South Texas Project Unit 2

2RE08 Steam Generator Tube Inspection Results

NRC Meeting April 19, 2001

ENCLOSURE 3

Meeting Purpose

Discuss 2RE08 steam generator tube inspection results with regard to Cycle 9 operations

Agenda

Introduction	M. Kanavos
Root Cause of Growth Rates	T. Pitterle
Operational Leakage Restrictions	M. Kanavos
Scope of Pressure Tests	M. Kanavos
Conclusions	M. Kanavos

Introduction

South Texas Project Unit 2 steam generators currently meet all structural and leakage requirements for full cycle operation consistent with RG 1.121 and the performance criteria of NEI 97-06.

Introduction (cont'd)

2RE08 Summary

- 1-volt criteria for TSP ODSCC licensed in 1998
- 3-volt criteria licensed for TSPs C, F, J
- Inspection plan included extended +Point profiles (1116 DSIs from 0.6 - 1.5v)

Introduction (cont'd)

- Plugged 106 tubes in accordance with voltage-based repair criteria in effect
- Preventively plugged all tubes with DSIs > 1.5 volts (105 tubes)
- Preventively plugged 524 tubes with DSIs from 0.6 - 1.5 volts

Root Cause of Growth Rates

Potential causes being evaluated

- Voltage growth rates
- Cycle chemistry
- Cycle shutdown frequency
- Support plate crevice blockage

Summary of Unit 2 Growth Rates

Largest Industry Voltage Growth Rates

	Volts/EFPY
Domestic	11.4
European	11
Braidwood-1 Cycle 4	9.6
South Texas-2 Cycle 8	8.6
Braidwood-1 Cycle 6	8.1

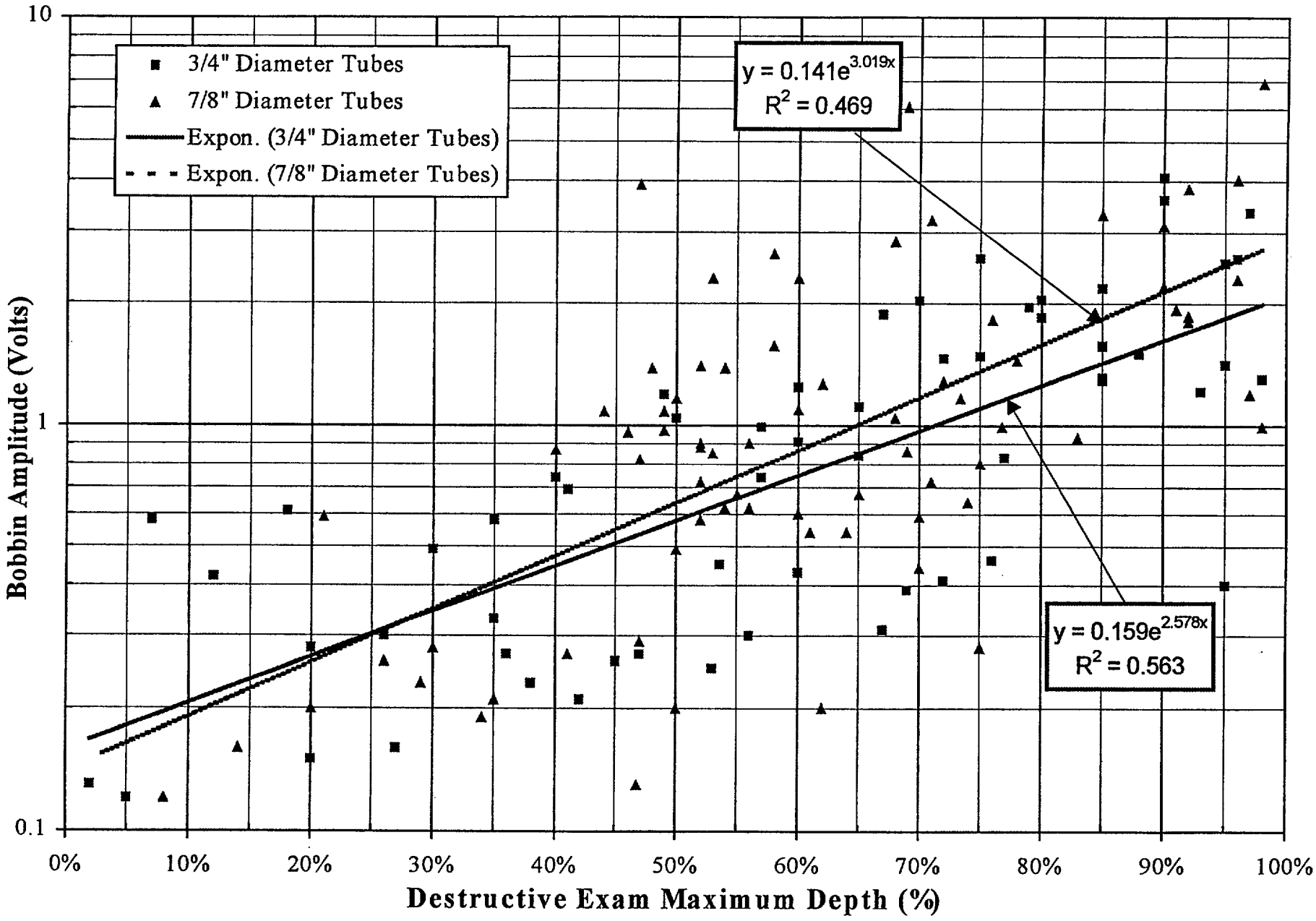
Summary of Growth Rates (cont'd)

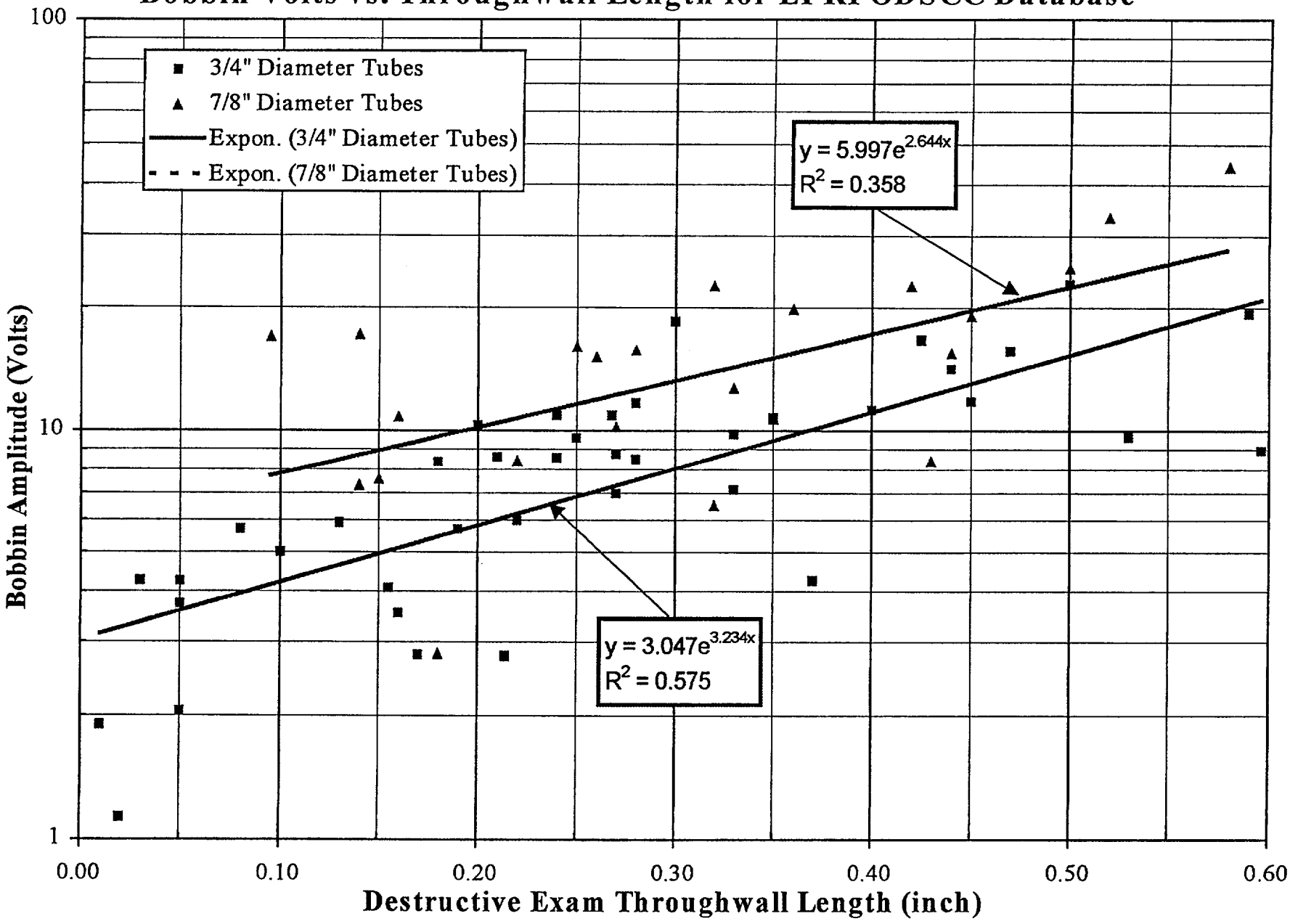
Average STP-2 Voltage Growth per EFPY

Cycle	8	7	6	5
Entire volt range	0.301	0.185	0.08	0.10
$V_{BOC} < 0.75$	0.297	0.175	0.08	0.10
$V_{BOC} \geq 0.75$	0.440	0.371	0.10	0.16

Voltage Growth vs. Actual Growth in Depth

Large increases in voltage growth rates do not imply similar increases in actual depth growth rates


Bobbin Volts vs. Maximum Depth for EPRI ODSCC Database
3/4" Diameter Tubes
7/8" Diameter Tubes
Expon. (3/4" Diameter Tubes)
Expon. (7/8" Diameter Tubes)
y = 0.141e^3.019x
R^2 = 0.469
y = 0.159e^2.578x
R^2 = 0.563
Bobbin Amplitude (Volts)
10
1
0.1
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Destructive Exam Maximum Depth (%)


Bobbin Volts vs. Throughwall Length for EPRI ODSCC Database
100
10
1
Bobbin Amplitude (Volts)
3/4" Diameter Tubes
7/8" Diameter Tubes
Expon. (3/4" Diameter Tubes)
Expon. (7/8" Diameter Tubes)
y = 5.997e^2.644x
R^2 = 0.358
y = 3.047e^3.234x
R^2 = 0.575
0.00
0.10
0.20
0.30
0.40
0.50
0.60
Destructive Exam Throughwall Length (inch)

Voltage Growth vs. Actual Growth in Depth

Upper bound of STP-2 Cycle 8 growth in depth for normal operating leakage evaluation was 40%

Depth increase from 55% to 95% ($\Delta D = 40\%$)

- **$\Delta V = 1.2$ volt (typical STP Cycle 6 ΔV_{max})**

Depth increase from 60% to TWL = 0.15" ($\Delta D \sim 40\%$)

- **$\Delta V = 4.2$ volts (typical STP Cycle 7 ΔV_{max})**

Depth increase from 65% to TWL = 0.35" ($\Delta D \sim 40\%$)

- **$\Delta V = 8.6$ volts (typical STP Cycle 8 ΔV_{max})**

Voltage Growth/Actual Growth (cont'd)

Conclusions

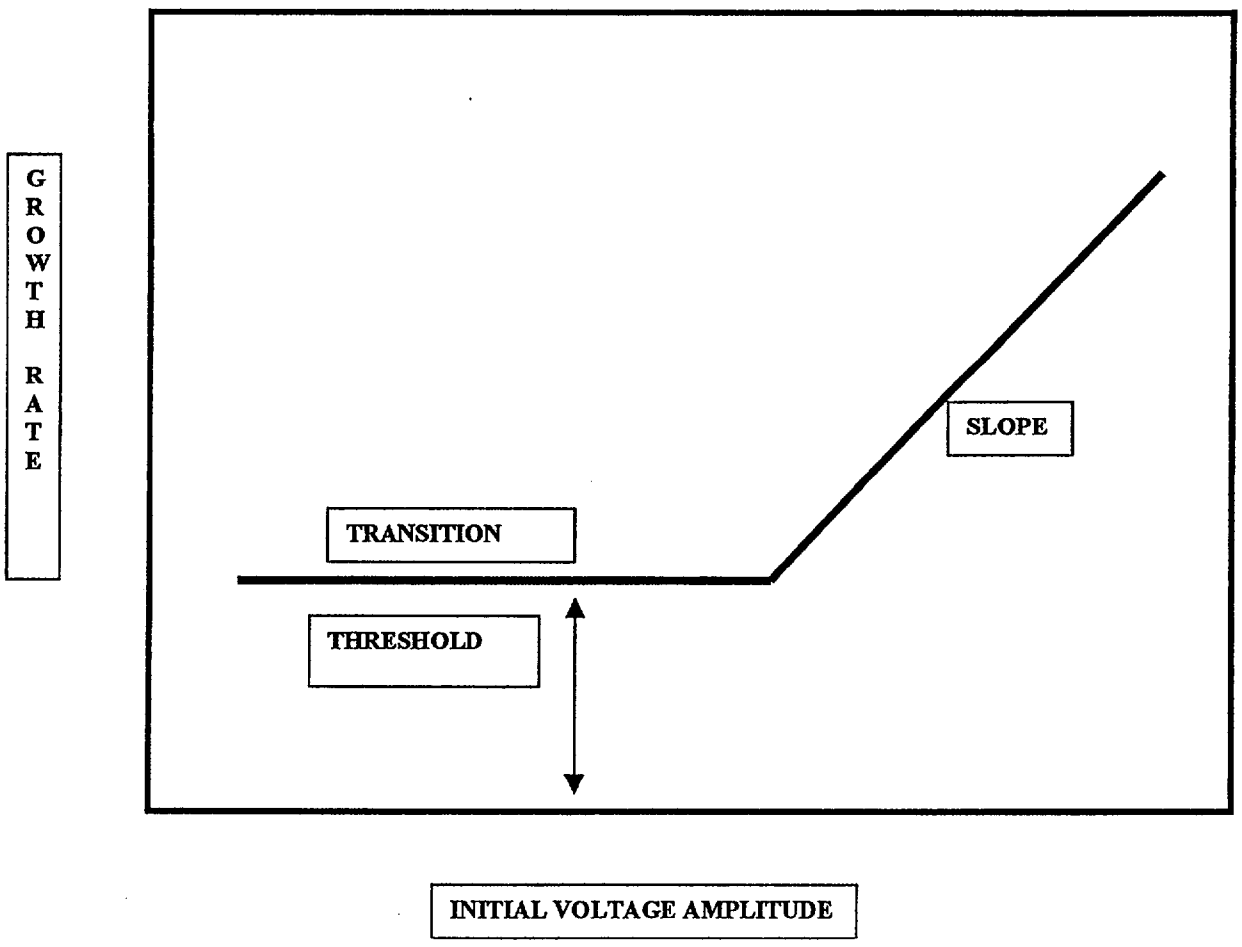
Large ΔV do not imply large ΔD

ΔV more dependent on larger BOC depth than on ΔD

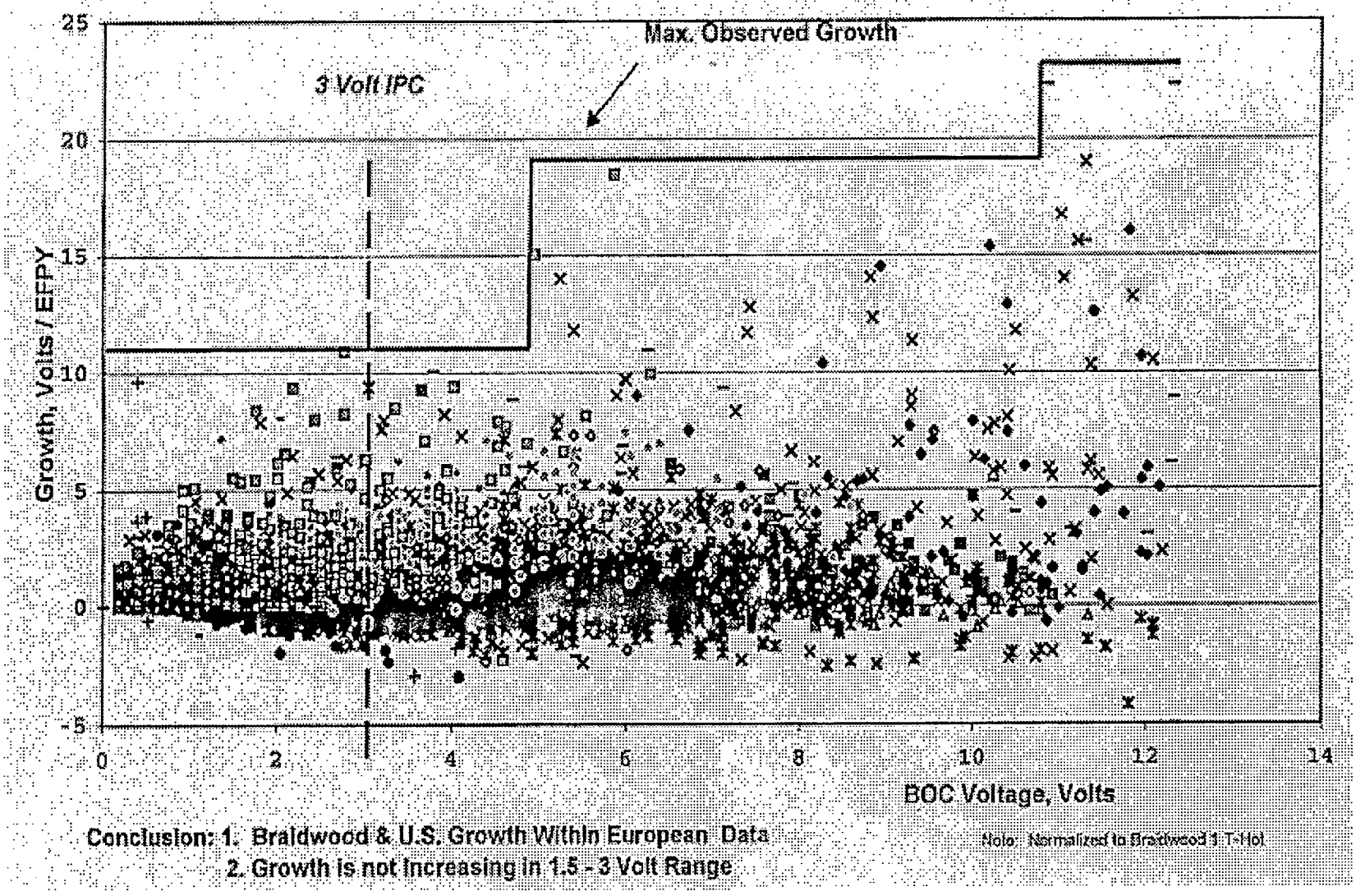
Expectations

- **Cycle 9 voltage growth should be similar to or may be slightly higher than in Cycle 8 voltage growth**
- **EOC-9 crack depths should be ≤ EOC-8 due to selective preventive plugging of deeper indications down to 0.6 volt**

Belgian Model E Voltage Growth Model

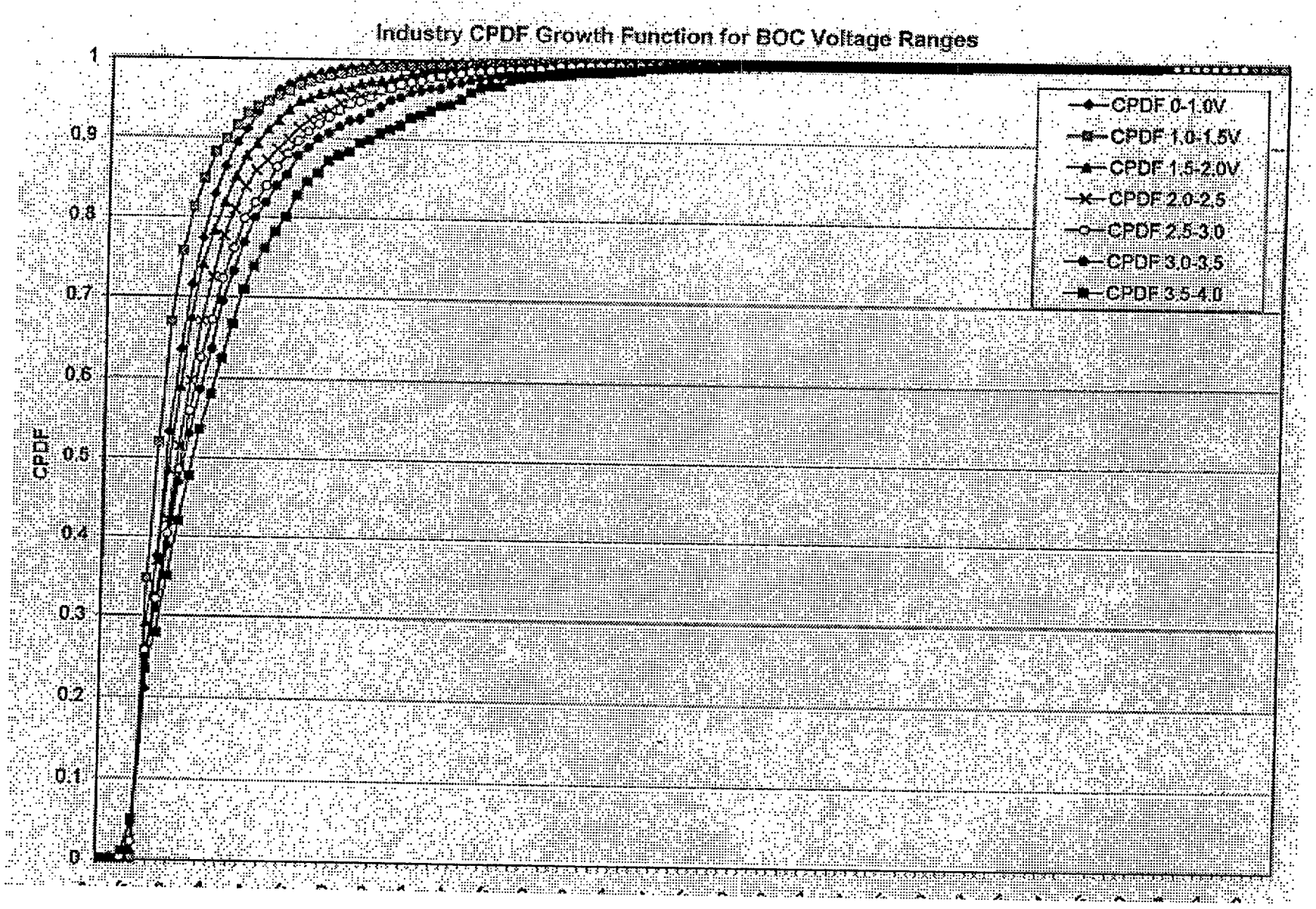


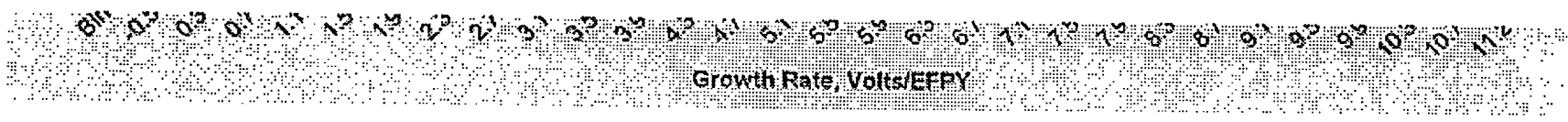
Combined European Data, Growth Vs BOC (23,700 Data Points)



Conclusion: 1. Braidwood & U.S. Growth Within European Data
2. Growth is not Increasing in 1.5 - 3 Volt Range

Note: Normalized to Braidwood 1 T-Hot


Industry CPDF Growth Function for BOC Voltage Ranges
CPDF
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
CPDF 0-1.0V
CPDF 1.0-1.5V
CPDF 1.5-2.0V
CPDF 2.0-2.5
CPDF 2.5-3.0
CPDF 3.0-3.5
CPDF 3.5-4.0


Growth Rate, Volts/EFPY

European Voltage Growth Data (cont'd)

Conclusions

- STP-2 growth rates comparable to and bounded by domestic and European data
- Significant STP-2 voltage dependent growth not expected for 1.5 volt repair limit
- Upper bound on voltage growth is 11 volts/EFPY
- No large step-increases in voltage growth

Root Cause (cont'd)

- Cycle chemistry
  - no chemistry changes in Cycle 8
  - no known upsets or resin intrusions
  - hideout return studies completed

- Cycle shutdown frequency
  - more shutdowns in Cycles 6, 7, 8

- Support plate crevice blockage
  - in situ tests do not support this contention

Growth Rate Trend is Acceptable

- Preventive plugging to reduce Cycle 9 leakage
- Doel-4 preventive plugging and other actions decreased average voltage growth rate
- EOC-9 voltages should be similar to EOC-8

Operational Leakage Restrictions for Cycle 9

Primary-to-Secondary Leakage

Current NOP leakage:	**not measurable**
EOC-8 NOP leakage:	**9 gpd (0.00625 gpm)**
EOC-8 SLB leakage:	**2.9 gpm (95-05 method)**
	5.7 gpm (IRB method)
EOC-9 SLB leakage:	**10.7 gpm (95-05 method)**
	14.4 gpm (IRB method)
Design basis SLB limit:	**15.4 gpm**

Leakage (cont'd)

SLB Leakage Limit

Tech Spec limit = 1.0 µC/gm dose equivalent I-131

- **design basis SLB leakage limit of 15.4 gpm**

Actual STP operating coolant activity is ~0.0001 µC/gm

STP administratively reduced limit to 0.1 µC/gm

- **SLB leakage limit of 34 gpm**

Leakage (cont'd)

Beyond GL 95-05 Assessment

- Reduced coolant activity assumed (34 gpm)
- Voltage growth bounded by 11 volts/EFPY
- Growth distribution increased by ratio of largest growth values (11 ÷ 8.6 = 1.28)
- SLB leakage with growth increased by 1.3
  - IRB methodology
  - SLB leakage limit = 30 gpm

Leakage (cont'd)

Normal Operating Leakage

Tech Spec limit is 150 gpd from one SG

EPRI guidance is 75 gpd from one SG

NRC postulated SLB/NOP leakage ratio

- **no precedent or predefined technique**
- **no SLB/NOP proportionality for IRBs**

Leakage (cont'd)

According to the postulated correlation:

if Cycle 8 SLB/NOP leakage ratio is
2.9 gpm ÷ 0.00625 gpm = 464

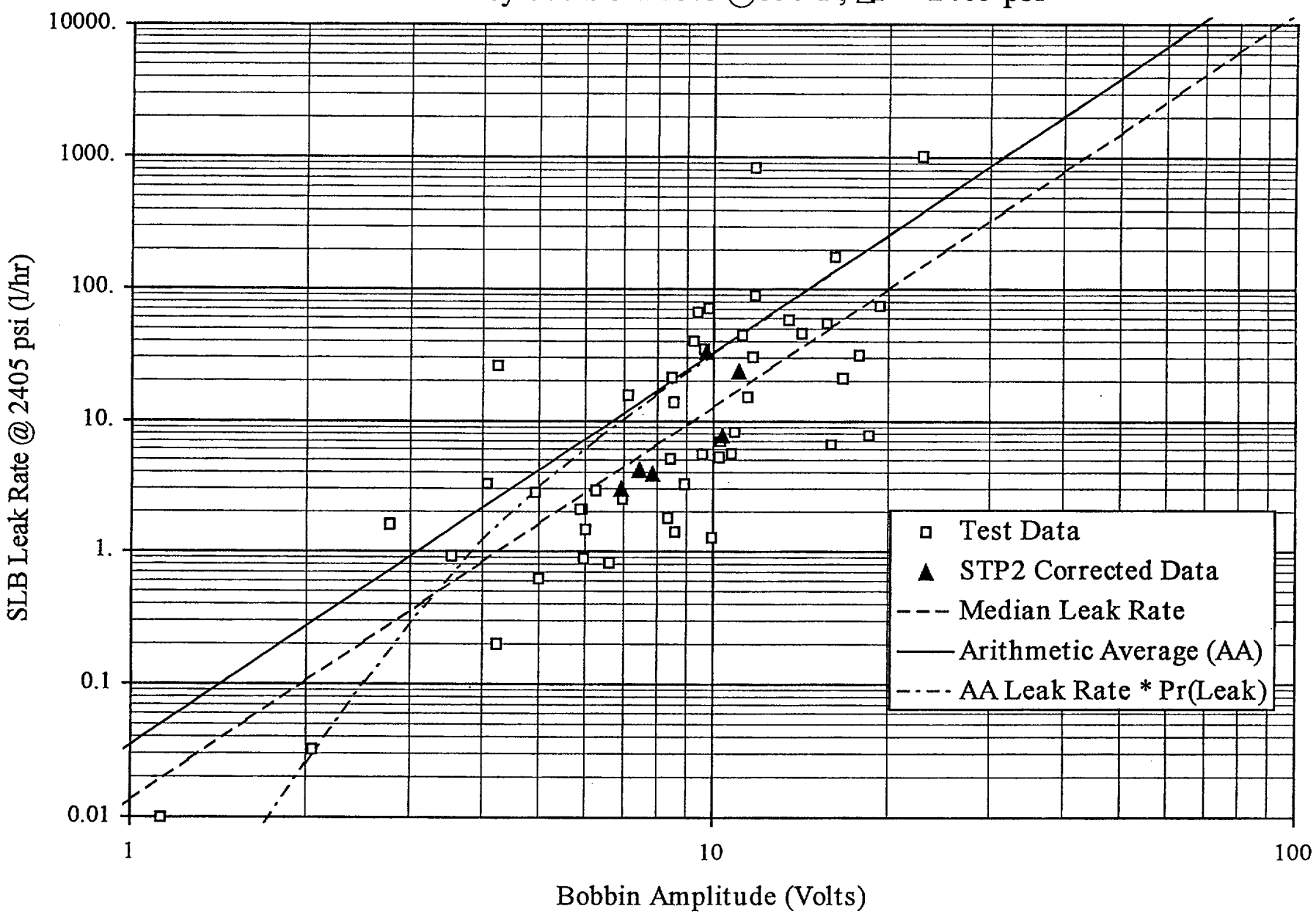
and Cycle 9 non-IRB leak rate is
34 gpm - 3.7 gpm (IRB) = 30.3 gpm

then Cycle 9 postulated NOP leakage is
30.3 gpm ÷ 464 = 0.065 gpm = 93.6 gpd

In Situ Test Scope

Tubes tested where most meaningful data could be obtained:

2 tubes	**free span axial cracks > screening criteria**
2 tubes	**previously unobserved degradation mechanism (TTS circ cracks)**
6 tubes	**large DSI structural test**
1 tube	**previously unobserved degradation mechanism (axial crack in U-bend)**
1 tube	**previously unobserved degradation mechanism (axial crack at one ding; circ crack at other)**


SLB Leak Rate (2405 psi) vs. Bobbin Amplitude
3/4" x 0.043" Alloy 600 SG Tubes @650°F, ΔP = 2405 psi
SLB Leak Rate @ 2405 psi (l/hr)
10000.
1000.
100.
10.
1.
0.1
0.01
1
10
100
Bobbin Amplitude (Volts)
Test Data
STP2 Corrected Data
Median Leak Rate
Arithmetic Average (AA)
AA Leak Rate * Pr(Leak)

In Situ Test Scope (cont'd)

- TR-107620-R1 Appendix E governs drilled TSPs
- Authors confirmed intent of Appendix E
- Appendix B direction to test known leakers not relevant to drilled TSPs

In Situ Test Scope (cont'd)

Test scope met TR-107620-R1 criteria

Only 2 tests required, but 12 conducted

Conclusions

- Conservative 2RE08 inspection plan
- Inspection plan included increased profiles for DSIs
- Very conservative preventive plugging program
- EPRI Guidelines for in situ pressure tests were met

Conclusions (cont'd)

- Large ΔV do not imply large ΔD
- Cycle 9 ΔV will be similar to Cycle 8
- Maximum ΔV bounded by 11 volts/EFPY for V_{BOC} < 5 volts
- No large step increases in ΔV
- Significant voltage-dependent growth not expected

Conclusions (cont'd)

South Texas Project Unit 2 steam generators currently meet all structural and leakage requirements for full cycle operation consistent with RG 1.121 and the performance criteria of NEI 97-06.