NRC FORM 658
(9-1999)

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DATE OF MEETING
06/08/2000

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Docket Number(s)	**50-368**
Plant/Facility Name	**Arkansas Nuclear One, Unit 2 (ANO-2)**
TAC Number(s) (if available)	**MA1951 and MA8418**
Reference Meeting Notice	**Meeting Notice Dated May 24, 2000**
Purpose of Meeting (copy from meeting notice)	**To facilitate review of EOI's February 11, 2000, deterministic operational assessment and March 9, 2000, risk-informed proposed license change regarding steam generator tubing.**

NAME OF PERSON WHO ISSUED MEETING NOTICE
T. Alexion

TITLE
Project Manager

OFFICE
Nuclear Reactor Regulation

DIVISION
Division of Licensing Project Management

BRANCH
Project Directorate IV & Decommissioning

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DF01

ANO Unit 2 Steam Generator Evaluation

June 8, 2000

Introduction

Craig Anderson

Vice-President Operations, ANO

ANO-2 Steam Generator Evaluation

Introduction.................................. Craig Anderson

Safety and Operational

Assessment Overview..................... Robert Bement

Operational Assessment (OA)........... Darol Harrison

- Background
- Continued Testing
- Deterministic OA

Risk Assessment................................ Mark Smith

Conclusions ....Craig Anderson

Safety and Operational Assessment Overview

Robert Bement

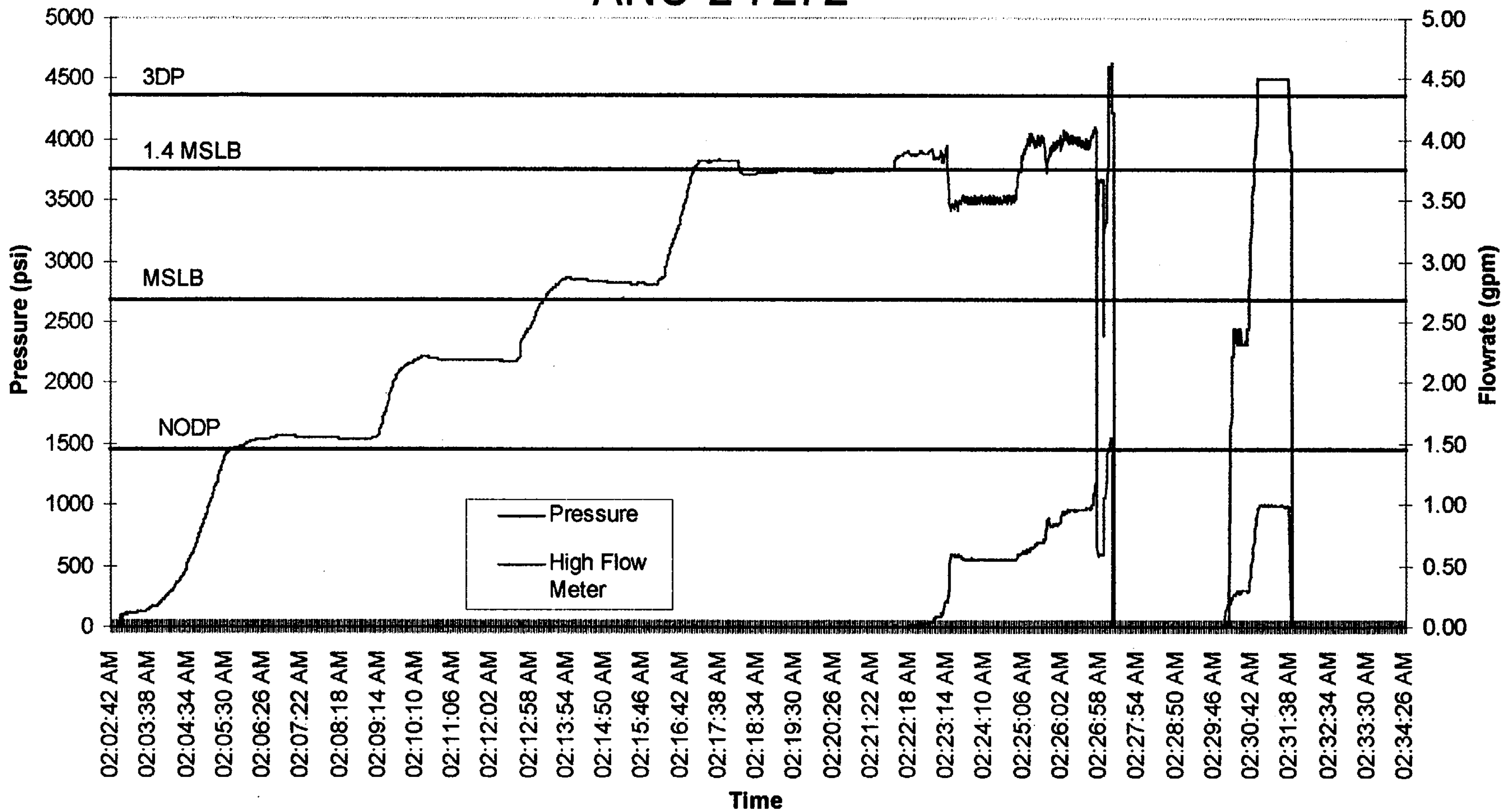
General Manager, ANO

ANO-2 Operational Assessment

- Safety Perspective
  - All in-situ pressure tested tubes exceeded MSLB pressures
  - Low probability of tube failure under MSLB pressure for remainder of current cycle
  - Limiting eggcrate flaws in-situ tested during last four outages
    - No leakage at MSLB pressure
    - One failure to meet $3\Delta P$
    - Corrective action taken

ANO-2 Operational Assessment

ANO-2 7272



ANO-2 Operational Assessment

- Safety Perspective (Continued)
  - Low level and diverse leakage detection capability
  - Operators trained on mitigating actions
  - Administrative limit established
    - 25 GPD verified leakage
  - Insights from risk evaluation (severe accident)
    - Compensating actions already taken to further reduce risk
      - Steps to maintain secondary pressure
    - Compensating actions to be taken to further reduce risk
      - Depressurize primary side

ANO-2 Operational Assessment Overview

- 2P99 In-situ Test Results
  - Tested a total of 6 indications
    - All met MSLB pressure with zero leakage
    - All six met 1.43 MSLB
    - Five met 4650 psi (3ΔP plus additional margin)
  - 1 flaw (72-72) taken to 4147 psi due to leakage in excess of pump capacity
    - Bladder could not be installed
    - Further analysis required to determine tube structural integrity

ANO-2 Operational Assessment Overview

- 2P99 In-situ Test Results (continued)
  - NEI 97-06 provides for the completion of tube structural integrity by analysis
  - Analysis supported by additional lab testing of notched tubes concludes that 72-72 did meet structural integrity requirements with margin

ANO-2 Operational Assessment Overview

- ANO-2 is safe to operate until 2R14
- Analysis demonstrated the unit can operate until the mid-September SG replacement outage in full compliance with our operating license and commitment to NEI 97-06

Operational Assessment

Darol Harrison
Supervisor, Engineering Programs

ANO-2 Deterministic Operational Assessment

- Deterministic Operational Assessment
  - Background
  - Review of previous data
    - Limited to eggcrate axial indications
    - In-situ results
  - Discuss continued testing
  - Original analysis still bounding

ANO-2 Operational Assessment

- Eggcrate Axial Cracking
  - 1st detected in 1991 (2R8)
  - Leaker in 1996 (2F96)
  - Began plug on detection in 1997 (2R12)
  - 1998 (2R13) eliminated resolution analysis from leaving flaws in service
  - 1999 (2P99) calibration standard improvement

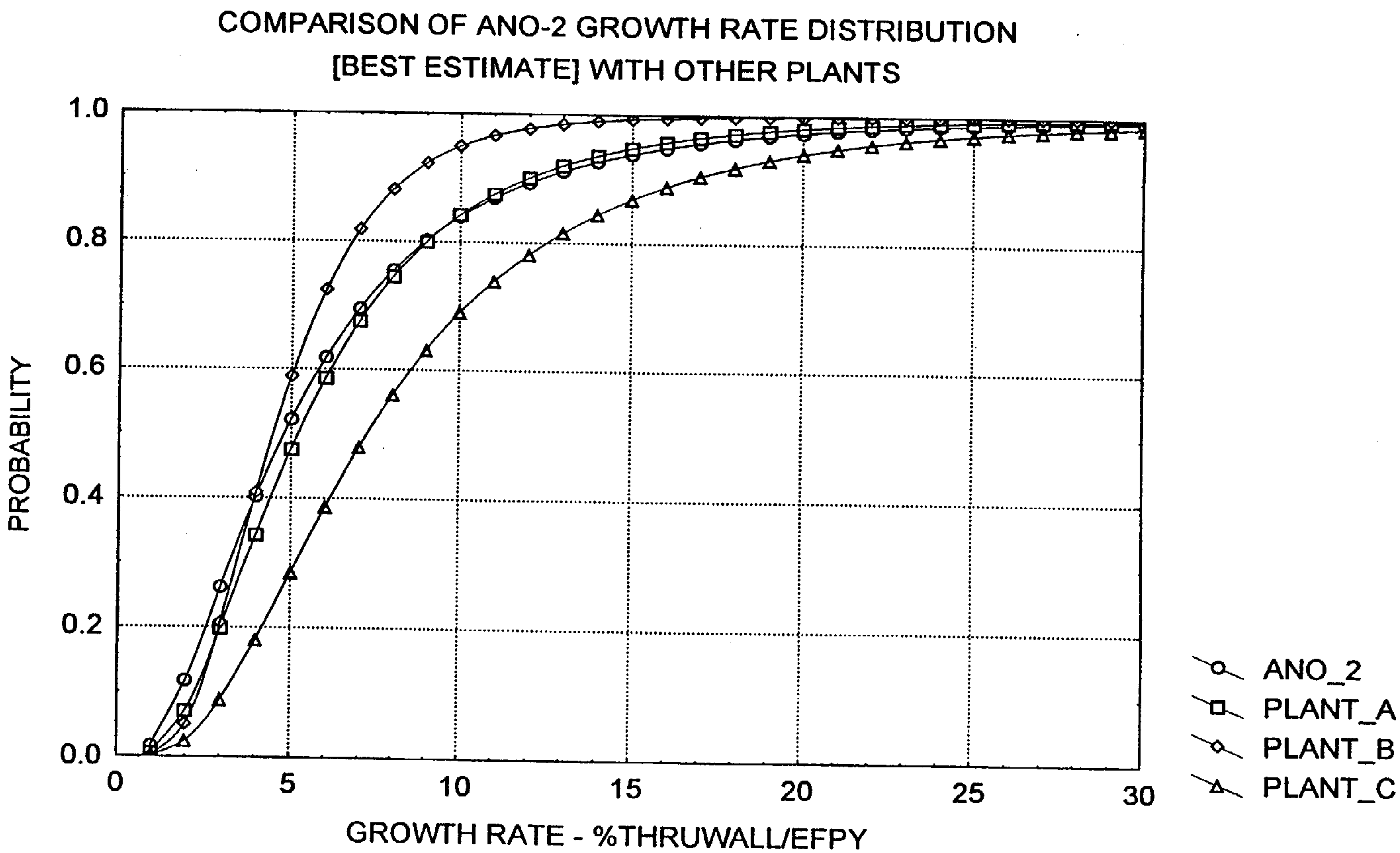
ANO-2 Operational Assessment

- 1998 Extensive SSPD Performed
  - Utilized pulled tube data
  - Performed under same conditions as during outage
    - Replicated 2R13 issue
    - Allowed quantification of POD in the field
  - Results showed POD improvement above 50% TW of about 20 points
    - Information incorporated in analyst training and testing program

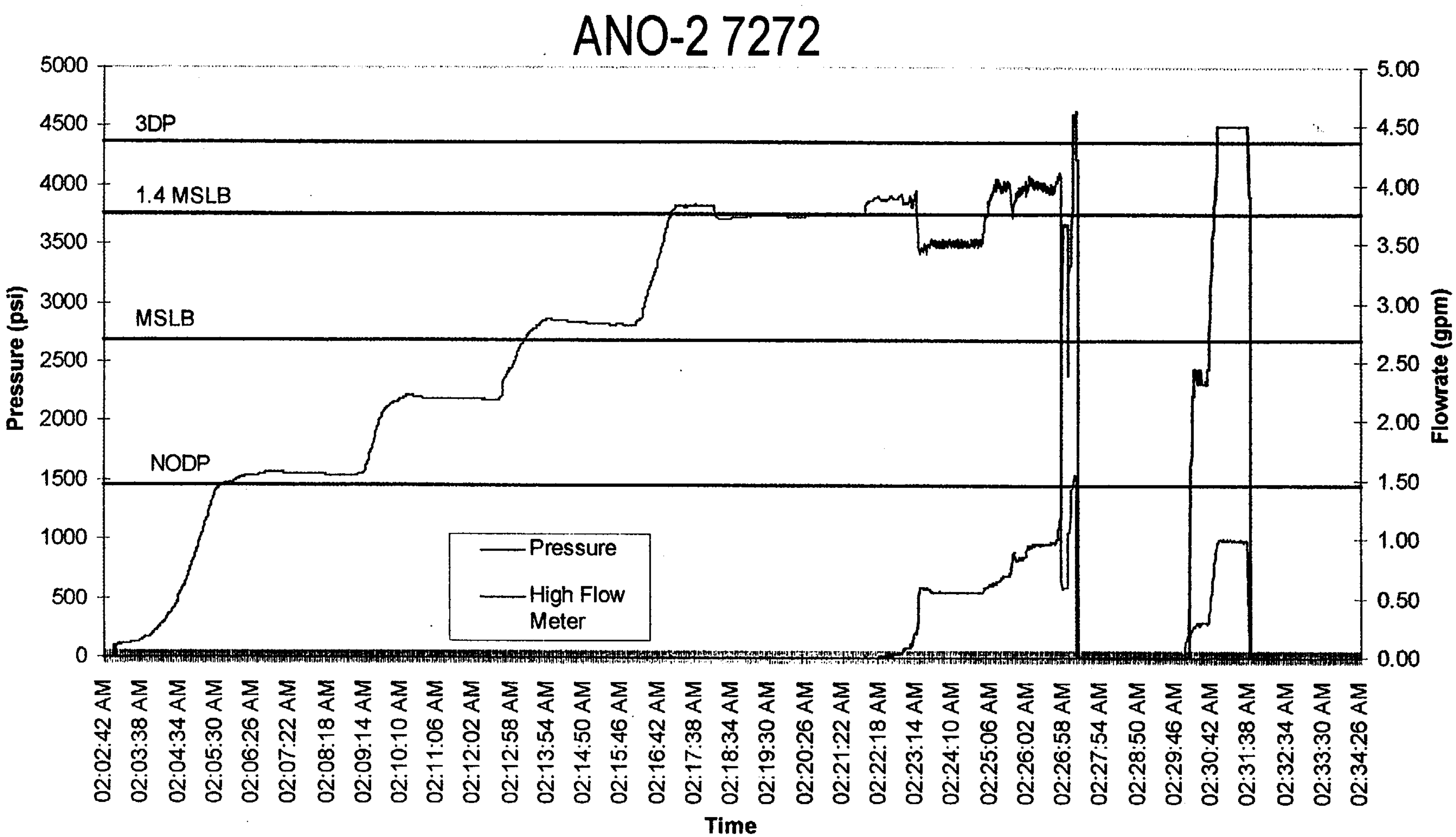
ANO-2 Operational Assessment

- 1999 Calibration Standard Change
  - Flaw voltages increased
  - Increased number of flaws detected due to this improvement
- Growth Rate Evaluations
  - Several growth rate studies conducted
    - Over different operating intervals
    - Compared to other CE plant data
  - Result is growth behavior is known
    - Growth rate has not changed in this operating period

ANO-2 Operational Assessment



ANO-2 Operational Assessment



ANO-2 Operational Assessment

- Margin of 3 to burst during normal operation
  - $3\Delta P$ = 4050 (4369 psid at room temperature)
    - ASME design code required $S_m < S_u/3$
    - Basis for repair limit
    - NEI 97-06 performance criteria
  - Design Basis Accident ΔP
    - 2500 psid for MSLB
    - Probability of MSLB very low

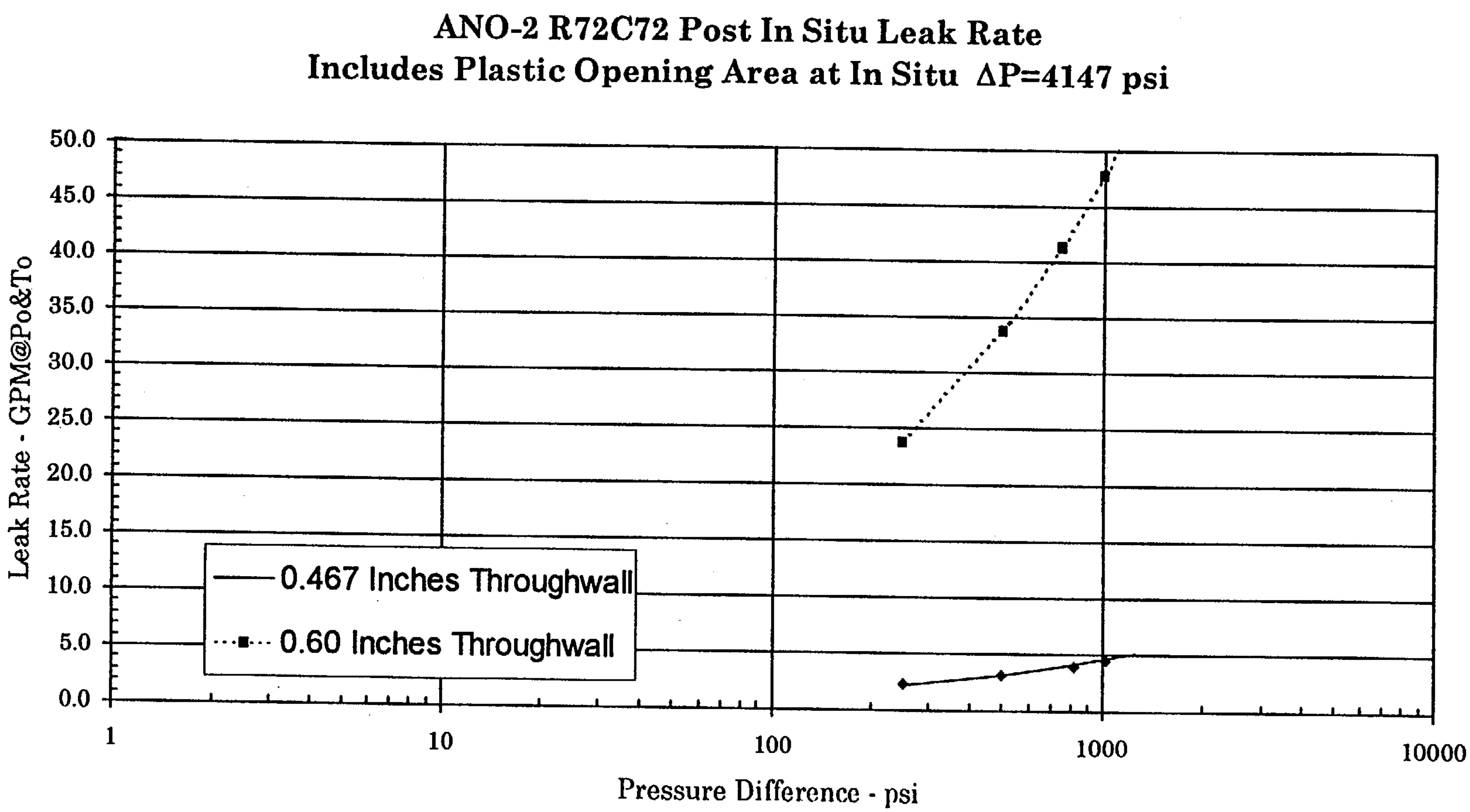
ANO-2 Operational Assessment 2P99 Condition Monitoring

- Conclusions From Initial Work
  - 72-72 did not burst
    - Post in-situ condition equivalent to ligament tearing to permit significant leakage
    - No crack extension (required for a burst)
  - Evaluation based upon Argonne National Lab (ANL) ligament tearing and Westinghouse burst pressure models
    - Objective to predict ΔP between ligament tearing and burst
    - Based on results, ~500 psi pressure increase above 4147
  - EDM Testing
    - Based on ΔP between complete and incomplete burst tests
    - Supported >500 psi pressure increase

ANO-2 Operational Assessment

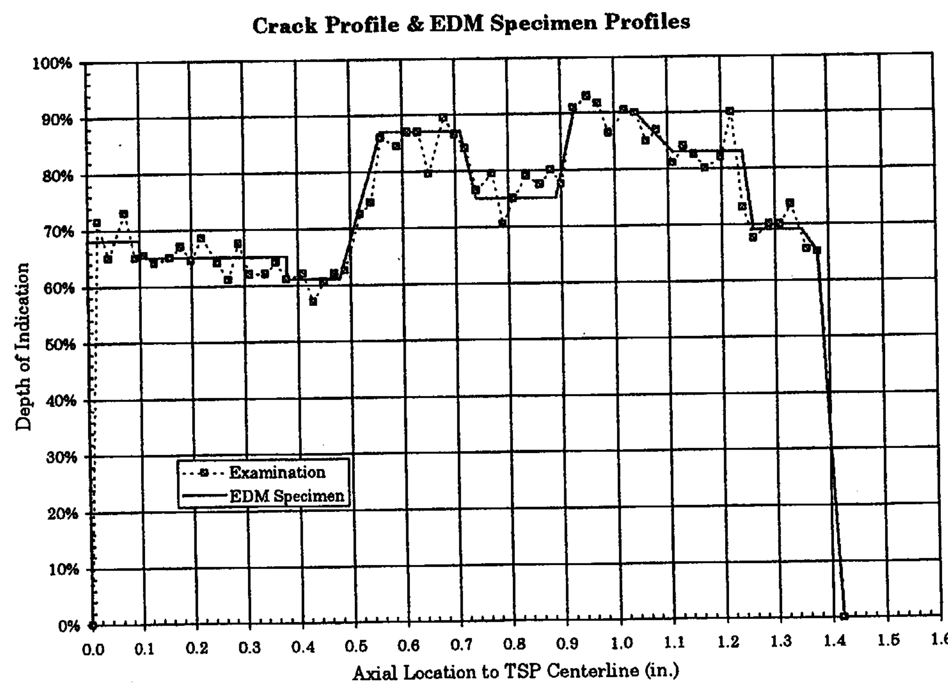
- Continued testing to support deterministic Operational Assessment
  - Test objectives
    - Match 72-72 leakage
    - Determine ΔP between ligament tearing and burst
  - More complex EDM samples
    - Leakage and burst
  - Analytical model
    - ANL model
    - WCAP

ANO-2 Operational Assessment



ANO-2 Operational Assessment

- EDM Samples
  - First developed complex EDM to mimic tube 72-72 ECT profile



ANO-2 Operational Assessment

- EDM Sample Results
  - Produced very low ligament tearing values (~2500 psi)
    - No leakage prior to tearing
    - Could not repressurize post ligament tearing
  - Concluded that the ECT profile was giving overly conservative estimates for depth
    - Supported by pulled tube results
    - Calculations estimate 8% TW correction would result in comparable pressures that 72-72 exhibited

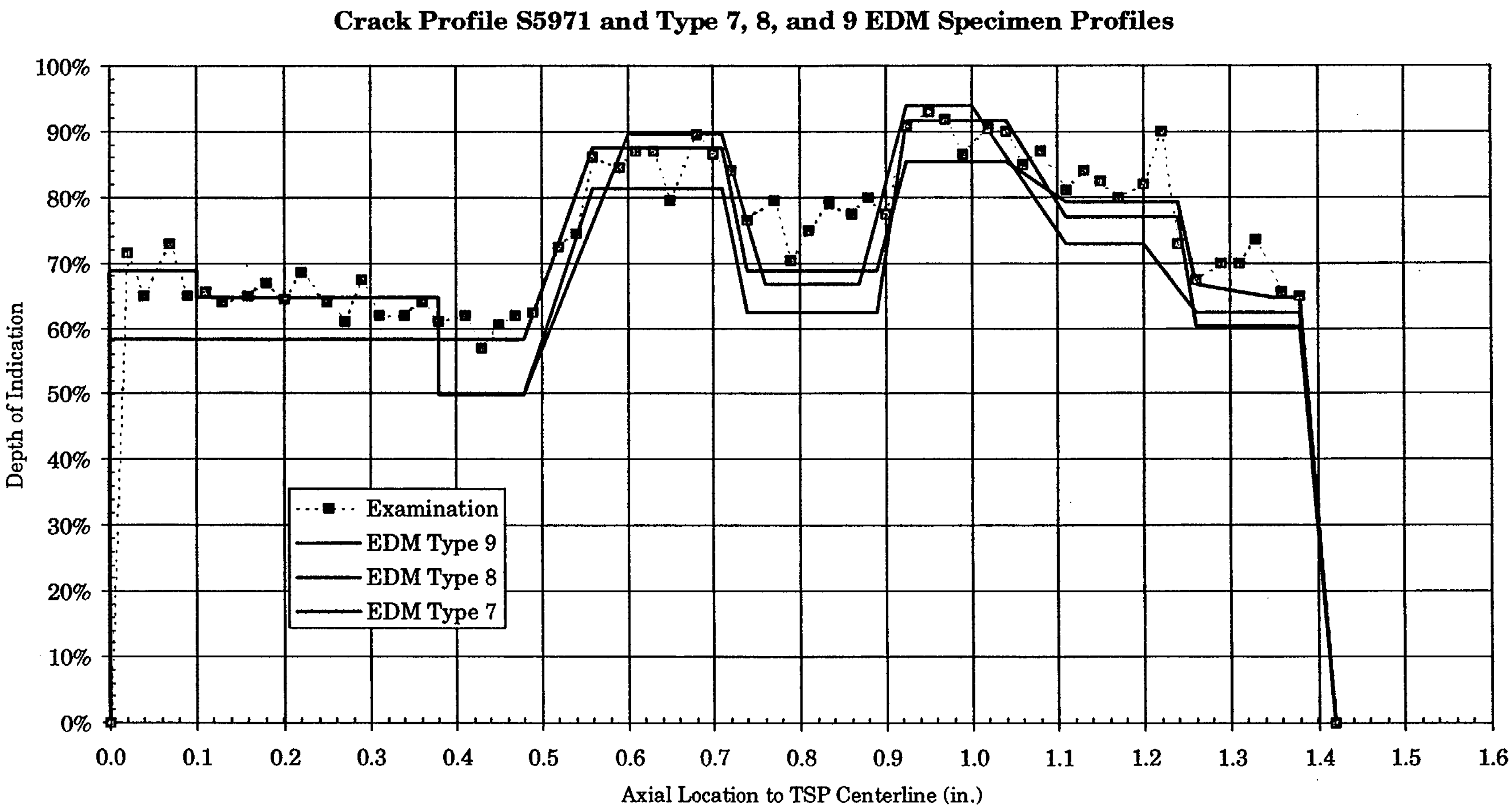
ANO-2 Operational Assessment

- EDM Sample Results
  - Next - Produced flaws that were reduced in depth by 7% and 10%
  - Resulted in increased ligament tearing pressures
    - No leakage prior to ligament tearing
    - Could not repressurize
    - Flaw lengths were ~ 1 inch
  - Leakage still in excess of 72-72
  - Modified profile in an attempt to get more accurate leakage profiles

ANO-2 Operational Assessment

- EDM Sample Results
  - Adjusted peak depths to get a correct pressure/leakage response
  - Adjusted ligament depth to obtain the flaw length matching the test results
  - Ligament failure pressure close to predicted
    - Length of the opening and leakage still not similar

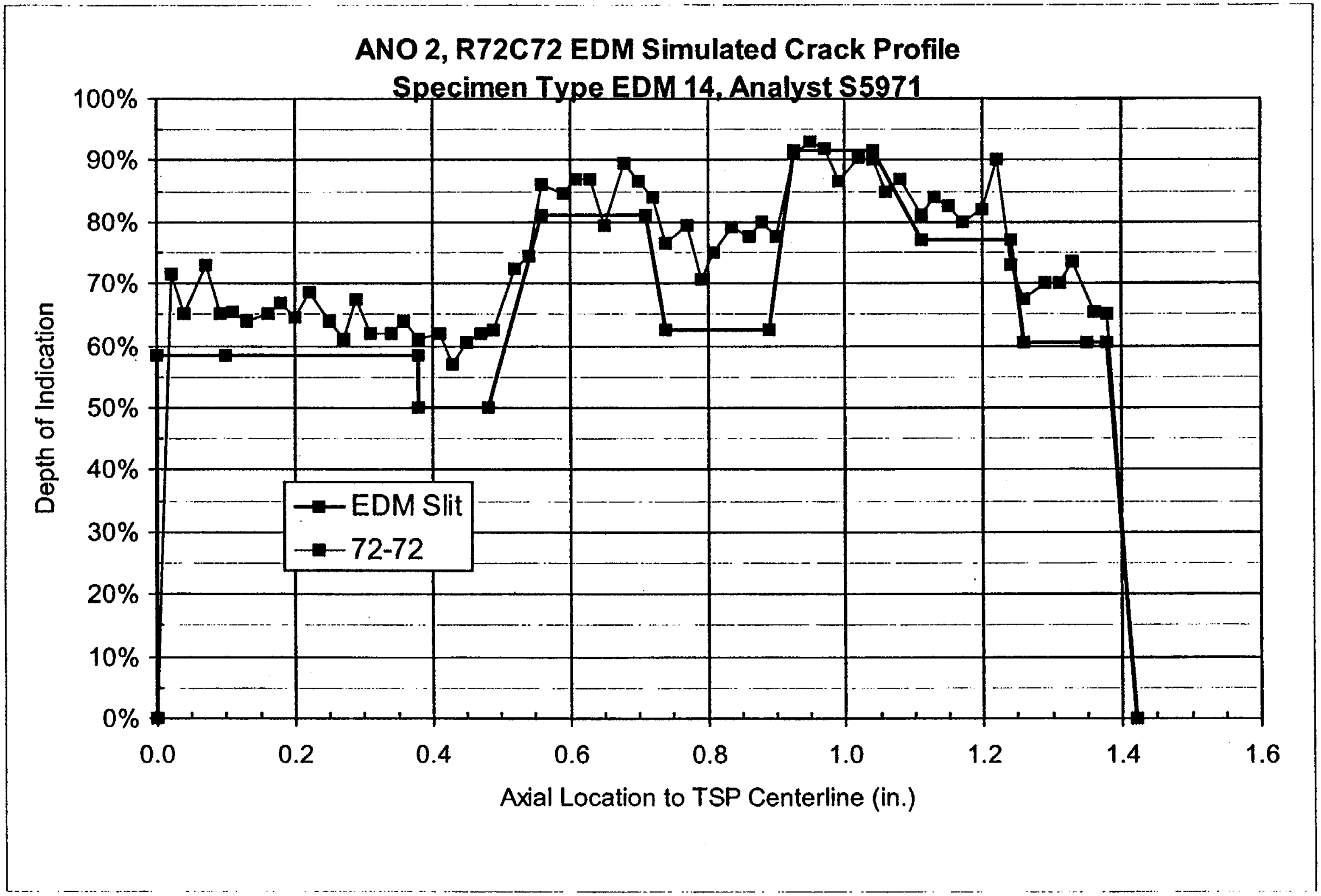
ANO-2 Operational Assessment



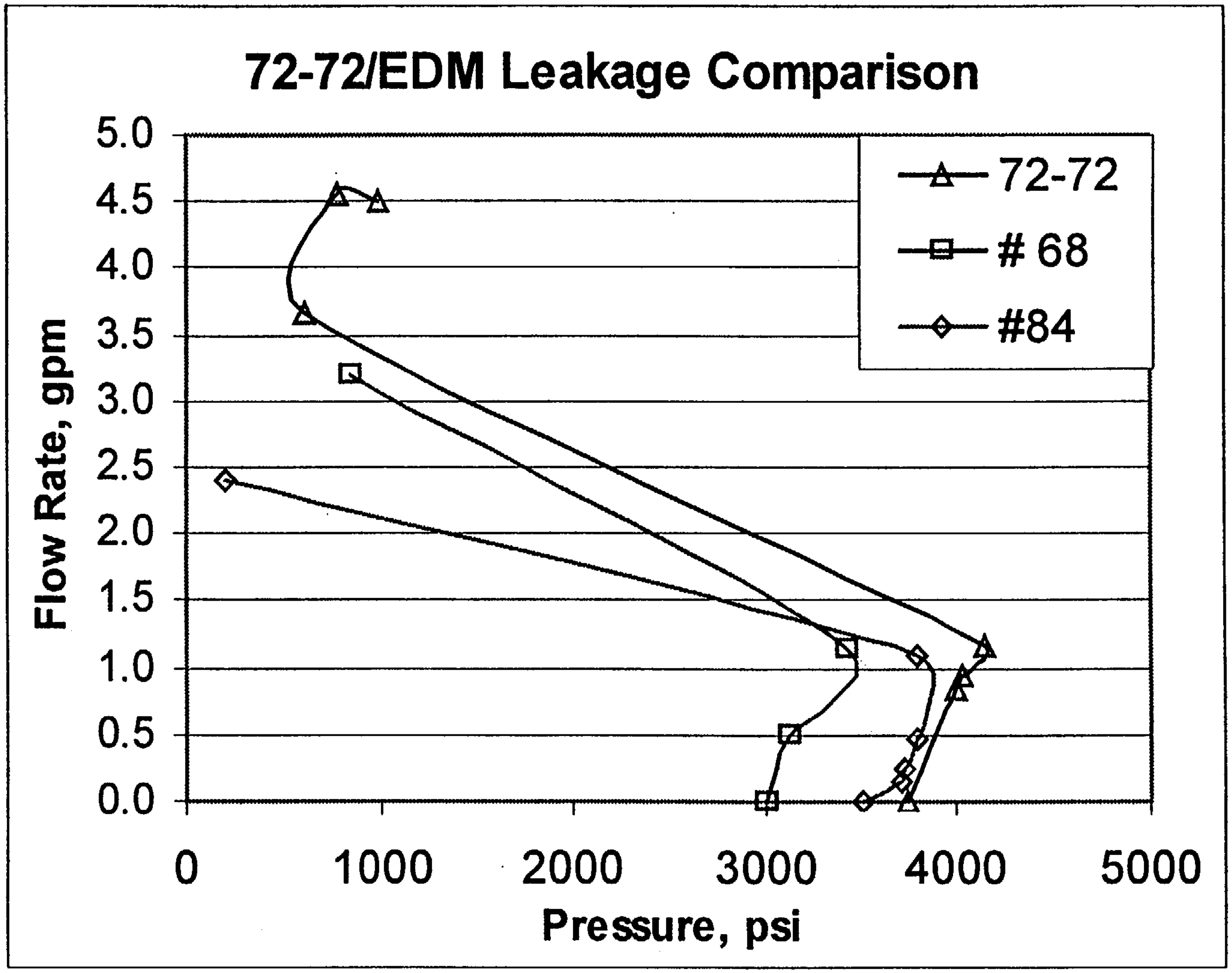
ANO-2 Operational Assessment

- EDM Sample Results
  - Next - Altered the angle of the peak depths
    - Resulted in a shorter flaw opening
    - Leakage response representative of 72-72
    - Able to repressurize two samples similar to 72-72

ANO-2 Operational Assessment



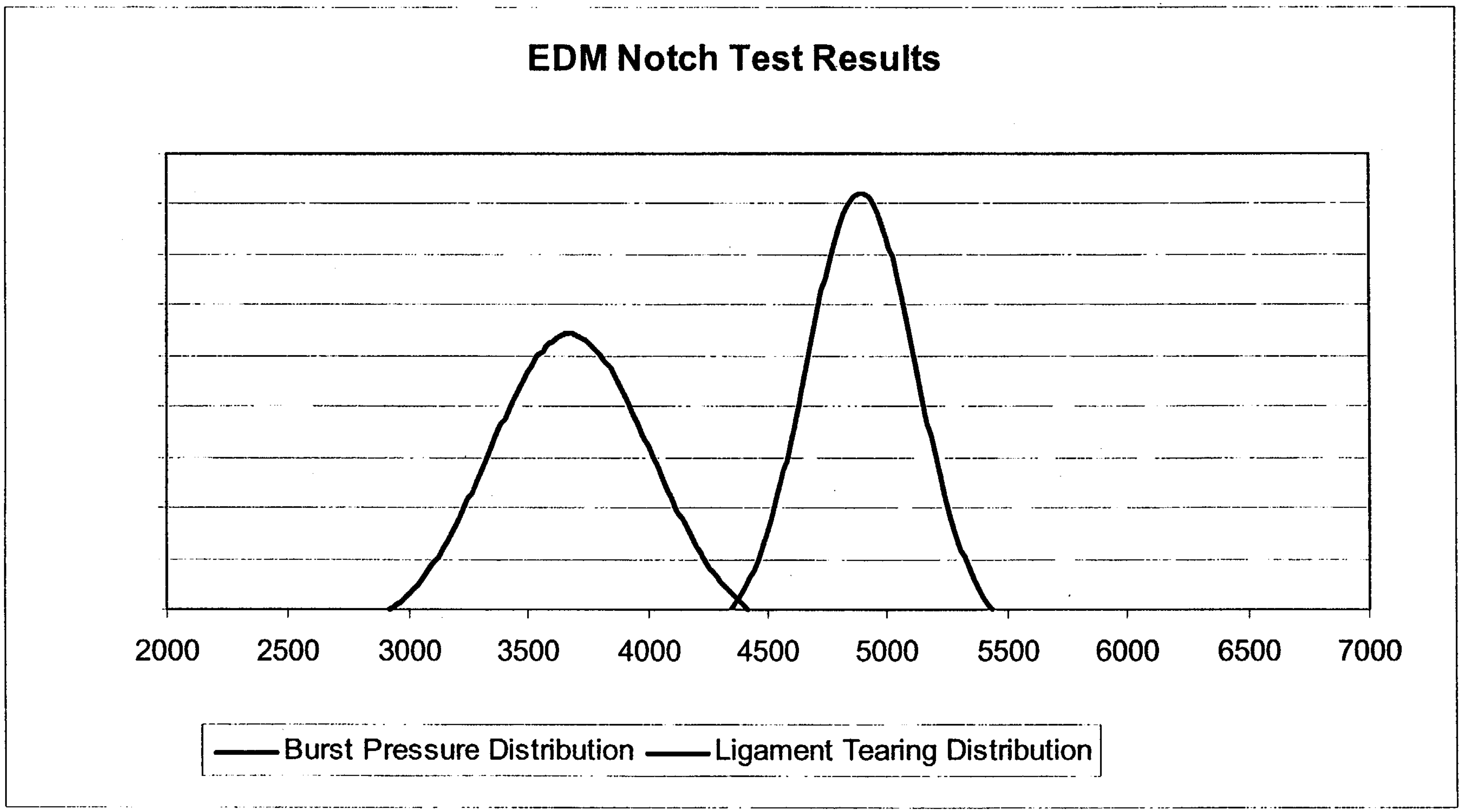
ANO-2 Operational Assessment



ANO-2 Operational Assessment

Type 14 Test Results				
	Specimen #	Ligament Tearing Pressure	Specimen #	Burst Pressure
	66	4010	75	5238
	67	4350	77	5140
	68	3956	87	4791
	69	3350	88	4654
	74	3855	93	4865
	76	3488	94	4865
	83	3442	95	4570
	84	3488	96	5011
	85	3689		
	Average	3736		4892
Standard Deviation		331		229
	Avg + 1 SD	4067	Avg - 1 SD	4663
Delta Pressure at 1SD		4663 - 4067 = 595		

ANO-2 Operational Assessment



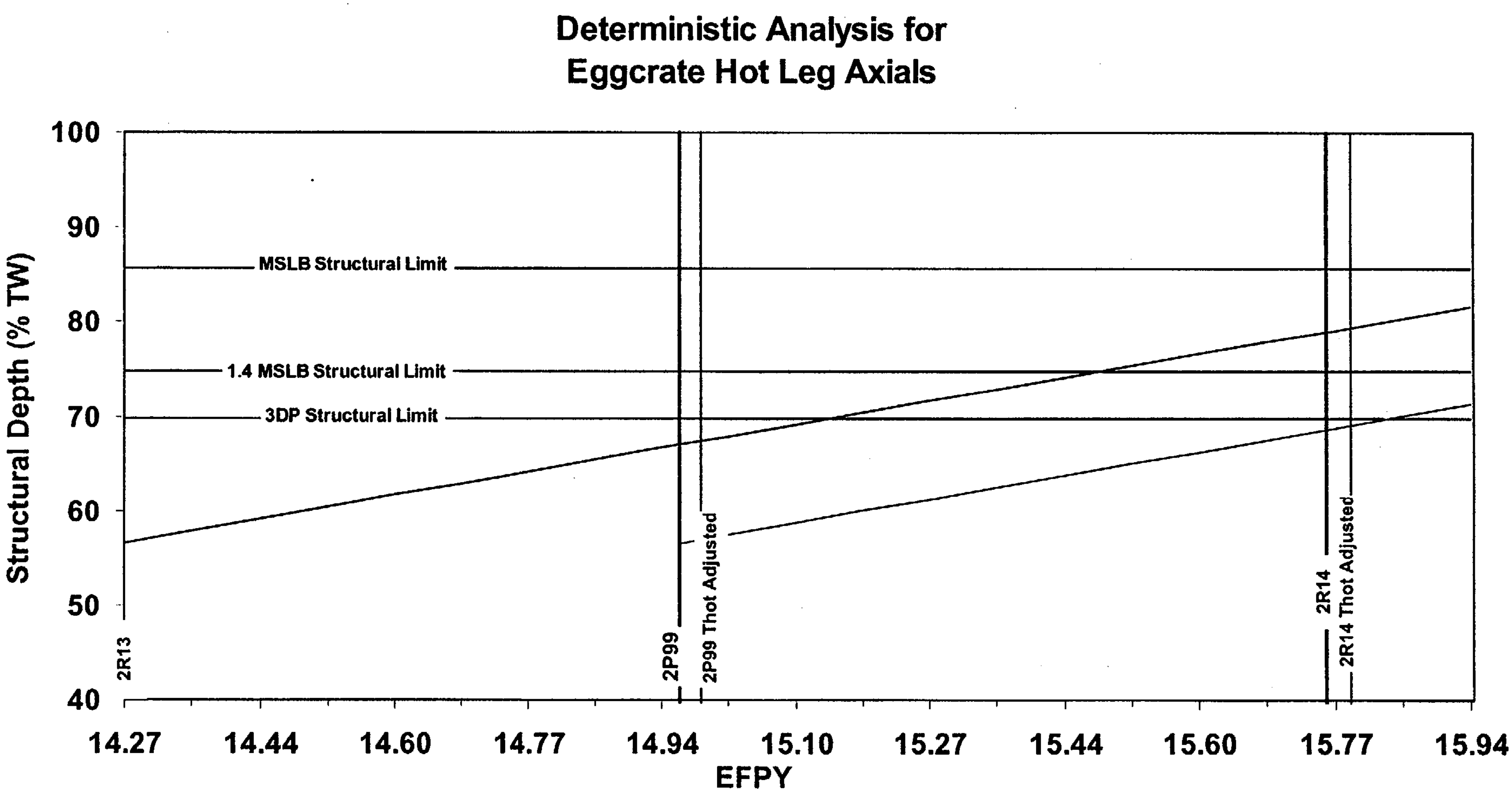
ANO-2 Operational Assessment

- EDM Sample Test Conclusions
  - 72-72 ECT profile over conservative
  - Post in-situ opening ~1/2" long
    - < critical crack length
  - Refined profiles based on model and test results
    - Able to produce flaw profile with a leak response that behaved like 72-72
  - Objective was to match leakage and estimate ΔP
    - Leakage results very similar
    - ΔP confirms analytical model result of ~500 psi above 4147 is conservative

ANO-2 Operational Assessment

PARAMETER	SGTI Guidelines
POD Value	**95%**
Structural Depth Equivalent	56.6%
Growth Rate	**95% Struct. Depth**
Growth Equivalent	15%
Length Value	**90% (2P99 data)**
Length Equivalent	0.98
Burst Correlation	**90% Value**
Material Properties	125,900
Material Equivalent	**90%**

ANO-2 Operational Assessment



ANO-2 Operational Assessment

- Summary of Deterministic Analysis
  - The original 500 psi delta is still valid
  - Tube 72-72 met $3\Delta P$ with margin
  - Operation until September 2000 remains justified

Risk Assessment

Mark Smith
Manager, Engineering Programs

ANO-2 SGTR Risk Assessment
Objective and Scope

- Objective
  - Evaluate the effect of continued operation to 2R14 on both Core Damage Frequency (CDF) and Large Early Release Frequency (LERF)
  - Scope of risk assessment consistent with NUREG-1570
    - Spontaneous Steam Generator Tube Rupture (SGTR)
    - Pressure Induced (PI) SGTRs
    - Temperature Induced (TI) SGTRs

ANO-2 SGTR Risk Assessment

Pressure Induced SGTR Risk

- Dominant PI SGTR Risk Contributors:
  - MSL Break-Induced SGTRs
  - ATWS-Induced SGTRs
- PI SGTR Risk Results:

$$\Delta CDF = 4E\text{-}9/rx\text{-}yr$$

$$\Delta LERF = 4E\text{-}9/rx\text{-}yr$$

ANO-2 SGTR Risk Assessment

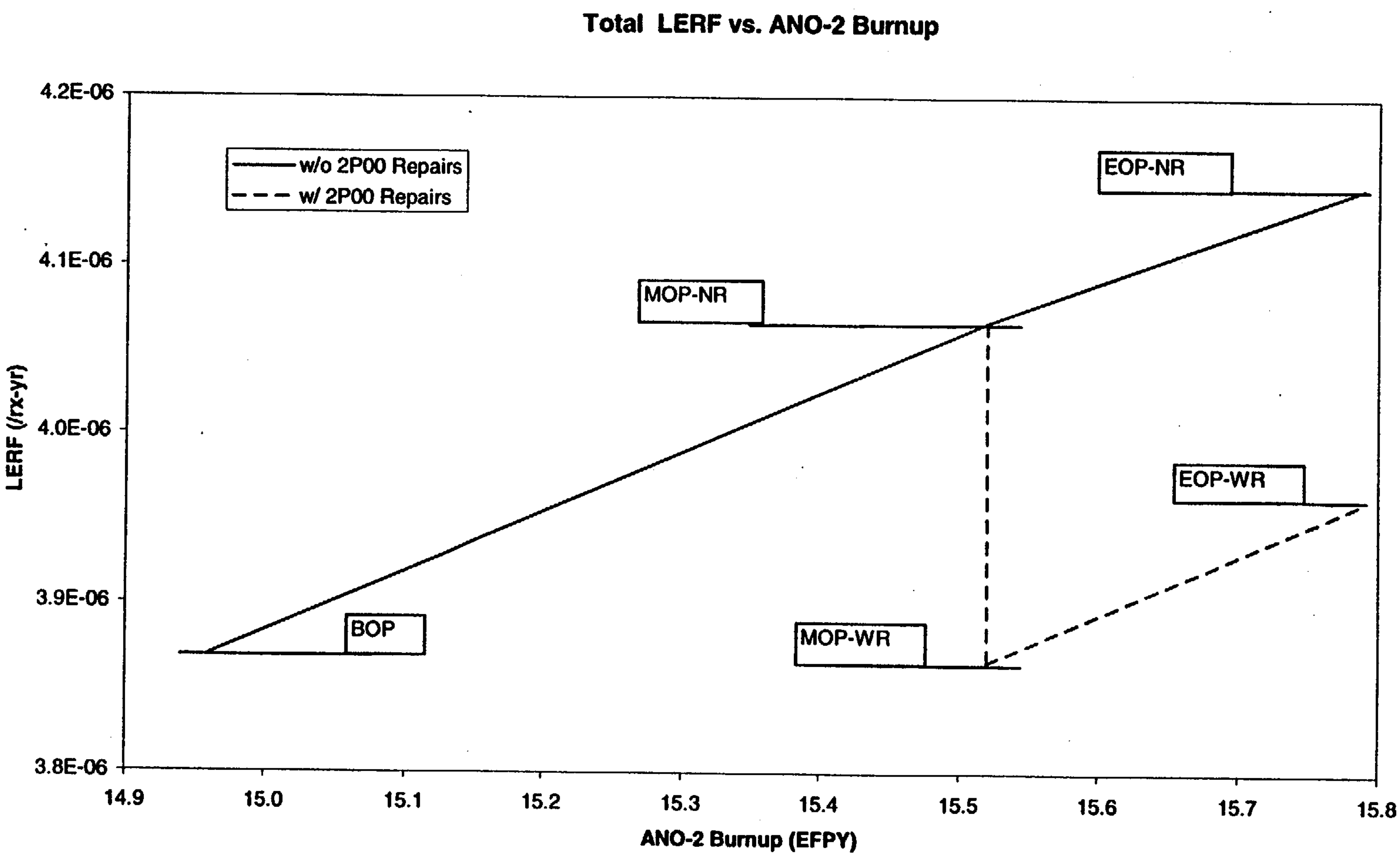
Severe Accident Risk

- Important Factors Affecting TI-SGTR Risk:
  - RCS Pressure
  - SG Inventory
  - SG Pressure
- TI-SGTR Risk Results

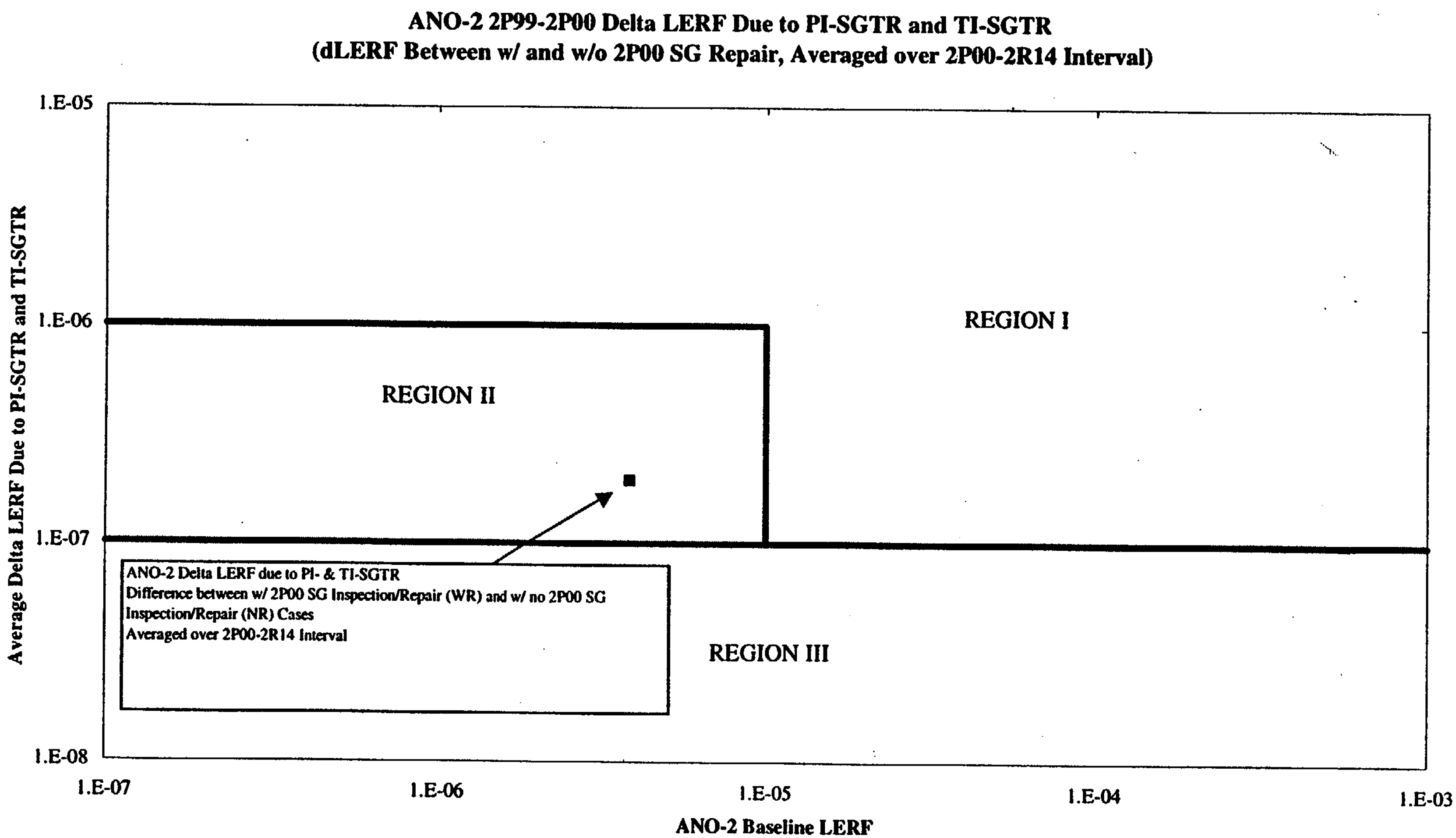
$$\Delta CDF = 0/rx\text{-}yr$$

$$\Delta LERF = 1.9E\text{-}7/rx\text{-}yr$$

ANO-2 SGTR Risk Assessment
Overall SGTR Risk Results



ANO-2 SGTR Risk Assessment
Overall SGTR Risk Results



ANO-2 SGTR Risk Assessment
Analysis Features

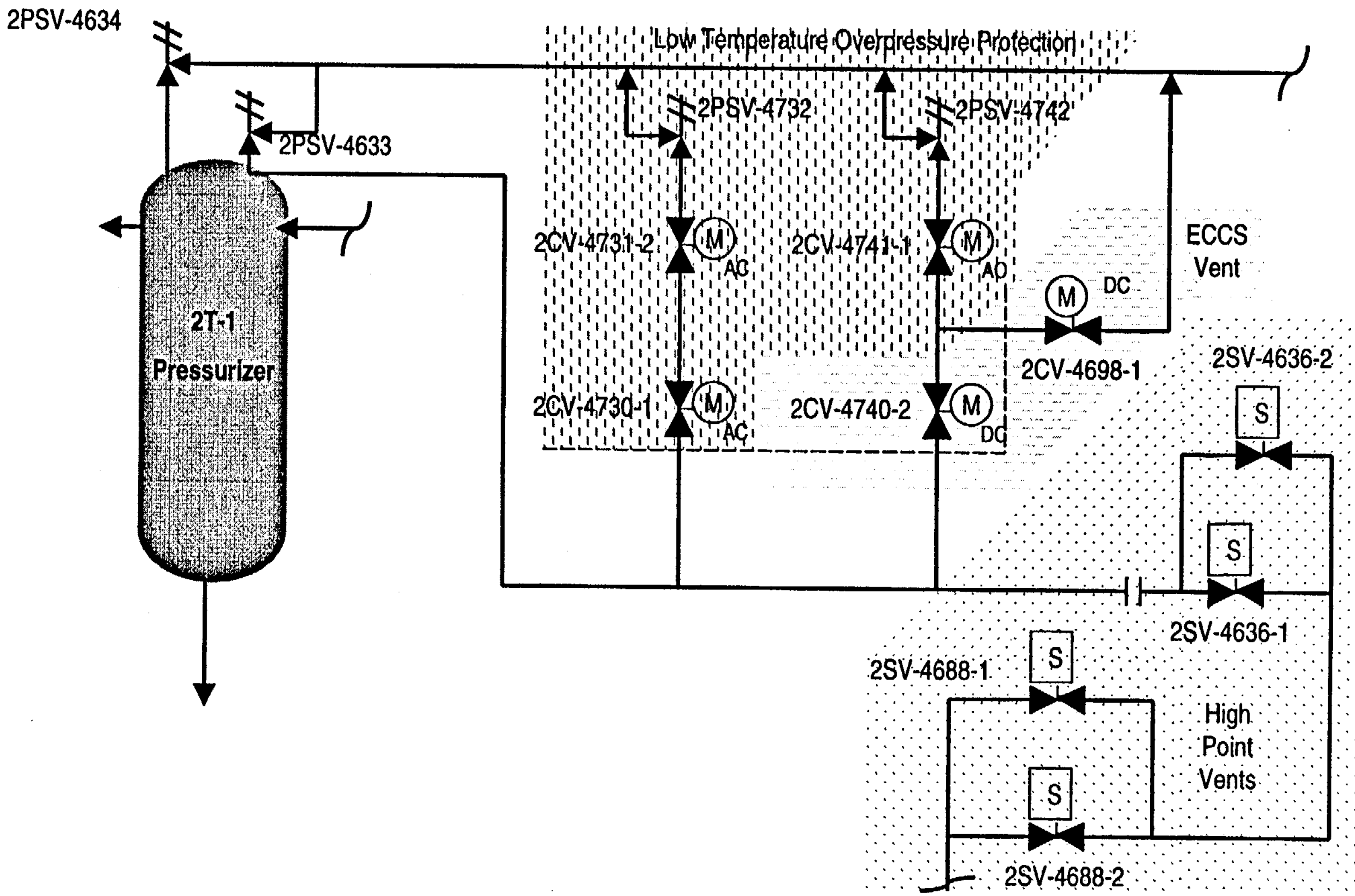
- Flaw Population Based on Realistic POD
- ANL Flawed Tube Failure Model (NUREG/CR-6575):
  - Creep Analysis of Ligament Failure as in NUREG-1570
  - Flow Stress Model to Predict Failure Mode

ANO-2 SGTR Risk Assessment
Sensitivity Analysis

- Assume Ligament Failure Leads to Rupture - Δ LERF Remains in Region II
- Credit for RCS Depressurization - Δ LERF Drops to Region III

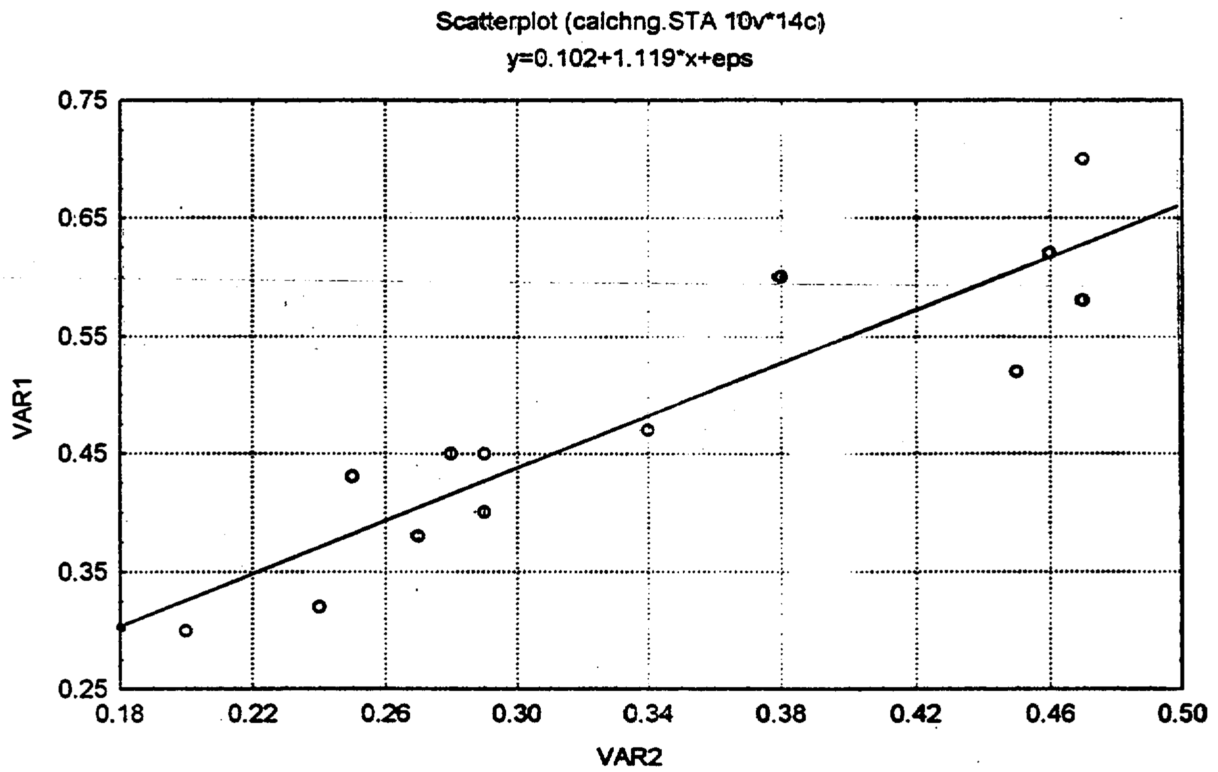
ANO-2 SGTR Risk Assessment

ANO-2 Pressurizer



ANO-2 SGTR Risk Assessment
Conclusions

- Continued Plant Operation to 2R14 is Safe
  - Design basis events
  - Severe accidents
- Actions Being Taken to Further Improve Safety
  - Maintain Secondary Pressure
    - EOP and SAMG Changes
  - Depressurize Primary Side
    - Hardware and SAMG Changes



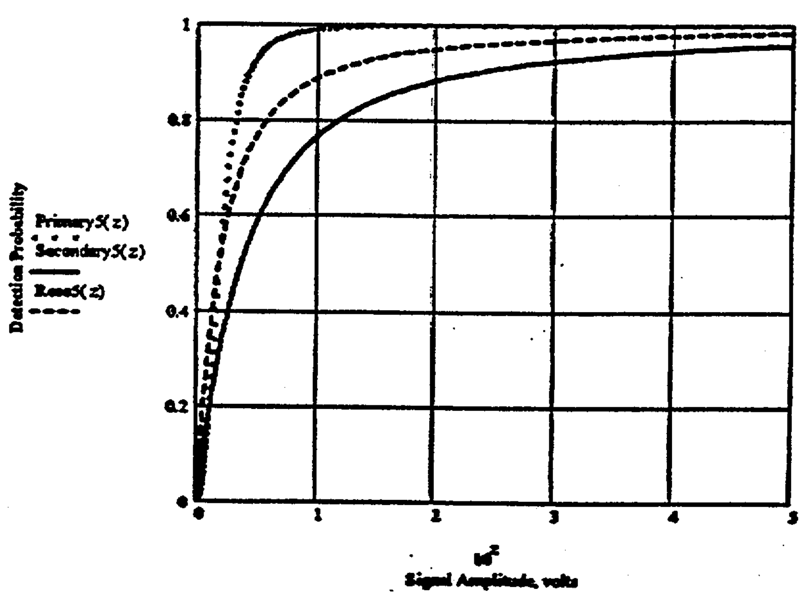
Scatterplot (calchng.STA 10v*14c)
y=0.102+1.119*x+eps
VAR1
VAR2
0.75
0.65
0.55
0.45
0.35
0.25
0.18
0.22
0.26
0.30
0.34
0.38
0.42
0.46
0.50

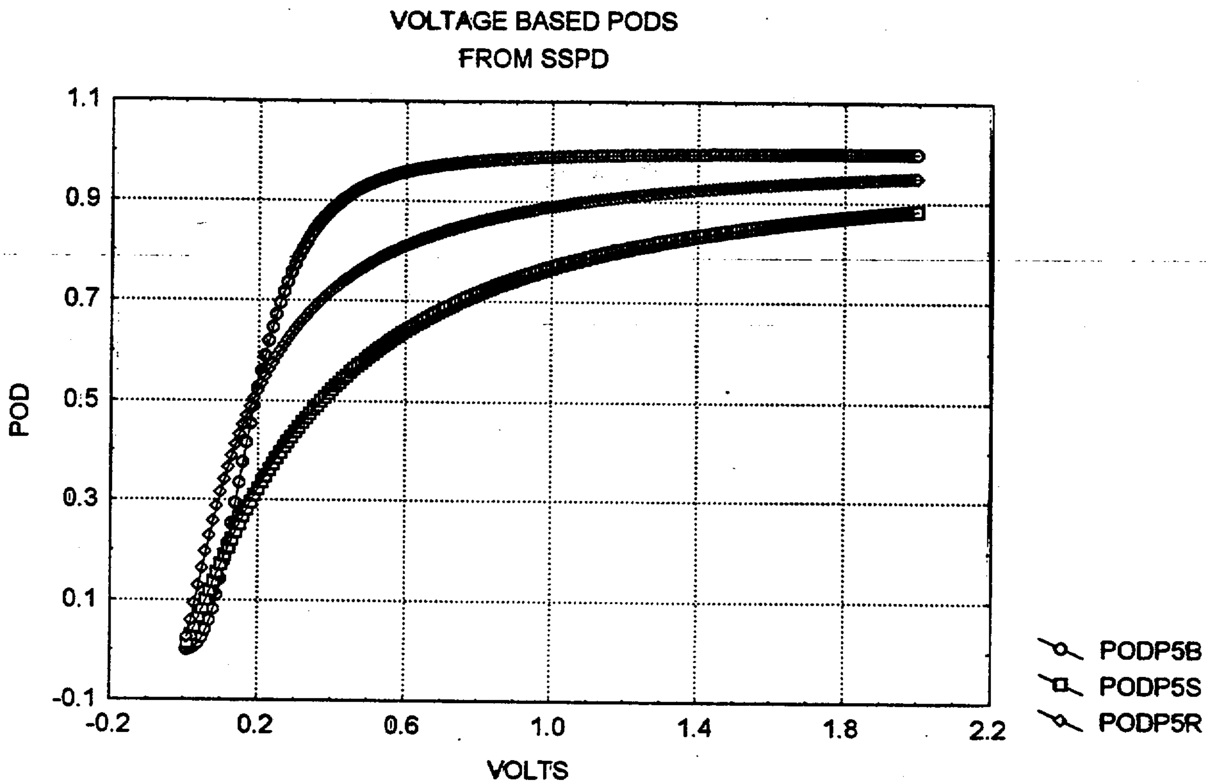
$$\log(z) := 0.1, 1 .. 100$$

$$\text{Primary5}(z) := \frac{\exp\left(P5b\_log_0 + P5b\_log_1 \cdot z\right)}{1 + \exp\left(P5b\_log_0 + P5b\_log_1 \cdot z\right)}$$

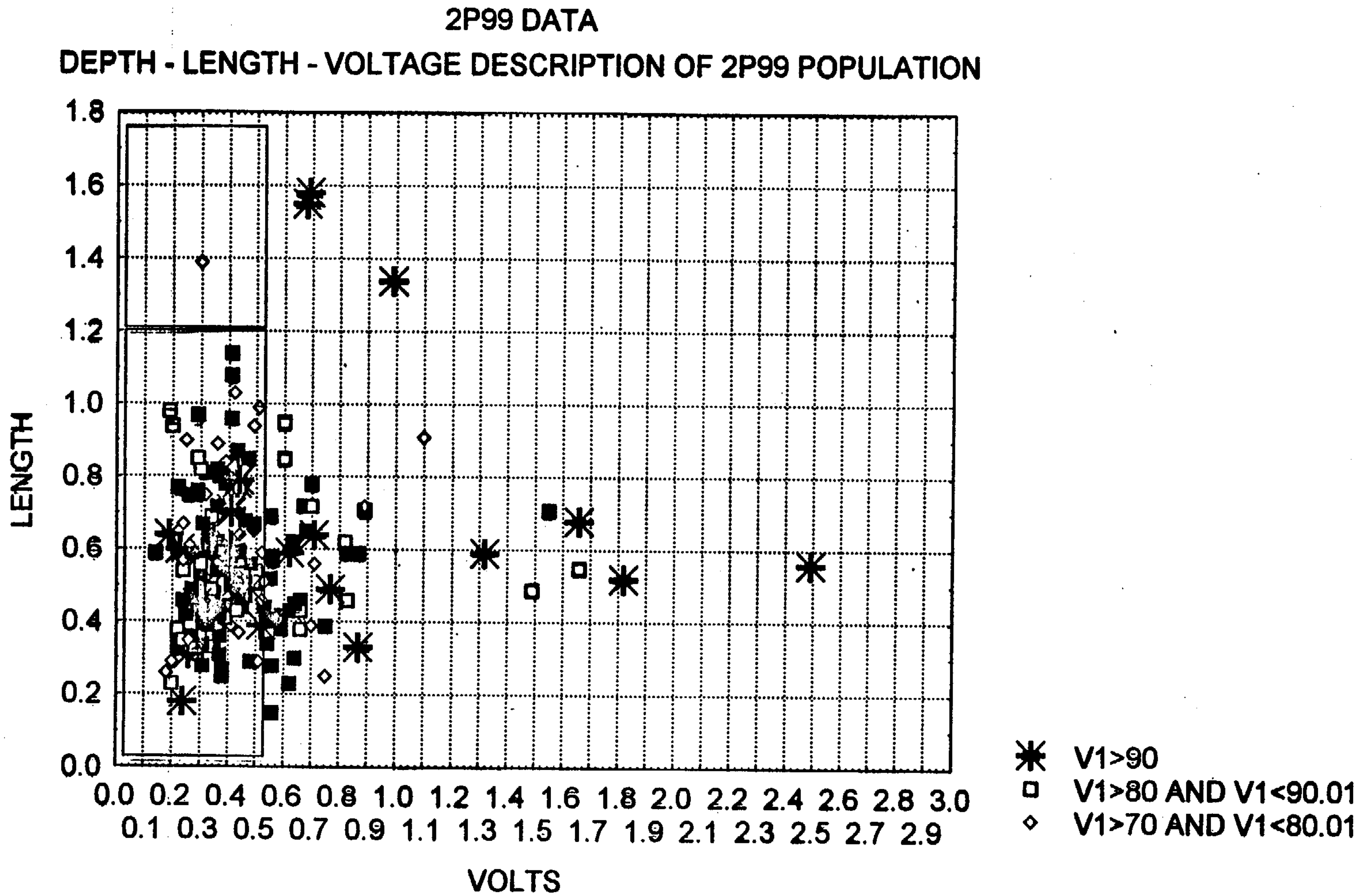
$$\text{Secondary5}(z) := \frac{\exp\left(S5b\_log_0 + S5b\_log_1 \cdot z\right)}{1 + \exp\left(S5b\_log_0 + S5b\_log_1 \cdot z\right)}$$

$$\text{Reso5}(z) := \frac{\exp\left(R5b\_log_0 + R5b\_log_1 \cdot z\right)}{1 + \exp\left(R5b\_log_0 + R5b\_log_1 \cdot z\right)}$$





VOLTAGE BASED PODS
FROM SSPD
POD
1.1
0.9
0.7
0.5
0.3
0.1
-0.1
-0.2
0.2
0.6
1.0
1.4
1.8
2.2
VOLTS
PODP5B
PODP5S
PODP5R


2P99 DATA
DEPTH - LENGTH - VOLTAGE DESCRIPTION OF 2P99 POPULATION
LENGTH
VOLTS
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0
0.1 0.3 0.5 0.7 0.9 1.1 1.3 1.5 1.7 1.9 2.1 2.3 2.5 2.7 2.9
V1>90
V1>80 AND V1<90.01
V1>70 AND V1<80.01

Conclusions

Craig Anderson

Vice-President, ANO