Indian Point 2 Condition Monitoring Operational Assessment Plan

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Definitions

- Condition Monitoring (Backwards Looking)
  - Evaluation of indications found this inspection against performance criteria
- Operational Assessment
  - Evaluation against performance criteria at the end of the next operating period
- Burst
  - Gross structural failure of tube wall---unstable opening displacement
  - Not ligament tearing

Performance Criteria

- Steam generator tubing shall retain structural integrity over full range of operating conditions
  - Margin of 3 against burst under normal steady state full power operation
  - Margin of 1.4 against burst under SLB
- Primary to secondary accident induced leakage not to exceed 1 gpm. under SLB

Issues

- Show that all structurally significant degradation has been detected and that which is undetected will not grow to be structurally significant during the next operating cycle
  - Probability of Detection (POD)
  - Growth Rate
  - NDE Sizing
- Complicating Factors
  - Secondary side scale deposits (copper) result in low signal to noise ratios making NDE data more difficult to interpret

Tube Integrity Considerations

- ***Low row U-bends (PWSCC)***
- Dented tube support plate intersections (primarily PWSCC but also potential for ODSCC)
- ***Sludge pile (within 10" TTS)--(ODSCC)***
- Area just above sludge pile (ODSCC)
- Tubesheet region
  - Dents at TTS (primarily PWSCC but also potential for ODSCC)
  - Crevice region (ODSCC)
  - Roll transition (PWSCC)

Low Row U-Bends

- R2C5 leaked in service
  - Would not have been "called"
  - Improvements in NDE would not leave an indication of this size in service in 2000 inspection
- POD
  - Improvements in analyst guidelines & training
  - High frequency probe has improved data quality & detection
    - Enhanced S/N ratio
    - Found additional smaller indications
    - No indications in rows 3 & 4
  - POD compared to other industry experience
    - PWSCC in symmetrical and axial dents

Figure 5-1. Comparisons of +Point Average Depth PODs

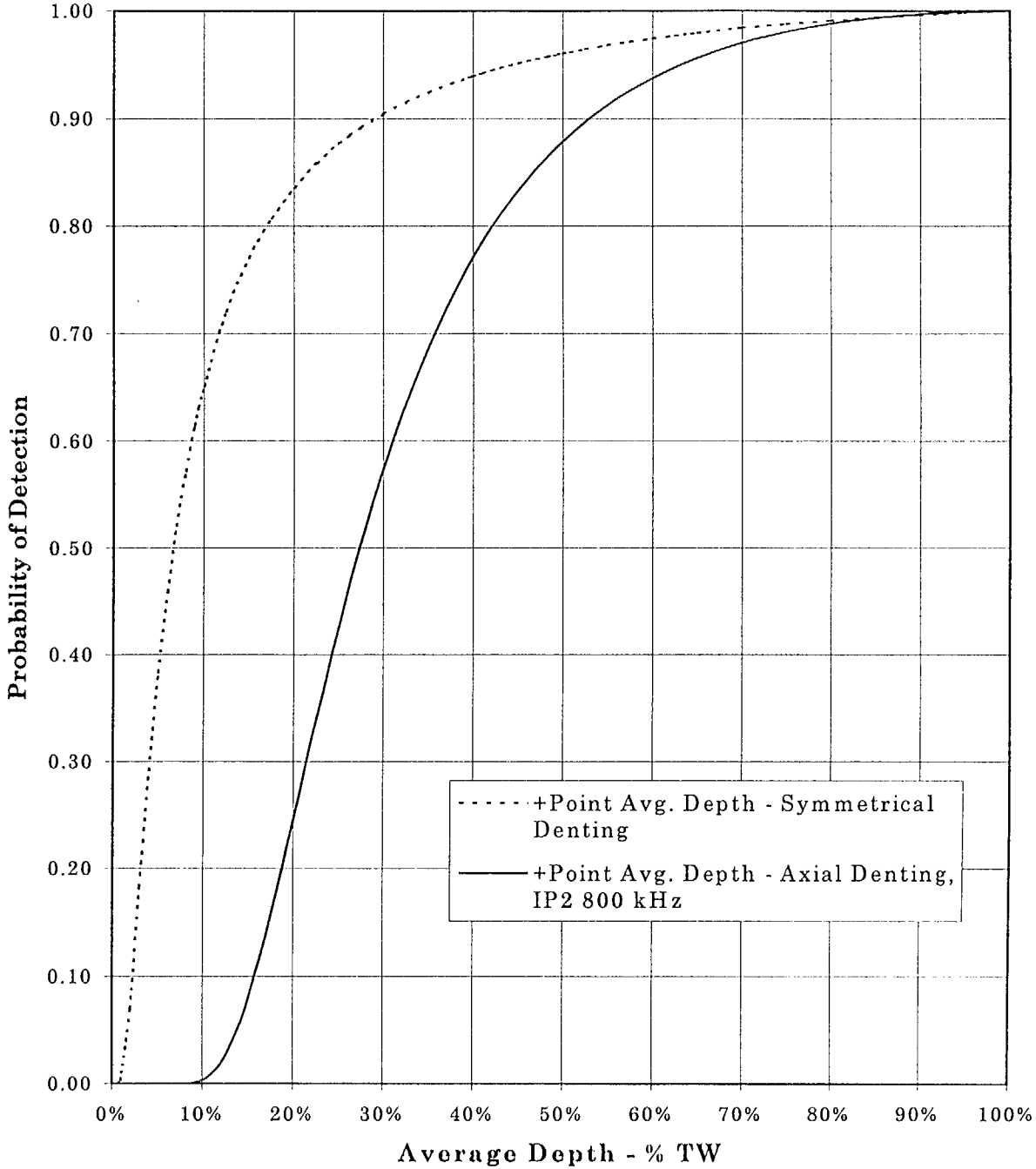
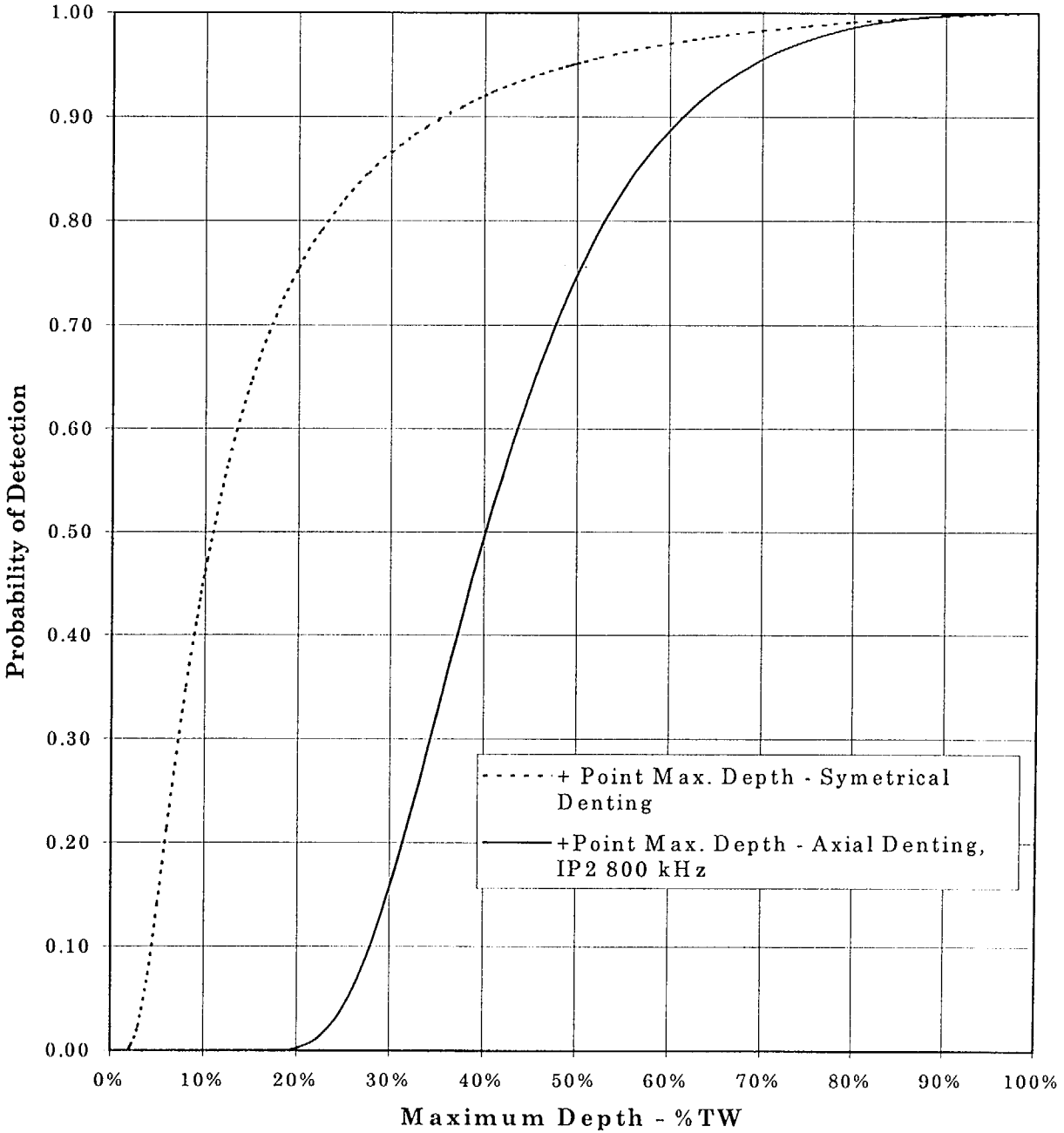


Figure 5-2. Comparisons of + Point Maximum Depth PODs



Low Row U-Bends

- Growth Rate
  - Establish operating period such that the largest "undetected" flaw will not grow to be structurally significant during next operating period
  - Combination of POD and growth rate determines operating period
- Determination of growth rate
  - Derive estimate from 9 indications in 5 tubes
    - Comparison of 400 KHz data
      - Must compare like data between 1997 & 2000
      - +Point sizing techniques based on 300-400 kHz techniques and uncertainties (std. dev. increased by 25%) from PWSCC at dented TSP intersections as used for PWSCC ARC (WCAP-15128)
      - 400 KHz sizing data more consistent with in-situ test results
    - Data adjusted for small sample size
  - Comparison to historical data from dented TSPs and other industry data

Table 5-1. Indian Point-2 U-Bend Axial PWSCC Growth Rates (400 kHz Data)																			
			+Point - 2000 inspection Midrange Coil						+Point - 1997 Inspection Midrange Coil						Growth per EFPY 2000-1997 = 1.48 EFPY					
SG	Tube	Crack No.	Max. Volts	Max. Depth	Avg. Depth	Length	Burst Avg. Depth	Burst Length	Max. Volts	Max. Depth	Avg. Depth	Length	Burst Avg. Depth	Burst Length	Max. Volts	Max. Depth	Avg. Depth	Length	Burst Avg. Depth	Burst Length
	R2C5 Note 1	1		100			90		2.27 2.31	92 92	63.2 70.6	2.43 2.43	73.8 80.2	1.26 1.87		8.00	10.95		10.95	
4	R2C69	1	2.71	74	55.2	0.91	58.3	0.79	1.33	84	57.0	0.9	62.8	0.7	0.93	-6.76	-1.22	0.01	-3.04	0.06
			1.03	74	44.5	0.11	44.5	0.11	0.54	50	31.5	0.25	39.0	0.16	0.33	16.22	8.78	-0.09	3.72	-0.03
			0.94	54	38.2	0.23	42.0	0.20	0.61	50	33.8	0.16	37.7	0.13	0.22	2.70	2.97	0.05	2.91	0.05
4	R2C72	11	3.17	82	59.8	0.54	66.6	0.44	1.3	79	61.8	0.39	66.4	0.35	1.26	2.03	-1.35	0.10	0.14	0.06
4	R2C71	1	2.43	96	64.0	0.57	69.0	0.48	1.87	87	57.5	0.68	63.1	0.57	0.38	6.08	4.39	-0.07	3.99	-0.06
1	R2C87	1	1.68	55	42.8	0.30	48.0	0.25	1.05	63	40.8	0.15	40.8	0.15	0.43	-5.41	1.35	0.10	4.86	0.07
		1	2.25	61	43.6	0.29	48.0	0.25	0.76	53	36.4	0.19	40.8	0.16	1.01	5.41	4.86	0.07	4.86	0.06
		1	2.28	53	41.6	0.35	44.3	0.31	0.95	63	36.5	0.27	45.2	0.19	0.90	-6.76	3.45	0.05	-0.61	0.08
														Avg.	0.68	2.39	3.80	0.03	3.09	0.04
														Max.	1.26	16.22	10.9	0.10	10.9	0.08

Note 1. R2C5 not sizeable in 2000 by NDE after crack opening resulting in leakage. Maximum depth in 2000 is assumed to be throughwall. For ligament tearing, which is the expected cause for opening the R2C5 crack, the average depth to tear the ligament of a 2.2 to 2.4 inch flaw would be about 90%. The 90% depth value is applied with the smaller burst effective depth estimate for R2C5 in 1997 to assign a conservative growth value to R2C5.

Figure 5-3. Indian Point-2 U-bend Average Depth Growth Data and Distribution

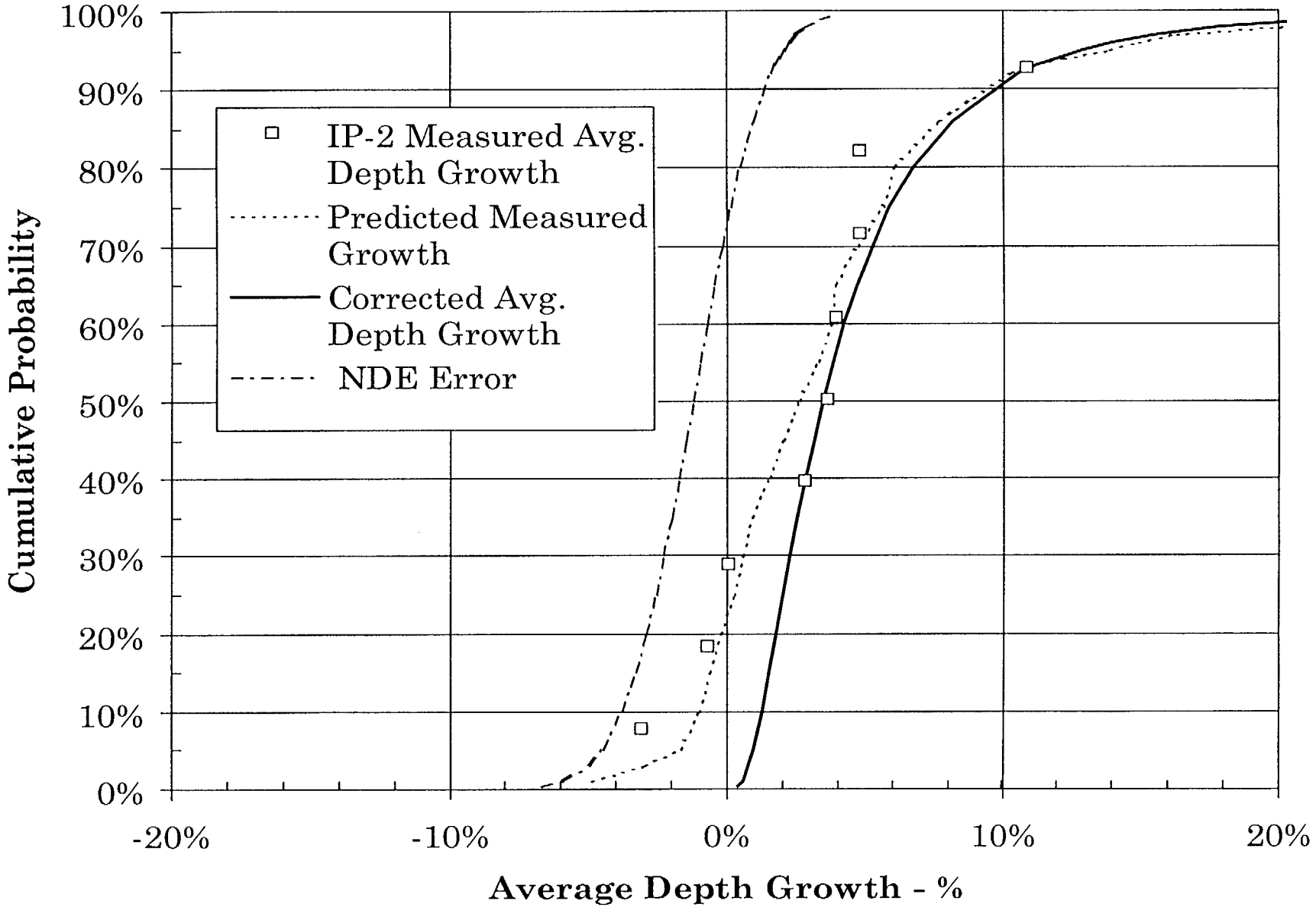


Figure 5-5.
Comparison of Indian Point-2 and Dented TSP PWSCC Growth at 590°F

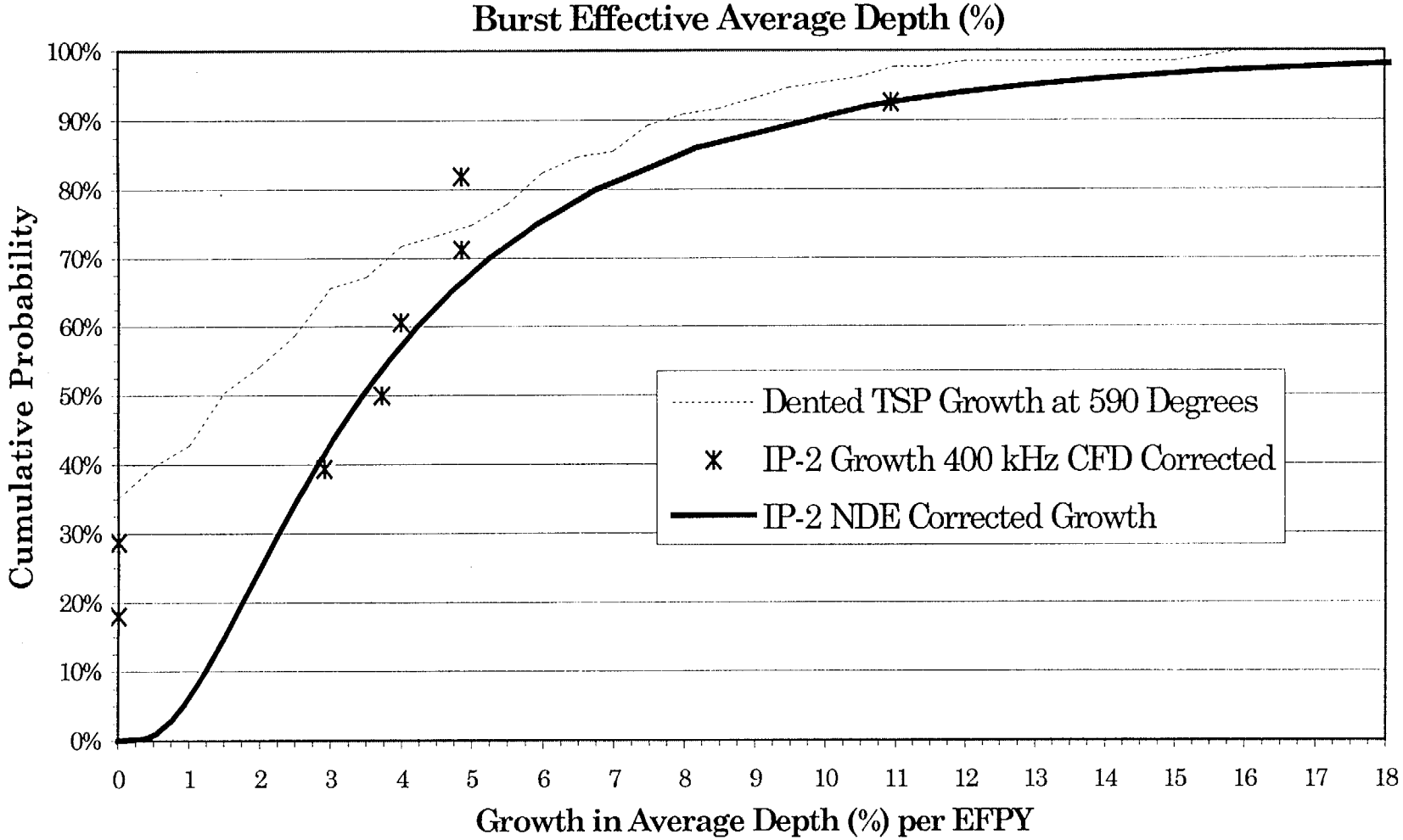


Figure 5-8. Comparison of Indian Point-2 Best Estimate "True" Growth with Distribution for Operational Assessment

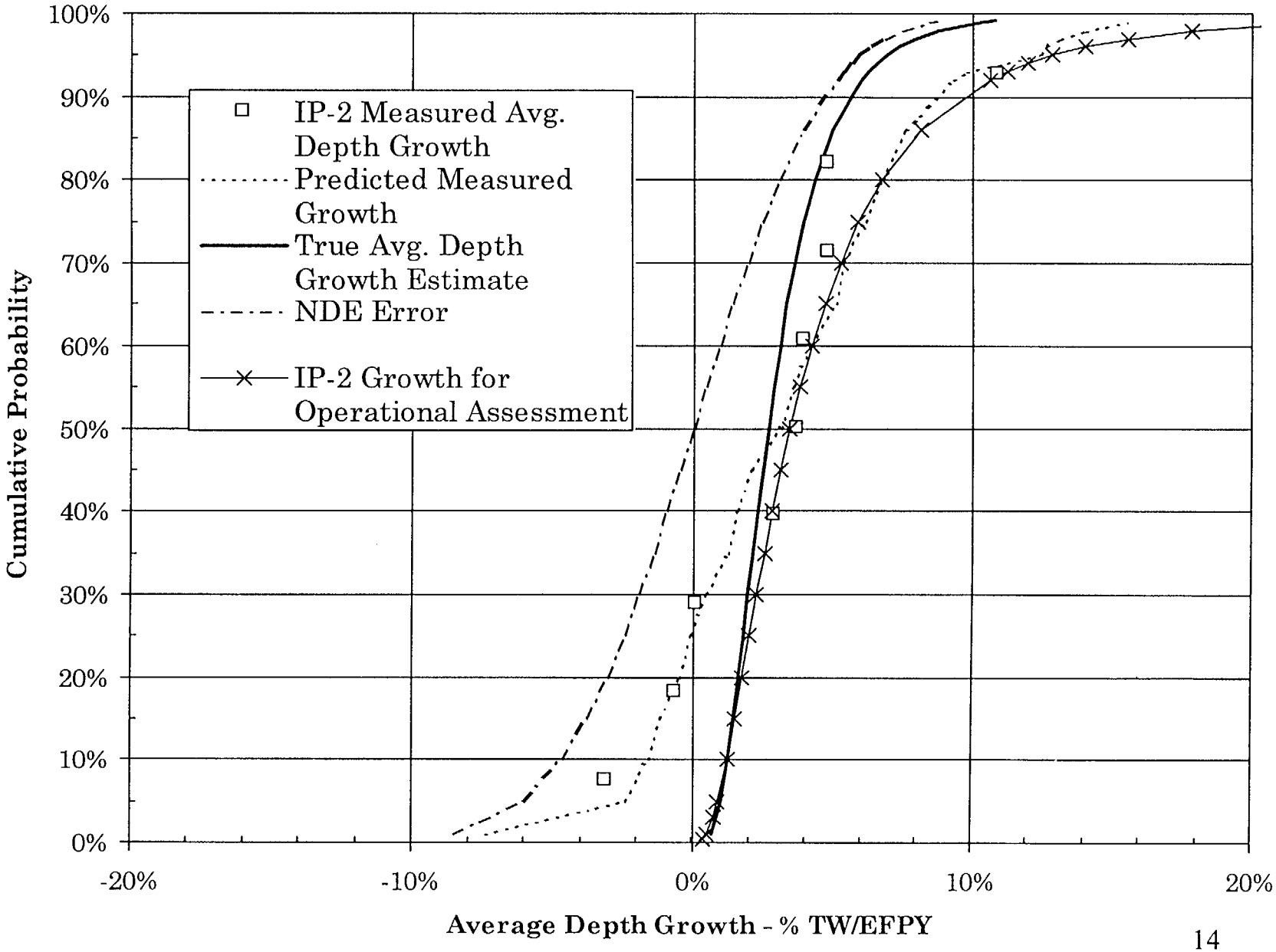


Figure 3-4. Indian Point-2: Comparison of SG 4 R2C69 400 and 800 kHz Depth Profiles

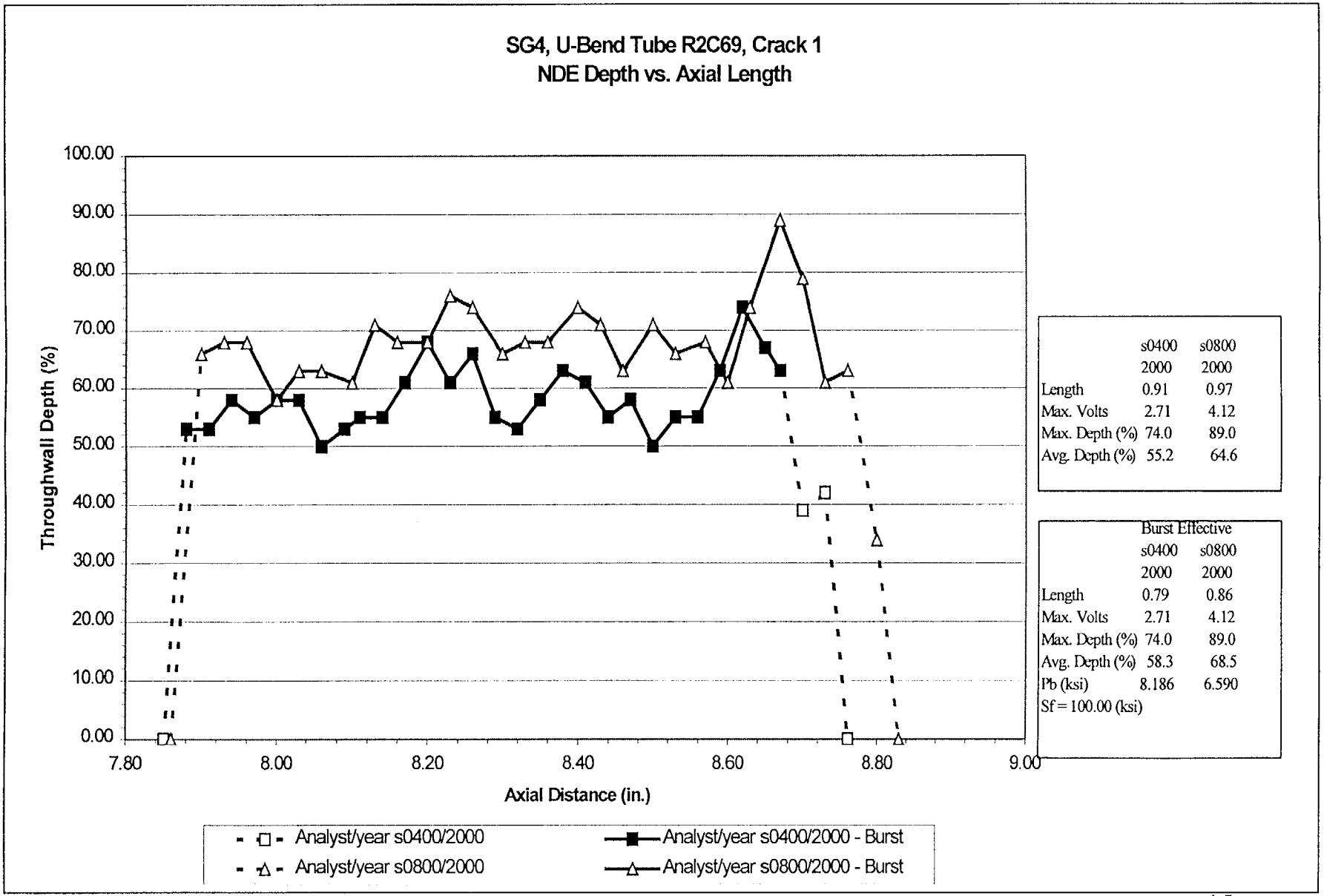
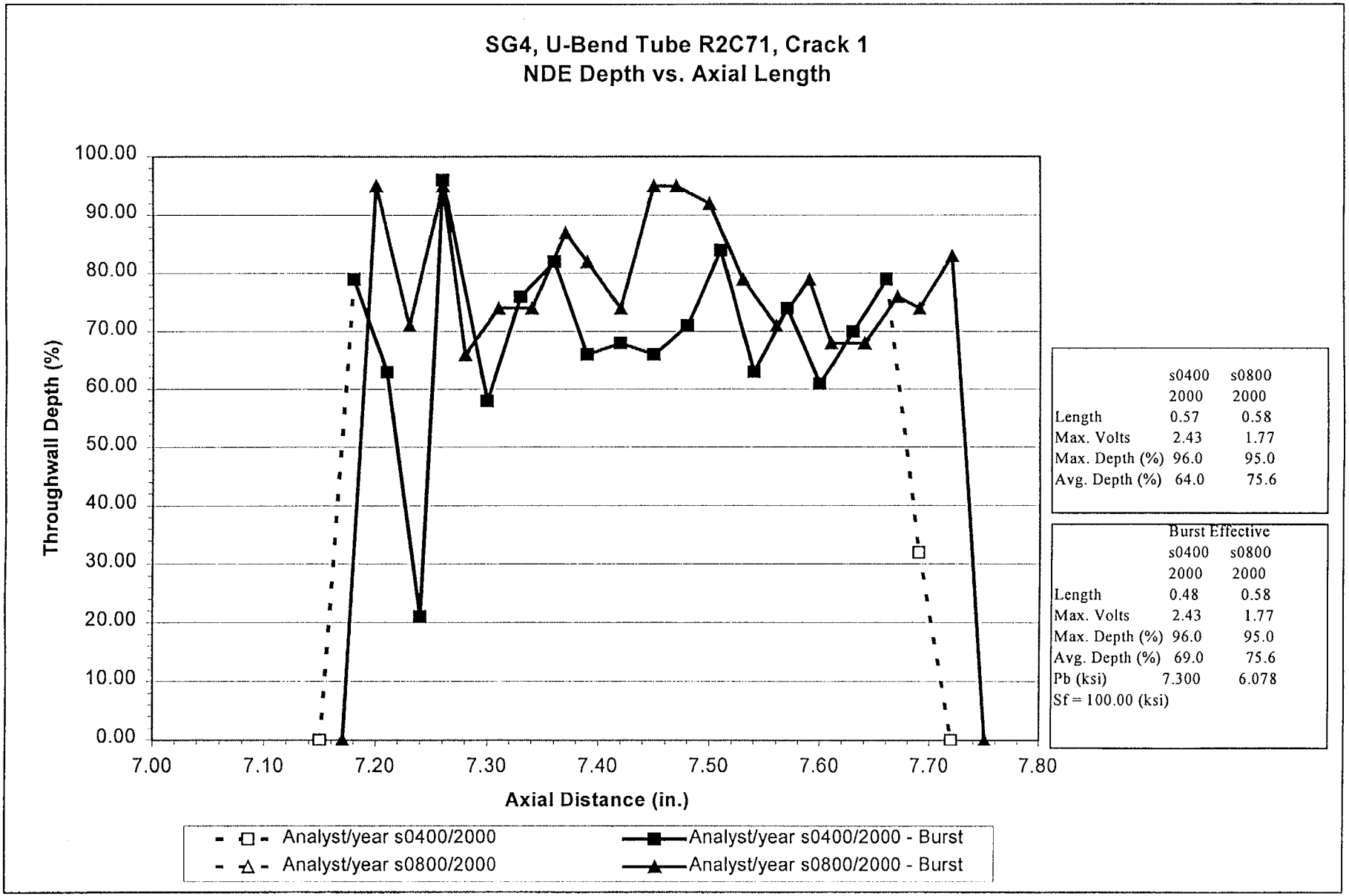


Figure 3-5. Indian Point-2: Comparison of SG 4 R2C71 400 and 800 kHz Depth Profiles



Low Row U-Bends

- Ovality has little or beneficial effect, particularly row 3 compared to row 2
- Effect of leg displacement on operating stresses
  - Site measurements of displacements input to plate model
  - Plate model determines displacements by row
  - Determine stresses at apex due to plate displacement
  - Row 3 stresses less than row 2, etc.
  - Stress effects from leg displacement present in the past and not changing significantly with time
- Industry Experience
  - Industry data suggests row 3 is not a concern
  - Row 2 is now plugged at Indian Point-2

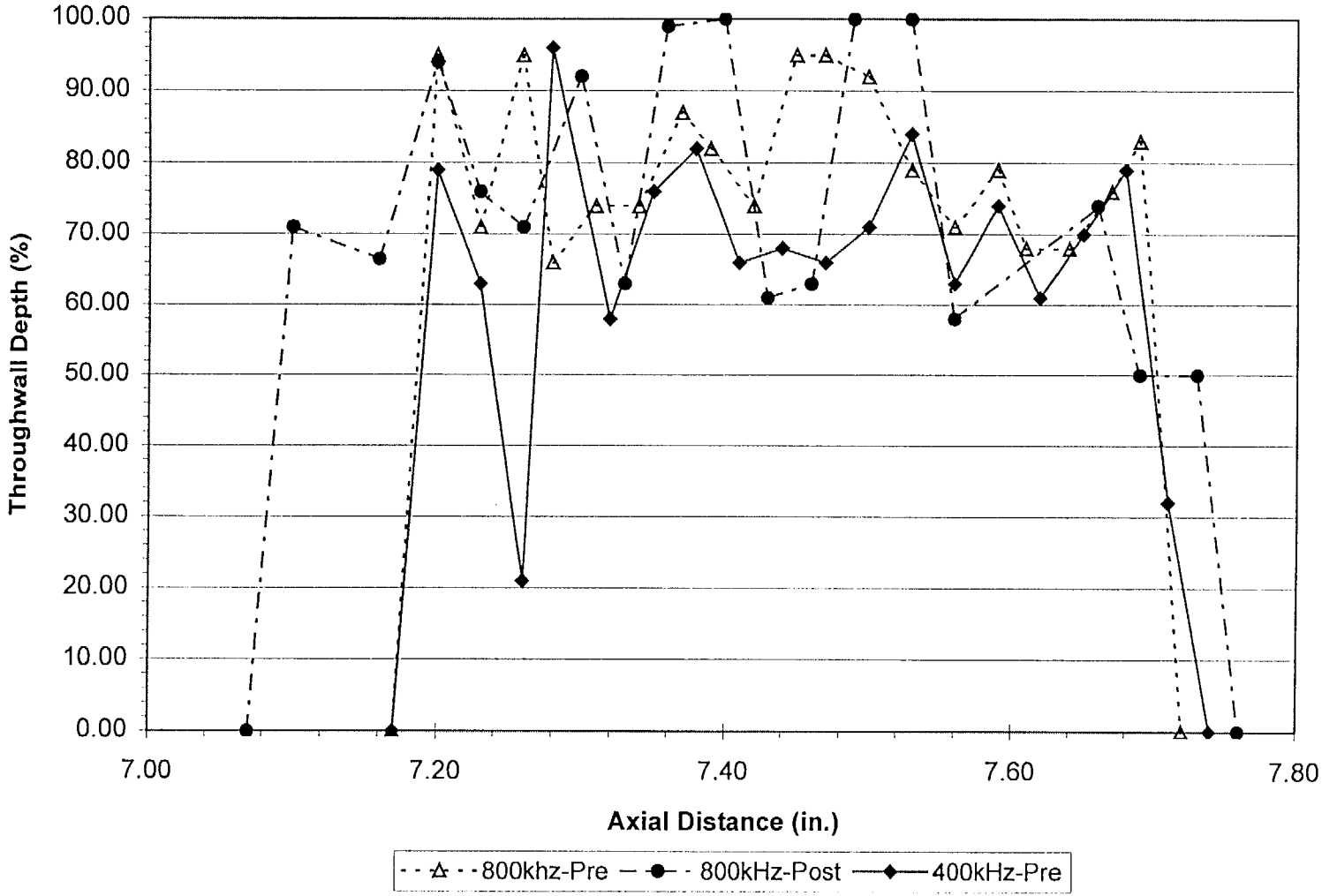
Benchmarking of Analysis Methods and Data

- Benchmarking Analyses performed to support adequacy of data and methods
  - Demonstrate the methods provide conservative predictions of structural and leakage integrity at specified confidence
  - Provide integral test of NDE sizing technique, NDE uncertainty, and material properties
- Compare 1997 projections to 2000 data
  - R2C5 leakage
  - In situ tests
  - Comparisons with burst pressures and leakage from year 2000 profiles
- Compare analyses using year 2000 profiles with in situ test for burst pressure and leakage thresholds

Low Row U-Bend In Situ Tests

- In-Situ testing--total 10 tubes
  - Tested to as high a pressure as possible to demonstrate margin (5500 psi.)
  - Test results used to benchmark tube integrity analysis methods
- Tested all indications
  - Test results met NEI-97-06 Criteria ($3\Delta P_{NO}$ = 4617 psi, hot)
- R2C71 in situ test
  - Test limited to 4206 psi (hot) by progressively increasing leakage
  - NDE and post peak pressure leak rates show short TW (<0.39")
  - Indication has not reached full ligament tearing of deep section (≈0.5") and burst pressure would be about 300 psi above tearing
- Tested 3 NDD tubes to >$3\Delta P_{NO}$ (5173psi)
  - 2 Row 2 tubes, 1 Row 3 tube
  - No leaks & no indications in post test NDE

Figure 8-3
SG 4, U-Bend Tube R2C71, Crack Depth Profiles
Comparison of Pre and Post In Situ
NDE Depth vs. Axial Length



Low Row U-Bend Operational Assessment

- Row 3 is now the limiting row
  - No Indian Point-2 indications found in row 3
  - Industry experience for Model 44/51 is no cracking in row 3
    - **Higher operating temperature plants with no row 3 heat treated tubes**
- Operating period very conservatively calculated by assuming indications found in row 2 were found in row 3
  - High frequency probe POD
  - POD correction per NRC GL 95-05 applied to account for potential undetected indications
- Analysis methods employed
  - Reference analysis is single cycle profile analysis as applied for PWSCC ARC at dented TSP intersections (WCAP-15128 Rev. 2)
  - Multi-cycle analysis methodology as independent check and guide to crack initiation history

Dented TSP Intersections

- Cecco results
- Qualification accepted by NRC
- No Cecco indications confirmed as flaws by +Point inspection

Area Above Sludge Pile

- Inspected with CECCO/bobbin probe
- 20% of tubes in each steam generator inspected with +Pt. to just below 1st TSP
  - Confirmed CECCO overcalls in this region
- 23 tubes in one steam generator inspected through 1st TSP with UTEC
  - UT inspection lessened influence of copper
  - 1 tube could not be inspected through 1st TSP
  - 2 tubes inspected after in-situ test
  - Confirmed CECCO calls
- 5 tubes in-situ tested in this region
  - All met NEI-97-06 structural and leakage criteria

Sludge Pile

- Detect with Cecco/confirm with + Point
  - Confirmation rate lower than qualification data
- Inspected 100% of hot leg tubes with + Point from TEH to 24" above top of tubesheet
  - Found a total of 6 small indications not found by CECCO
- UTEC inspection of 23 tubes in 1 steam generator
  - Confirmed CECCO calls
- 31 tubes in-situ tested in this region
  - All met NEI-97-06 structural and leakage criteria
  - R34C51: peak test pressure = 4985 psi = 4591 psi hot
  - Burst margin = 4591/1539(ΔP_{NO}) = 2.98 = 3ΔP_{NO} burst margin

Cold Leg Program

- Initial inspection with CECCO/bobbin probe
- Inspected 20% of 1 steam generator with +Pt from TEC to just below 1st TSP
- Inspected 20% of each of the other 3 steam generators with +Pt from TEC to 24" above top of tubesheet
- No crack-like indications found
- S/G 23 & 24 expanded to 40% due to pit indications
  - All pit indications plugged

Tubesheet Region

- Within tubesheet, burst prevented by tubesheet constraint
- Cecco/+ Point correlation similar to qualification
- Less of an influence of copper
- However---one indication within crevice did grow larger (crack opening and probable tearing) after an in situ test to 5000 psi for another indication
- Tubesheet region included in 100% H/L +PT. inspection and 20% C/L inspection
- In-situ tested 5 indications
  - All met NEI-97-06 leakage criteria

Other Tube Degradation Considerations

- Plugging all pits
- AVB wear is well understood
  - Growth rate consistent with industry experience
- Support plate condition
  - Analysis shows plates maintain tube integrity support function
- Wear due to loose parts also being evaluated