDC 19).

- o Projected tube burst probability for a postulated steam line break at EOC conditions shall be calculated and compared to a threshold value of 1 percent (1.0×10^{-02}) for the most limiting steam generator.

- o Tubes identified as subject to significant deformation (as discussed in Section 14.0 of this report) at a TSP under a postulated LOCA + SSE event shall be excluded from application of the ARC at that TSP location.

Inspection Requirements

- o The inspection shall include 100% bobbin coil inspection of all hot leg intersections and cold leg intersections down to the lowest TSP for which the ARC is to be applied.

- o All Bobbin coil flaw indications greater than 1.0 volt shall be inspected by MRPC to evaluate for detectable MRPC indications and to support axially oriented ODSCC as the degradation mechanism.

- o Eddy current analysis guidelines shall be equivalent to the requirements given in Appendix A.

Operating Leak Rate Limit

- o The normal operating leak rate requiring plant shutdown shall be limited to 150 gpd per steam generator.

3.0 GENERIC LETTER APPLICABILITY TO STP-1

3.1 Introduction

In the Generic Letter, the NRC describes the information necessary to justify the use of an ARC for ODSCC at TSP intersections. Voltage-based repair criteria are considered applicable only to indications at support plate intersections where the degradation mechanism is dominantly axial ODSCC with no significant cracks extending outside the thickness of the support plate.

For the purposes of the Generic Letter, ODSCC refers to degradation whose dominant morphology consists of axial stress corrosion cracks which occur either singularly or in networks of multiple cracks, sometimes with limited patches of general intergranular attack (IGA). Circumferential cracks may sometimes occur in the IGA affected regions resulting in a grid-like pattern of axial and circumferential cracks, termed cellular corrosion. Cellular corrosion is assumed to be relatively shallow (based on available data from tube specimens removed from the field), transitioning to dominantly axial cracks as the cracking progresses in depth. The circumferential cracks are assumed (based on available data) not to be of sufficient size to produce a discrete, crack-like circumferential indications during field nondestructive examinations (NDE) inspections. Thus, the failure mode of ODSCC is axial and the burst pressure is controlled by the geometry of the most limiting axial crack or array of axial cracks.

For purposes of the Generic Letter, ODSCC is confined to within the thickness of the tube support plate, based on available data from tube specimens removed from the field. Very shallow microcracks are sometimes observed on these specimens that initiate at locations slightly outside the thickness of the tube support plate; however, these microcracks are small compared to the cracks within the thickness of the support plate and are too small to produce an eddy current response.

Confirmation that the degradation mechanism is dominantly axial ODSCC should be accomplished by periodically removing tube specimens from the steam generators and by examining and testing these specimens as specified in Section 4 of the Generic Letter. The acceptance criteria should consist of demonstrating that the dominant degradation mechanism affecting the burst and leakage properties of the tube is axially oriented ODSCC. In addition, results of inservice inspections with motorized rotating pancake coil (MRPC) probes would be evaluated in accordance with Section 3.b of the Generic Letter to confirm the absence of detectable crack-like circumferential indications and detectable ODSCC indications extending outside the tube support plate thickness.

3.2 Generic Letter Applicability

The criteria in the Generic Letter are only applicable to ODSCC located at the tube-to-tube support plate intersections in Westinghouse designed steam generators. These criteria are not applicable to other forms of steam generator tube degradation, nor are they applicable to ODSCC that occurs at other locations within a steam generator. The voltage-based repair criteria can be applied only under the following constraints:

(1) The repair criteria of the Generic Letter apply only to Westinghouse designed steam generators with 1.9 cm [3/4-inch] and 2.2 cm [7/8-inch] diameter tubes and drilled hole tube support plates,

(2) The repair criteria of the Generic Letter apply only to predominantly axially oriented ODSCC confined within the tube-to-tube support plate intersection as discussed in Section 1.a of Enclosure 1 of the Generic Letter and,

(3) Certain intersections are excluded from the application of the voltage-based repair criteria as discussed in Section 1.b of Enclosure 1 of the Generic Letter.

Compliance with the Generic Letter Requirements

3.2.1 STP-1 Generic Letter Applicability

In compliance with Section 2 of the Generic Letter, STP-1 has 4 Westinghouse Model E steam generators. The tubes are 0.749" ± 0.005" OD x 0.043" ± 0.004" wall mill-annealed nickel-chromium-iron alloy UNS NO6600 tube per ASME material specification SB-163 [10].

In compliance with Section 2 of the Generic Letter, STP has confirmed, by pulling tubes from the STP-1 steam generators, that axially oriented ODSCC exists and is the dominate degradation mechanism within the tube-to-tube support plate intersections. During the last inspection outage for STP-1 in 1995, the unit had [ ]]d^{FP} ODSCC flaws.

In compliance with Section 2 of the Generic Letter, certain intersections are excluded from the application of the voltage-based repair criteria as discussed in Section 1.b of the Generic Letter. Section 14.0 of this report discusses the intersections excluded from application of ARC for STP-1.

This Page Left Blank

4.0 GENERIC LETTER EXCEPTIONS FOR STP-1

4.1 Introduction

Generic Letter 95-05: "Voltage-Based Repair Criteria for the Repair of Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking" was issued on August 3,1995. There are no exceptions to the requirements addressed in Generic Letter 95-05 for the STP-1 ARC submittal.

This Page Left Blank

5.0 STP-1 STEAM GENERATOR DESIGN INFORMATION

5.1 Introduction

The ARC evaluation shall consider as a minimum, the design and operational loading conditions for South Texas Project as summarized in this section, including Figure 5-1 and Table 5-1.

STP-1 has 4, Westinghouse Model E steam generators. The steam generator tubes are 0.749" $\pm$ 0.005" OD x 0.043" $\pm$ 0.004" wall mill-annealed nickel-chromium-iron alloy UNS NO6600 tube per ASME material specification SB-163 [10]. The tubing in the "as-built" condition was not stress relieved in the regions of interest at the TSPs. At STP-1, the tubes are roller expanded into the tube sheet and the tube support plates are carbon steel with drilled holes.

5.2 Tube Exclusions Based on Analysis Considerations

The analysis as required per the NRC Generic Letter, Section 1.b. of Enclosure 1, shall consider the effect of SSE and LOCA with respect to the maximum loads that may be generated in a TSP and reacted at the wedge locations. As specified in GDC-4 (52 FR 41288), with NRC acceptance, leak-before-break (LBB) has been evaluated at STP-1 and thus may be used to determine support plate loads [18,19]. With LBB, the large primary pipe breaks are eliminated and the next largest branch pipe break in the primary system, not included in LBB, shall be considered. The bounding branch line LOCA break is a 12" Schedule 140 attachment line. The use of LBB at STP-1 is also consistent with an NRC letter [12] which says that LBB of primary piping is acceptable in evaluating internals for steam generator replacements, provided that an assumed break occurs in the branch piping. With this in mind, the structural analysis to identify tube exclusion areas was performed with the following considerations:

[

] c^{FP}

TABLE 5-1
WESTINGHOUSE SERIES-E STEAM GENERATOR DESIGN AND OPERATING CHARACTERISTICS [10]

	PRIMARY	SECONDARY
[		
		]c^FP

__FIGURE 5-1__
W-E RSG GENERAL ARRANGEMENT

[

]c^{FP}

6.0 **REPAIR LIMITS**

6.1 Introduction

The voltage-based repair limits of the Generic Letter were determined considering the entire range of design basis events that could challenge tube integrity. The voltage repair limits ensure structural integrity and leakage limits for all postulated design basis events. The structural criteria are intended to ensure that tubes subjected to the voltage repair limits will be able to withstand a pressure of 1.4 times the maximum possible main steam line break (MSLB) differential pressure postulated to occur at the end of the operating cycle, consistent with the criteria of Regulatory Guide 1.121. The induced leakage under worst-case MSLB conditions calculated using licensing basis assumptions will not result in offsite dose releases that exceed the applicable limits of 10 CFR 100.

6.2 Voltage Repair Limits per the Generic Letter

Per the Generic Letter, the voltage repair limits for 1.9 cm [3/4 inch] diameter tubes are:

- Indications less than the lower voltage repair limit, as measured by bobbin coil, may remain in service. For 1.9 cm (3/4") diameter tubes, the lower voltage repair limit is 1.0 volt.
- Indications greater than the lower limit and less than or equal to the upper voltage limit, as measured by bobbin coil, can remain in service if MRPC inspections do not confirm the indications. The methodology for calculating the upper voltage repair limit is specified in Section 2.a.2 and 2.a.3 of Enclosure 1 of the Generic Letter.
- Indications greater than the lower limit and less than or equal to the upper limit, as measured by bobbin coil, that are confirmed by MRPC, and indications greater than the upper repair limit, as measured by bobbin coil, must be repaired.

STP-1 Compliance with Requirements

6.2.1 Voltage Repair Limit Methodology

The Generic Letter states that the lower repair limit is fixed and not plant specific. However, the upper repair limit is plant specific and not fixed. In compliance with the Generic Letter, the tube repair limit methodology described in this report is conservatively developed to preclude free span tube burst. The correlation between burst pressure and bobbin voltage amplitude, discussed in Section 10 of this report, is derived from the combined model boiler and pulled tube specimens discussed in References 3 and 27. The burst pressure versus bobbin voltage correlation was adjusted to account for operating temperature and minimum material properties. To establish the voltage structural limit (V_{SL}) that satisfies the RG 1.121 guidelines for margin against tube burst, the burst correlation must be evaluated at the higher of 1.43 times the faulted pressure or three times the normal operating pressure differential. For STP-1, this value is 1.43 times the faulted pressure of [ ]$^{c^{FP}}$. The voltage structural limit must be reduced to allow for NDE measurement error and ODSCC growth between steam generator tube inspections.

The upper voltage repair limit provides margins against tube rupture, consistent with RG 1.121 guidelines, including allowances for NDE measurement error and defect growth, and can be expressed as follows:

[ ]^{EP} Eq. 6-1 [6]

or

[ ]^{EP}

where: V_{RL} = voltage limit for tube repair,
V_{NDE} = NDE voltage measurement error,
V_{CG} = voltage growth anticipated between inspections, and
V_{SL} = voltage structural limit from the burst pressure and bobbin voltage correlation (volts)

The value for $\%V_{NDE}$ has been determined from available data and is provided in Reference 1 for the industry standard. As discussed in Reference 1, the $\%V_{NDE}$ = 20 with the use of a transfer standard. The value for $\%V_{CG}$ has been determined in Reference 1 for the industry standard and is $\%V_{CG}$ = 30/EFPY. Considering that the current growth rate at STP-1 is bounded by the EPRI value, for a cycle length of 1.5 EFPY, $\%V_{CG}$ = 45. If at some time in the future, the site specific growth rate for ODSCC at TSPs is determined to be greater than 30%/EFPY at STP-1, the site specific growth rate will be utilized in the determination of the upper voltage repair limit. The distributions for NDE uncertainty and voltage growth are utilized during a Monte Carlo simulation, in order to project an EOC voltage distribution that is used to determine the probability of burst and leak rate during MSLB conditions.

6.2.2 STP-1 ARC Repair Limits

HL&P plans to implement the 1.0 volt criterion at STP-1 as the lower voltage repair limit and a [ ]d^{FP} volt criterion as the upper voltage repair limit for EOC6. Prior to each subsequent steam generator inspection outage, the upper voltage repair limit will be re-calculated based upon changes in plant specific growth rate, eddy current uncertainties, or changes in the overall database that affect the structural limit voltage. If a mid-cycle inspection is performed based upon the results of the probability of burst or leakage calculations set forth in Generic Letter 95-05, the mid-cycle repair limits will be determined based upon the calculations in Attachment 2 of GL 95-05. Table 6-1 summarizes the development of the ARC upper voltage repair limit based on reducing the current structural voltage limit of [ ]d^{FP} volts by allowances for growth and NDE uncertainties at STP-1. At the lower 95% prediction interval, a bobbin voltage of [ ]d^{FP} volts establishes the structural requirement for 1.43 faulted pressure [ ]d^{FP} tube burst capability as shown on Figure 10-1. After adjusting the structural limit voltage by the allowances for growth and NDE uncertainties, the resulting equivalent ARC upper voltage repair limit is [ ]d^{FP} volts. The ARC upper voltage repair limit is used to define an upper bobbin voltage limit for leaving unconfirmed bobbin indications in service.

TABLE 6-1
STP-1 ARC UPPER VOLTAGE REPAIR LIMIT
TO SATISFY STRUCTURAL REQUIREMENTS

[

] d^FP

This Page Left Blank

7.0 NDE INSPECTION CRITERIA

7.1 Introduction

In order to apply the ARC to the applicable tube support plate (TSP) intersections, the Generic Letter (GL) requires that the bobbin coil inspection guidelines listed below be implemented. These guidelines ensure that the techniques used to inspect the steam generators are consistent with the techniques used in the development of the voltage-based repair limit methodology.

7.2 Bobbin Coil Inspection Scope and Sampling

The bobbin coil inspection should include 100% of the hot-leg TSP intersections and cold-leg intersections down to the lowest cold-leg TSP with known ODSCC. The determination of TSPs having ODSCC should be based on the performance of at least a 20% random sampling of tubes inspected full length.

STP-1 Compliance with Requirement

For Unit 1, implementation of the TSP ARC requires 100% bobbin coil inspection for all of the H/L TSP intersections and all cold leg intersections down to the lowest C/L support plate with ODSCC indications, for each inspection when ARC will be implemented. The determination of the TSP intersections having ODSCC indications shall be based on the performance of at least a 20% random sampling of tubes inspected over their full length.

7.3 Motorized Rotating Pancake Coil (MRPC) Inspection

MRPC inspections should be conducted as specified in the GL for the purposes of obtaining additional characterization of the ODSCC flaws found with the bobbin coil inspection and to further inspect intersections with significant bobbin interference signals which may influence the bobbin coil measurement or impair the detectablility of an ODSCC flaw. One of the main reasons for performing MRPC inspections is to

ensure the absence of detectable crack-like circumferential indications and detectable indications extending beyond the boundary of the TSP. The voltage-based repair criteria are not applicable to TSP intersections containing these types of indications, and special reporting requirements pertaining to the discovery of such indications are described in Section 6 of the Generic Letter.

7.3.1 MRPC inspection should be performed for all indications exceeding 1.0 volts as measured by bobbin coil, for 3/4 inch tubing.

7.3.2 All intersections with interfering signals from copper deposits should be inspected with MRPC. Any indications found at such intersections with MRPC should cause the tube to be repaired.

7.3.3 All intersections with dent signals greater than 5 volts should be inspected with MRPC. Any indication found at such intersections with MRPC should cause the tube to be repaired. If circumferential cracking or primary water stress corrosion cracking indications are detected, it may be necessary to expand the MRPC sampling plan to include dents less than 5.0 volts.

7.3.4 All intersections with large mixed residuals should also be inspected with MRPC. Large mixed residuals are those that could cause a 1.0 volt bobbin signal to be misread or missed. Any indication found by MRPC at such an intersection should cause the tube to be repaired.

STP-1 Compliance with Requirement

HL&P will address each of the requirements listed above, and specified in the Generic Letter, during steam generator inspection outages when ARC will be implemented. The specific requirements for the MRPC inspection scope are contained in Appendix A of this report.

7.4 <u>Data Acquisition and Analysis</u>

These inspection guidelines are intended to maintain a level of consistency for all plants utilizing an alternate repair criteria. They ensure that the inspection techniques used by the plants are consistent with those used in the development of the tube integrity methodologies for the voltage-based repair limits.

7.4.1 The bobbin coil calibration standard should be calibrated against the reference standard used in the laboratory in the development of the voltage-based approach by direct testing or through the use of a transfer standard.

7.4.2 Once the probe has been calibrated on the 20% through-wall holes, the voltage response of new bobbin coil probes for the 40-100% ASME through-wall holes should not differ from the nominal voltage by more than ± 10%.

7.4.3 Probe wear should be monitored by an in-line measuring device or through the use of periodic wear measurement. When utilizing the periodic wear measurement approach, if a probe is found to be out of specification, all tubes inspected since the last successful calibration should be reinspected with the new calibrated probe. Alternatives to this approach, which provide equivalent detection and sizing and are consistent with the tube integrity analyses discussed in Section 2 of Enclosure 1 of the Generic Letter, may be permitted subject to NRC approval.

7.4.4 Data analysts should be trained and qualified in the use of the guidelines and procedures. Analyst performance should be consistent with the assumptions made for analyst measurement variability in Section 2.b.2(1) of Enclosure 1 of the Generic Letter and used in the tube integrity

analysis. (Section 9 of this report).

7.4.5 Quantitative noise criteria, that which results from electrical noise, tube noise, or calibration standard noise, should be included in the data analysis guidelines. Data that fails to meet the criteria should be rejected and the tube reinspected.

7.4.6 Data analysts should review the mixed residuals on the standard itself and take action as necessary to minimize these residuals.

7.4.7 Smaller diameter probes can be used to inspect tubes where it is impractical to utilize a full sized probe, provided that the probes and procedures have been demonstrated on a statistical basis to give equivalent voltage response and detection capability when compared to a full size probe.

STP-1 Compliance with Requirement

HL&P will address each of the requirements listed above, and specified in the Generic Letter, during steam generator inspection outages that ARC will be implemented. The specific requirements pertaining to the items listed above are contained in Appendix A of this report.

8.0 TUBE REMOVAL AND EXAMINATION/TESTING

8.1 Introduction

Implementation of voltage-based plugging criteria should include a program of tube removals for testing and examination as described below. The purpose of this program is to confirm axial ODSCC as the dominant degradation mechanism at the TSP intersections and to provide additional data to enhance the burst pressure, probability of leakage, and conditional leak rate correlations, as described in Sections 10 and 11.

8.2 Number and Frequency of Tube Pulls

As stated in the Generic Letter, two pulled tube specimens with an objective of retrieving as many intersections as is practical (a minimum of four intersections) should be obtained for each plant either during the plant SG inspection outage that implements the voltage-based repair criteria or during an inspection outage preceding initial application of these criteria. On an ongoing basis, an additional (follow-up) pulled tube specimen with an objective of retrieving as many intersections as practical (minimum of two intersections) should be obtained at the refueling outage following accumulation of 34 effective full power months of operation or at a maximum interval of three refueling outages, whichever is shorter following the previous tube pull.

Alternatively, the request to acquire pulled tube specimens may be met by participating in an industry sponsored tube pull program endorsed by the NRC that meets the objectives of the Generic Letter.

STP-1 Compliance with Requirement

During the September, 1993, outage at STP-1 (2.9 EFPY), HL&P elected to pull four tubes from the Unit 1 steam generators (S/G). Three tubes were pulled from the 'D' S/G and one from the 'C' S/G. Each of these tubes contained three hot leg TSP intersections, thus producing 12 TSP intersections for

laboratory testing. HL&P has therefore met this requirement for STP-1, as specified. HL&P will continue to pull tubes from STP-1 in accordance with the requirements outlined in this report, during future inspection outages. In addition, HL&P pulled two additional tubes from STP-1 S/G 'D' during the March, 1995 (3.9 EFPY) inspection outage, to provide additional information about the flaw morphology at the TSPs.

HL&P will continue to provide information to the pulled tube data base either by electing to pull tubes from the STP-1 steam generators or by participating in an industry sponsored and NRC approved tube pull program.

8.3 Candidate Selection Criteria

The selection of tubes as candidates for pulling should consider the following criteria:

1. Tubes with large voltage indications.
2. Tubes should cover a range of voltages, including intersections with no detectable degradation (NDD).
3. Selected tube intersections comprising the total data set should include at least a representative number of intersections with MRPC signatures indicative of a single dominant crack as compared to intersections with MRPC signatures indicative of two or more dominant cracks about the circumference.

STP-1 Compliance with Requirement

The STP-1 1RE04 and 1RE05 pulled tubes met the requirements specified in the Generic Letter. During future outages at STP-1, HL&P will follow the guidelines listed above, and specifically in Reference 1, for developing a list of tube pull candidates to support the voltage-based repair criteria for axial ODSCC at TSPs.

8.4 Examination and Testing

Removed tube intersections should be subjected to leak and burst test under simulated MSLB conditions to confirm that the failure mode and the leakage rates are consistent with that assumed in the development of the voltage-based repair criteria. Additionally, these data may be used to enhance the supporting data sets for the burst pressure and leakage correlations subject to NRC review and approval. Subsequent to burst testing, the intersections should be destructively examined to confirm that the degradation morphology is consistent with that assumed for ODSCC.

STP-1 Compliance with Requirement

As previously stated, tubes were pulled from STP-1 during the 1RE04 outage, 1 from the 'C' steam generator, and 3 from the 'D' steam generator. The tubes that were pulled contained tubesheet and tube support plate indications confirmed through the laboratory tests. The test results concluded that axially oriented ODSCC was the degradation mechanism in the TSP intersections. None of the following were observed: PWSCC at TSPs, axial cracking extending beyond the confines of the TSP, or circumferential indications at TSP intersections.

[

] d[FP]

[

]d^FP

During future outages when tubes are pulled in support of the ARC for ODSCC at TSPs at STP-1, HL&P will follow the guidelines listed above, and specifically in Reference 1, for developing a list of tube pull candidates to support the voltage-based repair criteria for axial ODSCC at TSPs and for the testing to be performed on the TSP intersections.

8.5 <u>General Criteria for Burst and Leakage Models and Supporting Test Data</u>

Only the use of NRC approved burst and leakage models and correlations are to be utilized; this includes the approval of the data that supports the models and correlations.

STP-1 Compliance with Requirement

The use of the EPRI burst and leak databases as contained in References 27 and 28 were utilized in the development of the data correlations for the STP-1 ARC. Any modification performed on any of the data came only from NRC requirements on exclusion or inclusion of data points within the correlations [1]. These exclusions and inclusions of data are discussed in Sections 10 and 11 of this report.

<u>TABLE 8-1</u> (A)
RESULTS OF TUBE PULL EXAMINATIONS
ON STP-1 1993 H/L TSP INTERSECTIONS

[

]d[FP]

<u>Abbreviations</u>
DSI = Distorted support signal
IGA = Intergranular Attack
N/A = Not Inspected
NDD = No detectable degradation
SAI = Single Axial Indication
SVI = Single Volumetric Indication

TABLE 8-1 (B)
RESULTS OF TUBE PULL EXAMINATIONS
ON STP-1 1993 H/L TSP INTERSECTIONS

]d^{FP}

Abbreviations
DSI = Distorted support signal
IGA = Intergranular Attack
N/A = Not Inspected
NDD = No detectable degradation
SAI = Single Axial Indication
SVI = Single Volumetric Indication

TABLE 8-1 (C)
RESULTS OF TUBE PULL EXAMINATIONS ON STP-1 1993 H/L TSP INTERSECTIONS

[

]d[FP]

Abbreviations
DSI = Distorted support signal
IGA = Intergranular Attack
N/A = Not Inspected
NDD = No detectable degradation
SAI = Single Axial Indication
SVI = Single Volumetric Indication

TABLE 8-1 (D)
RESULTS OF TUBE PULL EXAMINATIONS ON STP-1 1993 H/L TSP INTERSECTIONS

[

]d[FP]

Abbreviations
DSI = Distorted support signal
IGA = Intergranular Attack
N/A = Not Inspected
NDD = No detectable degradation
SAI = Single Axial Indication
SVI = Single Volumetric Indication

TABLE 8-2 (A)
RESULTS OF TUBE PULL EXAMINATIONS
ON STP-1 1995 H/L TSP INTERSECTIONS

[

]d[FP]

Abbreviations
DSI = Distorted support signal
IGA = Intergrannular Attack
N/A = Not Inspected
NDD = No detectable degradation
SAI = Single Axial Indication
SVI = Single Volumetric Indication

TABLE 8-2 (B)
RESULTS OF TUBE PULL EXAMINATIONS
ON STP-1 1995 H/L TSP INTERSECTIONS

[

]d[FP]

Abbreviations
DSI = Distorted support signal
IGA = Intergranular Attack
N/A = Not Inspected
NDD = No detectable degradation
SAI = Single Axial Indication
SVI = Single Volumetric Indication

This Page Left Blank

9.0 VOLTAGE DISTRIBUTIONS AND PROJECTIONS

9.1 Introduction

In order to support the calculation of the conditional probability of burst and the total leak rate during MSLB conditions, the voltage distributions, beginning of cycle (BOC) and end of cycle (EOC), must both be developed as part of the ARC evaluation.

9.2 Distribution of Bobbin Indications as a Function of Voltage at BOC

As stated in the Generic Letter, the frequency distribution by voltage of bobbin indications actually found during inspection should be scaled upward by a factor of 1/POD to account for non-detected cracks which could potentially leak or rupture during MSLB conditions during the next cycle of operation. The probability of detection (POD) reflects the ability of the inspection method to detect all of the ODSCC flaws that exist in the steam generator tubing. The adjusted frequency distribution minus the detected flaws that have been plugged or repaired constitutes, for the purposes of ARC tube integrity analysis, the assumed frequency distribution of bobbin indications as a function of voltage at BOC. This can also be expressed as:

$$N_{BOC} = (1/POD) \times (N_{AsFound}) - N_{Repaired}$$

Eq. 9-1 [1]

where

N_{BOC}	=	assumed frequency distribution of bobbin indications at BOC
POD	=	probability of detection of ODSCC flaws
$N_{As\ Found}$	=	frequency distribution of indications detected during the inspection
$N_{Repaired}$	=	frequency distribution of repaired indications

POD should have an assumed value of 0.6, or as an alternative, an NRC approved POD function can be used if available.

STP-1 Compliance with Requirement

The STP-1 beginning of cycle voltage distribution has been determined from the 1RE05 outage bobbin voltage inspection data. Table 9-1 contains voltage calls for STP-1 1995 inspections. The total number of ODSCC flaws found in all STP-1 steam generators during the last inspection was [ ]d^{FP}. These previous inspections included 100% of the tube population in Unit 1. Evaluations for ARC probability of burst and leakage calculations, include separate analyses for each steam generator.

The approach taken for determining the BOC voltage distribution is consistent with the method outlined above. The "as-found" flaws were scaled upward by a factor of 1/POD, to account for the undetected cracks potentially not found during the ECT inspection. This scaling factor will have an assumed value of 0.6, per the Generic Letter, until a more realistic value of POD has been approved for use. After scaling the "as-found" voltage distribution, the flaws that were removed from service were subtracted from scaled number, to give the assumed BOC voltage distribution, N_{BOC} to be used in the burst and leakage analyses.

Note that $N_{As\ Found}$ includes all flaw indications detected by bobbin coil, regardless of MRPC confirmation. At the time of this submittal, HL&P does not have a plant specific adjustment factor for excluding those bobbin calls that were inspected with MRPC and were determined to have NDD. Per Section 2.b.1 of Enclosure 1 of the Generic Letter, a methodology can be implemented upon review and approval by the NRC where a fraction of bobbin indications at location which have been inspected with MRPC probe, but where the MRPC failed to confirm the bobbin indication, may be excluded from $N_{As\ Found}$. The BOC 6 voltage distribution of the STP-1 'C' steam generator is shown in Figure 9-1.

9.3 Voltage Growth Due to Defect Progression

Potential voltage growth rates during the next inspection cycle should be based on growth rates observed during the last one or two inspection cycles. For a given inspection, previous results at TSP intersections currently exhibiting a bobbin indication should be re-evaluated consistent with the data analysis guidelines in Section 3 of Enclosure 1 of the Generic Letter. In cases where data acquisition guidelines utilized during previous inspections differ from those in Section 3 of Enclosure 1 of the Generic Letter, adjustments to the previous data should be made to compensate for the differences. Voltage growth rates should be evaluated for TSP intersections where bobbin indications can be identified at two successive outages, except where an indication changes from NDD to a relatively high voltage (i.e. 2.0 volts).

The distribution of observed voltage growth rates should be determined for each of the last one or two inspection cycles. When the current or the current and the previous inspections employed data acquisition guidelines similar to those in Section 3 of Enclosure 1 of the Generic Letter, only the growth rate distribution for the previous cycle should be used to estimate the voltage growth rate expected for the next inspection cycle. If the Generic Letter, Section 3 of Enclosure 1 guidelines were used in both of the two previous inspections, the most limiting of the two growth rates should be used to estimate the voltage growth for the next cycle. The two distributions should be combined if one or both is based on a minimal number of indications (i.e., < 200). Per the Generic Letter, if fewer than 200 ODSCC indications were present in prior inspections, the use of a bounding growth rate distribution based on experience at similarly designed and operating units is acceptable.

It is acceptable to use a statistical model fit of the observed growth rate distribution as part of the tube integrity analysis provided that the model accounts for the tail of the distribution. It is also acceptable that the voltage growth distribution be in terms of Δ volts rather than

percent Δ volts, as long as the conservatism of this approach is supported by operating experience. Negative growth rates should be included as zero growth rates in the assumed distribution. However, for the purposes of determining the upper voltage repair limit, it is appropriate to consider negative growth rates as part of the estimate for average growth rate.

STP-1 Compliance with Requirement

The above method for evaluating the voltage growth due to defect progression will be utilized in the application of ARC at STP-1. Additionally, historical look-ups of new DSIs will be performed in the development of the STP-1 bounding growth rate, for the purposes of ARC evaluations. The STP-1 bounding growth rate cumulative distribution is presented in Table 9-2. The table is converted into a voltage growth distribution and is shown in Figure 9-2.

9.4 Eddy Current Voltage Measurement Uncertainty

Uncertainty in eddy current voltage measurements stems primarily from two sources:

1. voltage response variability (test repeatability error) resulting from probe wear, and

2. voltage measurement variability among data analysts (measurement repeatability error).

Each of these uncertainties should be quantified. An acceptable characterization of these uncertainties is contained in Reference 6, with the exception that no distribution cutoff should be applied to the voltage measurement variability distribution. The assumed 15% cutoff for the voltage response variability distribution in Reference 6 is acceptable.

STP-1 Compliance with Requirement

Acquisition and Analyst Errors

For the purposes of the STP-1 ARC analyses, the acquisition error that will be utilized will be sampled from [

]EP Reference 6. [

]eFP This method meets the requirements specified in the Generic Letter.

The analyst error is addressed in a similar fashion as the acquisition error. It is also represented by [

]EP suggested in Reference 6. [

]eFP This method also meets the requirements specified in the Generic Letter.

9.5 Projected End-of-Cycle (EOC) Voltage Distribution

As discussed above, the EOC voltage distribution is required in order to calculate the conditional probability of burst and leakage during a postulated MSLB. In order to project an EOC voltage distribution from the BOC voltage distribution determined in Section 9.2, the effects of voltage growth to account for defect progression (presented in 9.3), and eddy current voltage measurement uncertainty (presented in 9.4) must be considered. Monte Carlo techniques are an acceptable means for sampling EC measurement uncertainty and voltage growth distribution to determine the EOC voltage distribution.

STP-1 Compliance with Requirement

In order to project an EOC distribution, a Monte Carlo simulation is performed utilizing the BOC voltage distribution from Section 9.2, the voltage growth cumulative distribution table from Section 9.3, and the ECT uncertainties from Section 9.4. These values are consistent with EPRI Reference 6 and the requirements of the Generic Letter [1].

The first step in the Monte Carlo simulation is to combine the eddy current uncertainties with the measured BOC voltages to obtain the 'true', but unknown, BOC voltages. The method of accounting for these uncertainties assumes that both the acquisition and analysis uncertainties are distributed about the true voltage [26]. For the acquisition uncertainty, the deviation from the true voltage is given by:

$$\Delta V_{acq} = Z_{acq} \times \sigma_{acq} \times V_{true}$$

Eq. 9-2

where

Z_{acq} = randomly selected value from the normal distribution

σ_{acq} = standard deviation for acquisition uncertainty (0.070)

V_{true} = the true, but unknown, BOC voltage

For the analysis uncertainty, the deviation from the true voltage is given by:

$$\Delta V_{anal} = Z_{anal} \times \sigma_{anal} \times V_{true}$$

Eq. 9-3

where

Z_{anal} = randomly selected value from the normal distribution

σ_{anal} = standard deviation for analysis uncertainty (0.103)

V_{true} = the true, but unknown, BOC voltage

Combining these uncertainties to obtain the measured voltage (V_{meas}) as a function of the true voltage yields the equation:

$$V_{meas}=V_{true}+(Z_{acq}\times\sigma_{acq}\times V_{true})+(Z_{anal}\times\sigma_{anal}\times V_{true})$$

Eq. 9-4

Solving for V_{true} yields the following relationship:

$$V_{true}=\frac{V_{meas}}{1+Z_{acq}\times\sigma_{ACQ}+Z_{anal}\times\sigma_{anal}}$$

Eq. 9-5 [26]

To obtain an EOC voltage, a randomly selected value from the growth distribution is then added to the 'true' BOC voltage. This growth value is obtained from the cumulative growth distribution shown in Table 9-2. To obtain the growth value, a random number from a uniform distribution is generated. The cumulative growth distribution is then entered at this random value. The growth value used in the simulation is obtained by interpolating between the discrete growth values in the distribution.

Accounting for the eddy current uncertainties and defect growth, the EOC voltage becomes:

$$V_{EOC}=V_{true}+\Delta V_{growth}$$

$$V_{EOC}=\frac{V_{meas}}{1+Z_{acq}\times\sigma_{acq}+Z_{anal}\times\sigma_{anal}}+\Delta V_{growth}$$

Eq. 9-6

The Monte Carlo simulation calculates an EOC voltage for each BOC indication. The simulation starts in the smallest BOC voltage bin and calculates as many independent EOC voltages as there are indications in this bin. This process is repeated for each bin until EOC voltages have been calculated for all of the BOC indications. Each sampling of all of the BOC indications is defined as a 'trial'. Many trials (at least 100,000) are performed and the results are averaged to obtain

an EOC voltage distribution. The predicted EOC 6 voltage distribution for the 'C' steam generator is shown in Figure 9-3.

TABLE 9-1
STP-1 FIELD BOBBIN CALLS FOR DSIs AT H/L TSPs
1995 INSPECTION

S/G	ROW	COL	PLUGGED	IND	LOCATION		FIELD VOLTS	MRPC CONFIRM
A	1	64	N	DSI	03H	+0.08	0.26	N
A	7	106	N	DSI	02H	+0.21	0.33	N
A	7	112	N	DSI	02H	+0.05	0.3	N
A	8	38	N	DSI	02H	+0.05	0.3	N
A	14	72	N	DSI	08H	+0.05	0.18	N
A	15	15	N	DSI	04H	+0.00	0.67	N
A	15	16	N	DSI	04H	+0.05	0.39	N
A	16	26	N	DSI	04H	+0.00	0.38	N
A	16	28	N	DSI	04H	+0.00	0.26	N
A	16	47	N	DSI	04H	-0.08	0.32	N
A	16	93	N	DSI	02H	+0.00	0.33	N
A	17	17	N	DSI	04H	-0.03	0.37	N
A	17	36	N	DSI	02H	+0.11	0.33	N
A	17	100	N	DSI	03H	+0.08	0.68	N
A	18	15	N	DSI	04H	+0.00	0.95	N
A	19	16	N	DSI	04H	-0.03	0.4	N
A	19	92	N	DSI	03H	+0.00	0.54	N
A	20	28	N	DSI	04H	+0.05	0.3	N
A	21	16	N	DSI	04H	+0.05	0.36	N
A	21	39	N	DSI	04H	-0.06	0.33	N
A	22	34	N	DSI	02H	-0.03	0.92	N
A	22	97	N	DSI	04H	+0.03	0.83	N
A	23	14	N	DSI	04H	-0.05	0.45	N
A	23	30	N	DSI	04H	-0.05	0.24	N
A	23	30	N	DSI	02H	+0.05	0.27	N
A	23	74	N	DSI	07H	+0.19	0.31	N
A	24	31	N	DSI	04H	+0.08	0.3	N
A	24	75	N	DSI	02H	+0.00	0.23	N
A	25	39	N	DSI	04H	-0.06	0.25	N
A	25	40	N	DSI	02H	-0.05	0.3	N
A	25	86	N	DSI	04H	-0.03	0.34	N
A	25	87	N	DSI	03H	-0.03	0.34	N
A	26	73	N	DSI	03H	+0.00	0.42	N
A	27	22	N	DSI	05H	+0.09	0.26	N
A	27	22	N	DSI	04H	+0.09	0.33	N
A	27	62	N	DSI	02H	+0.05	0.56	N

TABLE 9-1
STP-1 FIELD BOBBIN CALLS FOR DSIs AT H/L TSPs
1995 INSPECTION

S/G	ROW	COL	PLUGGED	IND	LOCATION		FIELD VOLTS	MRPC CONFIRM
A	27	97	N	DSI	03H	-0.03	0.48	N
A	28	22	N	DSI	02H	-0.05	0.61	N
A	28	64	N	DSI	04H	+0.07	0.78	N
A	28	72	N	DSI	03H	+0.13	0.55	N
A	29	49	N	DSI	04H	-0.03	0.25	N
A	29	54	N	DSI	03H	-0.08	0.68	N
A	29	62	N	DSI	02H	+0.13	0.53	N
A	30	66	N	DSI	02H	-0.03	0.39	N
A	30	107	N	DSI	02H	+0.03	0.31	N
A	31	17	N	DSI	04H	+0.00	0.48	N
A	31	34	N	DSI	04H	+0.06	0.33	N
A	31	54	N	DSI	04H	-0.03	0.36	N
A	31	55	N	DSI	02H	-0.06	0.65	N
A	33	17	N	DSI	04H	+0.00	0.27	N
A	33	30	N	DSI	04H	+0.13	0.83	N
A	33	40	Y	DSI	02H	+0.05	0.49	Y
A	33	78	Y	DSI	07H	-0.03	0.47	Y
A	33	87	N	DSI	04H	+0.08	0.44	N
A	33	94	N	DSI	03H	-0.03	0.53	N
A	33	98	Y	DSI	02H	+0.03	0.63	Y
A	35	26	N	DSI	04H	-0.19	0.39	N
A	35	29	N	DSI	04H	+0.03	0.3	N
A	35	29	N	DSI	03H	+0.05	0.76	N
A	36	23	N	DSI	04H	-0.03	0.4	N
A	37	67	N	DSI	04H	+0.08	0.25	N
A	38	34	N	DSI	04H	+0.00	0.39	N
A	38	38	N	DSI	02H	-0.08	0.52	N
A	39	31	N	DSI	04H	+0.03	0.25	N
A	40	65	N	DSI	04H	-0.08	0.55	N
A	41	30	N	DSI	04H	+0.00	0.18	N
A	42	30	N	DSI	03H	+0.03	0.84	N
A	42	34	N	DSI	03H	+0.10	0.53	N
B	8	32	Y	DSI	02H	+0.00	0.24	Y
B	10	38	N	DSI	02H	-0.06	0.48	N
B	14	106	N	DSI	02H	+0.06	0.44	N
B	16	32	N	DSI	02H	+0.00	0.19	N

TABLE 9-1

STP-1 FIELD BOBBIN CALLS FOR DSIs AT H/L TSPs

1995 INSPECTION

S/G	ROW	COL	PLUGGED	IND	LOCATION		FIELD VOLTS	MRPC CONFIRM
B	16	63	N	DSI	07H	-0.03	0.14	N
B	17	32	N	DSI	02H	+0.03	0.32	N
B	17	102	N	DSI	03H	+0.08	0.5	N
B	17	102	N	DSI	02H	-0.06	0.46	N
B	18	37	N	DSI	03H	-0.03	0.12	N
B	18	103	N	DSI	03H	+0.06	0.44	N
B	19	32	N	DSI	02H	+0.11	0.3	N
B	19	37	N	DSI	03H	+0.05	0.36	N
B	20	38	N	DSI	02H	+0.06	0.3	N
B	21	18	N	DSI	02H	+0.00	0.39	N
B	21	26	N	DSI	02H	+0.03	0.57	N
B	21	33	Y	DSI	02H	+0.10	0.2	Y
B	21	92	N	DSI	03H	+0.08	0.3	N
B	21	92	N	DSI	02H	-0.03	0.27	N
B	21	95	N	DSI	02H	+0.00	0.37	N
B	21	96	Y	DSI	02H	+0.05	0.44	Y
B	21	103	N	DSI	03H	+0.06	0.27	N
B	21	104	N	DSI	02H	-0.03	0.55	N
B	22	32	N	DSI	02H	+0.11	0.47	N
B	23	36	N	DSI	04H	-0.05	0.24	N
B	23	40	N	DSI	04H	-0.08	0.25	N
B	23	91	N	DSI	02H	+0.05	0.24	N
B	23	93	N	DSI	04H	+0.00	0.16	N
B	23	93	N	DSI	02H	+0.00	0.37	N
B	23	95	N	DSI	02H	-0.03	0.17	N
B	24	29	N	DSI	04H	+0.12	0.27	N
B	24	44	N	DSI	04H	+0.00	0.22	N
B	24	73	Y	DSI	03H	+0.05	0.24	N
B	24	75	N	DSI	02H	+0.00	0.33	N
B	24	102	N	DSI	03H	+0.00	0.53	N
B	25	33	N	DSI	04H	+0.00	0.16	N
B	25	35	N	DSI	02H	+0.10	0.34	N
B	25	[illegible]	N	DSI	02H	+0.05	0.3	N
B	26	32	N	DSI	03H	+0.03	0.75	N
B	26	40	N	DSI	02H	+0.09	0.47	N
B	26	52	N	DSI	02H	+0.03	0.63	N

TABLE 9-1
STP-1 FIELD BOBBIN CALLS FOR DSIs AT H/L TSPs
1995 INSPECTION

S/G	ROW	COL	PLUGGED	IND	LOCATION		FIELD VOLTS	MRPC CONFIRM
B	26	53	N	DSI	02H	+0.00	0.66	N
B	26	66	N	DSI	04H	+0.03	0.37	N
B	26	67	N	DSI	04H	+0.05	0.34	N
B	26	69	N	DSI	04H	+0.00	0.43	N
B	27	52	N	DSI	02H	+0.06	0.45	N
B	27	70	N	DSI	03H	-0.05	0.5	N
B	28	27	N	DSI	04H	+0.09	0.09	N
B	28	34	N	DSI	04H	-0.03	0.51	N
B	28	36	N	DSI	04H	+0.12	0.17	N
B	28	37	N	DSI	03H	-0.03	0.43	N
B	28	38	N	DSI	04H	+0.00	0.45	N
B	28	62	N	DSI	02H	-0.05	0.40	N
B	28	66	N	DSI	02H	+0.03	0.73	N
B	28	67	N	DSI	04H	+0.00	0.62	N
B	28	68	N	DSI	03H	+0.00	0.35	N
B	29	41	Y	DSI	02H	+0.06	0.26	Y
B	29	43	N	DSI	03H	+0.00	0.39	N
B	29	48	N	DSI	04H	+0.03	0.66	N
B	29	54	N	DSI	03H	-0.03	0.19	N
B	29	54	N	DSI	02H	+0.09	0.38	N
B	29	87	N	DSI	09H	+0.05	1.33	Y
B	29	92	N	DSI	03H	-0.05	0.29	N
B	30	32	N	DSI	02H	+0.06	0.49	N
B	30	34	N	DSI	04H	-0.03	0.51	N
B	30	67	N	DSI	02H	+0.00	0.45	N
B	30	73	N	DSI	02H	-0.05	0.27	N
B	30	93	N	DSI	02H	+0.08	0.37	N
B	30	101	N	DSI	02H	+0.00	0.26	N
B	31	32	N	DSI	02H	+0.00	0.24	N
B	31	33	N	DSI	03H	+0.15	0.5	N
B	31	33	N	DSI	02H	+0.00	0.39	N
B	31	35	N	DSI	04H	+0.09	0.45	N
B	31	41	N	DSI	04H	+0.00	0.53	N
B	31	93	N	DSI	03H	+0.05	0.35	N
B	32	42	N	DSI	04H	+0.03	0.62	N
B	32	75	N	DSI	04H	+0.03	0.29	N

<u>TABLE 9-1</u>
STP-1 FIELD BOBBIN CALLS FOR DSIs AT H/L TSPs
1995 INSPECTION

S/G	ROW	COL	PLUGGED	IND	LOCATION	FIELD VOLTS	MRPC CONFIRM
B	32	75	N	DSI	03H +0.03	0.37	N
B	32	106	N	DSI	02H -0.08	0.72	N
B	33	34	N	DSI	03H +0.05	0.28	N
B	33	87	N	DSI	04H +0.13	0.16	N
B	33	93	N	DSI	02H -0.05	0.31	N
B	34	33	N	DSI	03H +0.14	0.77	N
B	34	75	N	DSI	04H -0.03	0.17	N
B	34	80	N	DSI	04H -0.06	0.55	N
B	35	32	N	DSI	04H +0.06	0.35	N
B	35	55	N	DSI	03H +0.19	0.41	N
B	36	33	N	DSI	04H +0.00	0.6	N
B	36	33	N	DSI	03H +0.12	0.51	N
B	36	33	N	DSI	02H -0.11	0.36	N
B	36	86	N	DSI	02H +0.05	0.25	N
B	37	33	N	DSI	04H +0.00	0.36	N
B	37	62	Y	DSI	02H +0.08	0.58	N
B	37	71	N	DSI	04H +0.06	0.27	N
B	38	32	N	DSI	02H +0.00	0.21	N
B	39	33	N	DSI	04H +0.00	0.19	N
B	39	33	N	DSI	02H +0.06	0.19	N
B	39	34	N	DSI	02H +0.03	0.23	N
B	41	74	N	DSI	04H +0.03	0.56	N
B	41	80	N	DSI	02H +0.05	0.23	N
B	42	39	N	DSI	03H +0.08	0.39	N
B	42	62	N	DSI	04H -0.03	0.39	N
B	42	65	N	DSI	02H -0.08	0.43	N
B	43	49	N	DSI	02H +0.00	0.53	N
B	43	63	N	DSI	07H -0.11	0.3	N
B	45	50	N	DSI	02H +0.09	0.32	N
B	46	73	N	DSI	04H -0.05	0.18	N
C	7	9	N	DSI	02H +0.00	0.53	N
C	8	9	N	DSI	02H +0.00	0.2	N
C	10	30	N	DSI	02H +0.03	0.12	N
C	12	27	N	DSI	04H +0.05	0.09	N
C	13	16	N	DSI	03H +0.07	0.35	Y
C	13	28	N	DSI	02H -0.10	0.53	N

TABLE 9-1
STP-1 FIELD BOBBIN CALLS FOR DSIs AT H/L TSPs
1995 INSPECTION

S/G	ROW	COL	PLUGGED	IND	LOCATION		FIELD VOLTS	MRPC CONFIRM
C	13	29	N	DSI	02H	+0.10	0.32	N
C	13	30	N	DSI	02H	+0.00	0.64	N
C	13	58	N	DSI	03H	+0.07	0.3	N
C	13	102	N	DSI	02H	-0.03	0.27	N
C	13	103	N	DSI	02H	+0.06	0.76	N
C	14	15	N	DSI	03H	+0.07	0.27	N
C	14	17	N	DSI	02H	+0.05	0.57	N
C	14	94	N	DSI	02H	-0.03	0.31	N
C	14	98	N	DSI	02H	+0.08	0.73	N
C	15	18	N	DSI	02H	+0.06	0.4	N
C	15	24	N	DSI	05H	+0.03	0.18	N
C	15	24	N	DSI	04H	-0.08	0.22	N
C	15	24	N	DSI	03H	-0.03	0.19	N
C	15	25	N	DSI	02H	+0.03	0.39	N
C	15	29	N	DSI	02H	+0.13	0.46	N
C	15	32	N	DSI	03H	+0.04	0.24	N
C	15	33	N	DSI	02H	+0.05	0.62	N
C	15	88	N	DSI	02H	-0.03	0.57	N
C	15	95	N	DSI	02H	+0.11	0.35	N
C	15	102	N	DSI	02H	+0.00	0.17	N
C	15	104	N	DSI	02H	+0.00	0.34	N
C	16	18	N	DSI	02H	+0.11	0.23	N
C	16	21	N	DSI	03H	+0.05	0.49	N
C	16	94	N	DSI	02H	-0.13	0.12	N
C	16	96	N	DSI	03H	+0.09	0.54	N
C	16	105	N	DSI	04H	-0.03	0.23	N
C	16	109	N	DSI	02H	+0.00	0.37	N
C	17	15	N	DSI	02H	+0.01	0.27	N
C	17	16	N	DSI	04H	+0.00	0.46	N
C	17	17	N	DSI	02H	+0.05	0.32	N
C	17	23	N	DSI	03H	+0.00	0.48	N
C	17	25	N	DSI	02H	-0.06	0.33	N
C	17	26	N	DSI	02H	-0.03	0.59	N
C	17	27	N	DSI	04H	-0.03	0.25	N
C	17	29	N	DSI	05H	+0.08	0.33	N
C	17	29	N	DSI	03H	+0.08	0.45	N

TABLE 9-1
STP-1 FIELD BOBBIN CALLS FOR DSIs AT H/L TSPs
1995 INSPECTION

S/G	ROW	COL	PLUGGED	IND	LOCATION		FIELD VOLTS	MRPC CONFIRM
C	17	30	N	DSI	03H	+0.03	0.32	N
C	17	49	N	DSI	02H	+0.08	0.12	N
C	17	100	N	DSI	03H	+0.00	0.45	N
C	18	14	N	DSI	02H	+0.00	0.23	N
C	18	18	N	DSI	05H	+0.11	0.27	N
C	18	18	N	DSI	04H	+0.08	0.46	N
C	18	24	N	DSI	02H	+0.00	0.29	N
C	18	27	N	DSI	04H	+0.00	0.28	N
C	18	27	N	DSI	03H	-0.05	0.23	N
C	18	27	N	DSI	02H	+0.08	0.3	N
C	18	28	N	DSI	02H	+0.05	0.13	N
C	18	29	N	DSI	03H	+0.05	0.34	N
C	18	29	N	DSI	02H	+0.05	0.49	N
C	18	94	N	DSI	02H	-0.08	0.23	N
C	19	14	N	DSI	02H	+0.07	0.7	N
C	19	16	N	DSI	02H	+0.07	0.59	N
C	19	17	N	DSI	02H	+0.05	0.88	N
C	19	19	N	DSI	02H	+0.00	0.39	N
C	19	23	N	DSI	02H	-0.03	0.6	N
C	19	26	N	DSI	02H	+0.00	0.9	N
C	19	29	N	DSI	02H	+0.03	0.52	N
C	19	38	N	DSI	02H	+0.08	0.91	N
C	19	39	N	DSI	03H	+0.05	0.18	N
C	19	46	N	DSI	04H	+0.05	0.41	N
C	19	85	N	DSI	04H	+0.08	0.22	N
C	20	26	N	DSI	04H	-0.03	0.22	N
C	20	28	N	DSI	05H	+0.08	0.55	N
C	20	28	N	DSI	02H	+0.03	0.61	N
C	20	29	N	DSI	02H	+0.05	0.19	N
C	20	31	N	DSI	02H	+0.05	0.41	N
C	20	33	N	DSI	02H	+0.08	0.23	N
C	20	38	N	DSI	03H	-0.03	0.56	N
C	20	40	N	DSI	02H	+0.00	0.58	N
C	20	41	N	DSI	03H	+0.00	0.18	N
C	20	46	N	DSI	03H	-0.03	0.33	N
C	20	47	N	DSI	02H	+0.09	0.26	N

TABLE 9-1
STP-1 FIELD BOBBIN CALLS FOR DSIs AT H/L TSPs
1995 INSPECTION

S/G	ROW	COL	PLUGGED	IND	LOCATION		FIELD VOLTS	MRPC CONFIRM
C	20	79	N	DSI	02H	-0.11	0.76	N
C	20	81	N	DSI	02H	-0.03	0.68	N
C	20	82	N	DSI	02H	+0.06	0.47	N
C	20	84	N	DSI	02H	+0.00	0.26	N
C	20	97	N	DSI	02H	+0.03	0.67	N
C	20	98	N	DSI	02H	+0.00	0.48	N
C	20	99	N	DSI	02H	-0.03	0.24	N
C	21	14	N	DSI	02H	+0.12	0.94	N
C	21	22	N	DSI	02H	-0.07	0.5	N
C	21	33	N	DSI	02H	+0.03	0.8	N
C	21	39	N	DSI	02H	+0.08	0.55	N
C	21	42	N	DSI	04H	+0.05	0.4	N
C	21	75	N	DSI	04H	+0.03	0.51	N
C	21	75	N	DSI	03H	+0.08	0.22	N
C	21	76	N	DSI	03H	-0.03	0.43	N
C	21	76	N	DSI	02H	-0.05	0.36	N
C	21	85	N	DSI	02H	+0.05	0.68	N
C	21	95	N	DSI	02H	+0.00	0.31	N
C	22	16	N	DSI	04H	-0.02	0.22	N
C	22	27	N	DSI	02H	+0.03	0.29	N
C	22	30	N	DSI	02H	+0.24	0.61	N
C	22	32	N	DSI	02H	+0.03	0.18	N
C	22	37	N	DSI	03H	+0.08	0.38	N
C	22	37	N	DSI	02H	-0.05	0.44	N
C	22	78	N	DSI	02H	+0.00	0.6	N
C	22	79	N	DSI	02H	-0.03	0.54	N
C	22	82	N	DSI	04H	+0.11	0.32	N
C	23	20	N	DSI	02H	+0.00	0.5	N
C	23	47	N	DSI	03H	-0.10	0.5	N
C	23	66	N	DSI	04H	-0.03	0.82	N
C	23	77	N	DSI	04H	-0.06	0.45	N
C	23	82	N	DSI	02H	-0.08	0.44	N
C	23	102	N	DSI	02H	+0.00	0.24	Y
C	24	13	N	DSI	03H	+0.09	0.29	N
C	24	17	N	DSI	03H	+0.00	0.18	N
C	24	34	N	DSI	02H	+0.15	1.11	N

TABLE 9-1
STP-1 FIELD BOBBIN CALLS FOR DSIs AT H/L TSPs
1995 INSPECTION

S/G	ROW	COL	PLUGGED	IND	LOCATION		FIELD VOLTS	MRPC CONFIRM
C	24	63	N	DSI	03H	+0.08	0.43	N
C	24	64	N	DSI	03H	+0.03	0.45	N
C	24	64	N	DSI	02H	+0.08	0.3	N
C	24	66	N	DSI	04H	+0.16	0.46	N
C	24	78	N	DSI	03H	-0.03	0.23	N
C	24	78	N	DSI	02H	+0.03	0.53	N
C	24	80	N	DSI	02H	+0.00	0.9	N
C	24	82	N	DSI	04H	-0.03	0.39	N
C	24	83	N	DSI	02H	+0.00	0.45	N
C	24	84	N	DSI	02H	+0.00	0.27	N
C	24	85	N	DSI	04H	+0.00	0.6	N
C	24	85	N	DSI	02H	+0.03	0.54	N
C	24	86	N	DSI	02H	+0.08	0.47	N
C	24	103	N	DSI	02H	+0.00	0.57	N
C	25	17	N	DSI	04H	-0.02	0.56	Y
C	25	17	N	DSI	02H	+0.00	0.71	N
C	25	23	N	DSI	05H	-0.11	0.41	N
C	25	39	N	DSI	03H	+0.10	0.73	N
C	25	52	N	DSI	03H	+0.00	0.31	N
C	25	55	N	DSI	02H	+0.00	0.44	N
C	25	62	N	DSI	03H	+0.08	0.47	N
C	25	90	N	DSI	02H	+0.00	0.32	N
C	25	101	N	DSI	04H	-0.06	0.41	N
C	26	18	N	DSI	02H	+0.08	0.67	N
C	26	63	N	DSI	02H	+0.21	0.42	N
C	26	64	N	DSI	05H	+0.00	0.45	N
C	26	64	N	DSI	02H	+0.08	0.8	N
C	26	65	N	DSI	02H	+0.05	0.5	N
C	26	66	N	DSI	04H	+0.03	0.46	N
C	26	67	N	DSI	04H	+0.10	0.64	N
C	26	67	N	DSI	03H	+0.05	0.54	N
C	26	67	N	DSI	02H	+0.00	0.87	N
C	26	71	N	DSI	04H	+0.00	0.23	N
C	26	81	N	DSI	02H	-0.06	0.34	N
C	26	86	N	DSI	02H	+0.08	0.43	N
C	26	102	N	DSI	02H	-0.03	0.74	N

TABLE 9-1
STP-1 FIELD BOBBIN CALLS FOR DSIs AT H/L TSPs
1995 INSPECTION

S/G	ROW	COL	PLUGGED	IND	LOCATION		FIELD VOLTS	MRPC CONFIRM
C	27	17	N	DSI	02H	+0.08	0.23	N
C	27	34	N	DSI	02H	+0.00	0.6	N
C	27	51	N	DSI	02H	-0.05	0.29	N
C	27	79	N	DSI	02H	+0.03	0.41	N
C	27	81	N	DSI	02H	+0.08	0.49	N
C	27	95	N	DSI	02H	+0.00	0.21	N
C	27	104	N	DSI	04H	+0.03	0.76	N
C	28	18	N	DSI	04H	+0.03	0.2	N
C	28	18	N	DSI	03H	+0.08	0.58	N
C	28	58	N	DSI	02H	+0.03	0.73	N
C	28	66	N	DSI	02H	+0.08	0.29	N
C	28	67	N	DSI	02H	+0.00	0.42	N
C	28	68	N	DSI	02H	+0.05	0.2	N
C	28	91	N	DSI	02H	+0.03	0.28	Y
C	29	23	N	DSI	04H	-0.11	0.25	N
C	29	30	N	DSI	04H	+0.02	0.38	N
C	29	63	N	DSI	03H	+0.03	0.37	N
C	29	66	N	DSI	04H	+0.14	0.28	N
C	29	74	N	DSI	02H	+0.08	0.25	N
C	29	76	N	DSI	02H	+0.00	0.62	N
C	29	77	N	DSI	02H	+0.00	0.64	N
C	29	80	N	DSI	02H	-0.06	0.2	N
C	29	83	N	DSI	05H	+0.03	0.39	N
C	29	83	N	DSI	02H	-0.08	0.4	N
C	29	84	N	DSI	02H	+0.08	0.44	N
C	29	98	N	DSI	04H	+0.06	0.36	N
C	30	26	N	DSI	05H	+0.03	0.26	N
C	30	34	N	DSI	02H	+0.08	0.24	N
C	30	47	N	DSI	02H	-0.05	0.19	N
C	30	50	N	DSI	02H	-0.05	0.3	N
C	30	52	N	DSI	02H	+0.06	0.45	N
C	30	57	N	DSI	04H	+0.14	0.41	N
C	30	57	N	DSI	02H	+0.14	0.39	N
C	30	64	N	DSI	02H	+0.08	0.39	N
C	30	65	N	DSI	02H	-0.03	0.45	N
C	30	66	N	DSI	03H	+0.00	0.5	N

TABLE 9-1
STP-1 FIELD BOBBIN CALLS FOR DSIs AT H/L TSPs
1995 INSPECTION

S/G	ROW	COL	PLUGGED	IND	LOCATION		FIELD VOLTS	MRPC CONFIRM
C	30	66	N	DSI	02H	+0.00	0.4	N
C	30	67	N	DSI	04H	+0.03	0.39	N
C	30	69	N	DSI	02H	+0.13	0.34	N
C	30	74	N	DSI	02H	+0.03	0.26	N
C	30	82	N	DSI	02H	-0.06	0.33	N
C	30	84	N	DSI	02H	-0.03	0.35	N
C	30	91	N	DSI	02H	+0.03	0.3	N
C	31	27	N	DSI	05H	+0.10	0.22	N
C	31	62	N	DSI	03H	+0.08	0.53	N
C	31	67	N	DSI	02H	+0.03	0.24	N
C	31	74	N	DSI	06H	+0.05	0.12	N
C	31	83	N	DSI	02H	+0.06	0.55	N
C	31	91	N	DSI	02H	-0.11	0.38	N
C	32	33	N	DSI	05H	+0.11	0.45	N
C	32	33	N	DSI	02H	+0.10	0.18	N
C	32	64	N	DSI	02H	+0.00	0.93	N
C	32	65	N	DSI	04H	+0.08	0.13	N
C	32	65	N	DSI	02H	+0.00	0.21	N
C	32	69	N	DSI	06H	+0.03	0.51	N
C	32	75	N	DSI	04H	-0.03	0.38	N
C	32	81	N	DSI	02H	-0.11	0.29	N
C	33	28	N	DSI	02H	-0.02	0.3	N
C	33	42	N	DSI	02H	+0.03	0.4	N
C	33	85	N	DSI	07H	-0.03	0.15	N
C	34	29	N	DSI	04H	+0.03	0.22	N
C	34	41	N	DSI	02H	+0.03	0.86	N
C	34	80	N	DSI	04H	+0.11	0.34	N
C	34	80	N	DSI	02H	+0.03	0.42	N
C	34	82	N	DSI	04H	+0.14	0.28	N
C	34	82	N	DSI	02H	-0.06	0.24	N
C	35	35	N	DSI	04H	+0.05	0.14	N
C	35	36	N	DSI	04H	+0.10	0.38	N
C	35	36	N	DSI	03H	+0.08	0.65	N
C	35	39	N	DSI	02H	+0.00	0.38	N
C	35	58	N	DSI	02H	+0.03	0.39	N
C	35	64	N	DSI	02H	+0.06	0.34	N

TABLE 9-1
STP-1 FIELD BOBBIN CALLS FOR DSIs AT H/L TSPs
1995 INSPECTION

S/G	ROW	COL	PLUGGED	IND	LOCATION		FIELD VOLTS	MRPC CONFIRM
C	35	74	N	DSI	02H	+0.13	0.46	N
C	35	82	N	DSI	02H	+0.03	0.54	N
C	35	84	N	DSI	02H	+0.00	0.84	N
C	35	85	N	DSI	04H	+0.08	0.42	N
C	35	93	N	DSI	03H	-0.19	0.57	N
C	36	30	N	DSI	02H	+0.08	0.18	N
C	36	71	N	DSI	02H	+0.05	0.43	N
C	37	30	N	DSI	02H	+0.03	0.69	N
C	37	39	N	DSI	03H	+0.05	0.78	N
C	37	47	N	DSI	03H	+0.03	0.48	N
C	37	57	N	DSI	04H	-0.03	0.4	N
C	37	81	N	DSI	02H	-0.05	0.55	N
C	37	85	N	DSI	04H	-0.03	0.32	N
C	38	49	N	DSI	04H	+0.06	0.56	N
C	38	49	N	DSI	02H	+0.08	1.51	N
C	38	68	N	DSI	04H	+0.08	0.34	N
C	38	77	N	DSI	02H	+0.00	0.34	N
C	38	82	N	DSI	02H	+0.08	0.78	N
C	38	83	N	DSI	04H	+0.03	0.49	N
C	38	83	N	DSI	02H	+0.08	0.5	N
C	39	28	N	DSI	02H	+0.03	0.52	N
C	39	50	N	DSI	03H	+0.03	0.26	N
C	39	76	N	DSI	04H	-0.05	0.44	N
C	39	77	N	DSI	02H	-0.06	0.41	N
C	40	28	N	DSI	04H	+0.08	0.22	N
C	40	48	N	DSI	04H	+0.05	0.17	N
C	40	50	N	DSI	02H	+0.00	0.39	N
C	40	64	N	DSI	04H	+0.29	0.32	N
C	40	67	N	DSI	02H	+0.08	0.8	N
C	40	71	N	DSI	04H	+0.05	0.22	N
C	40	75	N	DSI	04H	+0.00	0.29	N
C	40	87	N	DSI	04H	+0.00	0.35	N
C	40	87	N	DSI	03H	+0.03	0.56	N
C	41	48	N	DSI	04H	+0.09	0.28	N
C	42	48	N	DSI	04H	-0.03	0.33	N
C	42	71	N	DSI	02H	+0.03	0.58	N

TABLE 9-1
STP-1 FIELD BOBBIN CALLS FOR DSIs AT H/L TSPs
1995 INSPECTION

S/G	ROW	COL	PLUGGED	IND	LOCATION		FIELD VOLTS	MRPC CONFIRM
C	42	75	N	DSI	04H	+0.03	0.47	N
C	42	76	N	DSI	02H	-0.05	0.37	N
C	42	81	N	DSI	02H	+0.14	0.65	N
C	43	64	N	DSI	04H	-0.06	0.46	N
C	43	74	N	DSI	02H	+0.08	0.68	N
C	43	76	N	DSI	04H	-0.03	0.28	N
C	43	77	N	DSI	02H	+0.03	0.42	N
C	44	42	N	DSI	02H	+0.05	0.63	N
C	44	72	N	DSI	02H	+0.05	0.13	N
C	45	74	N	DSI	02H	-0.03	0.2	N
C	46	50	N	DSI	02H	+0.00	0.5	N
C	46	72	N	DSI	02H	+0.05	0.2	N
D	3	67	N	DSI	02H	-0.08	0.33	N
D	5	13	N	DSI	05H	+0.08	0.2	N
D	8	56	N	DSI	03H	+0.00	0.53	N
D	9	109	N	DSI	02H	+0.08	0.59	N
D	10	7	N	DSI	02H	+0.00	0.16	N
D	10	10	N	DSI	02H	+0.06	0.24	N
D	10	16	N	DSI	02H	-0.03	0.47	N
D	10	17	N	DSI	02H	+0.06	0.33	N
D	12	15	N	DSI	02H	+0.09	0.35	N
D	13	12	N	DSI	02H	+0.03	0.12	N
D	13	97	N	DSI	02H	+0.00	0.4	N
D	14	14	N	DSI	04H	+0.18	0.33	N
D	14	16	N	DSI	04H	+0.08	0.29	N
D	14	17	N	DSI	04H	+0.03	0.25	N
D	14	17	N	DSI	02H	+0.00	0.4	N
D	15	9	N	DSI	02H	-0.03	0.32	N
D	15	10	N	DSI	02H	+0.12	0.49	N
D	15	12	N	DSI	05H	+0.00	0.3	N
D	15	12	N	DSI	02H	+0.03	0.33	N
D	15	13	N	DSI	04H	+0.00	0.29	N
D	15	16	Y	DSI	02H	+0.03	0.34	Y
D	15	18	N	DSI	02H	+0.03	0.34	N
D	17	5	N	DSI	02H	+0.08	0.13	N
D	17	12	N	DSI	02H	+0.06	0.51	N

TABLE 9-1
STP-1 FIELD BOBBIN CALLS FOR DSIs AT H/L TSPs
1995 INSPECTION

S/G	ROW	COL	PLUGGED	IND	LOCATION		FIELD VOLTS	MRPC CONFIRM
D	17	32	N	DSI	02H	+0.03	0.37	N
D	17	97	N	DSI	03H	+0.08	0.63	Y
D	17	103	N	DSI	02H	+0.00	0.6	N
D	17	104	N	DSI	03H	+0.05	0.51	N
D	17	104	N	DSI	02H	+0.00	0.48	N
D	17	111	N	DSI	02H	+0.00	0.54	N
D	18	12	N	DSI	02H	+0.09	0.19	N
D	18	90	N	DSI	03H	+0.00	0.55	N
D	18	94	N	DSI	02H	+0.06	0.85	N
D	18	95	N	DSI	02H	-0.03	0.89	N
D	18	98	N	DSI	02H	+0.03	0.67	N
D	18	102	N	DSI	02H	+0.05	0.52	N
D	19	12	Y	DSI	02H	+0.03	0.37	Y
D	19	16	N	DSI	02H	+0.09	0.31	N
D	19	29	N	DSI	02H	+0.03	0.19	N
D	19	34	N	DSI	02H	-0.03	0.24	N
D	19	35	Y	DSI	02H	+0.16	0.25	Y
D	19	83	N	DSI	04H	+0.00	0.36	N
D	19	87	N	DSI	05H	+0.11	0.31	N
D	19	90	N	DSI	02H	-0.03	0.48	N
D	19	93	N	DSI	02H	+0.00	0.41	N
D	19	94	N	DSI	02H	-0.03	0.4	N
D	19	95	N	DSI	02H	+0.00	0.32	N
D	19	99	N	DSI	02H	+0.05	0.24	N
D	19	102	N	DSI	03H	+0.00	0.4	N
D	19	102	N	DSI	02H	-0.05	0.3	N
D	20	94	N	DSI	04H	+0.00	0.52	N
D	21	21	N	DSI	02H	+0.00	0.16	N
D	21	32	N	DSI	02H	-0.05	0.22	N
D	21	75	N	DSI	03H	+0.11	0.27	N
D	21	90	N	DSI	03H	+0.06	0.22	N
D	21	92	N	DSI	02H	+0.03	0.99	N
D	21	93	N	DSI	02H	+0.03	0.96	N
D	21	95	N	DSI	02H	+0.00	0.16	N
D	21	97	N	DSI	02H	-0.05	0.45	N
D	22	36	N	DSI	02H	+0.13	0.48	N

TABLE 9-1
STP-1 FIELD BOBBIN CALLS FOR DSIs AT H/L TSPs
1995 INSPECTION

S/G	ROW	COL	PLUGGED	IND	LOCATION	FIELD VOLTS	MRPC CONFIRM
D	22	74	N	DSI	02H +0.04	0.54	N
D	22	80	N	DSI	02H +0.03	0.19	N
D	22	93	N	DSI	02H +0.03	0.55	N
D	22	96	N	DSI	02H -0.03	0.52	N
D	22	98	N	DSI	03H +0.03	0.29	N
D	23	18	Y	DSI	02H +0.06	0.34	Y
D	23	28	N	DSI	02H +0.03	0.41	Y
D	23	31	N	DSI	02H +0.00	0.31	N
D	23	75	N	DSI	04H -0.03	0.37	N
D	23	107	N	DSI	05H +0.03	0.23	N
D	24	15	N	DSI	02H +0.03	0.51	N
D	24	18	N	DSI	02H +0.03	0.5	N
D	24	38	N	DSI	02H -0.05	0.18	N
D	24	43	N	DSI	02H +0.03	0.35	N
D	24	62	N	DSI	03H +0.00	0.61	Y
D	24	74	Y	DSI	02H +0.08	0.37	Y
D	24	78	N	DSI	02H +0.00	0.29	N
D	24	98	N	DSI	04H +0.03	0.35	N
D	24	98	N	DSI	02H -0.03	0.37	N
D	24	108	N	DSI	02H +0.03	0.47	N
D	25	16	N	DSI	03H +0.06	0.32	N
D	25	16	N	DSI	02H +0.00	0.45	N
D	25	32	N	DSI	02H -0.08	0.21	N
D	25	63	N	DSI	02H +0.00	0.37	N
D	25	64	N	DSI	02H +0.04	1.22	N
D	25	67	N	DSI	03H +0.00	0.33	N
D	25	73	N	DSI	03H +0.03	0.42	N
D	25	73	N	DSI	02H -0.02	0.74	N
D	25	75	N	DSI	02H +0.03	0.71	N
D	25	88	N	DSI	02H +0.11	0.76	N
D	25	89	N	DSI	02H -0.05	0.46	N
D	25	90	N	DSI	02H +0.00	0.45	N
D	25	92	N	DSI	03H +0.08	0.85	N
D	26	35	N	DSI	02H +0.00	0.68	N
D	26	63	Y	DSI	02H +0.03	0.48	Y
D	26	64	N	DSI	04H +0.03	0.47	N

TABLE 9-1
STP-1 FIELD BOBBIN CALLS FOR DSIs AT H/L TSPs
1995 INSPECTION

S/G	ROW	COL	PLUGGED	IND	LOCATION		FIELD VOLTS	MRPC CONFIRM
D	26	64	N	DSI	02H	-0.02	0.64	N
D	26	68	N	DSI	02H	+0.04	0.36	Y
D	26	70	N	DSI	02H	+0.06	0.16	N
D	26	76	N	DSI	04H	+0.10	0.95	N
D	26	82	N	DSI	02H	+0.00	0.39	N
D	26	84	N	DSI	02H	+0.00	0.55	N
D	26	97	N	DSI	02H	+0.00	0.77	N
D	27	43	N	DSI	02H	+0.00	0.36	N
D	27	64	N	DSI	02H	+0.06	0.35	N
D	27	73	N	DSI	02H	+0.03	0.82	N
D	27	105	N	DSI	04H	-0.03	0.62	N
D	28	66	N	DSI	02H	+0.00	0.7	N
D	28	74	N	DSI	02H	-0.03	0.45	N
D	29	18	N	DSI	04H	+0.03	0.41	N
D	29	32	N	DSI	02H	-0.05	0.34	N
D	29	43	N	DSI	02H	+0.00	0.26	N
D	29	66	N	DSI	05H	-0.05	0.63	N
D	29	72	N	DSI	02H	-0.05	0.32	N
D	29	92	N	DSI	03H	+0.00	0.45	N
D	29	99	N	DSI	03H	+0.05	0.36	N
D	29	103	N	DSI	04H	+0 13	0.24	N
D	29	107	N	DSI	04H	-0.03	0.36	N
D	29	110	N	DSI	02H	+0.00	0.32	N
D	29	111	N	DSI	02H	-0.03	0.26	N
D	30	98	N	DSI	04H	+0.03	0.47	N
D	30	98	N	DSI	02H	+0.00	0.45	N
D	30	103	N	DSI	02H	+0.06	0.24	N
D	31	65	N	DSI	02H	+0.16	0.23	N
D	31	75	N	DSI	02H	-0.03	0.36	N
D	31	82	N	DSI	02H	+0.03	0.72	N
D	32	87	N	DSI	03H	+0.00	0.21	N
D	33	34	N	DSI	04H	+0.19	0.37	N
D	33	94	N	DSI	02H	+0.08	0.5	N
D	34	19	N	DSI	02H	+0.06	0.62	N
D	35	18	N	DSI	02H	+0.03	0.45	N
D	35	83	N	DSI	04H	+0.05	0.15	N

TABLE 9-1
STP-1 FIELD BOBBIN CALLS FOR DSIs AT H/L TSPs
1995 INSPECTION

S/G	ROW	COL	PLUGGED	IND	LOCATION		FIELD VOLTS	MRPC CONFIRM
D	35	83	N	DSI	02H	+0.03	0.14	N
D	35	88	N	DSI	04H	-0.03	0.31	N
D	35	91	N	DSI	04H	-0.05	0.4	N
D	35	94	N	DSI	03H	-0.03	0.42	N
D	35	96	N	DSI	04H	-0.08	0.44	N
D	36	73	N	DSI	02H	+0.03	0.31	N
D	37	32	N	DSI	02H	+0.00	0.98	N
D	37	35	N	DSI	03H	+0.13	0.38	N
D	37	82	N	DSI	04H	+0.03	0.22	N
D	37	87	N	DSI	03H	+0.03	0.45	N
D	37	90	N	DSI	02H	+0.08	0.66	N
D	38	64	N	DSI	02H	-0.08	0.41	N
D	39	64	N	DSI	07H	+0.00	0.15	N
D	39	64	N	DSI	05H	-0.05	0.22	N
D	39	82	N	DSI	02H	+0.03	0.73	N
D	40	64	N	DSI	04H	+0.08	0.81	N
D	43	88	N	DSI	02H	+0.19	0.2	N
D	45	67	N	DSI	02H	-0.03	0.53	N

Note: During the 1RE05 Eddy Current Inspection at STP-1, the Voltage Based Repair Criteria was not approved for implementation. During the RPC examination, certain locations did not exhibit axial crack-like indications. They were classified as volumetric in nature. Therefore it was concluded by HL&P that these indications did not compromise the integrity of the tube, did not require to be repaired under the current Technical Specifications, and thus were left in service during Cycle 6. However, upon implementation of the voltage-based repair criteria, at STP-1, all indications that confirm with RPC, will be repaired. Those indications greater than the upper voltage repair limit will be repaired regardless of their RPC confirmation.

TABLE 9-2

BOUNDING VOLTAGE GROWTH DISTRIBUTION FOR SOUTH TEXAS PROJECT UNIT 1

[

] d[FP]

FIGURE 9-1

STP-1 S/G C BOC 6

VOLTAGE DISTRIBUTION

[

]d^{FP}

FIGURE 9-2

STP-1 BOUNDING VOLTAGE GROWTH DISTRIBUTION

(FROM TABLE 9-2)

[

] d[FP]

FIGURE 9-3
STP-1 C S/G EOC 6
PREDICTED VOLTAGE DISTRIBUTION

[

]d[FP]

This Page Left Blank

10.0 **PROBABILITY OF BURST**

10.1 Introduction

Calculation of conditional burst probability should be performed per the guidance of Section 2.a of Enclosure 1 of the Generic Letter. This is a calculation to assess the voltage distribution of the indications left in service against a threshold value.

Per the Generic Letter, Licensees should perform an evaluation prior to plant restart to confirm that the steam generator tubes will retain adequate structural and leakage integrity until the next scheduled inspection. The first portion of this evaluation, referred to as the conditional burst probability calculation, assesses the voltage distribution of the axial ODSCC indications left in service against a threshold value of 1×10^{-2} probability of rupture under postulated main steam line break (MSLB) conditions. The conditional burst probability calculation is intended to provide a conservative assessment of tube structural integrity during a postulated MSLB occurring at end-of-cycle (EOC). It is used to determine whether the NRC needs to focus additional attention on the particular voltage repair limit application. If the calculated conditional burst probability exceeds 1% or 1×10^{-2}, the licensee should notify the NRC per the guidance provided in Section 6 of the Generic Letter.

STP-1 Compliance with Requirement

10.1.1 STP-1 Probability of Burst

In compliance with Section 2.a of Enclosure 1 of the Generic Letter, a conditional probability of burst will be calculated for South Texas Unit 1 at the end of each cycle where ARC was implemented. The most limiting probability of burst (POB) was [ ]d^{FP} in the 'C' SG compared to the 1×10^{-2} threshold level identified by the staff as not requiring additional evaluation or justification.

The value was determined in accordance with the methodology described in Section 10.2. This method utilizes Monte Carlo simulations in accordance with 2.b.2 of Enclosure 1 of the Generic Letter and Reference 26. The Monte Carlo program accounts for defect growth and ECT uncertainties as discussed in Section 9. The program also accounts for uncertainties in the burst pressure vs. voltage correlation and material properties. The Monte Carlo method will be utilized in the determination of tube burst probabilities for future inspection outages.

10.2 Conditional Probability of Burst During MSLB

For the Generic Letter, the conditional probability of burst refers to the probability that the burst pressure associated with 1 or more indications in the faulted steam generator will be less than the maximum pressure differential associated with a postulated MSLB (2560 psid) assumed to occur at EOC. A methodology should be submitted for NRC review and approval for calculating this conditional burst probability. After the NRC approves a method for calculating conditional probability of burst, licensees may reference the approved method. This methodology should involve (1) determining the distribution of indications as a function of their voltage response at beginning of cycle (BOC), as discussed in Section 2.b.1 of Enclosure 1 of the Generic Letter, (2) projecting this BOC distribution to an EOC voltage distribution based on consideration of voltage growth due to defect progression between inspections, as discussed in Section 2.b.2(2) and voltage measurement uncertainty, as discussed in Section 2.b.2(1), and (3) evaluating the conditional probability of burst for the projected EOC voltage distribution using the correlation between burst pressure and voltage discussed in Section 2.a.1. The solution methodology should account for uncertainties in voltage measurement (Section 2.b.2(1)) the distribution of potential voltage growth rates applicable to each indication (Section 2.b.2(2)), and the distribution of potential burst pressure as a function of voltage (Section

2.a.1). Monte Carlo simulations constitute an acceptable approach for accounting for these various sources of uncertainty.

STP-1 Compliance with Requirement

In compliance with 2a items (1) and (2) of Enclosure 1 of the Generic Letter, a BOC voltage distribution was determined and this distribution was projected to an EOC voltage distribution as discussed in Section 9 of this report. In compliance with 2a, item (3), of the Generic Letter for evaluating the conditional probability of burst, a Monte Carlo simulation was utilized. This method is discussed below.

In the Monte Carlo simulation, a burst pressure is calculated for each indication. This burst pressure is based on the end-of-cycle voltage as determined in Section 9. The calculated burst pressure is then compared to the accident pressure differential to determine if that tube would burst under accident conditions.

The burst pressure calculation accounts for uncertainties in the burst pressure vs. bobbin voltage model as specified in the Generic Letter, as well as material properties associated with the tubes. [

]d[FP]

The first step in the random estimation of the correlation is to calculate a random variance of the error of the burst

pressure about the regression line.

$$\sigma^2_{random} = \frac{n-2}{\chi^2_{(n-2),random}} \sigma^2_{reg} = f_v \sigma^2_{reg}$$

Eq. 10-1
[26]

where

n	=	number of data pairs
χ^2	=	random deviate from the Chi-square distribution for n-2 degrees of freedom
σ_{reg}	=	variance from the regression data

Therefore, the random standard deviation can be calculated as:

$$\sigma_{random} = \alpha_2 = \sigma_{reg}\sqrt{f_v}$$

Eq. 10-2

where

f_v	=	factor as defined in Eq. 10-1

The random intercept for the regression is calculated as:

$$\alpha_0 = a_0 + Z_1\sqrt{V_{11}}$$

Eq. 10-3
[26]

where

a_0	=	intercept from the regression equation
Z_1	=	a random normal deviate
V	=	value from the estimated variance-covariance matrix of the parameters

The random slope is calculated as:

$$\alpha_1 = a_1 + Z_2 \frac{V_{12}}{\sqrt{V_{11}}} + Z_3 \sqrt{V_{22} - \frac{V_{21}^2}{V_{11}}}$$

Eq. 10-4
[26]

where

a_1	=	slope from the regression equation
Z_2, Z_3	=	random normal deviates
V_{ij}	=	values from the estimated variance-covariance matrix of the parameters

The values for the estimated variance-covariance matrix of the parameters are calculated as follows.

$$V_{ij} = f_V V_{ij_{reg}}$$

Eq. 10-5
[26]

where

$V_{ij(reg)}$	=	values for the variance-covariance matrix from the regression data

The estimated parameters of the correlation as calculated above are then used to estimate a burst pressure for each indication.

$$P_{ref} = \alpha_0 + \alpha_1 \log(V_i) + Z_i \alpha_2$$

Eq. 10-6
[26]

where

P_{ref}	=	burst pressure corresponding to material with the reference flow stress

This value must now be corrected for the varying material properties. A random estimate of the flow stress is obtained as:

$$S_i = S_m + t\sigma_S$$

Eq. 10-7
[26]

where

S_m = mean flow stress
t = random t-distribution value
σ_s = standard deviation of the flow stress

The mean and standard deviation of the flow stress for Westinghouse 3/4 inch tube material is shown in Table 10-1.

Table 10-1
Material Properties For
Westinghouse Alloy 600 Mill Annealed 3/4" x 0.043" Tubing [26]

Yield Strength Mean	45.78 ksi
Tensile Strength Mean	97.35 ksi
Flow Stress Mean	71.57 ksi
Flow Stress Standard Deviation	3.5668 ksi
Sample Size	627

The final estimate of the burst pressure is then calculated as:

$$P_i = P_{ref} \frac{S_i}{S_{ref}}$$

Eq. 10-8
[26]

This value for the burst pressure is compared to the MSLB differential pressure to determine if the tube would burst under accident conditions.

Burst pressures are calculated for each indication in the steam generator. The number of indications with burst pressures resulting in failures is counted for each trial. If the number of indications resulting in a burst in a single trial is greater than or equal to one, then that trial is counted as one trial with a burst. Due to application of the 0.6 probability of detection, some of the voltage bins may contain fractional parts of indications (e.g., 0.3 or 0.7). The tails of the distribution are not integrated to a pre-determined value. The probability of burst program accounts for all fractional portions of an indication by running that fractional amount through the burst correlation. If, due to these fractional indications, the number of indications resulting in a burst in a single trial is less than one, then that fractional value is added to the number of trials with a burst tube.

The best estimate for the probability of burst is the number of trials with a burst divided by the total number of trials. The 95% upper confidence limit for the probability of burst is calculated using a set of subroutines. The bases of these routines is contained in Reference 29. The source of the approximations used in these routines is Reference 30.

The results of the STP-1 probability of burst evaluation are summarized in Table 10-2 below. These results were obtained by running the Monte Carlo simulation for 1×10^6 trials.

TABLE 10-2

STP-1 EOC-6 PROBABILITY OF BURST RESULTS

[

]d[FP]

10.3 Burst Pressure Versus Bobbin Voltage

Per the Generic Letter, an empirical model, for 3/4-inch diameter tubing, should be used to relate burst pressure to bobbin voltage response for purposes of estimating the conditional probability of burst during a postulated MSLB. This model should explicitly account for burst pressure uncertainty as indicated by scatter of the supporting test data and should also account for the parametric (i.e., slope and intercept) uncertainty of the regression fit of the data. The supporting data sets for 3/4-inch diameter tubing include all applicable data consistent with the industry recommendations as stated in the Generic Letter.

STP-1 Compliance with Requirements

10.3.1 Burst Pressure - Voltage Correlation Database

To comply with Section 2.a.1 of Enclosure 1 of the Generic Letter a correlation between burst pressure and bobbin voltage amplitude was developed by EPRI[3]. The relationship between burst pressure and voltage is used to establish a voltage threshold to ensure that the structural requirements of Regulatory Guide 1.121 are satisfied during normal operating and postulated

accident loading conditions. The correlation for the 3/4-inch diameter tubing is based on 45 model boiler specimens and 46 pulled-tube specimens from operating plants as summarized in Table 10-3. The data from tests of pulled tubes and model boiler specimens were combined to form an aggregate database which was then used to develop the burst pressure correlations described later.

The database used for the development of the burst correlation (Burst Strength vs. Bobbin Coil Voltage Amplitude) for 3/4 inch diameter tubing is derived from model boiler specimens and pulled tubes. All of the data were derived from Alloy 600 tubing with 3/4 inch OD and 0.043 inch nominal wall thickness. The model boiler test results for 3/4 inch tubing are described in detail in Reference 3.

On the basis of References 27, exclusion of data criteria 1-3 , all data were reviewed by EPRI for identification of data which were excluded from the databases supporting the ARC correlations for ODSCC. Table 10-4 summarizes the data removed from the burst database by EPRI [27,28]. Per the Generic Letter [1], data excluded under criteria 1, 2a, and 2b are acceptable exclusion criteria. The data excluded from the EPRI database was reviewed by FTI for this evaluation. FTI concurs that the excluded data meets the criteria contained Reference 27 and 28 and therefore was not included in this evaluation.

10.3.2 Burst Pressure Correlation for 3/4" Dia. Tubing

The bobbin coil voltage amplitude and burst pressure data of Table 10-3 were used to determine a correlation between burst pressure and bobbin voltage amplitude. The data considered are shown in Figure 10-1 along with the results of the correlation analyses.

From the methodology discussed in Section 6 of Reference 3, the correlation line for the burst-voltage correlation is given by:

[

]e^{FP} Eq. 10-9

[3]

where the burst pressure is measured in ksi and the bobbin amplitude is measured in volts. The correlation line from the equation above is shown in Figure 10-1.

Per Enclosure 1 of the Generic Letter, Section 2.a.1, the burst pressure model should account for data scatter of the linear regression fit. Therefore, the residual values were plotted against the predicted burst pressures. The results, shown in Figure 10-2, indicate a scatter about a mean of zero for the full range of predicted burst pressures. Per Reference 3, this scatter for the data indicates an acceptable set of data points and an acceptable correlation.

A cumulative probability plot of the ordered residuals was also prepared and is shown in Figure 10-3. Verification of the regression is obtained by plotting the ordered residuals on normal probability paper. Since the data form a straight line, it has been shown that the distribution of the residuals is normal, as proven in Reference 3.

In order to determine the voltage structural limit (V_{SL}) for STP-1, the 95% prediction bound was reduced to a level corresponding to the 95%/95% lower tolerance limit (LTL) for the material properties of the tubes. The estimated standard deviation of the residuals, i.e., the error of the estimate, S_p,

of the burst pressure was 0.91 ksi. The lower 95% prediction curve adjusted for 95%/95% lower tolerance limit on material properties, is defined by the equation:

[

]^{EP} Eq. 10-10
[6]

where:
σ = (Su + Sy) at 650 ^{0}F
Su = tube material ultimate tensile strength
Sy = tube material yield strength
a_0 = constant from regression [Eq. 10-9]
a_1 = Slope from regression [Eq. 10-9]
V_i = Voltage
P_{Bi} = Mean Burst Pressure at (V_i)
t = Student's t-distribution value corresponding to the upper tail area of 5%
S_p = Standard Deviation of Residuals (error of estimate)
n = Total number of data points used
j = index
BarV_0 = average of the voltages

A Monte Carlo simulator is used to predict EOC voltages as an input to the probability of burst model. Each resulting EOC voltage is processed via a "randomized regression" version of the burst pressure-voltage correlation, where the intercept and slope are randomly taken from their bivariate normal distribution. The t-distribution with n-2 degrees of freedom is also randomly chosen for the simulation. The simulator also randomly samples from a uniform distribution of the material properties of the tubes. A mean value of flow stress of 71.57 and a flow stress standard deviation of 3.5668 from a sample size of 627 samples was used per Reference 26 for the material

properties of 3/4" Alloy 600 mill annealed SG tubing. The predicted probability of burst is then calculated from the simulation.

In order to determine the repair limit (Section 6) for STP-1, the voltage structural limit at MSLB conditions is calculated utilizing Equation 10-10. Using this Equation, the V_{SL} corresponding to 1.43 times faulted differential pressure, or [ ]d[FP] ksi, is [ ]d[FP] volts. The [ ]d[FP] ksi pressure differential is 1.43 x ΔP_{MSLB}, where ΔP_{MSLB} is equal to [ ]d[FP]. The lower 95% prediction bound for LTL material property is shown in Figure 10-1.

10.4 South Texas Project Unit 1 Data from Pulled Tubes

During the 1RE04 and 1RE05 refueling outages, STP-1 pulled tubes containing an axial ODSCC-type indications in the TSP regions. The testing procedure and pulled tube burst test data from South Texas is described in detail in Reference 4 and Reference 32. The burst test result from the STP-1 pulled tubes are shown in Table 10-3 and Figure 10-1.

TABLE 10-3 [27,28]

VOLTAGE-BURST-LEAK RATE-PROBABILITY OF LEAK DATA TABLE

[

] EP

TABLE 10-3 [27,28]

VOLTAGE-BURST-LEAK RATE-PROBABILITY OF LEAK DATA TABLE

[

] EP

TABLE 10-3 [27,28]

VOLTAGE-BURST-LEAK RATE-PROBABILITY OF LEAK DATA TABLE

[

]EP

TABLE 10-3 [27,28]

VOLTAGE-BURST-LEAK RATE-PROBABILITY OF LEAK DATA TABLE

[

] EP

TABLE 10-3 [27,28]

VOLTAGE-BURST-LEAK RATE-PROBABILITY OF LEAK DATA TABLE

[ ]

] EP

TABLE 10-3 [27,28]

VOLTAGE-BURST-LEAK RATE-PROBABILITY OF LEAK DATA TABLE

[

]EP

* Plant AC-1 is South Texas Unit 1 ARC Pulled Tube Data.

NOTES:

1. All voltages normalized to the recommended values of Reference 27,28.
2. MSLB leak rates are adjusted to reference ΔP shown.
3. Normalized to 150 ksi flow stress (sum of yield and ultimate stress).
4. Column indicates application of specimen in leak rate and/or burst correlation. 0 = No, 1 = Yes
5. Leak rate inferred from destructive examination crack morphology.
6. N.R. - Not Reliable, not used in leak rate correlation.
7. Burst tests performed with TSP constraint; data not used in ARC burst correlation.
8. Included per NRC directive.
9. Data excluded per outlier criteria 2a.
10. Burst test showed insignificant extension at the corrosion crack tips. Therefore, the burst pressure is a minimum value since burst is defined to include crack extension.
11. Data meeting exclusion criteria 3.

TABLE 10-4 [27,28]
BASIS FOR EXCLUDING DATA FROM THE 3/4 INCH
BURST CORRELATION

[

] EP

FIGURE 10-1 [27,28]
BURST PRESSURE vs. BOBBIN AMPLITUDE
FOR 3/4 INCH ALLOY 600 S/G TUBE
MODEL BOILER AND FIELD DATA

[

] d^FP

FIGURE 10-2 [27,28]

BURST PRESSURE vs. BOBBIN AMPLITUDE

RESIDUALS vs. PREDICTED VALUES

[

] d FP

FIGURE 10-3 [27,28]
BURST PRESSURE vs. BOBBIN AMPLITUDE
ACTUAL vs. EXPECTED CUMULATIVE PROBABILITY

[

] d^FP

11.0 **EVALUATION OF LEAKAGE**

11.1 Introduction

Calculation of leakage should be performed per the guidance of Section 2.b of Enclosure 1 of the Generic Letter. This calculation, in conjunction with the use of licensing basis assumptions for calculating offsite releases, enables licensees to demonstrate that the applicable limits of 10 CFR 100 continue to be met.

Per the Generic Letter, a methodology should be submitted for calculating the total primary-to-secondary leak rate in the faulted steam generator during a postulated MSLB assumed to occur at EOC. This methodology involves (1) determining the distribution of indications as a function of their voltage response at beginning of cycle (BOC) as discussed in Section 2.b.1, (2) projecting this BOC distribution to an EOC voltage distribution based on consideration of voltage growth due to defect progression between inspections as discussed in Section 2.b.2(2) and voltage measurement uncertainty as discussed in Section 2.b.2(1), and (3) evaluating the total leak rate model as discussed in Section 2.b.3(2). The solution methodology should account for uncertainties in voltage measurement (Section 2.b.2(1)), the distribution of potential voltage growth rates applicable to each indications (Section 2.b.2(2)), the uncertainties in the probability of leakage as a function of voltage (Section 2.b.3(1)), and the distribution of potential conditional leak rates as a function of voltage (Section 2.b.3(2)). Monte Carlo simulations are an acceptable method for accounting for these sources of uncertainty provided that the calculated total leak rate reflects an upper 95% quantile value.

This portion of the tube integrity evaluation is intended to assure that the total leak rate from the affected steam generator (SG) during a postulated MSLB occurring at EOC would be less than that which could lead to radiological releases in excess of the licensing basis for the plant. If calculated leakage exceeds the allowable limit determined by the

licensing basis dose calculation, licensees can either repair tubes, beginning with the largest voltage indications until the leak limit is met, or reduce reactor coolant system specific iodine activity.

11.2 Calculation of Projected MSLB Leakage

Using the projected EOC voltages as calculated from the method presented in Section 9, the leakage for the postulated MSLB is calculated utilizing two models: (1) the probability of leakage model and (2) the conditional leak rate model. As previously discussed in Section 2.b of the Generic Letter, Monte Carlo techniques are an acceptable approach for accounting for uncertainties implicit in these models.

STP-1 Compliance with Requirements

11.2.1 Calculation of Projected MSLB Leakage for STP-1

In compliance with Section 2.b.3 of the Generic Letter, the probability of leakage correlation and the conditional leak rate correlation provide the basis for a best-estimate ODSCC leak rate model. The methodology described in Section 11.3 and 11.4 of this report is consistent with that prescribed by Reference 6 and 26.

The probability of leakage (POL) model for STP-1 was developed using field and laboratory data provided by EPRI [3,6,27,28]. Due to a number of uncertainties in the input variables to the ODSCC leak rate model, the leak rate for an individual tube may deviate from the value predicted by this correlation.

A Monte Carlo simulator is used to predict the leak rate under MSLB conditions at EOC. The simulator program accounts for the uncertainties by randomly varying the parameters of both the POL and leak rate correlations. The random values for the slope, intercept, and standard deviation are determined in accordance with Reference 26. This procedure is similar to the method described in Section 10 for the burst pressure correlation. The random correlation parameters are used for all of the EOC voltages for a single trial. At the beginning of the next trial, a new set of parameters are estimated.

For the POL correlation, the values of the parameters are randomly estimated as follows.

$$\eta_0 = n_0 + Z_1\sqrt{V_{11}}$$

Eq. 11-1
[26]

$$\eta_1 = n_1 + Z_2\frac{V_{12}}{\sqrt{V_{11}}} + Z_3\sqrt{V_{22} - \frac{V_{21}^2}{V_{11}}}$$

Eq. 11-2
[26]

where

χ^2 = random deviate from the Chi-square distribution for n-2 degrees of freedom

Z_i = a random normal deviate

n_0, n_1 = parameters from the regression data

V_{ij} = values from the estimated variance-covariance matrix

Since the data for the POL correlation are binary, there is no standard deviation term to estimate.

For the leak rate correlation, the standard deviation can be estimated as:

$$\sigma_{random}=\sigma_{reg}\sqrt{\frac{n-2}{\chi^2_{(n-2),random}}}=\sigma_{reg}\sqrt{F_v}$$

Eq. 11-3
[26]

where

n	=	number of data pairs
σ_{reg}	=	standard deviation from regression data
$\chi 2$	=	random deviate from the Chi-square distribution for n-2 degrees of freedom

The random intercept for leak rate correlation is estimated as:

$$\beta_0=b_0+Z_1\sqrt{V_{11}}$$

Eq. 11-4
[26]

where

b_0	=	intercept from the regression equation
Z_1	=	a random normal deviate
V_{ij}	=	value from the estimated variance-covariance matrix of the parameters

The random slope for the leak rate correlation is estimated as:

$$\beta_1 = b_1 + Z_2 \frac{V_{12}}{\sqrt{V_{11}}} + Z_3 \sqrt{V_{22} - \frac{V_{21}^2}{V_{11}}}$$

Eq. 11-5
[26]

where

b1	=	slope from the regression equation
Zi	=	random normal deviates
Vij	=	values from the estimated variance-covariance matrix of the parameters

The values for the estimated variance-covariance of the parameters are calculated as:

$$V_{ij}=f\;V_{.j(reg)}$$

Eq. 11-6
[26]

where

fv	=	factor as defined in Eq. 11-3
$V_{ij(reg)}$	=	values for the variance-covariance matrix from the regression data

After all of the parameters are estimated, the end-of-cycle voltages are calculated as discussed in Section 9. For each EOC voltage, a probability of leakage is calculated using the estimated parameters. A random number between 0 and 1 is then selected from a uniform distribution and is compared to the estimated POL value. If the random number is greater than the POL, then that indication is considered to have no leakage under MSLB conditions. In this case, a leak rate calculation is not necessary and the program returns to calculate the POL for the next EOC voltage. If the random number is less than the

POL, then the indication is considered to leak. For those EOC voltages that result in leakage, the amount of leakage must be calculated from the estimated leak rate parameters. This random estimated leak rate is calculated as:

$$Q_i=10^{\beta_0+\beta_1\log(V_i)+Z_4\sigma_{random}}$$

Eq. 11-7
[26]

This leak rate is added to a summing variable which totals the leak rates for all of the indications in the steam generator which result in leakage. After all of the BOC indications have been processed, the total leak rate for that trial is saved to a file and another trial is started.

At the end of the last Monte Carlo trial, the data in the file containing the individual trial leak rates for the steam generator is sorted, and a 95%/95% one-sided upper tolerance limit is determined on a distribution-free basis. This is done to ensure a conservative measure of the leak rate for the faulted steam generator under MSLB conditions. Reference 31 explains the method used to determine the 95%/95% one-sided upper tolerance limit.

The 95%/95% one-sided upper tolerance limit for leakage calculated during MSLB at EOC 06 at STP-1 is approximately [ ]d[FP] for steam generator C. For an accident, this leakage must be evaluated in the form of offsite dose release per 2.b.4 of the Generic Letter and is addressed in Section 11.5 of this report. The results for all of the STP-1 steam generators are shown in Table 11-1.

TABLE 11-1

PROJECTED EOC-6 LEAK RATE

[

]d^FP

11.3 Probability of Leakage as a Function of Voltage

The probability of leakage (POL) model should utilize the log-logistic functional form [1]. This model should explicitly account for parameter uncertainty of the POL functional fit of the data. The supporting data sets for 3/4-inch diameter tubing include all applicable data consistent with industry recommendations as stated in the Generic Letter.

STP-1 Compliance with Requirements

11.3.1 Probability of Leakage Model

Per the Generic Letter, once the EOC distribution has been determined, the probability of leakage (POL) needs to be evaluated. Probability of leakage is determined from the magnitude of the bobbin coil voltage measurement for a specific TSP intersection. For a number of TSP intersections containing equal amounts of degradation, based on voltage, a proportion is statistically predicted to be leakers, while the remaining proportion is predicted to be non-leaking.

Based on industry test data, the logistic function best represents the probability of leakage (POL) and therefore was used for the leak rate model [6]. This probability distribution function is appropriate for binary-type variables, such as the leak/no-leak designation. The POL for an ODSCC produced voltage measurement at a specific TSP location is therefore determined by:

[

]EP Eq. 11-8
[6]

where: P = probability of leakage
V = voltage measurement at TSP location
n_0 = coefficient determined from analysis
n_1 = coefficient determined from analysis

The parameters of the logistic function are determined from an iterative maximum likelihood procedure which is applied to the leak/no-leak data.

A probability of leak model was developed using the method described in Appendix D of Reference 6. A logistic regression fitting procedure from Reference 24 was applied to the data set shown in Table 1 of Reference 27 and amended by Reference 28.

On the basis of the Reference 27 and 28 exclusion criteria 1-3, all data documented in Reference 27 and 28 were reviewed by EPRI for identification of data which were excluded from the databases supporting the ARC correlations for ODSCC. FTI

excluded data on the basis of Criteria 1 and 2 in this analysis based on review of the data and the requirements of the Generic Letter. The data excluded from the probability of leakage correlation are summarized in Table 11-3 of this report.

The resulting parameter estimates for the POL model are depicted in Table 11-2, below. The factors needed to estimate the uncertainty for the POL model were computed using the method shown in Reference 6., Appendix D. The values for the variance-covariance estimates are also listed below.

TABLE 11-2

PROBABILITY OF LEAKAGE PARAMETERS

[

]EP

where: n_0 = coefficient determined from analysis
n_1 = coefficient determined from analysis
Γ_{11} = variance-covariance value determined from the analysis
Γ_{12} = variance-covariance value determined from the analysis
Γ_{13} = variance-covariance value determined from the analysis

11.4 Conditional Leakage Rate under MSLB Conditions

The conditional leak rate model should incorporate a linear regression fit to the log of the leak rate data for 3/4-inch diameter tubing, as a function of the log of the bobbin voltage and should account for both data scatter and parameter uncertainty of the linear regression fit. Use of this approach is subject to demonstrating that the linear regression fit is valid at the 5% level with a "p-value" test. If this condition is not satisfied, the linear regression fit should be assumed to have zero slope (i.e., the linear regression fit should be assumed to be constant with voltage).

The supporting data set for 3/4-inch diameter tubing includes all applicable data consistent with the industry recommendations as stated in the Generic Letter.

STP-1 Compliance with Requirements

11.4.1 Conditional Leak Rate versus Voltage Model Database

In compliance with 2.b.3(2) of Enclosure 1 of the Generic Letter, the database used for the development of the leak rate correlation (MSLB Leak Rate versus Bobbin Coil Voltage Amplitude) for 3/4 inch diameter tubing is derived from model boiler specimens and pulled tubes. All of the data were derived from Alloy 600 tubing with 3/4 inch OD and 0.043 inch nominal wall thickness. The model boiler test results for 3/4 inch tubing are described in detail in Reference 3. The database used for the Leak Rate - Voltage correlation is shown in Table 10-3 of this report.

On the basis of the Reference 3 exclusion criteria 1-3, all data documented in References 3, 27 and 28 were reviewed by EPRI for identification of data which were excluded from the databases supporting the ARC correlations for ODSCC. FTI excluded data on the basis of Criteria 1 and 2 in this analysis

based on review of the data and the requirements of the Generic Letter. Table 11-4 summarizes the data removed from the leak rate correlation database by EPRI [3, 27, 28].

11.4.2 Leak Rate Versus Voltage Correlation

The bobbin coil voltage amplitude and leak rate data of Table 10-3 were used to determine a correlation between leak rate and bobbin voltage. The data considered are shown in Figure 11-1 along with the results of the correlation analyses.

From the methodology discussed in Section 7 of Reference 3, the correlation between leak rate and bobbin voltage is achieved by considering the log of the voltage as the independent variable and the log of the leak rate as the dependent variable. The correlation line for the leak rate-voltage correlation for 46 data points is given by:

$$\log(Q) = b_0 + b_1 \log(V)$$

where:
- b_0 = [ ]d^FP
- b_1 = [ ]d^FP
- Q = Leak Rate (l/hr)
- V = Voltage

Therefore: log(Q) = [ ]d^FP

Eq. 11-9

Solving for Q gives the following equation.

$$Q = 10^{b_0 + b_1 \log(v)}$$

Eq. 11-10

The error of the estimate from the evaluation, S_p, was 0.7884. A 95% prediction band for individual values of leak rate, Q_j, as a function of voltage was also calculated per for following equation:

[

]EP Eq. 11-11

[3]

where: b_0 = constant from regression [Eq.11-9]

b_1 = constant from regression [Eq.11-9]

V_i = Voltage

Q_i = Leak Rate at (Vi)

t = Student's t-distribution corresponding to the upper tail area of 5%

S_p = Standard Deviation of Residuals (error of estimate)

n = number of data points used

j = index

Bar V_0 = average of the voltages

A plot of the expected leak rate is provided in Figure 11-1.

11.4.3 Analysis of Residuals

Per the Generic Letter Section 2.b.3(2), the leak rate model should account for data scatter of the linear regression fit. Figure 11-2 shows the scatter plot of the log(Q) residuals as a function of the prediction log(Q) for the MSLB pressure of [ ]dFP The arrangement of the points is non-descript, indicating no apparent correlation between the residuals and the predicted values.

The cumulative probability plot prepared for MSLB differential pressure of [ ]d^{FP} psi is shown in Figure 11-3. A straight line is approximated, typical of the behavior of normally distributed residuals.

Given the results of the residuals scatter plot and the normal probability plot, it is appropriate to use the regression curve and statistics can be used for the prediction of leak rate as a function of bobbin amplitude, and for the establishment of statistical inference bounds.

11.5 Calculations of Offsite and Control Room Doses

For the MSLB leak rate calculated above, offsite and control room doses should be calculated utilizing currently accepted licensing basis assumptions. Licensees should note that Enclosure 2 of the Generic Letter provides example Technical Specification (TS) pages for reducing reactor coolant system specific iodine activity limits. Reactor Coolant system iodine activities may be reduced to .35 microcurie per gram dose equivalent I-131. Licensees wishing to reduce iodine activities below this level should provide a justification supporting the request that addresses the release rate data. Reduction of reactor coolant iodine activity is an acceptable means for accepting higher projected leakage rates and still meeting the applicable limits of 10 CFR 100 utilizing licensing basis assumptions.

STP-1 Compliance with Requirements

11.5.1 Leakage Evaluation Per 10 CFR 100

The maximum allowable end of cycle primary-to-secondary steam generator leak rate will be evaluated to determine whether the radiological consequences will remain within the limits of 10 CFR 100 and GDC 19 design criteria for STP-1 during a postulated main steam line break.

The evaluation will be based on an acceptance criteria of 30 rem thyroid dose at the Exclusion Area Boundary per the Standard Review Plan (NUREG 0800) Section 15.1.5, Appendix A. For the pre-accident spike, the initial primary coolant activity was 60 μCi/gm dose equivalent Iodine 131 (I 131), and for the concurrent spike the activity was 1 μCi/gm. The secondary coolant activity was 0.1 μCi/gm I 131. The leak rate in the three intact steam generators was assumed to be the proposed Technical Specification limit of 150 gallons per day (about 0.1 gpm) in each generator. The leak rate from the reactor coolant system was assumed to be 1 gpm also per the technical specification.

The activity released to the environment due to a main steam line break was analyzed in two distinct releases: 1. the release of the iodine activity that has been established in the secondary coolant prior to the accident, and 2. the release of the primary coolant iodine activity due to tube leakage. The bounding leak rate will be determined and maintained as part of the design basis.

The STP-1 EOC 6 predicted leakage is [ ]d[FP] gpm for the faulted steam generator (SG 'C') which is much less than the current design basis leakage of 1 gpm. Therefore, it is reasonable that the 150 gpd proposed technical specification limit per steam generator is sufficient to preclude unexpected crack propagation leakages which would result in a MSLB dose release in excess of 10 CFR 100 or GDC 19.

TABLE 11-3 [3,27,28]
BASIS FOR EXCLUDING DATA FROM THE 3/4" PROBABILITY OF LEAK CORRELATION

[

]FP

TABLE 11-4 [3,27]
BASIS FOR EXCLUDING DATA FROM 3/4"
LEAK RATE CORRELATION

[

Tu

]FP

FIGURE 11-1 [3,27]
2560 PSI MSLB LEAK RATE VS. BOBBIN AMPLITUDE
3/4" TUBES, MODEL BOILER AND FIELD DATA

[

] C^FP

FIGURE 11-2 [3,27]
RESIDUALS VS. PREDICTED LOG OF LEAK RATES
3/4" TUBES, MODEL BOILER AND FIELD DATA

[

] c^{FP}

FIGURE 11-3 [3,27]
CUMULATIVE PROBABILITY OF RESIDUAL LEAK RATES

[

] C^{FP}

This Page Left Blank

12.0 **OPERATIONAL LEAKAGE LIMITS**

12.1 Introduction

The operational leak limit is a defense-in-depth measure that provides a means for identifying leaks during operation to enable repair before such leaks result in tube failure.

Review of leakage monitoring measures includes the procedures for timely detection, trending, and response to rapidly increasing leaks. The objective is to ensure that should a significant leak be experienced in service, it will be detected and the plant shutdown in a timely manner to reduce the likelihood of potential tube rupture.

12.2 Operational Leakage Limits

Per the Generic Letter, the operational leakage limit should be reduced to 150 gallons per day (gpd) through each steam generator.

Licensees should review their plant specific leakage monitoring measures to ensure that if a significant in-service leak occurs, it will be detected and the plant shutdown in a timely manner to reduce the likelihood of tube rupture. Specifically, the effectiveness of the plants' procedures to ensure timely detection, trending, and response to rapidly increasing leaks should be assessed. Alarm setpoints on primary-to-secondary leakage detection instrumentation and the various criteria for specific operator actions in response to detected leakage must also be evaluated.

Steam generator tubes with known leaks should be repaired prior to returning the steam generators to service following a steam generator inspection outage.

STP-1 Compliance with Requirement

HL&P will, in its Revised Technical Specification submittal, commit to an operational leakage limit of 150 gpd per steam generator, for STP-1.

HL&P has reviewed STP-1 plant specific leakage monitoring procedures and actions to ensure that any leaks that develop during an operational cycle will be detected, trended, and the plant shutdown in a timely manner.

HL&P has committed to repair all tubes with known leaks prior to returning steam generators to service following an inspection outage.

13.0 REPORTING REQUIREMENTS

13.1 Introduction

Per Section 6 of Enclosure 1 of the Generic Letter, documentation reporting the EOC voltage distribution, cycle growth rate distribution, voltage distribution for EOC repaired indications (indications confirmed and unconfirmed by MRPC) and NDE uncertainty distribution in predicting the next EOC distribution shall be submitted to the NRC.

13.2 Threshold Criteria for Requiring Prior Staff Approval to Continue with Voltage-Based Criteria

This guidance allows licensees to implement the voltage-based repair criteria on a continuing basis after the NRC staff has approved the initial TS amendment. However, there are several situations for which the NRC staff must receive prior notification before a licensee can continue with the implementation of the voltage-based repair criteria:

13.2.a If the projected EOC voltage distribution results in an estimated leakage greater than the leakage limit (determined from the licensing basis calculation), then the licensee should notify the NRC of this occurrence and provide an assessment of its significance prior to returning the SGs to service. If it is not practical to complete this calculation prior to returning the SGs to service, the measured EOC voltage distribution can be used (from the previous cycle of operation) as an alternative (refer to Section 2.c of Enclosure 1 of the Generic Letter). If it is determined that the projected calculated leakage will exceed the leakage limit (during the operating cycle) after the SGs are returned to service, then licensees should provide an assessment of the safety significance of the occurrence, describe the compensatory measures being taken to resolve the issue, and follow any other applicable

reportability regulations.

13.2.b If (1) indications are identified that extend beyond the confines of the TSP or (2) indications are identified that appear to be circumferential in nature, or (3) are attributable to primary water stress corrosion cracking, the NRC staff should be notified prior to returning the steam generators to service.

13.2.c If the calculated conditional probability of burst based on the projected EOC voltage distribution exceeds 1×10^{-2}, licensees should notify NRC and provide an assessment of the significance of this occurrence prior to returning the steam generators to service. This assessment should address the safety significance of the calculated conditional probability. If it is not practical to complete this calculation prior to returning the SGs to service, the measured EOC voltage distribution can be used (from the previous cycle of operation) as an alternative (refer to Section 2.c of Enclosure 1 of the Generic Letter).

STP-1 Compliance with Requirements

13.2.1 STP-1 Threshold Criteria for Requiring Prior Staff Approval to Continue with Voltage-Based Criteria

Per Section 6.a of Enclosure 1 of the Generic Letter STP-1 will notify the NRC if the projected EOC voltage distribution results in an estimated leakage limit greater that the leakage limit determined in the licensing basis calculation and provide an assessment of its significance, prior to returning the SGs to service.

STP-1 will notify the NRC if axial indications that extend beyond the TSP, if PWSCC indications, or indications that appear to be circumferential in

nature are identified at TSP intersections, prior to returning the SGs to service.

STP-1 will notify the NRC if the calculated conditional probability of burst based on the EOC voltage distribution is greater than 1×10^{-2} and provide an assessment of the significance of this occurrence, prior to returning the SGs to service.

13.3 Information To Be Provided Following Each Restart

The following information should be submitted to the NRC staff within 90 days of each restart following a steam generator inspection:

(a) The results of metallurgical examinations performed for tube intersections removed from the steam generator. If it is not practical to provide all the results within 90 days, as a minimum, the burst test, leakage test and morphology conclusions should be provided within 90 days. The remaining information should be submitted when it becomes available.

(b) The following distributions should be provided in both tabular and graphical form. This information is to enable the staff to assess the effectiveness of the methodology, determine whether the degradation is changing significantly, determine whether the data supports higher voltage repair limits, and to perform confirmatory calculations:

(i) As found EOC voltage distribution - all indications found during the inspection regardless of MRPC confirmation

(ii) cycle voltage growth rate distribution (i.e., from BOC to EOC- the data should indicate whether the distribution has been adjusted for the length of the operating interval, and the length of the operating interval should be

provided (i.e.,in EFPY). The planned length of the next operating interval should also be provided (in EFPYs).

(iii) voltage distribution for EOC repaired indications - distribution of indications presented in (i) above that were repaired (i.e., plugged or sleeved)

(iv) voltage distribution for indications left in service at the beginning of the next operating cycle regardless of MRPC confirmation - obtained from (i) and (iii) above

(v) voltage distribution for indications left in service at the beginning of the next operating cycle that were confirmed by MRPC to be crack-like or not MRPC inspected

(vi) non-destructive examination uncertainty distribution used in predicting the EOC (for the next cycle of operation) voltage distribution.

(c) The results of the tube integrity evaluations described in Section 2 of Enclosure 1 of the Generic Letter and discussed in Sections 10.0 and 11.0 of this report. Note that these calculations must be completed prior to restart to ensure that an adequate number of tubes have been repaired to meet the leakage limit and ensure continued tube integrity.

STP-1 Compliance with Requirements

13.3.1 Information To Be Provided by STP-1 Following Restart

Consistent with the Generic Letter requirements discussed in Section 13.3 of this report, the following actions shall be taken to ensure that the NRC is aware of the on-going status of STP-1 ARC implementation. Beginning with the upcoming Refueling Outage 6 data for Unit 1 and subsequent outages;

(1) All indications found during the inspection regardless of MRPC confirmation will be reported to the NRC.

(2) The cycle growth rate distribution will be evaluated to determine whether the growth rate assumed remains bounding. The results of the growth rate distribution will be reported to the NRC. The cycle voltage growth rate distribution will indicate whether the distribution has been adjusted for the length of the operating interval, and the length of the operating interval will be provided (i.e.,in EFPY). The planned length of the next operating interval will also be provided (in EFPYs).

(3) Voltage distribution for EOC repaired indications that were repaired will be reported to the NRC.

(4) Voltage distribution for indications left in service at the beginning of the next operating cycle regardless of MRPC confirmation will be reported to the NRC.

(5) Voltage distribution for indications left in service at the beginning of the next operating cycle that were confirmed by MRPC or not MRPC inspected will be reported to the NRC.

(6) NDE uncertainty models used in the prediction of the EOC (Next cycle) voltage distribution will be provided to the NRC.

(7) The results of the pulled tube data per Section 8.0 shall be reviewed against the burst correlation data for continued applicability or adjustment. The metallurgical examination and testing results shall be reported. The inspection data shall be reviewed along with destructive examination results to verify that the morphology remains consistent with this submittal. Any indication of changing morphology or observation of cracks extending beyond the confines of the TSP shall be reported.

(8) Results of the tube integrity and leak rate evaluations described in Section 2 of Enclosure 1 of the Generic Letter to ensure that an adequate number of tubes have been repaired to meet the leakage limit and ensure continued tube integrity.

14.0 EXCLUSION OF INTERSECTIONS

Per the NRC Generic Letter, the alternate repair criteria (ARC) cannot be applied to;

1) Tube support plate intersections where the tubes may potentially collapse or deform following a postulated loss-of-coolant accident (LOCA) plus a safe shutdown earthquake (SSE) event.

2) Tube support plate intersections having dent signals greater than 5 volts as measured with the bobbin probe.

3) TSP locations where there are mixed residuals of sufficient magnitude to cause a 1-volt ODSCC indication (as measured with a bobbin probe) to be missed or misread,

4) Intersections with interfering signals from copper deposits, and

5) Tube-to-flow distribution baffle plate intersections except as discussed in Section 2.a.3 of Enclosure 1 of the Generic Letter.

The implementation of ARC for ODSCC at TSPs at STP-1 will not include any of the above intersections. Item 1 is addressed through analysis and is documented in this section of the report. Specifically, the tube locations adjacent to wedge supports at the upper tube support plates (TSPs) are of primary concern due to the potential yielding of the plate and subsequent deformation of the tubes during a MSLB. Items 2-4 are implementation issues which are addressed through eddy current inspection requirements as delineated in Appendix A. All of the intersections containing indications identified in 2-3 above, will be inspected with RPC and not have the ARC applied to bobbin coil signals there. Presently, STP-1 does not plan to utilize ARC at the flow distribution baffle (FDB) plate. STP-1 will provide the necessary justification per Section 2.a.3 of Enclosure 1 of the Generic Letter when

choosing to implement ARC at the FDB.

14.1 Background

The concern in applying ARC to tube support plate intersections near the wedge locations has the following basis. If a LOCA event were to occur coupled with a SSE event, the pressure (rarefaction) wave created primarily in the U-bend region will generate loads in the upper TSPs which are then reacted at the TSP-to-wrapper wedge locations. The loads generated may be exacerbated as a result of stimulation from SSE through acceleration or shaking of the steam generator. If the loads are of sufficient magnitude, deformation of the TSP in the vicinity of the wedge locations will occur, thereby deforming tubes in these areas as well. The significance of this deformation is related to the following scenario.

It may be possible that a significant amount of in-leakage occurs from secondary makeup water back to the core through opened ARC cracks in the tubes. Since the secondary side may still be near operating pressure, the large secondary-to-primary ΔP may force in-leakage back through primary piping to the core. This in-leakage has the potential of diluting the boron injection from the emergency core cooling system thus, decreasing the overall neutron poisoning effect of the boron. An analysis was performed, as discussed in the following section, to identify tube locations which may potentially exhibit this failure mode so that they are excluded from application of ARC.

14.2 Tube Deformation Analysis at Wedge Locations Due to LOCA & SSE

14.2.1 Description of Loads

LOCA loads are a resultant of pressure waves acting over various surfaces as a result of a postulated pipe break. The first and largest contributing load acting on the upper tube support plate is caused by the rarefaction wave. This is a pressure wave initiated at the break

location and travels through the tubes which causes a horizontal in-plane loading predominantly on the upper tube support plate. The second type of load is the LOCA shaking load. This load is due to the response of the RCS loop from the various hydraulic loadings. The third type of load is the seismic load. The LOCA loads are conservatively added together and a dynamic load factor is applied. The seismic load is probabilistically combined via the SRSS method with the LOCA load.

LOCA

As specified in GDC-4 (52 FR 41288), dynamic effects of pipe ruptures in nuclear power plant units may be excluded from the design basis provided it is demonstrated that the probability of pipe rupture is extremely low under conditions consistent with the design of piping. Dynamic effects covered by this rule are missile generation, pipe whipping, pipe break reaction forces, jet impingement forces, decompression waves within the ruptured pipe and dynamic or non-static pressurization in cavities, subcompartments, and compartments. The NRC has concluded in References 18 and 19 that STP-1 is in compliance with GDC-4. As such, it has been demonstrated that the probability of a rupture of the primary reactor coolant piping and the surge line is extremely low. Hence, the dynamic effects of postulated pipe ruptures of the large primary piping and the surge line are eliminated from the design basis at STP-1. (Note: The pressurizer surge line was requalified for LBB due to stratified loads per References 20 and 8). Thus, the design loadings are the smaller attachment line breaks. For the analysis of the upper tube support plate at STP-1, a 12" diameter schedule 140 attachment line was considered as the design break.

LOCA loads for STP-1 were developed based on loads from a similar replacement recirculating steam generator (RSG) model. The design load for the upper support plate

utilized a postulated break in a 14" diameter Schedule 140 attachment line versus that from a 12" diameter Schedule 140 line design break as described in Section 5.2. The RSG model loads were evaluated specifically for applicability to the South Texas Plant and were determined to be conservative [11]. Some of the conservatisms used in the analysis include the following:

- The loads were based on a larger attachment line break (14" diameter schedule 140 versus the actual STP-1 12" diameter schedule 140 line size).

- A stress-strain curve based on the ASME Code minimum yield and tensile strength properties for the support plate was used. It is highly likely that the actual material has greater than Code minimum properties.

- The increase in yield strength due to the rapidly applied load (high strain rate) was neglected.

- It was assumed that the tube deformation is equal to the hole ID deformation in the finite element analysis even though a gap may exist. Also, the TSP stiffness neglected any contribution provided by the tubing.

- It was assumed that the interface between the support plate and wedges is frictionless even though the wedges were snugly installed and are securely welded to wrapper support blocks.

- It was assumed that the entire LOCA rarefaction load is reacted out at the top support plate only.

The resulting load on the TSP due to the rarefaction wave was [ ]d^{FP} kips for STP-1. The associated shaking load was [ ]d^{FP} kips. These loads were conservatively added and a dynamic load factor of 2 was applied, yielding a total LOCA load of [ ]d^{FP} kips [15].

Seismic

The seismic loads considered result from ground motion during an earthquake. This motion causes an excitation of the steam generators in the form of acceleration response at the steam generator supports. The acceleration response is converted to a time history response to determine the load contribution within the tubes and support plates. The loading evaluation was previously performed and the results are contained in the stress report [15] as in-plane loading of the tube support plates. The SSE load was determined to be [ ]d^{FP} kips.

The total TSP load was determined to be [ ]d^{FP} kips by combining the LOCA loads probabilistically with the SSE load using SRSS [15].

14.2.2 Analysis Methodology

The steam generator upper tube support plate was input into an inelastic ANSYS finite element model to evaluate the two wedge groups for one quadrant (symmetry) as the bounding case for all wedge groups at the top support plate. An overall illustration of the model is provided in Figure 14-1. A detailed view of the elements modeled is provided in Figures 14-2 and 14-3. The total load of [ ]d^{FP} kips was applied to the finite element model. The loading and deformation results are provided in Reference 11. Each of the lower support plates were conservatively assumed to exhibit this worst case loading as well. However since the wedge groups are vertically aligned, the number of tubes affected is minimized. A

summary of the excluded tubes is provided in Section 14.3.

14.3 Summary of Excluded Tube Locations

Figure 14-4 provides a sketch of the tube bundle showing the TSP locations and designations for identifying the elevation of the wedge group locations. Figures 14-5 and 14-6 show the circumferential locations of the wedge groups for the tube support plates. The corresponding nomenclature from South Texas Project is also provided for additional information. The tube locations which deformed greater than the [ ]d^FP inch criterion as described in Section 5.3 were characterized through the analysis [11] as unacceptable. [

]d^FP Figures 14-7 through 14-10 summarize the exclusion tubes. Table 14-1 provides a summary of all excluded SG tubes due to deformation in the vicinity of the wedge locations.

The total number of tubes excluded per steam generator is[ ]d^FP. The most limiting wedge group location (32 degree reference) has [ ]d^FP tubes excluded due to tube deformation. This large number of tubes excluded is mainly the result of the previously described conservatisms used in developing and evaluating the analysis results. A submittal for another plant shows the limiting wedge group exclusion region to be approximately 30 tubes for a similar steam generator with slightly higher loading conditions from a large primary pipe break [16]. The exclusion region for STP-1 is nearly [ ]d^FP times as large, for the limiting wedge group. Thus, the number of tubes excluded at STP-1 is representative.

FIGURE 14-1

TSP MODEL

[

] d^{FP}

<u>FIGURE 14-2</u>

MODEL ELEMENTS 32 DEGREE WEDGE LOCATION

[

] d[FP]

FIGURE 14-3

MODEL ELEMENTS 16 DEGREE WEDGE LOCATION

[

] d[FP]

FIGURE 14-4

TUBE BUNDLE SHOWING TSP ELEVATIONS FOR IDENTIFYING WEDGE GROUPS

[

] d[FP]

<u>FIGURE 14-5</u>

WEDGE GROUP LOCATIONS: TSPs 1-11

[

]d[FP]

FIGURE 14-6

WEDGE GROUP LOCATIONS: TSP 12

[

]d[FP]

FIGURE 14-7

EXCLUDED TUBE REGION: TSPs 1-11

(NOZZLE SIDE)

[

]d^{FP}

Note: This drawing is a depiction of the tubes contained in this exclusion area. Only an actual tubesheet map should be used to show the exact tube exclusion locations.

FIGURE 14-8
EXCLUDED TUBE REGION: TSPs 1-11
(MANWAY SIDE)

[

] d^FP

Note: This drawing is a depiction of the tubes contained in this exclusion area. Only an actual tubesheet map should be used to show the exact tube exclusion locations.

FIGURE 14-9

EXCLUDED TUBE REGION: TSP 12

(NOZZLE SIDE)

[

] d[FP]

Note: This drawing is a depiction of the tubes contained in this exclusion area. Only an actual tubesheet map should be used to show the exact tube exclusion locations.

<u>FIGURE 14-10</u>

EXCLUDED TUBE REGION: TSP 12

(MANWAY SIDE)

[

] d[FP]

Note: This drawing is a depiction of the tubes contained in this exclusion area. Only an actual tubesheet map should be used to show the exact tube exclusion locations.

TABLE 14-1

SUMMARY OF TUBES TO BE EXCLUDED FROM ARC

[

]d^FP

This Page Left Blank

15.0 CONCLUSIONS

This assessment demonstrates that a correlation relating tube burst pressure to bobbin voltage and main steam line break (MSLB) leakage to bobbin voltage can be used to conservatively satisfy the Reg Guide 1.121 guidelines for tube integrity at South Texas Project Unit 1.

Application of the generic ODSCC ARC methodology developed through EPRI is appropriate for South Texas Unit 1 ODSCC flaws, satisfies the NRC Generic Letter requirements on ODSCC ARC, and is consistent with other approved ODSCC ARC methodologies.

Enclosure 1 of the Generic Letter consists of six sections of requirements for a licensee to include in a proposed program to implement ARC STP-1 complies with these as follows:

(1) Confirmation that the degradation mechanism is predominantly axial ODSCC confined to the TSP.

STP-1 Compliance with Requirement

During 1RE04 and 1RE05, STP-1 pulled 6 tubes to verify ODSCC is the dominant degradation mechanism at the TSP. The indications at the TSP were burst tested to demonstrate that the dominant mechanism affecting the burst and leakage properties of the tube is axially oriented ODSCC.

(2) Confirmation that the steam generator tubes will retain adequate structural and leakage integrity until the next scheduled inspection.

STP-1 Compliance with Requirement

Section 10 of this report discusses the methodology used to calculate the probability of burst for STP-1 EOC-6. The probability of burst for SG 'C' is [ ]d^{FP} for EOC-6, which is well within the threshold value of 1×10^{-2} provided by the NRC in the Generic Letter. Section 11 of this report

discusses the methodology used to calculate the predicted conditional MSLB leak rate of the steam generators at STP-1. For STP-1, EOC-6 leak rates were calculated for each steam generator. Steam generator 'C' had the largest leak rate of [ ]d[FP] gpd which is well within the current design basis of [ ]d[FP] gpd.

(3) Inspection scope, data acquisition, and data analysis should be performed in a manner consistent with the methodology utilized to develop the voltage limits.

STP-1 Compliance with Requirement

Section 7 and Appendix A of this report address the NDE inspection criteria and ECT analysis requirements to be followed during 1REO6 and future outages at STP-1 when implementing the ARC and, are in accordance with the requirements provided by the Generic Letter.

(4) Implementation of voltage-based plugging criteria should include a program of tube removals for testing and examination as described in Section 4 of Enclosure 1 of the Generic Letter.

STP-1 Compliance with Requirement

Section 8 discusses the requirements for tube removal and examination at STP-1 during 1RE05 and future outages.

(5) The operational leakage limit should be reduced to 150 gpd through each steam generator

STP-1 Compliance with Requirement

Section 12 of this report addresses operational leakage limits at STP-1. In compliance with the Generic Letter, STP-1 will review leakage monitoring measures to ensure that a significant leak will be detected.

(6) Reporting Requirements - amendment to the Technical Specifications

STP-1 Compliance with Requirement

STP-1 will submit the amendment to the TS with the submittal of this report to the NRC.

This Page Left Blank

16.0 REFERENCES

1. NRC Generic Letter 95-05: "Voltage-Based Repair Criteria for the Repair of Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking", August 3, 1995.

2. [

   ]EP

3. [

   ]EP

4. [

   ]cFP

5. NRC Regulatory Guide 1.121 "Bases for Plugging Degraded PWR Steam Generator Tubes", August 1976.

6. [

   ]EP

7. [

   ]cFP

8. USNRC to HL&P Letter, "NRC Bulletin 88-11, "Pressurizer Surge Line Thermal Stratification - South Texas Project, Units 1 and 2 (TAC No. 72168)", September 17, 1990.

9. "ASME Boiler and Pressure Vessel Code", Section III, Subsection NB and Division I Appendices, 1989 Edition.

10. [

] c^{FP}

11. [

] c^{FP}

12. NRC letter from Allen R. Johnson to Robert C. Mecredy "Application of Leak-Before-Break Technology, R.E. Ginna Nuclear Power Plant (TAC No. M86376)", Docket No. 50-244, 1993.

13. [

] c^{FP}

14. [

] c^{FP}

15. HL&P Document No. 120 (1) 00019-CWN, "Model E2 Steam Generator Stress Report" and addendum.

Reference [15] is not available for entry into the BWNT Records Center, but may be referenced for use on Task 1101 of BWNT Contract 1010277. Use of this reference is permitted by BWNT Procedure, BWNT-0402-01, Appendix 2.

16. NRC Letter from George F. Dick, Jr. to D.L. Farrar "Issuance of Amendments (TAC Nos. M90052 and M90053), dated October 24, 1994; Amendment No. 66, Docket STN 50-454 p.15.

17. Meeting Minutes with Industry 1/18/95, Resolution of Public Comments NRC Draft GL 94-XX.

18. NUREG-0781, "Safety Evaluation Report related to the operation of South Texas Project, Units 1 & 2", Supplement No. 2, January 1987.

19 NUREG-0781, "Safety Evaluation Report related to the operation of South Texas Project, Units 1 & 2", Supplement No. 4, July 1987.

20. HL&P to USNRC Letter ST-HL-AE-3016, "Pressurizer Surge Line Thermal Stratification", March 14, 1989.

21. NUREG-1477, "Voltage-Based Interim Plugging Criteria for Steam Generator Tubes", June, 1993.

22. NUREG-0800, "Radiological Consequences of Main Steam Line Failures Outside Containment of a PWR, Rev. 2, July, 1981.

23. WCAP-13523, "V.C. Summer Steam Generator Tube Plugging Criteria for Indications at Tube Support Plate, Westinghouse Non-Proprietary, January, 1993.

24. BMDP Solo, Version 4, BMDP Statistical Software, Inc., 12121 Wilshire Blvd, Los Angeles, CA 90025.

25. HL&P Letter, PFN M18.05.02, ST-HS-2U-0009, Mechanical Properties of Unit 1 and Unit 2 Steam Generator Tubing, dated February 18, 1994.

26. WCAP-14277 NON-PROPRIETARY CLASS 3 (SG-95-01-007), SLB Leak Rate and Tube Burst Probability Analysis Methods for ODSCC at TSP Intersections, January, 1995.

27. Westinghouse Letter to David A. Steininger (EPRI), NSD-JNE-3143, Revised ARC Database for 3/4" Tubes, dated December 1, 1995.

28. Westinghouse Letter from V(Seena) Srinivas (Westinghouse) to John Fox (STP), Response to STP's Request for Clarifications on Revised ARC Database for 3/4" Tubes, dated December 14, 1995.

29. Huebel J.G. and G.K. Myers, "Tables of Confidence Bounds for Failure Probabilities", UCRL-51990, Lawrence Livermore Laboratory, UCAL at Livermore, January 8, 1976.

30. Abramowitz, M. and I.A. Stegun, Editors, "Handbook of Mathematical Functions", National Bureau of Standards Applied Mathematics Series 55, 10th Printing, December, 1972.

31. Carver, H.C. and S.S. Wilks, Editors, "The Annals of Mathematical Statistics", The Official Journal of the Institute of Mathematical Statistics, Volume 29, No.2, June, 1958.

32. LTC: 96:0016-02:01 "Failure Analysis of Steam Generator Tubing from South Texas Project Unit 1", September, 1995.

APPENDIX A

NDE DATA ACQUISITION AND ANALYSIS REQUIREMENTS FOR ODSCC AT TSP ARC

A.1 INTRODUCTION

This appendix documents required techniques for the inspection of South Texas Project Unit 1 steam generator tubes related to the identification of ODSCC at the tube support plate regions.

This appendix contains requirements which provide direction in applying the ODSCC alternate repair criteria (ARC) described in this report. The procedures for eddy current testing using bobbin coil (BC) and rotating pancake coil (RPC) techniques are summarized. The procedures given apply to the bobbin coil inspection, except as explicitly noted for MRPC inspection.

The following sections define specific acquisition and analysis parameters and methods to be used for the inspection of steam generator tubing.

A.2 DATA ACQUISITION

The following guidelines are specified for non-destructive examination of the tubes within TSP at South Texas Project Unit 1.

A.2.1 Instrumentation

Eddy current equipment shall be the Zetec MIZ-18 or engineering approved equivalent.

A.2.2 Probes

A.2.2.1 Bobbin Coil Probes

To maximize consistency with laboratory ARC data, differential probes with the following parameters shall be used for examination of tube support plate intersections:

- 0.610 outer diameter

- two bobbin coils, each 60 mils long x 60 mils deep, with 60 mils between coils (coil centers separated by 120 mils)

In addition, the probe design must incorporate centering features that provide for minimum probe wobble and offset; the centering features must maintain constant probe center to tube ID offset for nominal diameter tubing. For locations which must be inspected with smaller than nominal diameter probes, it is essential that the reduced diameter probe be calibrated to the reference normalization (Section A.2.6.1 and A.2.6.2) and that the centering feature permit constant probe center to tube ID offset. Any indication that is inspected with any probe size smaller than the nominal size specified in GL 95-05 for ARC bobbin inspections, will not have ARC applied to it unless prior approval has been obtained from the NRC.

A.2.2.2 Rotating Pancake Coil Probes

Pancake coils designs (vertical dipole moment) with a coil diameter d, where d is 0.060" $\leq$ d $\leq$ 0.125", shall be used. While other multi-coil (i.e., 1, 2, or 3-coil) probes can be utilized, it is recommended that if a 3-coil single pancake probe is used, any voltage measurements should be made with the probe's pancake coil rather than its circumferential or axial coil.

At STP-1, the MRPC pull speed will be 0.2 inches per second and the rotational speed will be 300 rpm for the 3-coil probe, when implementing the ARC. STP-1 will submit for NRC approval any changes in pull or rotational speed prior to use during an ARC MRPC inspection.

A.2.3 Calibration Standards

A.2.3.1 Bobbin Coil Standards

The bobbin coil calibration standards contain the following items:

Voltage Normalization Standard:

- One 0.052" diameter 100% through wall hole
- Four 0.028" diameter through wall holes, 90 degrees apart in a single plane around the tube circumference; the hole diameter tolerance shall be +/- 0.001"

- One 0.109" diameter flat bottom hole, 60% through from the OD

- Four 0.187" diameter flat bottom holes, 20% through from the OD, spaced 90 degrees apart in a single plane around the tube circumference. The tolerance on hole diameter and depth shall be +/- 0.001".

- A simulated support ring, 0.75" long, comprised of SA-285 Grade C carbon steel.

All holes shall be machined using a mechanical drilling technique. This calibration standard will need to be calibrated against the reference standard used for the ARC laboratory work by direct testing or through the use of a transfer standard. The current STP-1 calibration standards have been normalized to the laboratory standard via a transfer standard. Any new calibration standards utilized in future ARC bobbin inspections at STP-1 will also be normalized via a transfer standard.

The calibration standard does not contain a .187" diameter 40%TW FBH. The use of dual probing and the need for using guide tube standards, requires that the minimum number of calibration flaws are provided in the standard, due to limited space.

Since the 40% ASME hole is not utilized for the calibration of the bobbin coil data, it has been excluded from the calibration standards. The 100%, 60%, and 20% ASME holes are used to establish the phase analysis curve. ARC bobbin analysis is related to voltage response in amplitude, not phase. For amplitude normalization, the 20% ASME holes are used to normalize the data.

Probe Wear Standard

- A probe wear standard is used for monitoring the degradation of probe centering devices leading to off-center coil positioning and potential variations in flaw amplitude responses. This standard shall include four 0.052" +/- 0.001" diameter through-wall holes, spaced 90 degrees apart around the tube circumference with an axial spacing such that signals can be clearly distinguished from one another. See Figure A-1.

A.2.3.2 Rotating Probe Standard

A satisfactory MRPC standard may contain:

- Two axial EDM notches, located at the same axial position but 180 degrees apart circumferential, each 0.006" wide and 0.5" long, one 80% and one 100% through wall from the OD.

- Two axial EDM notches, located at the same axial position but 180 degrees apart circumferentially, each 0.006" wide and 0.5" long, one 60% and one 40% through-wall from the OD.

- Two circumferential EDM notches, one 50% through wall from the OD with a 75 degree (0.49") arc length, and one 100% through wall with a 26 degree (0.17") arc length, with both notches 0.006" wide.

- A simulated support segment 270 degrees in circumferential extent, 0.75" thick, comprised of SA-285 Grade C carbon steel or equivalent for Unit 1.

Similar configurations which satisfy the intent of calibrating MRPC probes for OD axial and circumferential cracking are satisfactory, pending prior approval from the NRC. The center to center distance between the support plate simulation and the nearest slot shall be at least 1.25". The center to center distance between the EDM notches shall be at least 1.0". The tolerance for widths and depths of the notches shall be 0.001". The tolerance for the slot lengths shall be 0.010".

A.2.4 Application of Bobbin Coil Wear Standard

A calibration standard has been designed to monitor bobbin coil probe wear. During steam generator examination, the bobbin probe is inserted into the wear monitoring standard; the initial (new probe) amplitude response from each of the four holes is determined and compared on an individual basis with subsequent measurements. Signal amplitudes from the individual holes - compared with their initial amplitudes - must remain within 15% of their initial amplitude (i.e., {(worn-new)/new}) for an acceptable probe wear condition. If this condition is not satisfied, then the probe must be replaced.

STP-1 plans to implement the Probe Wear Criteria presented by NEI in a January 23, 1996 letter, and approved by the NRC with comments, during ARC bobbin coil inspections. The following are the requirements for implementation of the NEI criteria:

1. The 90-day report will provide a comparison between the actual and projected EOC distributions and assess any large differences with respect to probe wear. If probe wear is considered as one of the factors, actions will be taken to prevent recurrence.

2. Probes that fail the probe wear check during an inspection will be replaced immediately.

3. Tubes with indications within 75% of the repair limit (.75 volts) that were inspected with a worn probe will be re-inspected with a good probe, the entire length of the tube, and all of the data from the good probe will be evaluated (all H/L TSPs down to the lowest C/L TSP with known ODSCC). If large indications were not detected with the worn probe, an

assessment of the significance will be performed during the outage, and will address the need to re-inspect tubes which were inspected with a worn probe. This assessment will be included in the 90 day report.

4. An evaluation will be included in the 90-day report if large indications and/or a non-proportionate number of new indications are detected in tubes which were inspected with a worn probe (failed wear check) in a previous outage. Such an evaluation may identify the need for a more restrictive probe wear criteria.

5. Data acquired during the outage will be continuously monitored to ensure the adequacy of the 75% criteria. If an indication is re-sized during the re-inspection significantly larger than its previous voltage, an evaluation will be provided in the 90-day report.

A.2.4.1 Bobbin Coil Wear Standard Placement

Under ideal circumstances, the incorporation of a wear standard in line with the conduit and guide tube configuration would provide continuous monitoring of the behavior of bobbin probe wear. However, the curvature of the channelhead places restrictions on the length of in line tubing inserts which can be accommodated. The spacing of the ASME Section XI holes and the wear standard results in a length of tubing which cannot be freely positioned within the restricted space available. The flexible conduit sections inside the channelhead, together with the guide

tube, limit the space available for additional in line components. Voltage responses for the wear standards are sensitive to bending of the leads, and mock up tests have shown sensitivity to the robot end effector position in the tubesheet, even when the wear standard is placed on the bottom of the channelhead. Wear standard measurements must permit some optimization of positions for the measurement and this should be a periodic measurement for inspection efficiency. The pre-existing requirement to check calibration using the ASME tubing standard is satisfied by periodic probing at the beginning and end of each probe's use as well as at four hour intervals. This frequency is adequate for wear standard purposes as well. Evaluating the probe wear under uncontrollable circumstances would present variability in response due to channelhead orientations rather than changes in the probe itself.

A.2.5 Acquisition Parameters

The following parameters apply to bobbin coil data acquisition and should be incorporated in the applicable inspection procedures to supplement (not necessarily replace) the parameters normally used.

A.2.5.1 Test Frequencies

This technique requires the use of bobbin coil 550 kHz and 130 kHz test frequencies in the differential mode. It is recommended that the absolute mode also be used, at test frequencies of 130 kHz and 10 kHz. The low frequency (~10 kHz)

channel is recorded to provide a means of verifying tube support plate edge detection for flaw location purposes. The use of 10 kHz provides enhanced resolution of the TSP edges. The 550/130 kHz mix or the 550 kHz differential channel is used to access changes in signal amplitude for the probe wear standard as well as for flaw detection.

MRPC frequencies should include channels adequate for detection of OD degradation in the range of 100 kHz to 550 kHz, as well as a low frequency channel to provide support location of the TSP edges. The primary frequency for flaw detection is the 300 kHz frequency because of its proximity to the optimum of 280 kHz for this type of probe. The use of the 550 kHz for excitation is well outside the coil's operating range, resulting in reduced flaw amplitude response.

A.2.5.2 Digitizing Rate

A minimum digitizing rate of 30 samples per inch should be used for both bobbin and MRPC. Combinations of probe speeds and instrument sample rates should be chosen such that:

$$\frac{\text{Sample Rate (samp./sec.)}}{\text{Probe Speed (in./sec.)}} \geq 30 \text{(samp./in.)}$$

A.2.5.3 Spans and Rotations

Spans and rotations can be set at the discretion of the user and/or in accordance with the applicable procedures, but all TSP intersections must be viewed at a span setting one-half or less than that which provides 3/4 full screen amplitude for 4 x 20% holes with bobbin probes and 1/10 or less the corresponding span for 0.5" TW slot (EDM notch) with RPC probes.

A.2.5.4 Mixes

A bobbin coil differential mix is established with 550 kHz as the primary frequency and 130 kHz as the secondary frequency, and suppression of the TSP simulation should be performed.

A.2.6 Analysis Parameters

This section discusses the methodology for establishing bobbin coil data analysis variables such as spans, rotations, mixes, voltage scales, and calibration curves. Although indicated depth measurement may not be required to support an alternative repair limit, the methodology for establishing the calibration curves is presented. The use of these curves is recommended for consistency in reporting and to provide compatibility of results with subsequent inspections of the same steam generator and for comparison with other steam generators and/or plants.

A.2.6.1 Bobbin Coil 550 kHz Differential Channel

Rotations: The signal from the 100% through-wall hole should be set to 40° (+/- 1 degree) with the initial signal excursion down and to the right during probe withdrawal.

Voltage Scale: The peak-to-peak signal amplitude of the signal from the four 20% through-wall holes should be set to produce a voltage equivalent to that obtained from the ARC lab standard. The laboratory standard normalization voltage is 4.0 volts at 550 kHz.

The transfer/field standard will be calibrated against the laboratory standard using a reference laboratory probe to establish voltages for the field standard that are equivalent to the above laboratory standard. These equivalent voltages are then set on the field standard to establish calibration voltages for any other standard.

Voltage normalization to the standard calibration voltages at 550 kHz is the preferred normalization to minimize analyst sensitivity in establishing the mix. However, if the bobbin probes used result in a 550/130 kHz mix to 550 kHz voltage ratios differing from the laboratory standard ratio of 0.69 by more than 5% (0.66 to 0.72), the 550/130 kHz mix calibration voltage should be used for voltage normalization.

Once the probe has been calibrated on the 20% through-wall holes, the voltage response of new bobbin coil probes for the 40-100% ASME through-wall holes should not differ from the nominal voltage by more than ± 10%.

As an alternative, probes can be supplied with certification of meeting the variability requirements upon shipment from the vendor. STP-1 currently procures probes that are certified as meeting the new probe variability requirements. If probes are purchased without such certification, variability checks will be performed on-site prior to use.

Calibration Curve: Establish a phase versus depth calibration curve using measured signal phase angles in combination with the "as-built" flaw depths for the 100%, 60%, and 20% holes.

A.2.6.2 Bobbin Coil 550/130 kHz Differential Mix Channel

Rotations: Probe motion is set horizontal with the initial excursion of the signal from the single 100% through-wall hole going down and to the right during probe withdrawal.

Voltage Scale: The peak-to-peak signal amplitude of the signal from the four 20% through-wall holes should be set to produce a voltage equivalent to that obtained from the ARC lab standard. The laboratory standard normalization voltage is 2.75 volts for the 550/130 kHz mix.

Calibration Curve: Mix 1 is a 550/130 kHz differential support mix; mix on ASME standard support ring. Set 3-point phase angle-depth calibration curve using ASME 100%, 60%, and 20% drill hole signals. Mix 1 is the primary channel for reporting indications at support structures.

A.2.6.3 Rotating Pancake Coil Inspection

Rotations: Probe motion is set horizontal (+/- 5 degrees) with the initial excursion of the signal from the 100% through-wall notch directed upwards during probe withdrawal.

Voltage Scale: The MRPC amplitude will be referenced to 20 volts for a 0.5" long 100% through wall notch at 300 kHz. Each channel shall be set individually to the desired amplitude for the EDM notches on the plant standards.

A.2.7 Analysis Methodology

Bobbin coil indications at support plates attributable to ODSCC are quantified using the Mix 1 (550 kHz/130 kHz) data channel. This is illustrated with the example shown in Figure A-2. The 550/130 kHz mix channel or other channels appropriate for flaw detection (550 kHz, 300 kHz, or 130 kHz) may be used to locate the indications of interest within the support plate signal. The largest amplitude portion of the Lissajous signal representing the flaw should then be measured using the 550/130 kHz Mix 1 channel to establish the peak-to-peak voltage as shown in Figure A-2. Initial placement of the dots for identification of the flaw location may be performed as shown in

Figures A-3 and A-4, but the final peak-to-peak measurements must be performed on the Mix 1 Lissajous signal to include the full flaw segment of the signal. It may be necessary to iterate the positions of the dots between the identifying frequency and the 550/130 kHz mix to obtain proper placement. As can be seen in Figure A-4, failure to do so can reduce the voltage measurements of Mix 1 by as much as 65% to 70% due to the interference of the support plate signal in the raw frequencies. The voltage as measured from Mix 1 is then entered as the analysis of record for comparison with the repair limit voltage.

To support the uncertainty allowances maintained in the ARC, the difference in amplitude measurements for each indication will be limited to 20%. If the voltage values called by the independent analysts deviate by more than 20% and one or both of the calls exceeds 1.0 volts, analysis by the resolution analyst will be performed. These triplicate analyses result in assurance that the voltage reported departs from the correct call by no more than 20%.

There is no industry recognized method for measuring the eddy current test signal-to-noise ratio to determine which data is too noisy and should be re-acquired. However, the EPRI Steam Generator Management Program has been tasked with identifying or developing such methods. Until such methods are identified, electrical noise in excess of 0.3 volts peak-to-peak on channel 1 will be rejected and the data will be re-acquired.

A.2.8 Reporting Guidelines

The reporting requirements identified below are in addition to any other reporting requirements specified by the user.

A.2.8.1 Minimum Requirements

All bobbin coil flaw indications in the 550/130 kHz mix channel at the tube support plate intersections regardless of the peak-to-peak signal amplitude must be reported. All TSP locations with indications exceeding 1.0 volt must be examined with MRPC probes.

A.2.8.2 Additional Requirements

For each reported indication, the following information should also be recorded:

Tube identification (row, column)
Signal amplitude (volts)
Signal phase angle (degrees)
Test channel (ch#)
Axial position of tube (location)
Extent of test (extent)

MRPC reporting requirements should include as a minimum: type of degradation (axial, circumferential, or other), maximum voltage and location of the center of the crack within the TSP. The crack axial center to edge need not coincide with the position of the maximum amplitude. MRPC indications with circumferential cracks, cracks extending outside the TSP or indications attributable to PWSCC must be repaired and will be reported to the NRC per

Generic Letter 95-05.

A.3 DATA EVALUATION

A.3.1 Use of 550/130 Differential Mix for Extracting the Bobbin Flaw Signal

In order to identify a discontinuity in the composite signal as an indication of a flaw in the tube wall, a simple signal processing procedure of mixing the data from the two test frequencies is used which reduces the interference from the support plate signal by approximately one order of magnitude. The test frequencies most often used for this signal processing are 550 kHz and 130 kHz for 43 mil wall Alloy 600 tubing. Any of the differential data channels including the mix channel may be used for flaw detection (though the 130 kHz for 43 mil wall Alloy 600 tubing is often subject to the influence from many different effects), but the final evaluation of signal detection, amplitude and phase angle will be made from the 550/130 kHz differential mix channel. Upon detection of a flaw signal in the differential mix channel, confirmation from other raw channels is not required; all such signals must be reported as indications of possible ODSCC. The voltage scale for the 550/130 kHz differential channel should be normalized as described in Section A.2.6.1 and A.2.6.2.

The present evaluation procedure requires that there is no minimum voltage for flaw detection purposes and that all flaw signals, however small, be identified. The intersections with flaw signals > 1.0 volt will be inspected with MRPC. Although the signal voltage is rot a measure of flaw depth, it is an indicator of the tube burst pressure when the flaw is identified as axial ODSCC with or without minor IGA. If an indication less than the

upper voltage repair limit is not confirmed by MRPC, no action is required and the tube may remain in service.

A.3.2 Amplitude Variability

It has been observed that voltage measurements taken from the same data by different analysts may vary, even when using identical analysis guidelines. This is largely due to differences in the analyst interpretation of where to place the dots on the Lissajous figure for the peak-to-peak amplitude measurement. Figures A-5 and A-6 show the correct placement of the dots on the Mix 1 Lissajous figures for the peak-to-peak voltage amplitude measurements for two tubes from Plant S. In Figure A-5, the placement is quite obvious. In Figure A-6, the placement requires slightly more of a judgement call. Figure A-7 and A-8 show these same two tubes with peak-to-peak measurements being made, but in both cases the dots have been placed at locations where the normal max-rate dots would be located. The reduction in the voltage amplitude measurement is 19.3% in Figure A-7 and 16.3% in Figure A-8. While this is an accepted method of analysis for phase-angle measurements, it is not appropriate for the voltage amplitude measurements required.

In Figures A-5 and A-6, the locations of the dots for the peak-to-peak measurements being performed from Mix 1 show the corresponding dots on the 550 kHz raw frequencies as also being located at the peak or maximum point of the flaw portion of the Lissajous figure. In <u>no case</u> should the dots used to measure the voltage amplitude be at locations less than the maximum points of the flaw portion of the 550 kHz raw frequency.

Figure A-9 is an example of where the dots have been placed on the transition region of the 550 kHz raw frequency data Lissajous figure that this does not correspond to the maximum voltage measurement. The correct placement on the Mix 1 Lissajous figure is shown in Figure A-10. This placement also corresponds to the maximum voltage measurement on the 550 kHz raw frequency data channel.

In some cases, it will be found that little if any definitive help is available from the use of the raw frequencies. Such an example is shown in Figure A-11, where there are no significantly sharp transitions in any of the raw frequencies. Consequently, the placement of the measurement dots must be made completely on the basis of the Mix 1 channel Lissajous figure as shown in the upper left of the graphic. An even more difficult example is shown in Figure A-12. The logic behind the placement of the dots in the Mix 1 is that sharp transitions in the residual support plate signals can be observed at the locations of both dots. In the following graphic, Figure A-13, somewhat the same logic could be applied in determining the flaw-like portion of the signal from the Mix 1 Lissajous pattern. However, inasmuch as there is no sharp, clearly defined transition, coupled with the fact that the entry lobe into the support plate is distorted on all of the raw frequencies, the dots should be placed as shown in Figure A-14. This is a conservative approach and should be taken whenever a degree of doubt as to the dot placement exists.

A.3.3 Alloy Property Changes

This signal manifests itself as part of the support plate "mix residual" in both the differential and absolute mix channels. It has often been confused with copper deposit as the cause. Such signals are often found at support plate intersections of operating plants, as well as in some model boiler test samples, and are not necessarily indicative of tube wall degradation. Six support plate intersections from Plant A, judged as free of tube wall degradation on the basis of the mixed differential channel using the guidelines given in Section A.2.7 of this document, were pulled in 1989. Examples of the bobbin coil field data are shown in Figure A-15 (inspection data from a plant with 7/8" diameter tubing). The mix residual for this example is approximately 3 volts in the differential mix channel and no discontinuity suggestive of a flaw can be found in this channel. An offset in the absolute mix channel which could be confused as a possible indication is also present. These signals persisted without any significant change even after chemically cleaning the OD and ID of the tubes. The destructive examination of these intersections showed very minor or no tube wall degradation. Thus, the overall "residuals" of both the differential and the absolute mix channels were not indications of tube wall degradation. One needs to examine the detailed structure of the "mix residual" (as outlined in Section A.2.7) in order to assess the possibility that a flaw signal is present in the residual composite. Verification of the integrity of TSP intersections exhibiting large mixed residuals is accomplished by MRPC testing of all such signals during STP-1 ARC inspections.

A.3.4 Denting and Copper Influences

In situations where significant copper interference in the eddy current data is noted, the eddy current technique basically becomes unreliable. This results from the unpredictability of the amount and morphology of copper deposit on the tubes which may be found in operating steam generators. The above observation is true for both bobbin and RPC or any other eddy current probe. South Texas Project Unit 1 has not experienced significant corrosion-assisted denting ncr have reported support plate indications indicative of copper deposits. STP-1 will not apply the ARC to any TSP intersection influenced by copper. Additionally, STP-1 plans to inspect with RPC, any support plate intersection containing copper influence during an ARC inspection, and repair any tubes with indications detected at these types of intersections.

A.3.4.1 Dent Interference

The 550/130 kHz (differential) support plate suppression mix reduces or eliminates the support plate and the magnetite which may be present with the support plate, but the resulting processed signal will still be a composite flaw, other artifacts and a dent, if present. These composite signals represent vectorial combinations of the constituent effects, and as such they may not conform to the behavior expected from simple flaw simulations as a function of test frequencies.

The effect of the dent on the detection and evaluation of a flaw signal depends on both the relative amplitudes of the flaw and dent signals and the relative

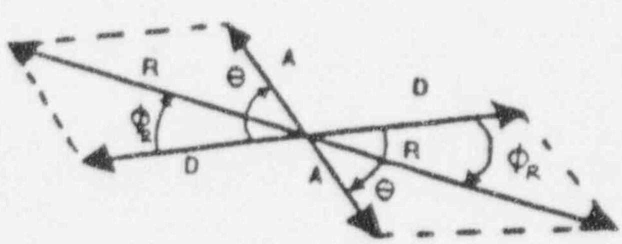
spatial relationship between them. If the flaw is located near the center of the dent signal, interference with flaw detection may become insignificant, even for relatively large dent-to-flaw ratios. The flaw's signal in a typical support plate dent in this event occurs at mid-plane, away from the support plate edges where the dent signal exhibits maximum voltage; thus the flaw in the middle section of the support plate appears as a discontinuity in the middle of the composite signal. It can be observed in Figures A-20 through A-25, from Plant A, that one can often extract a flaw signal even when the flaw signal-to-noise (dent) ratio (S/N) is less than unity. The question of S/N ratio requirements necessary for flaw detection is not a number that can be readily determined; but, as can be seen from these figures, even with ratios as low as 0.184/1.0, the flaw signal can be detected and evaluated.

The greatest challenge to flaw detection due to dent interference occurs when the flaw occurs at the peak of the dent signal. Detection of flaw signals of amplitudes greater than 1.0 volts (flaws greater than 1.0 volts require RPC testing) in the presence of peak dent voltages can be understood by vectorial combination of a 1.0 volt flaw signal across the range of phase angles associated with 40% (110°) to 100% (40°) through wall penetrations with dent signals of various amplitudes. It is easily shown that 1.0 volt flaw signals combined with dent signals up to

approximately 5.0 volts peak-to-peak will yield resultant signals with phase angles that fall within the flaw reporting range, and in all cases will exceed 1.0 volts. All such dent signals with a flaw indication signal will be subjected to RPC testing. To demonstrate this, one-half the dent peak-to-peak voltage (entrance of exit lobe) can be combined with the 1.0 volt flaw signal at the desired phase angle.

The Plant A inspection data is shown in Figures A-20 through A-25 to permit flaw detection and evaluation for flaws situated away from the peak dent voltages. The vector combination analysis shows that for moderate dent voltages where flaws occur coincident with dent entrance or exit locations, flaw detection at the 1.0 volts amplitude level is successful via phase discrimination of combined flaw/dent signals from dent only signals.

The vector addition model for axial cracks coincident with denting at the TSP edge is illustrated as follows:



where R = Resultant Signal Amplitude

A = Flaw Signal Amplitude

D = TSP Dent Amplitude - one edge (Peak-to-Peak = 2D)

θ = Flaw Signal Phase Angle (100% = 40°; 40% ~ 110°)

ϕ_R = Phase Angle of Resultant Signal

and $R^2 = (D + A\cos\theta)^2 + (A\sin\theta)^2$

$\theta_R = \arctan^{-1} (A\sin/D + A\cos\theta)$

For dents without flaws, a nominal phase angle of 180° is expected. The presence of a flaw results in rotation of the phase angle to < 180° and into the flaw plane. A phase angle of 170° (10° away from nominal dent signal) provides a sufficient change to identify a flaw. For dents with peak-to-peak amplitude of 5.0 volts, D = 2.5 v and the minimum phase angle rotation (OR) for a 1.0 volt ODSCC flaw signal greater than 40% throughwall is predicted to be at least 11°, sufficiently distinguishable from the 180° (0°) phase angle associated with a simple dent.

Supplement information to reinforce this phase discrimination basis for flaw identification can be obtained by examination of a 300/130 kHz mix channel; dent response would be lessened while the OD originating flaw response is increased relative to the 550/130 kHz mix. RPC testing of indications identified in this fashion will confirm the dependability of flaw signal detection. At STP-1, all intersections with dent voltages

- exceeding 5.0 volts will be RPC inspected during ARC inspections.

A.3.5 MRPC Flaw Characterization

The MRPC inspection of all support plate intersections with bobbin coil indications > 1.0 volts is required in order to verify the applicability of the alternate repair limit. This is based on establishing the presence of ODSCC with minor IGA as the cause of the bobbin indications.

The signal voltage for MRPC data evaluation will be based on 20 volts for the 100% throughwall 0.5" long EDM notch at all frequencies.

The nature of the degradation and its orientation (axial or circumferential) will be determined from careful examination of the isometric plots of the MRPC data. The presence of axial ODSCC at the support plates has been well documented, but the presence of circumferential indications related to ODSCC at support plate intersections has also been established by tube pulls at two plants. Figure A-16 to A-18 show examples of single and multiple axial ODSCC from Plant S.

Figure A-19 is an example of a circumferential indication related to ODSCC at a tube support plate location from another plant. If circumferential involvement results from circumferential cracks as opposed to multiple axial crack, discrimination between axial and circumferentially oriented cracking can be generally established for affected arc lengths of about 45 degrees to 60 degrees or larger. Axial cracking has been found by pulled tube exams for MRPC arcs of 150 degrees when the axial extent is significant, such as > 0.2 inch.

Pancake coil resolution is considered adequate for separation between circumferential and axial cracks. This can be supplemented by careful interpretation of 3-coil results. Since significant denting has not occurred at STP-1, neither PWSCC or circumferential cracking is expected to occur.

The response from pits of significant depth is expected to produce geometric features readily identifiable with small area to amplitude characteristics. When multiple pits become so numerous as to overlap in the isometric display, the practical effect is to mimic the response from wastage or wear at comparable depths. In these circumstances the area affected is generally large relative to the peak amplitudes observed.

The presence of IGA as a local effect directly adjacent to crack faces is expected to be indistinguishable from the crack responses and as such of no structural consequence. When IGA exists as a general phenomenon, the eddy current response is proportional to the volume of affected tube material, with phase angle corresponding to depth of penetration and amplitude relatively larger than that expected for small cracks. The presence of distributed cracking, e.g., cellular SCC, may produce responses from microcracks of sufficient individual dimensions to be detected but not resolved by the MRPC, resulting in volumetric responses similar to three-dimensional degradation.

For hot leg TSP locations, there is little industry experience on the basis of tube pulls for volumetric degradation, i.e., actual wall loss or general IGA. For cold leg TSP locations, considerable experience is available for volumetric degradation in the form of thinning of peripheral tubes, favoring the lower TSP elevations.

Therefore, in the absence of confirmed pulled tube experience to the contrary, volumetric OD indications at hot-leg tube support plates should be considered to represent ODSCC.

A.3.6 Confinement of ODSCC/IGA within the Support Plate Region

In order to establish that a bobbin indication is within the support plate. the displacement of each end of the signal is measured relative to the support center. The field measurement is then corrected for field spread (look-ahead) to determine the true distance from the TSP center to the crack tip. If this distance exceeds one-half the support plate axial length (0.375"), the crack will be considered to have progressed outside the support plate. This scenario will require NRC notification and repair of the tube.

The measurements of axial crack lengths from MRPC isometrics can be determined using the following analysis practices. For the location of interest, the low frequency channel (e.g., 10 kHz) is used to set a local scale for measurement. By establishing the midpoint of the support plate response, a reference point for indication location is established. Calibration of the distance scale is accomplished by setting the displacement between the 10 kHz absolute, upper and lower support plate transitions equal to 0.75 inch.

A.3.7 Length Determination with MRPC Probes

At the analysis frequency, 300 kHz, the ends of the crack are located using the slope-intercept method; i.e., the leading and trailing edges of the signal pattern are extrapolated to cross the null baseline (See Figure A-26). The difference between these two positions is the crack length estimate.

Alternately, the number of scan lines indicating the presence of the flaw times the pitch of the rotating probe provides a conservative estimate of crack length which may then be corrected for beam spread.

A.3.8 MRPC Inspection Plan

The MRPC inspection plan will include 100% of the following intersections upon implementation of the ARC repair limits:

1) Bobbin indications greater than 1 volt for justification of these indications as typical of ODSCC.

2) Dented tubes at TSP intersections with bobbin dent voltages exceeding 5 volts.

3) Artifact signals (alloy property changes) or large mixed residuals. A large mixed residual is one that could cause a 1.0 bobbin signal to be misread or missed.

4) Intersections exhibiting interference from copper.

Consideration for expansion of the MRPC inspection program would be based on identifying unusual or unexpected indications such as clear circumferential cracks, PWSCC, or indications extending beyond the confines of the TSP. In this case, structural assessments of the significance of the indications would be used to guide the need for further MRPC inspection. Additionally, these indications should cause the tube to be repaired, and notification to the NRC in the 90-day report.

A.3.8.1 3-Coil MRPC Usage

It is Houston Lighting & Power's standard practice to use 3-coil MRPC probes, incorporating a pancake coil, an axial preference coil, and a circumferential preference coil. Comparisons for ODSCC with bobbin amplitudes exceeding 1.0 volts have shown that the pancake coil fulfills the need for discrimination between axial and circumferential indications, when compared against the outputs of the preferred direction coils. Pancake coils have been the basis for reporting MRPC voltages for model boiler and pulled tube indications in the ARC database; these data permit semi-quantitative judgements on the potential significance of MRPC indications. The requirement for a pancake coil is satisfied by the single coil, 2-coil, and 3-coil probes in common use for MRPC inspections.

A.3.9 Noise Criteria

Quantitative noise criteria (resulting from electrical noise, tube noise, or calibration standard noise) should be included in the data analysis procedures. Actions should be taken to correct the data by re-performing the calibration or re-inspecting the affected tube(s).

Eddy current data acquired from active tubes and calibrations standards shall be reviewed for the presence of electrical and tube noise. General eddy current data quality shall be monitored to ensure that a minimum 3:1 signal-to-noise ratio (S/N) is maintained. This value of S/N is a commonly accepted industry value for data quality

ensuring reliable signal detection.

A.3.9.1 ID Chatter or Pilgering Noise

Tubes identified with noise associated with ID chatter or pilgering in excess of 5 volts peak-to-peak on Channel 1 shall also be screened using Channel 5.

A.3.9.2 Probe Noise

Electrical noise due to a failing or intermittent probe is readily recognizable as the noise signal often assumes the shape of a random square wave modulating the eddy current signal.

Electrical noise in excess of 0.3 volts peak-to-peak on Channel 1 will be rejected by the analyst and the tube will be re-inspected.

FIGURE A-1

PROBE WEAR STANDARD SCHEMATIC

[

]EP

Figure derived from EPRI TR-100407, Rev. 2A, Appendix B.

FIGURE A-2

BOBBIN COIL AMPLITUDE ANALYSIS OF ODSCC AT TSP

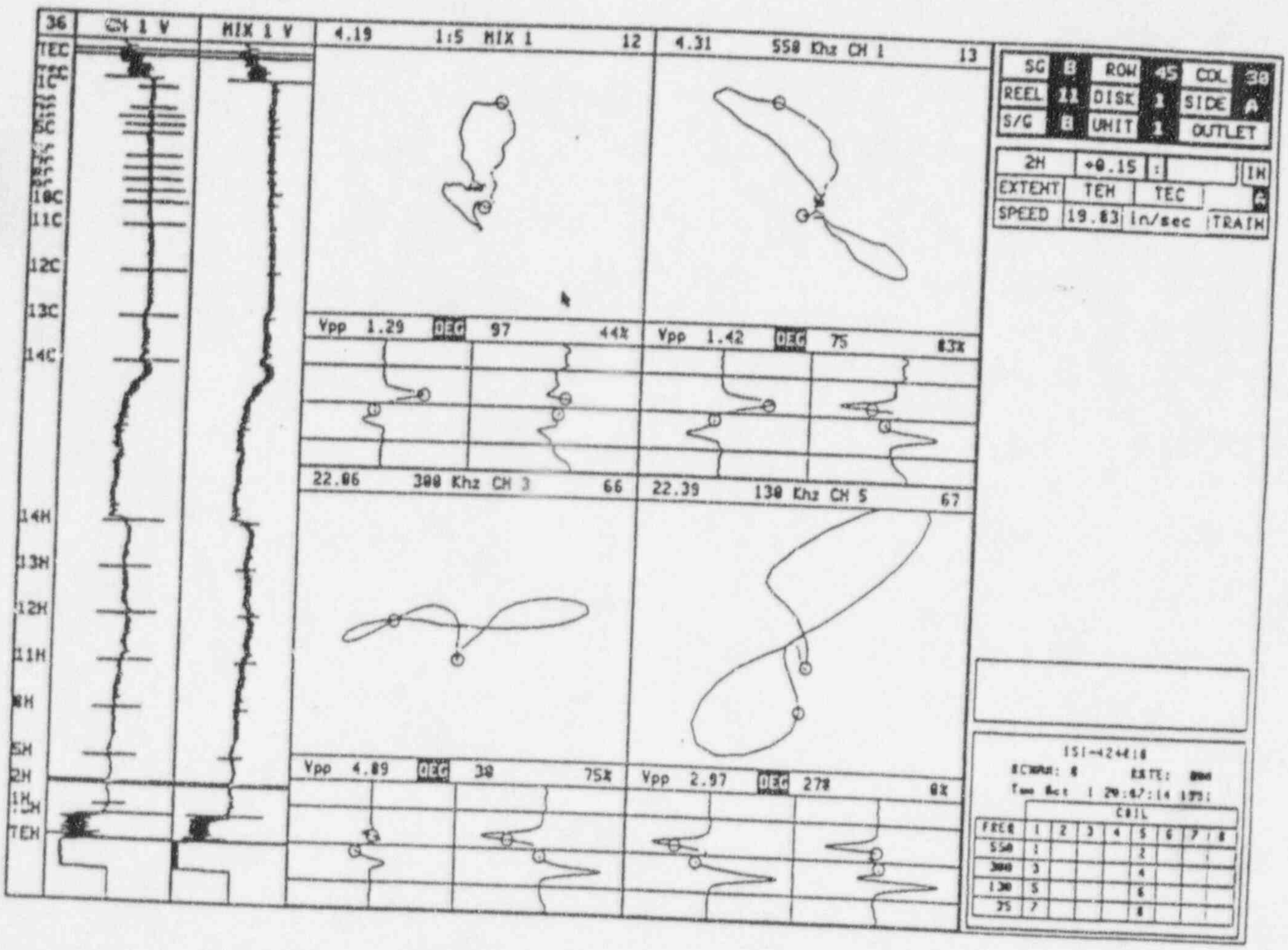


Figure derived from WCAP 13523 [23].

FIGURE A-3

BOBBIN COIL AMPLITUDE ANALYSIS OF ODSCC INDICATION AT TSP-IMPROPER IDENTIFICATION OF FULL FLAW SEGMENT RESULTING IN REDUCED VOLTAGE MEASUREMENT WHEN COMPARED WITH FIGURE A-2

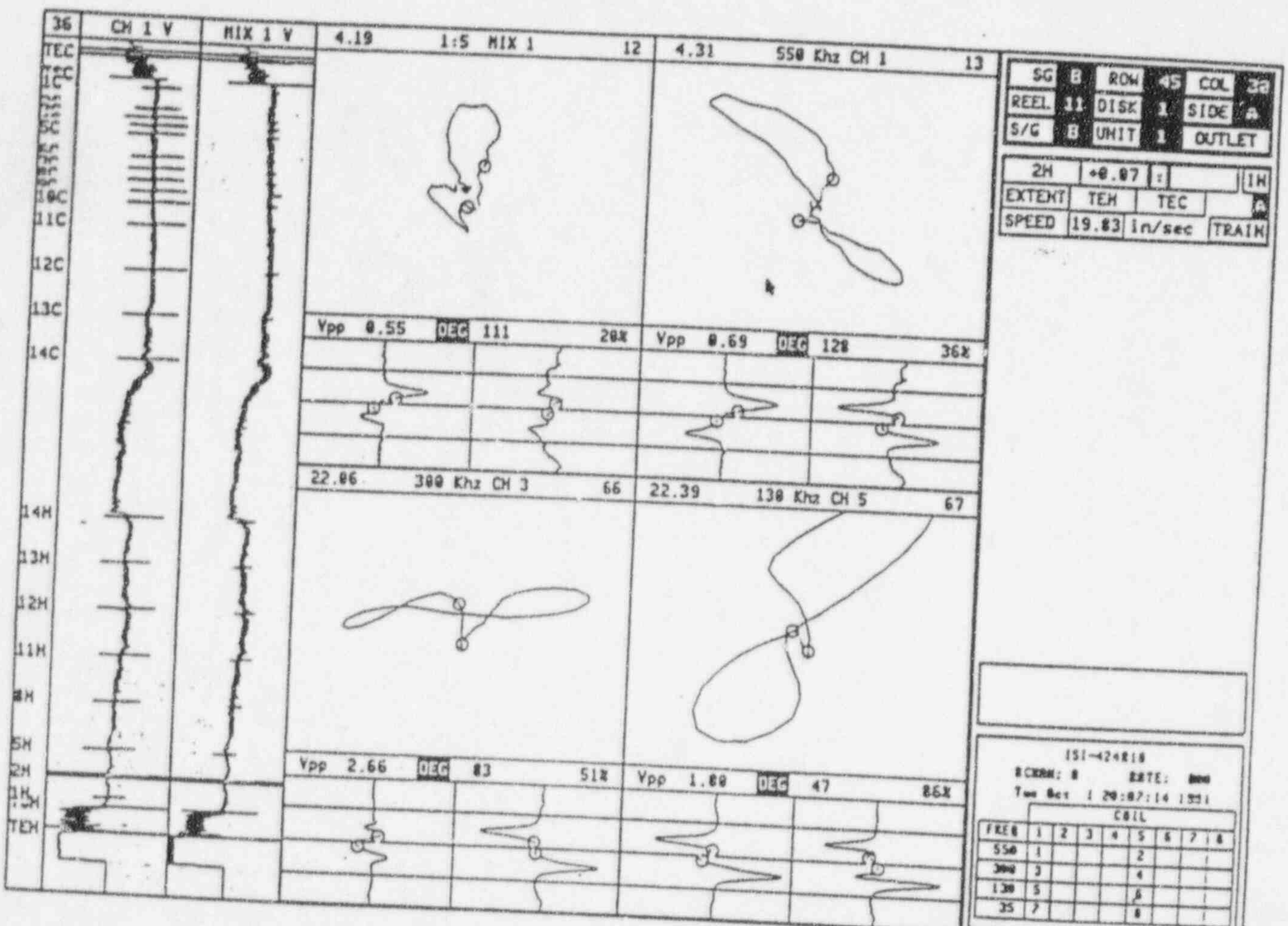


Figure derived from WCAP-13523 [23].

FIGURE A-4

BOBBIN COIL AMPLITUDE ANALYSIS OF ODSCC INDICATION AT TSP-IMPROPER IDENTIFICATION OF FULL FLAW SEGMENT RESULTING IN REDUCED VOLTAGE MEASUREMENT WHEN COMPARED TO FIGURE A-2

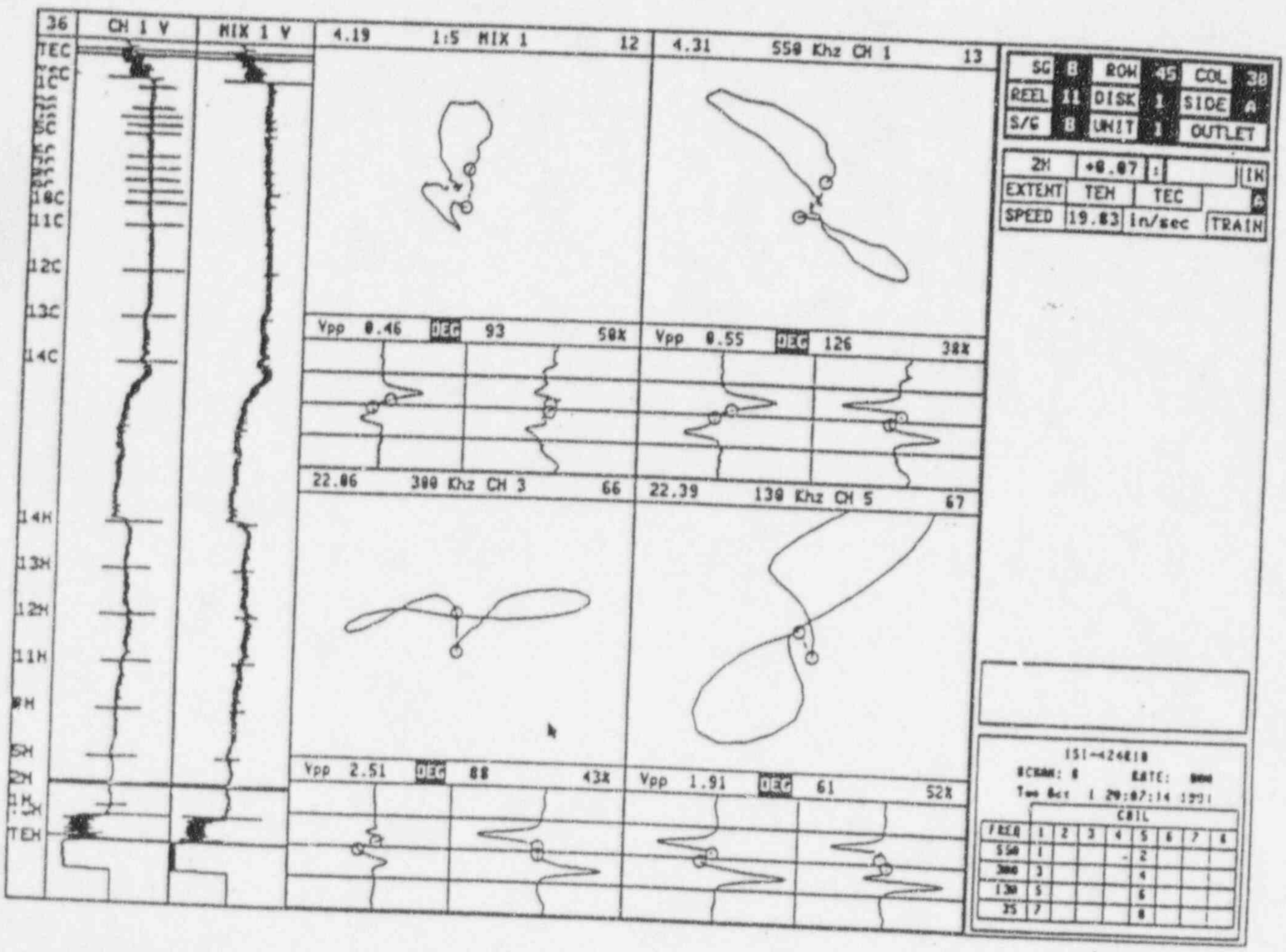


Figure derived from WCAP-13523 [23].

FIGURE A-5

CORRECT PLACEMENT OF VOLTAGE SET POINTS ON MIX 1 LISSAJOUS TRACES FOR R18C103

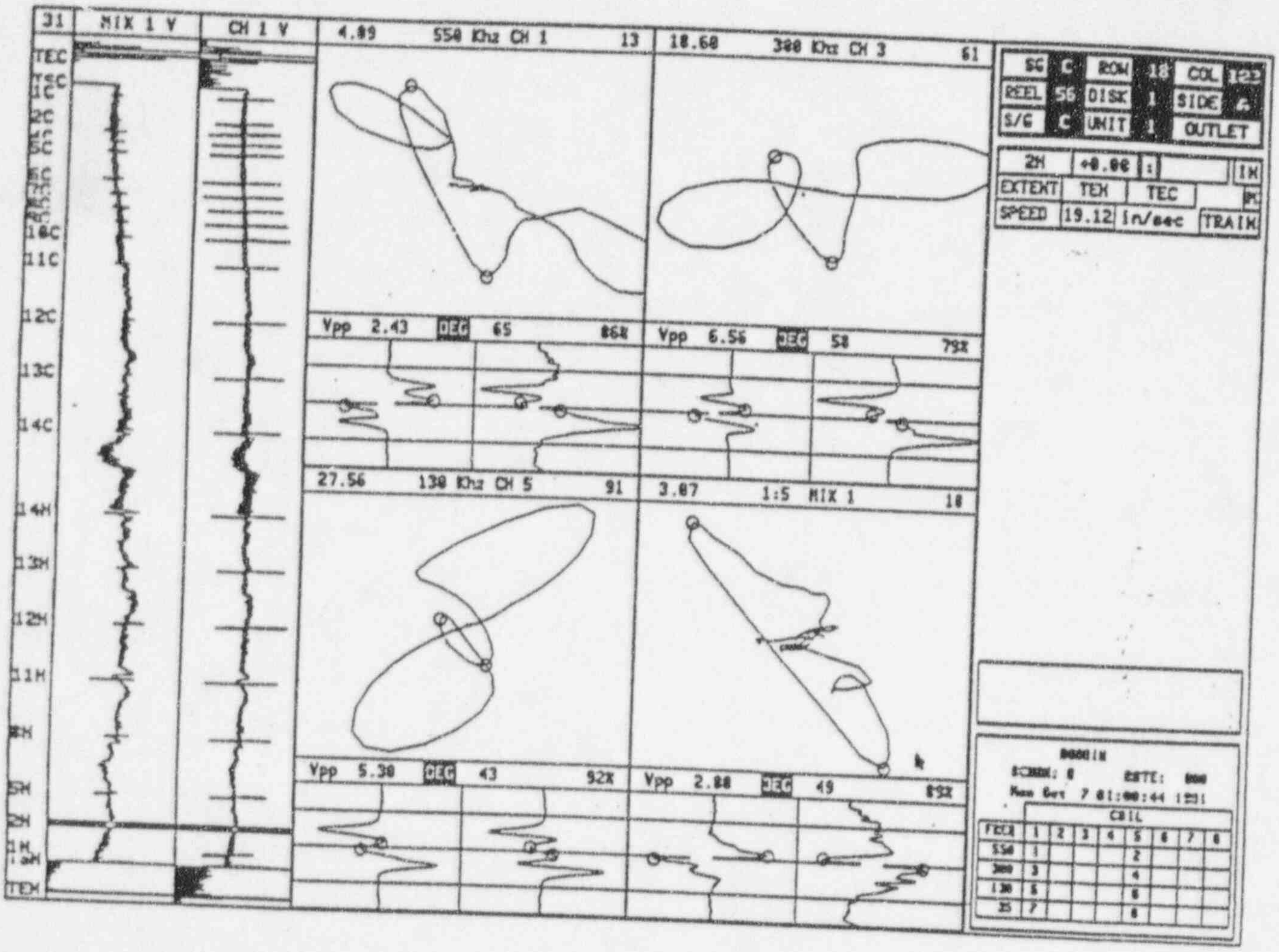


Figure derived from WCAP-13523 [23].

FIGURE A-6
CORRECT PLACEMENT OF VECTOR DOTS ON MIX 1 LISSAJOUS TRACES FOR R22C40

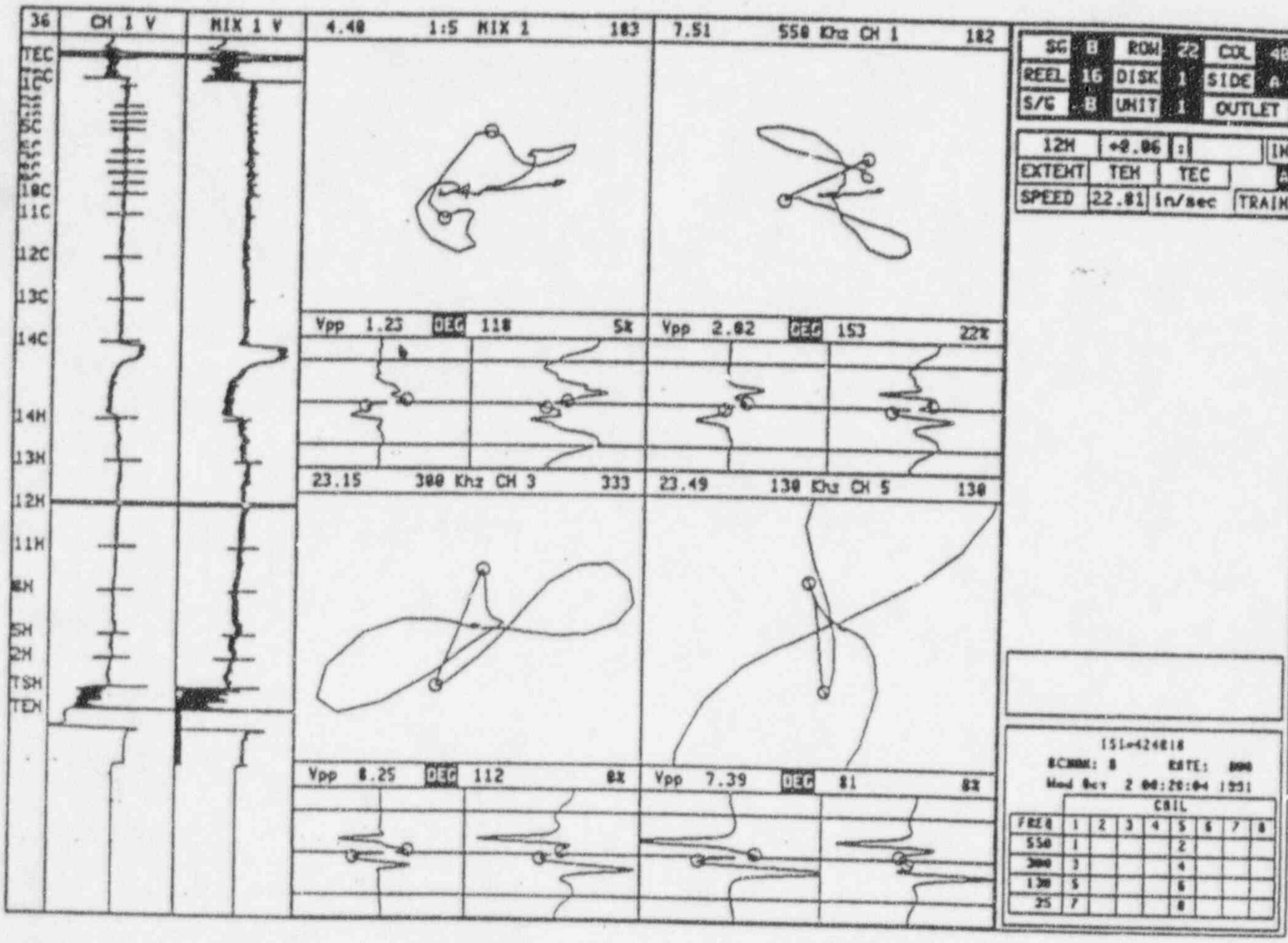


Figure derived from WCAP-13523 [23].

FIGURE A-7

INCORRECT PLACEMENT OF VECTOR DOTS ON MIX 1 LISSAJOUS TRACES FOR R18C103

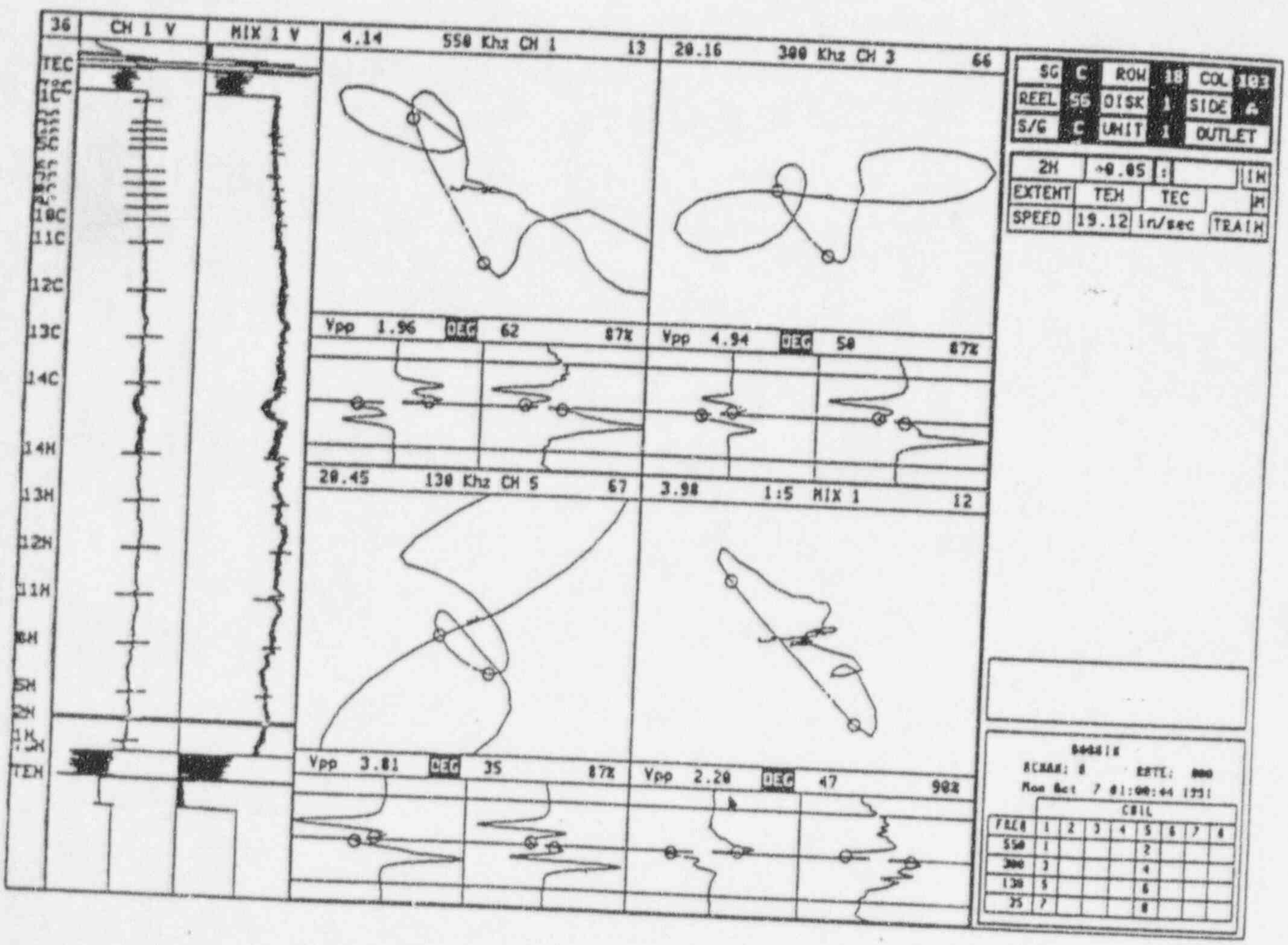


Figure derived from WCAP-13523 [23].

FIGURE A-8
INCORRECT PLACEMENT OF VECTOR DOTS ON MIX 1
LISSAJOUS TRACES FOR R22C40

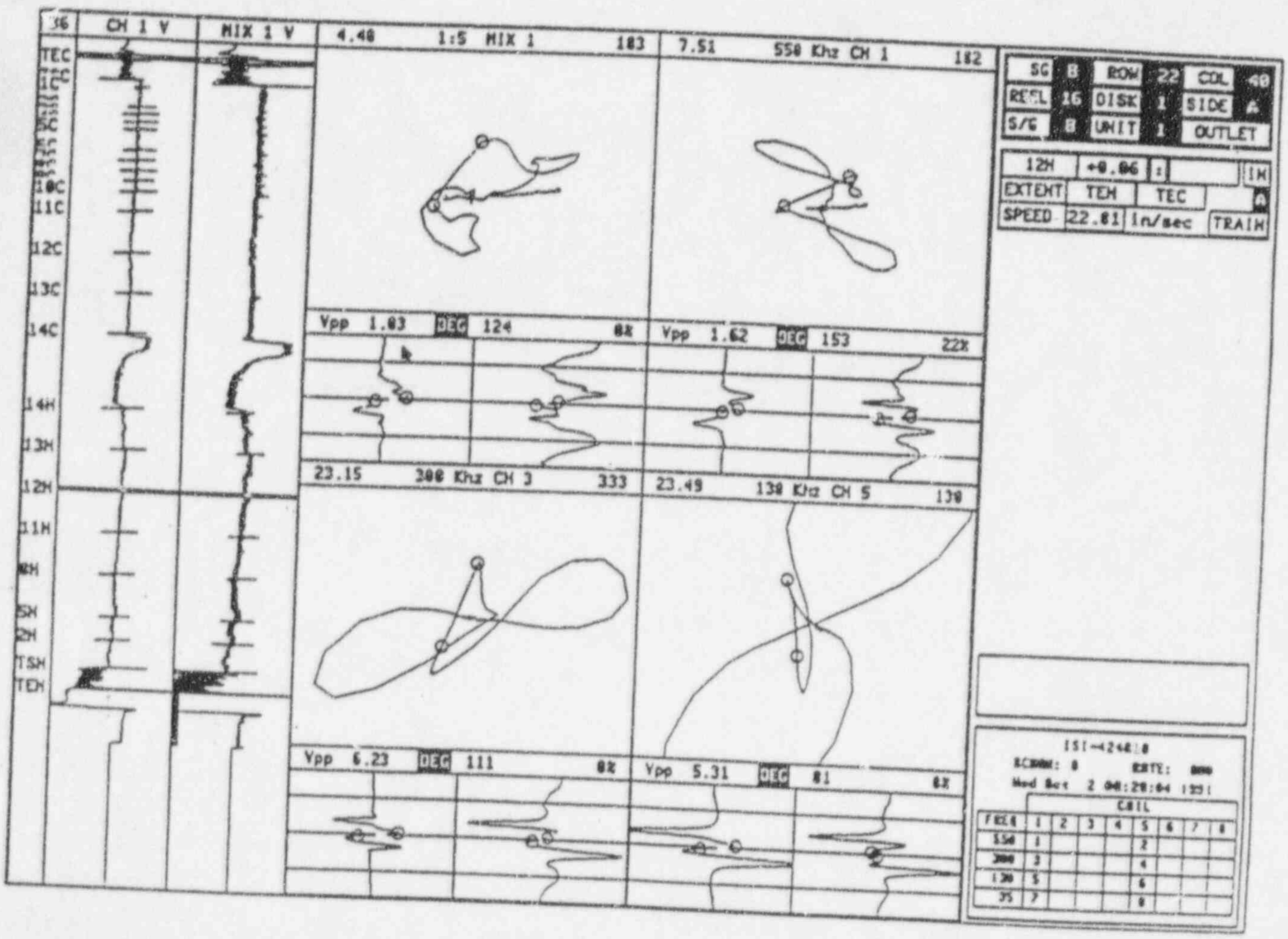


Figure derived from WCAP-13523 [23].

FIGURE A-9

INCORRECT MAXIMUM VOLTAGE DERIVED FROM PLACEMENT OF VECTOR DOTS ON TRANSITION REGION OF 550 kHz RAW FREQUENCY DATA LISSAJOUS TRACE FOR R42C44

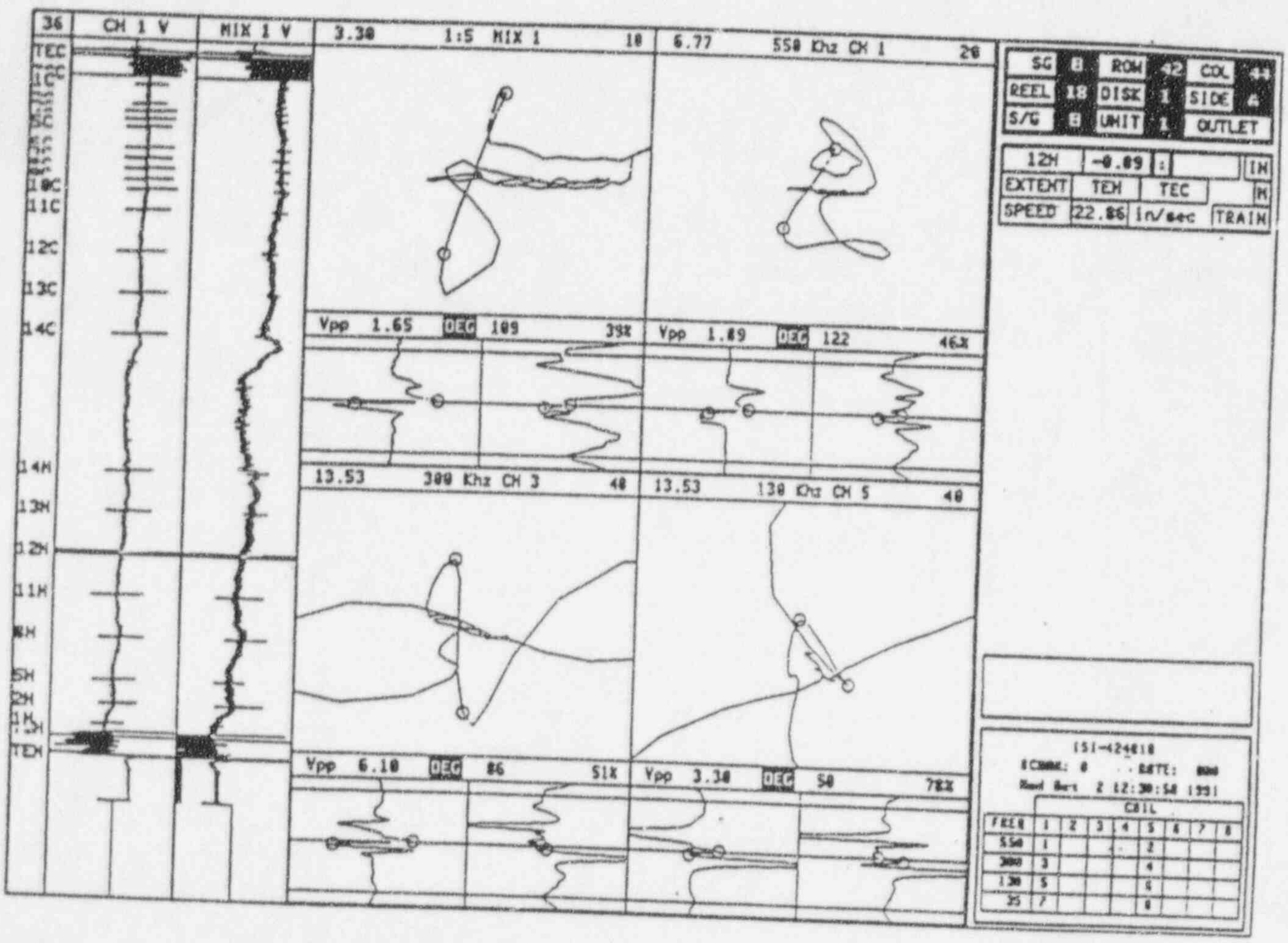


Figure derived from WCAP-13523 [23].

FIGURE A-10
CORRECT PLACEMENT OF VECTOR DOTS ON MIX 1
LISSAJOUS FIGURE FOR R42C44

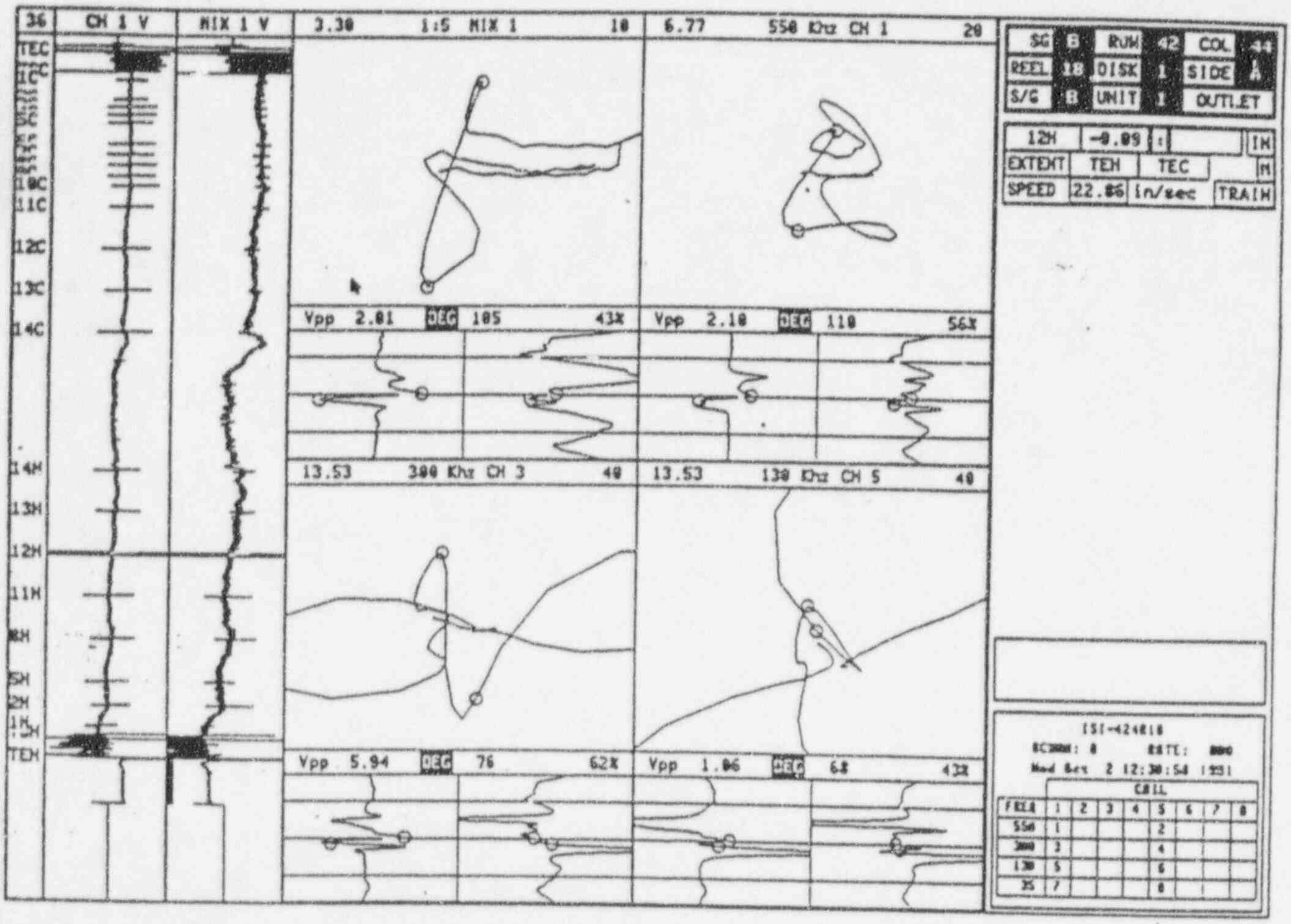


Figure derived from WCAP-13523 [23].

FIGURE A-11

PLACEMENT OF VECTOR DOTS BASED SOLELY ON MIX 1 LISSAJOUS FIGURE (NO SIGNIFICANT SHARP TRANSITIONS IN ANY OF THE RAW FREQUENCIES) - R10C44

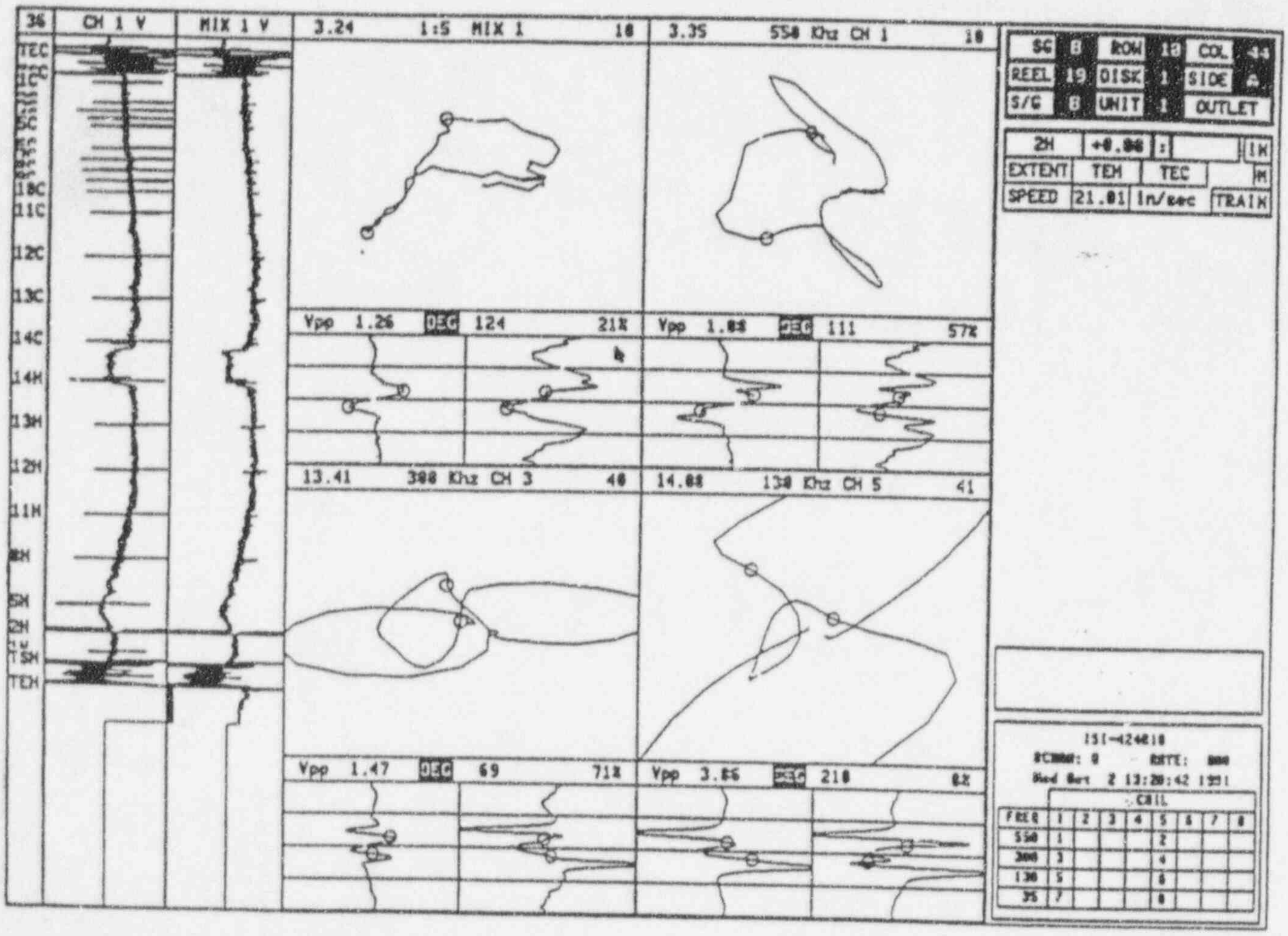


Figure derived from WCAP-13523 [23].

FIGURE A-12

PLACEMENT OF DOTS MARKING MIX 1 LISSAJOUS FIGURE FOR R16C26

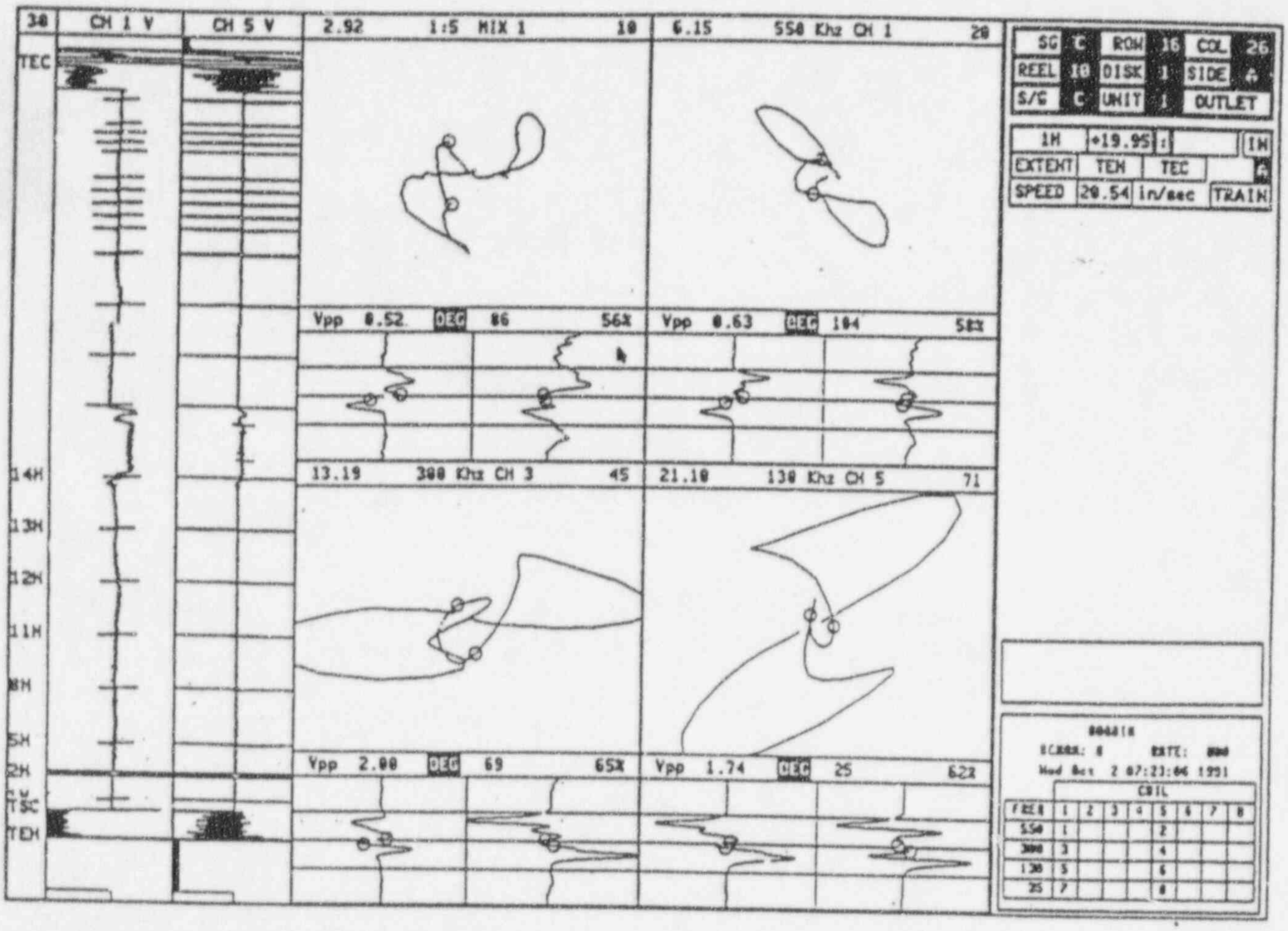


Figure derived from WCAP-13523 [23].

FIGURE A-13

INCORRECT PLACEMENT OF VECTOR DOTS MARKING MIX 1 LISSAJOUS FIGURE FOR R30C74

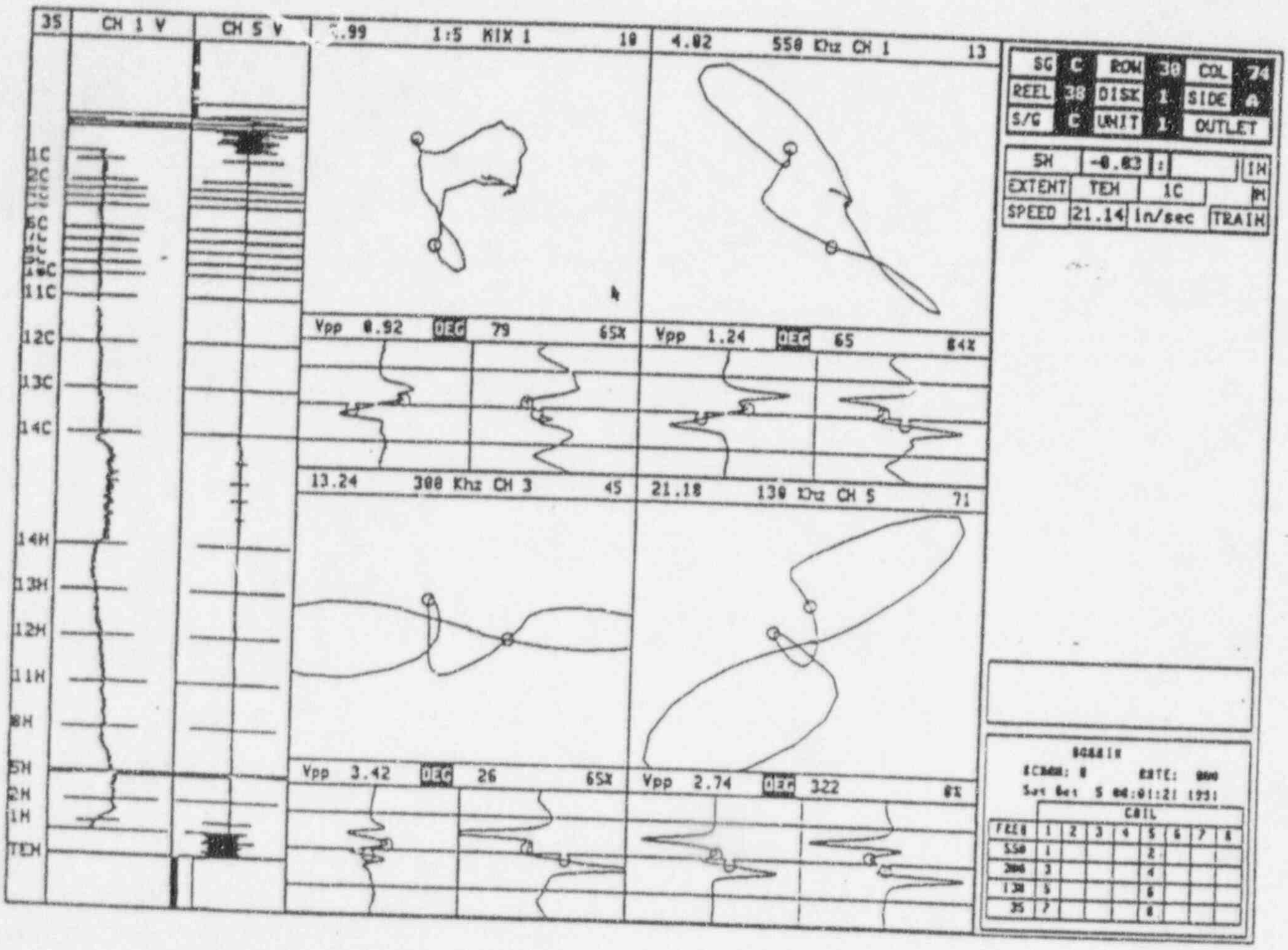


Figure derived from WCAP-13523 [23].

FIGURE A-14

CORRECT PLACEMENT OF DOTS TO EFFECT MAXIMUM VOLTAGE - R30C74

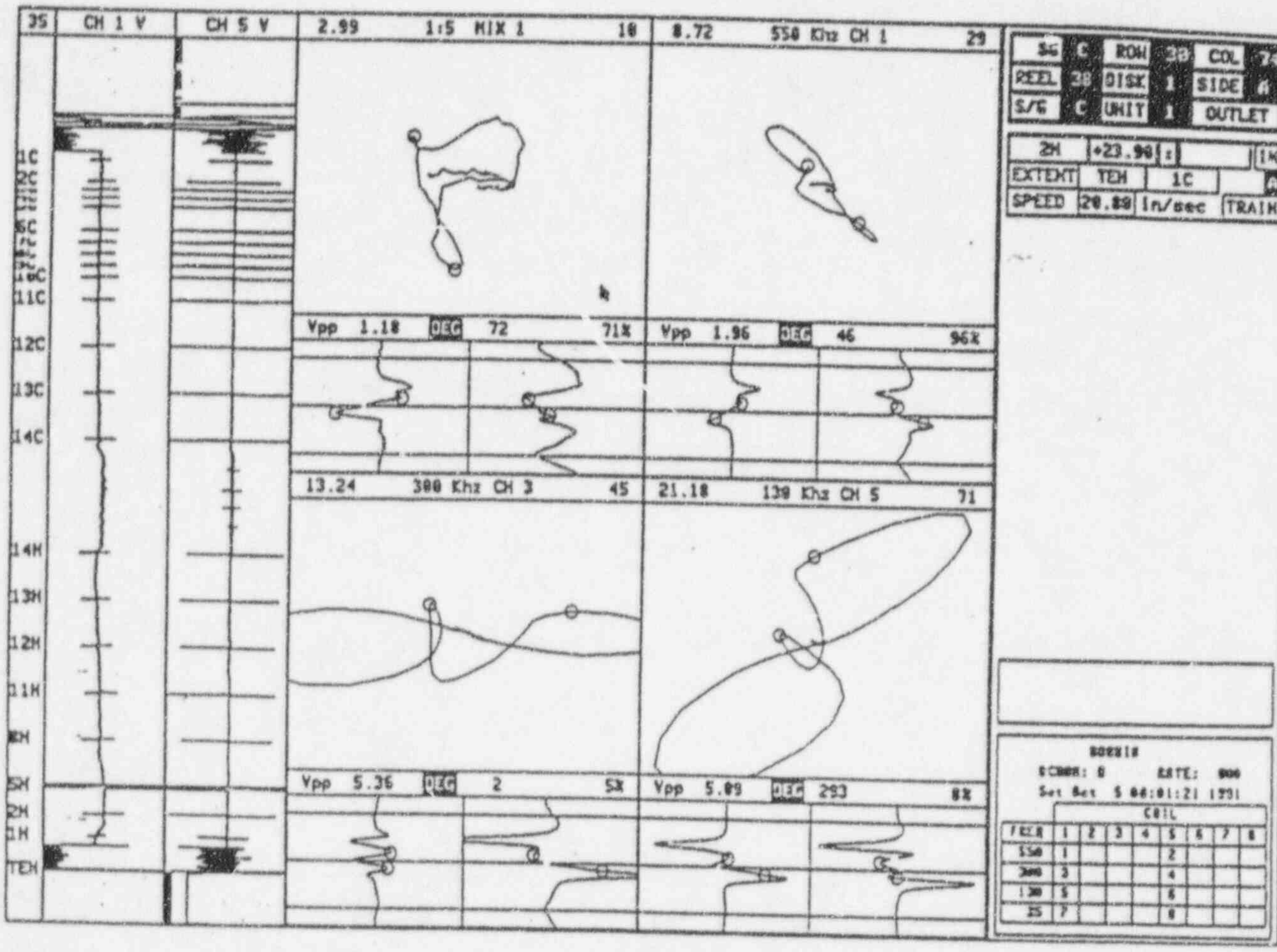


Figure derived from WCAP-13523 [23].

FIGU -15

EXAMPLE OF BOBBIN COIL FIELD DATA -
MIX RESIDUAL DUE TO ALLOY CHANGE

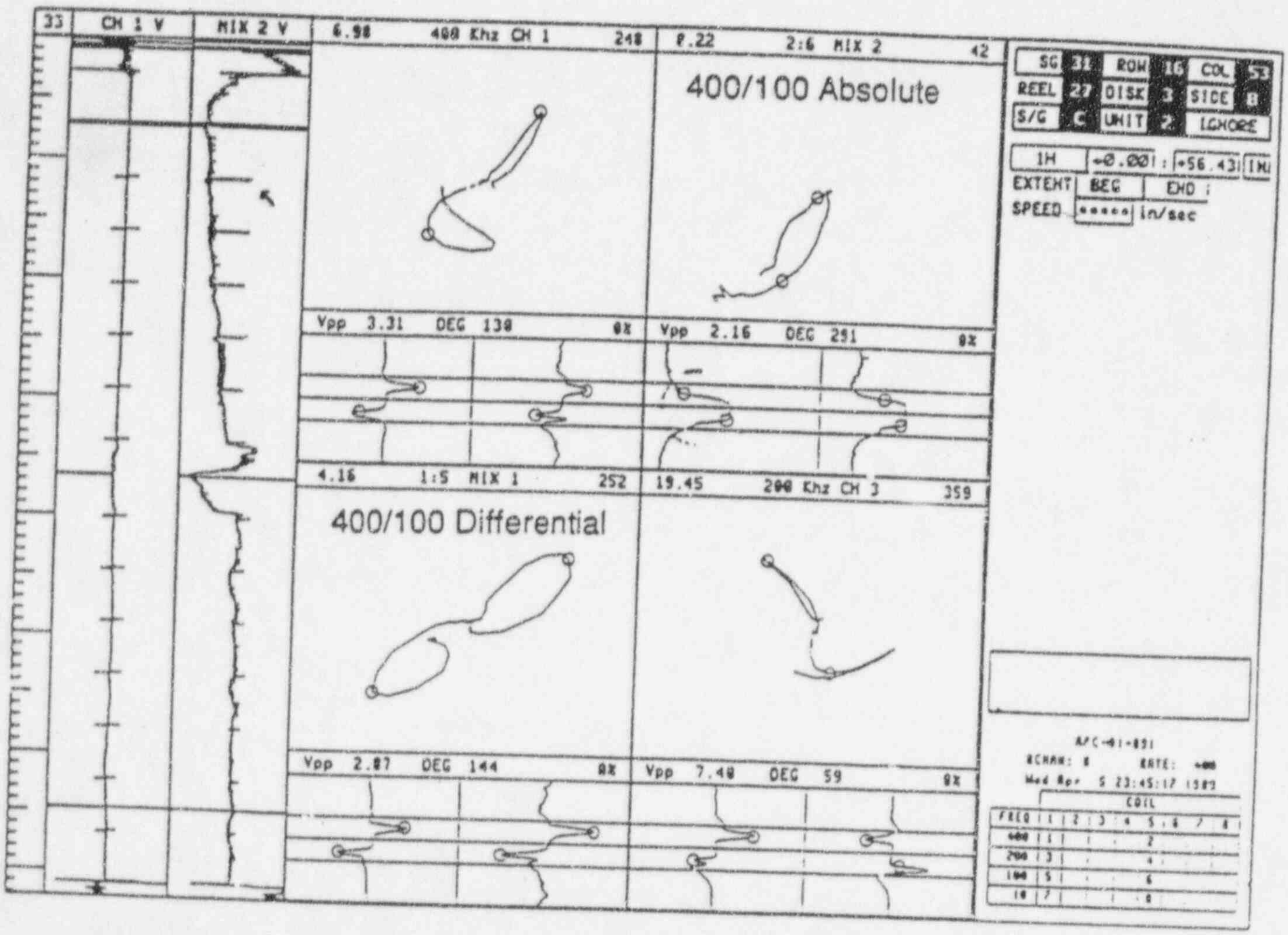


Figure derived from WCAP-13523 [23].

FIGURE A-16

EXAMPLE OF MRPC DATA FOR SINGLE AXIAL INDICATION (SAI) ATTRIBUTED TO ODSCC - PLANT S

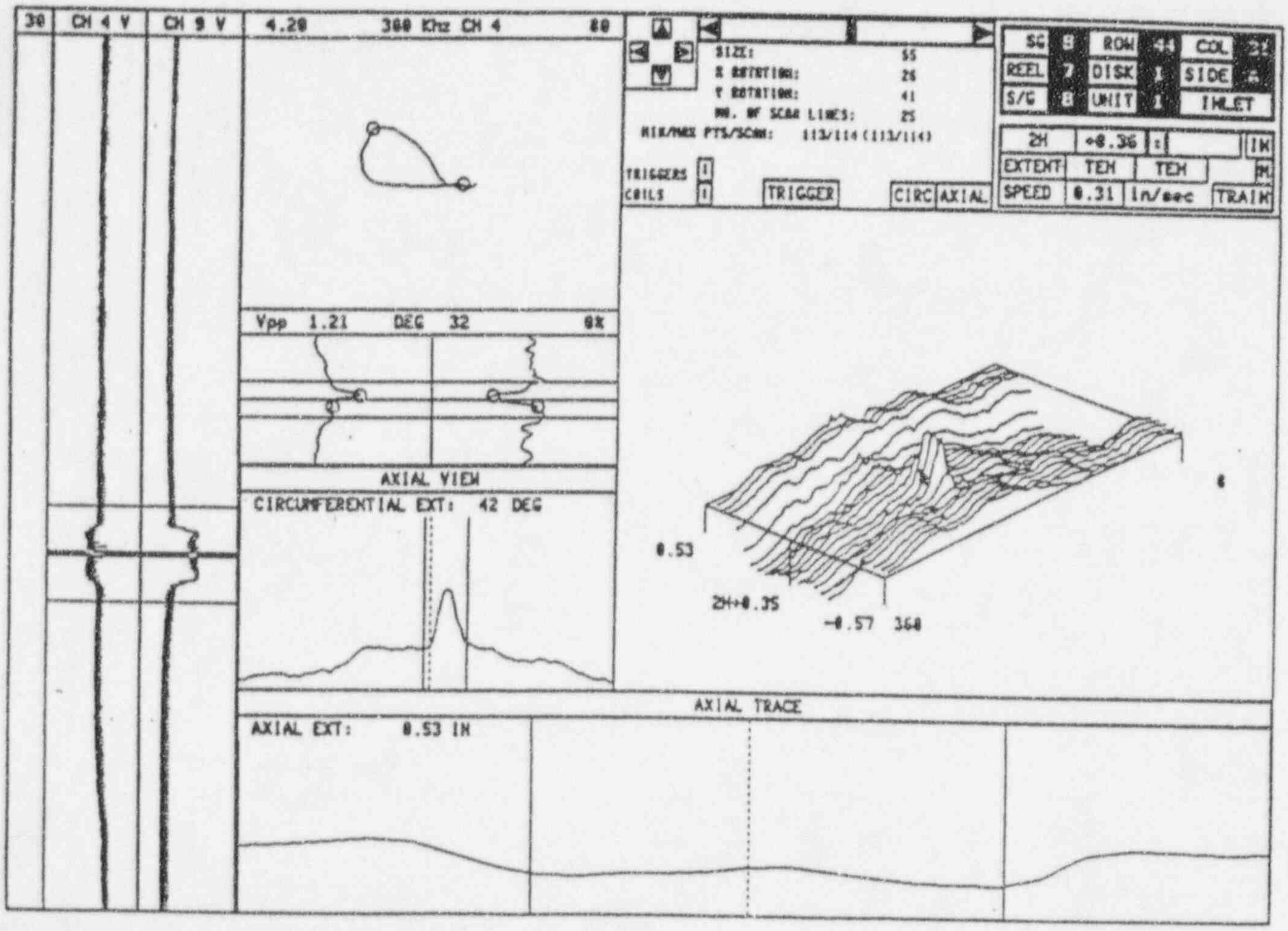


Figure derived from WCAP-13523 [23].

FIGURE A-17

MRPC DATA FOR SINGLE AXIAL ODSCC INDICATION(SAI) - PLANT S

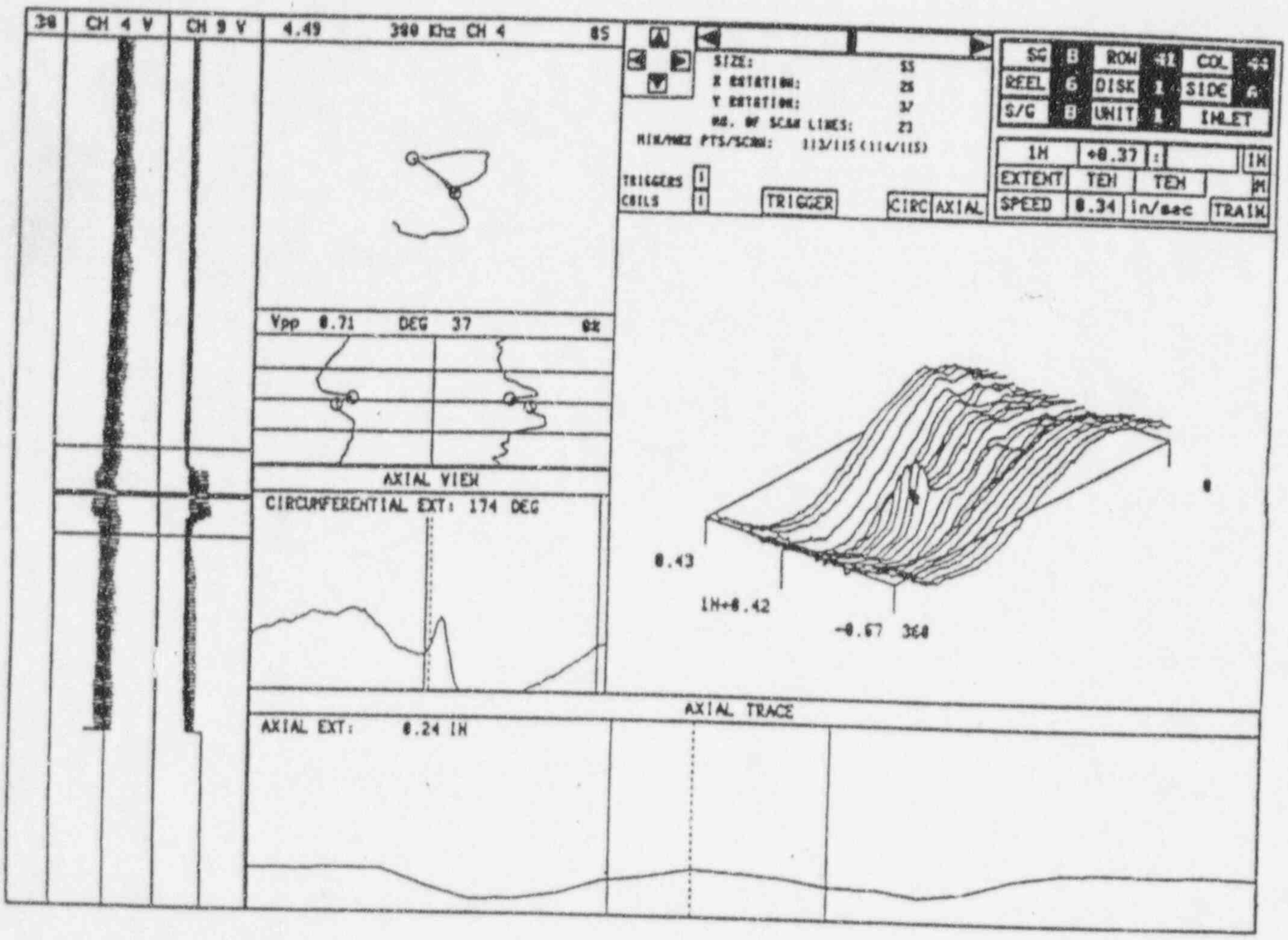


Figure derived from WCAP-13523 [23].

<u>FIGURE A-18</u>

MRPC DATA FOR MULTIPLE AXIAL ODSCC INDICATIONS (MAI) - PLANT S

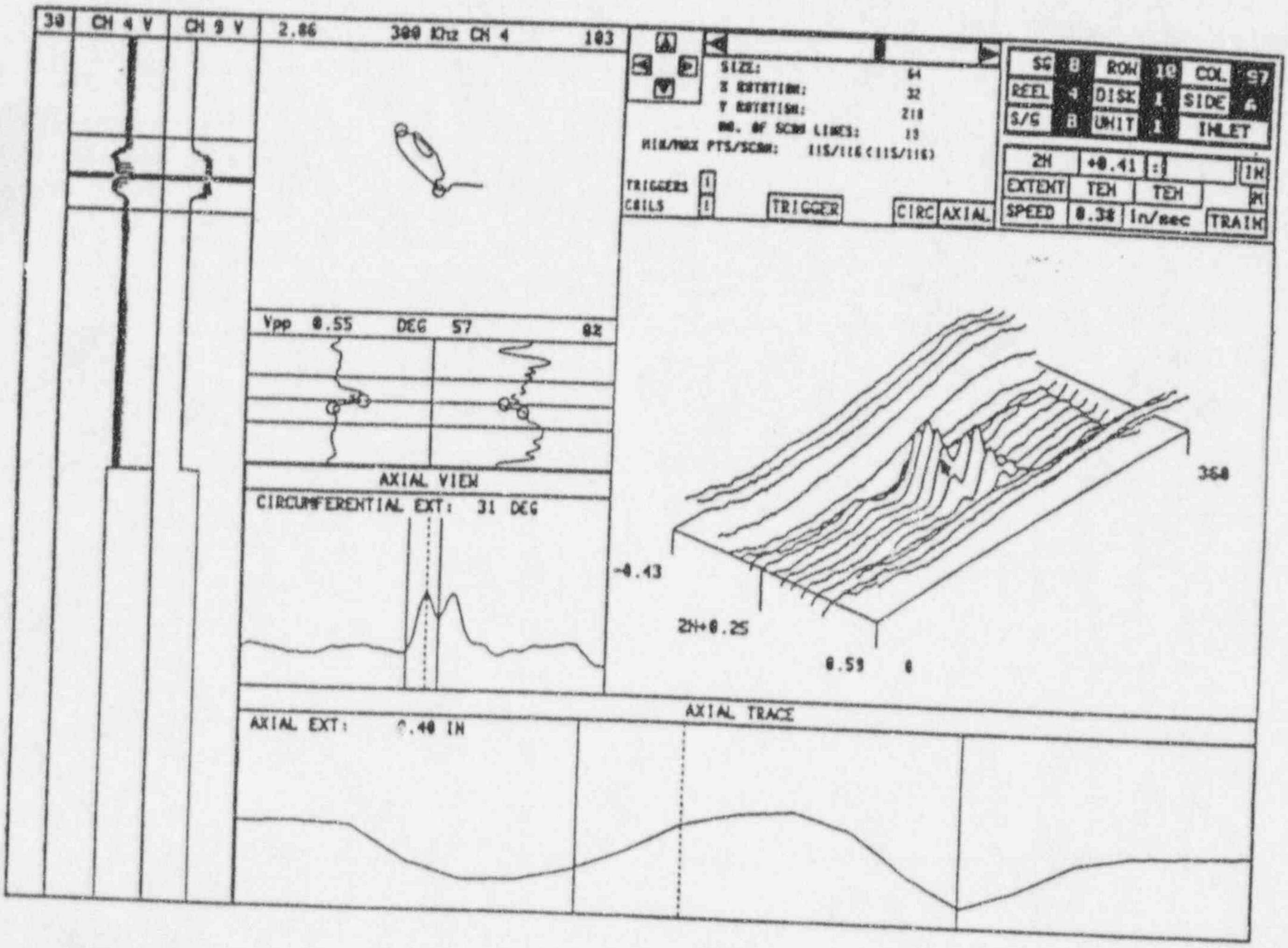


Figure derived from WCAP-13523 [23].

FIGURE A-19

MRPC DATA FOR CIRCUMFERENTIAL ODSCC INDICATIONS AT DENTED UPPER AND LOWER TSP EDGES

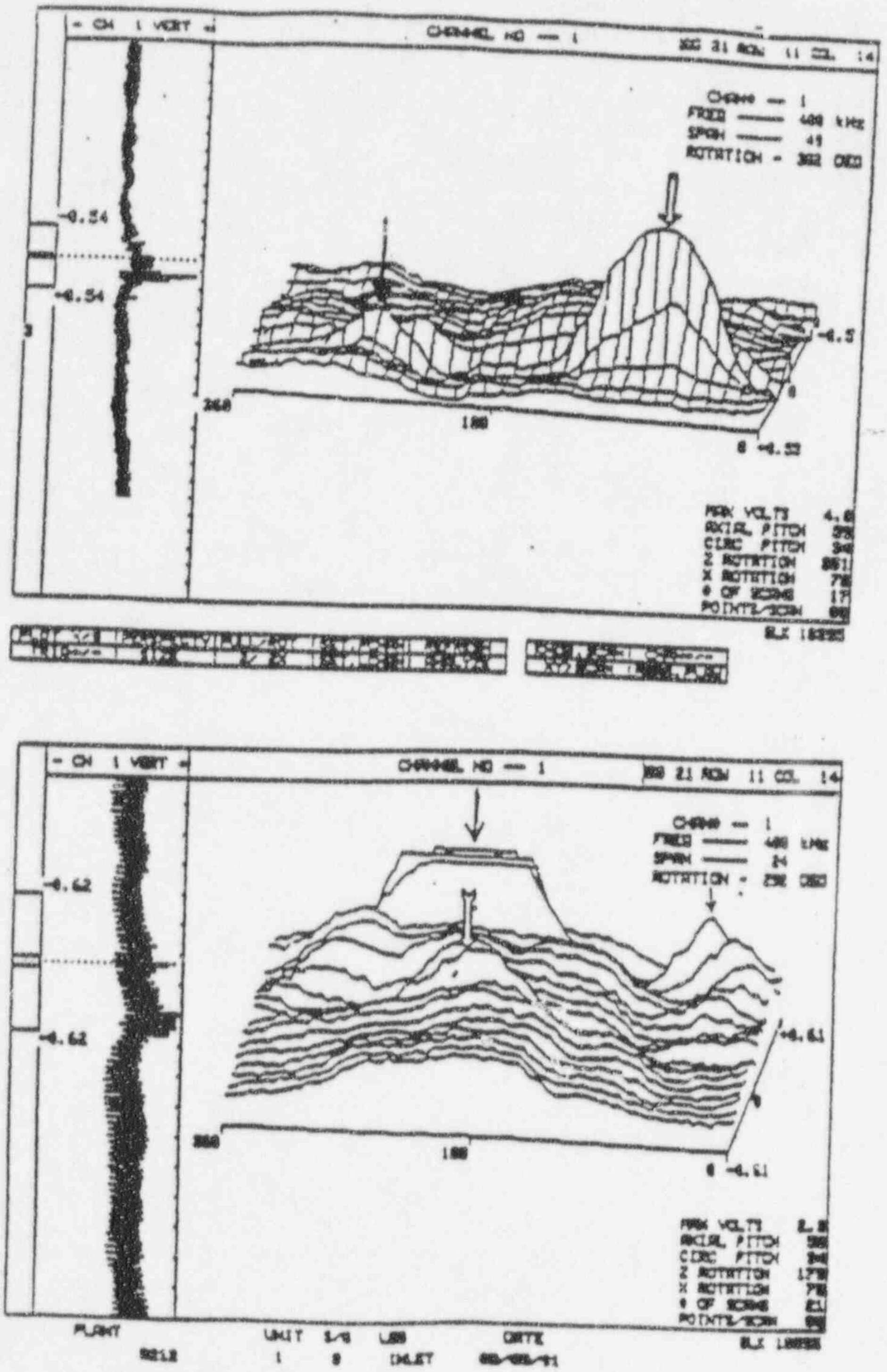


Figure derived from WCAP-13523 [23].

FIGURE A-20

EXAMPLE OF BOBBIN COIL FIELD DATA - FLAW SIGNALS FOR ODSCC AT DENTED TSP INTERSECTION FROM PLANT A

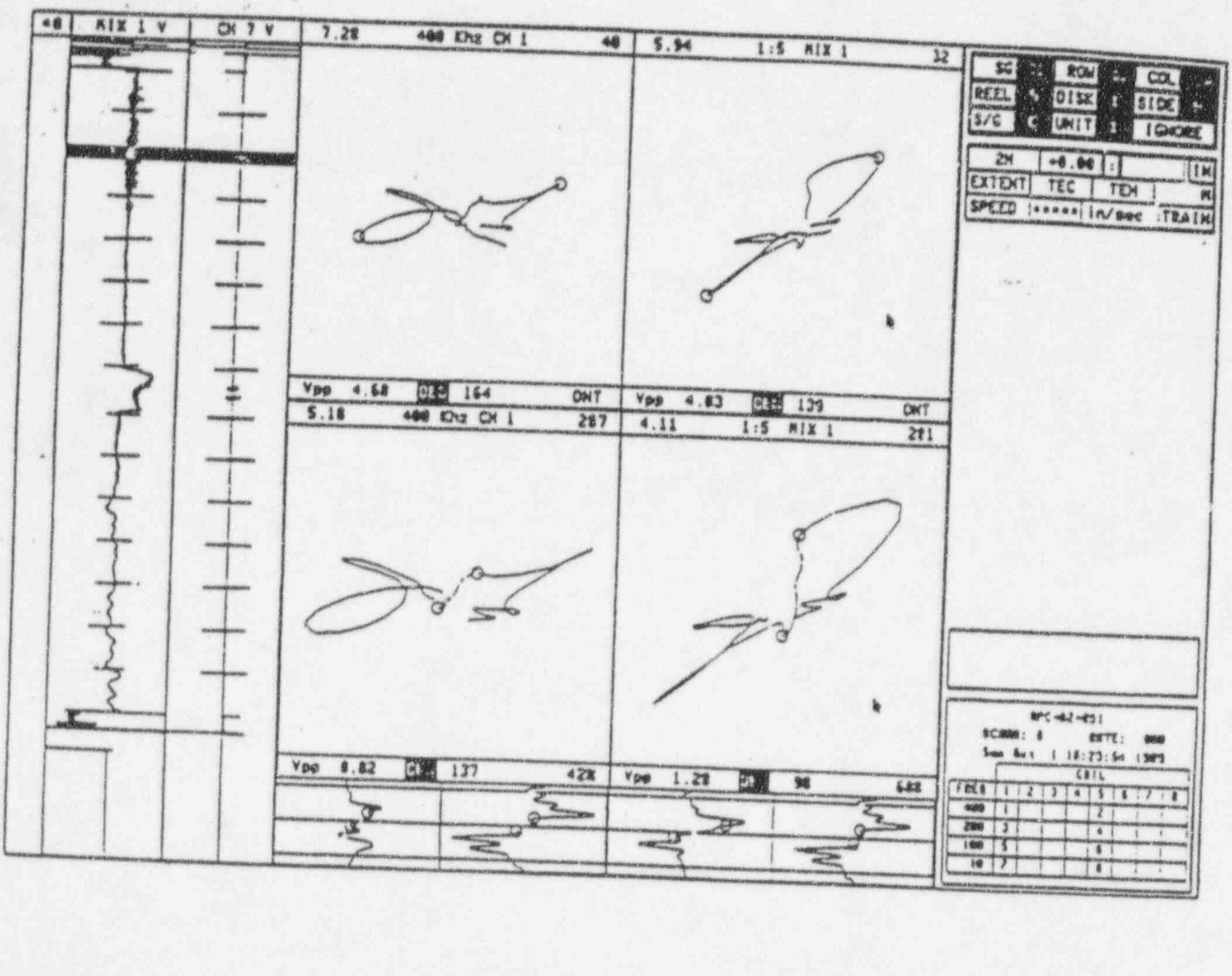


Figure derived from WCAP-13523 [23].

<u>FIGURE A-21</u>

EXAMPLE OF BOBBIN COIL FIELD DATA - FLAW SIGNALS FOR ODSCC AT DENTED TSP INTERSECTION FROM PLANT A

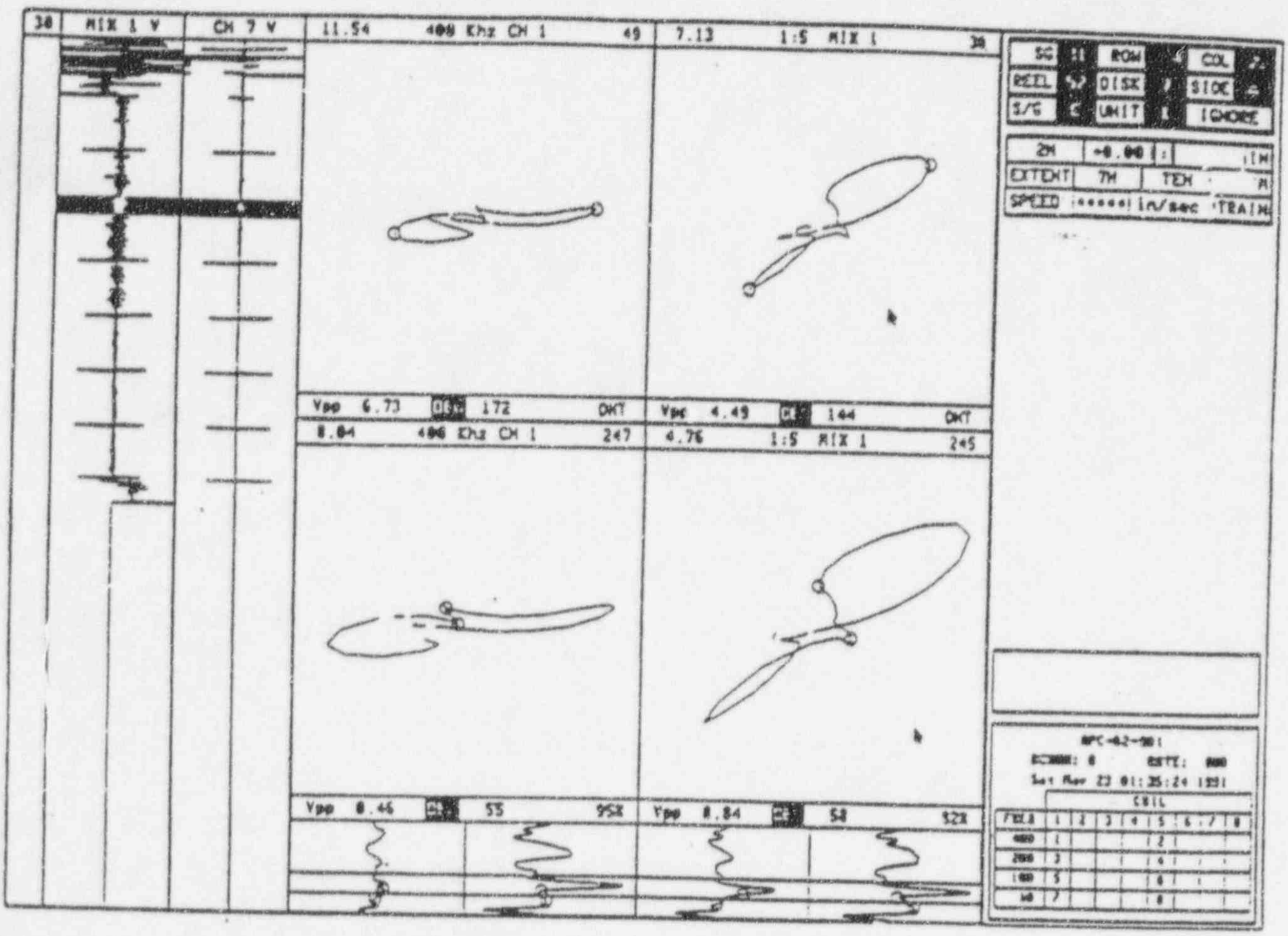


Figure derived from WCAP-13523 [23].

FIGURE A-22

EXAMPLE OF BOBBIN COIL FIELD DATA - FLAW SIGNALS FOR ODSCC AT DENTED TSP INTERSECTION FROM PLANT A

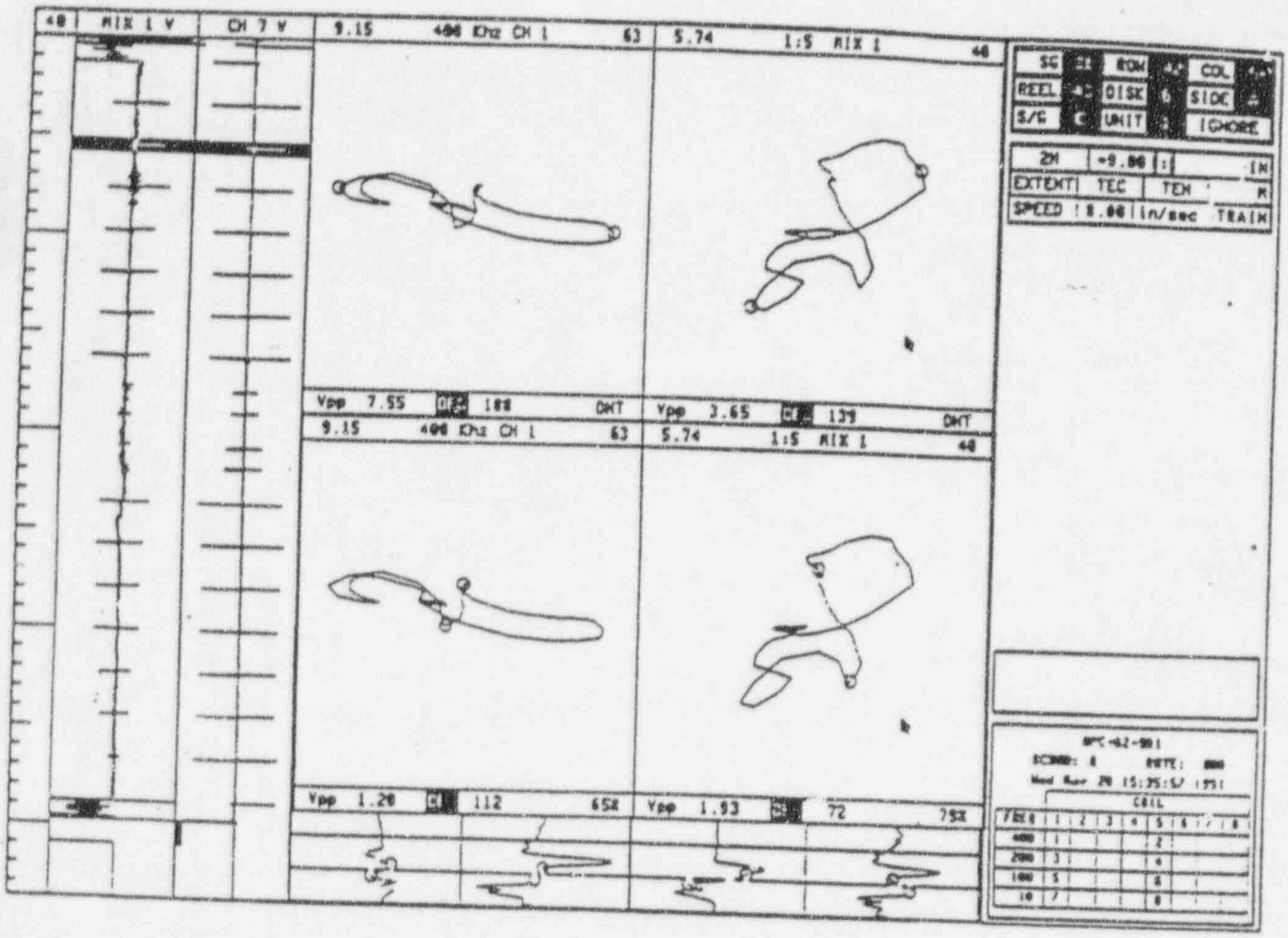


Figure derived from WCAP-13523 [23].

<u>FIGURE A-23</u>

EXAMPLE OF BOBBIN COIL FIELD DATA - FLAW SIGNALS FOR ODSCC AT DENTED TSP INTERSECTION FROM PLANT A

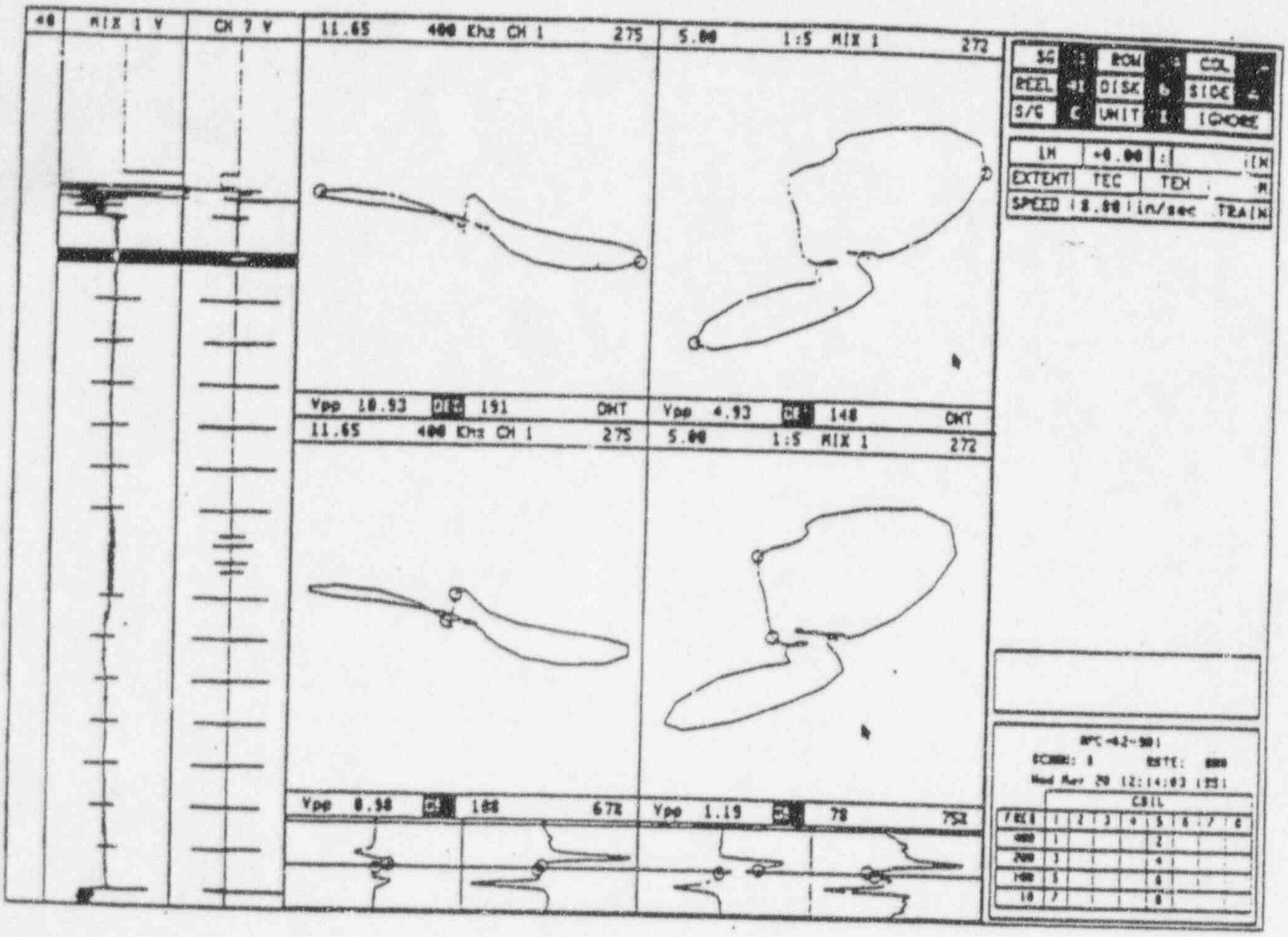


Figure derived from WCAP-13523 [23].

FIGURE A-24

EXAMPLE OF BOBBIN COIL FIELD DATA - FLAW SIGNALS FOR ODSCC AT DENTED TSP INTERSECTION FROM PLANT A

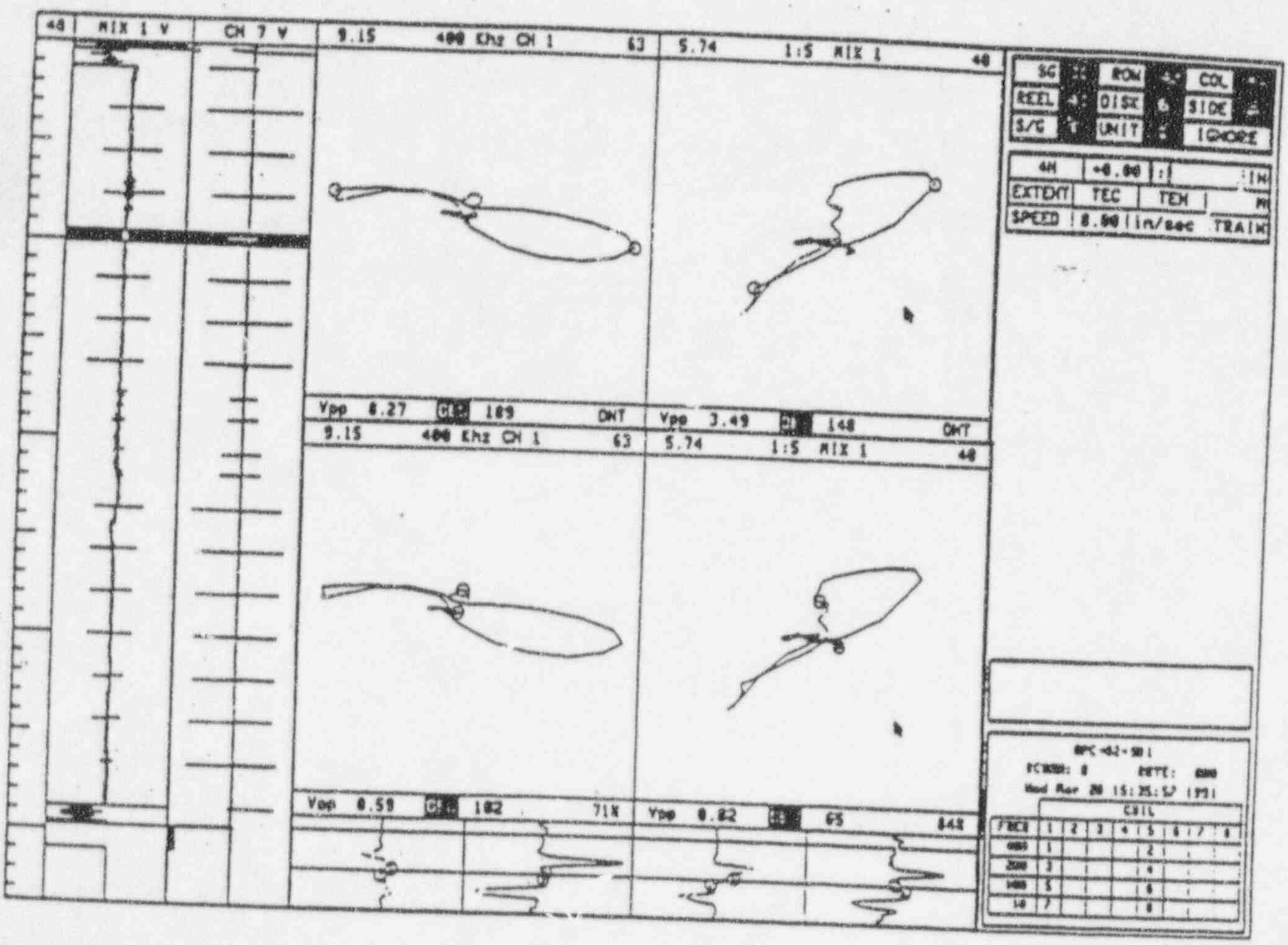


Figure derived from WCAP-13523 [23].

FIGURE A-25

EXAMPLE OF BOBBIN COIL FIELD DATA - FLAW SIGNALS FOR ODSCC AT DENTED TSP INTERSECTION FROM PLANT A

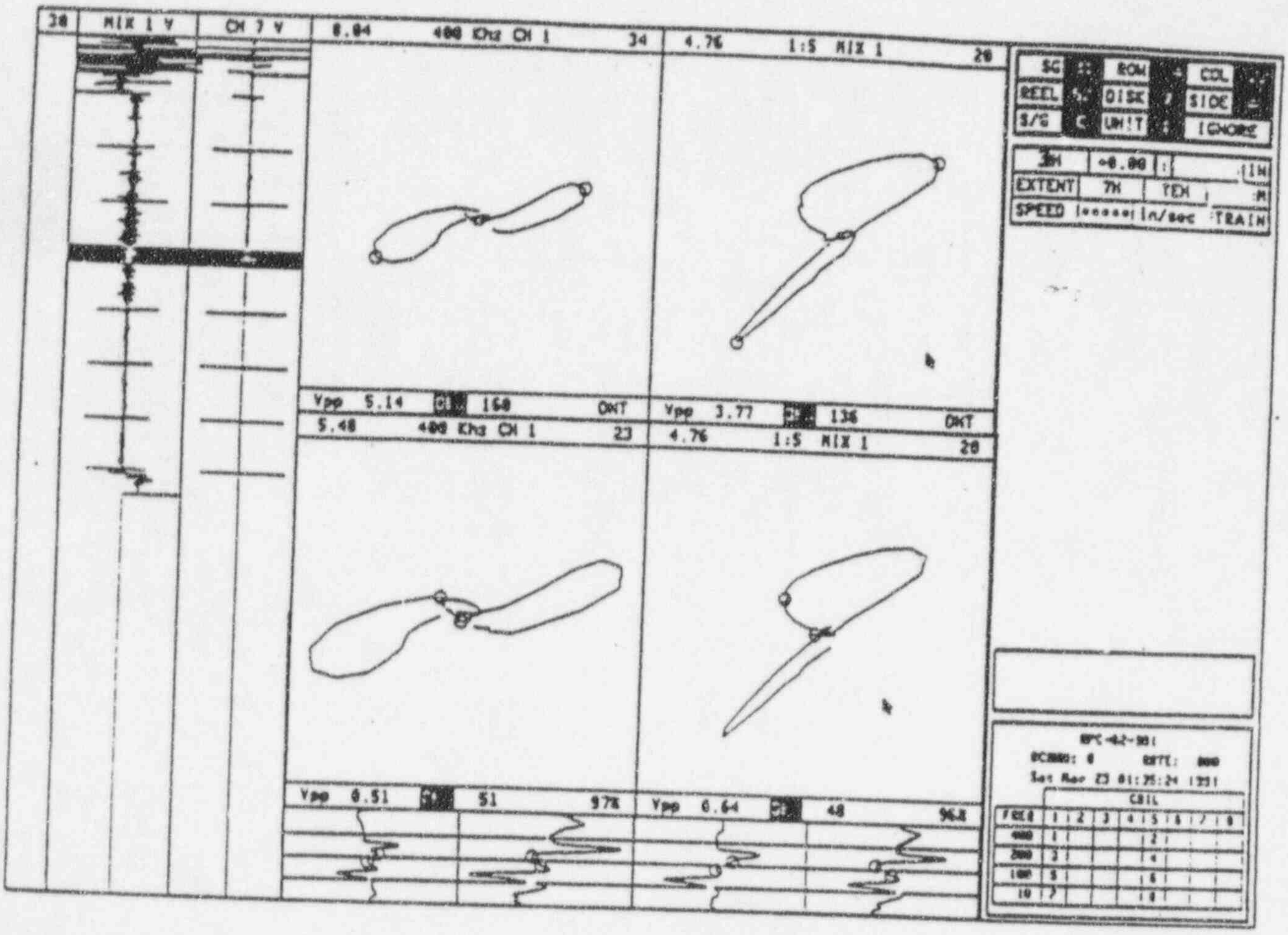


Figure derived from WCAP-13523 [23].

FIGURE A-26

LOCATION OF ONE END OF AN INDICATION USING AN RPC PROBE

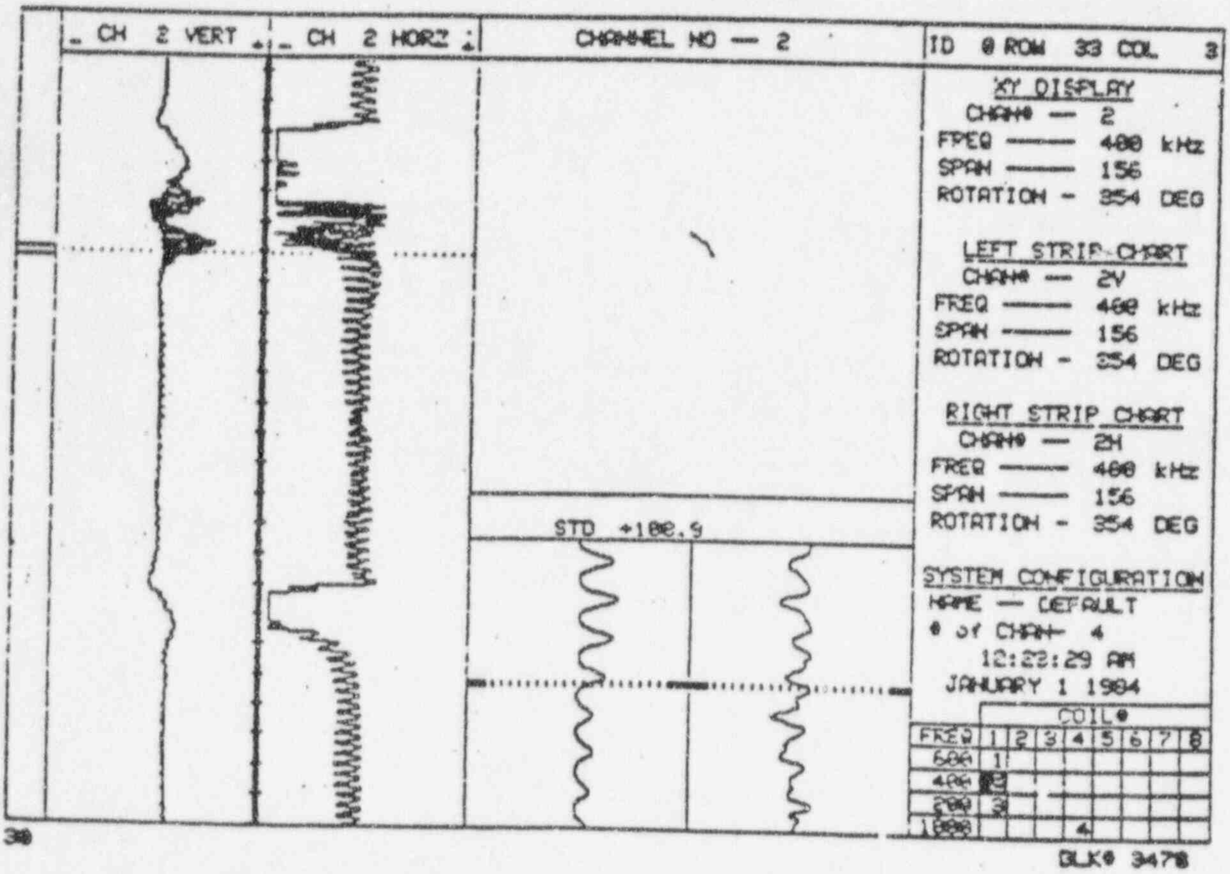


Figure derived from WCAP-13523 [23].

ATTACHMENT 2

Topical Report BAW-10204P,
Revision 3, May, 1996,

"South Texas Project -Unit 1 Tube Repair Criteria
for
ODSCC at Tube Support Plates"

FTI PROPRIETARY