Manual High Frequency Eddy Current System Performance Variability and Control

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Overview

- Introduction
- Performance Measurement Approach
- Eddy Current Instrument Variability
- Probe Performance Variability
- Cable Performance Variability
- Reference Standard Variability
- Probe Angulation Induced Variability
- Conclusions

Eddy Current System Variability Study

Purpose:
Determine magnitude of performance variance resulting from probe, cable, reference standard and eddy-current instrument variability

Approach:

- Measure performance response of sample population of instruments
  - 25 portable eddy current units tested

- Measure performance response from a sample population representing standard probes, cables and reference standards from typical depot
  - Probes/Cables - 4 manufacturers
    - 17 probes total (bridge w/ balance coils, 50-500KHz)
    - 14 cables total
  - Reference Standards – 4 manufactures
    - 10 reference standards total

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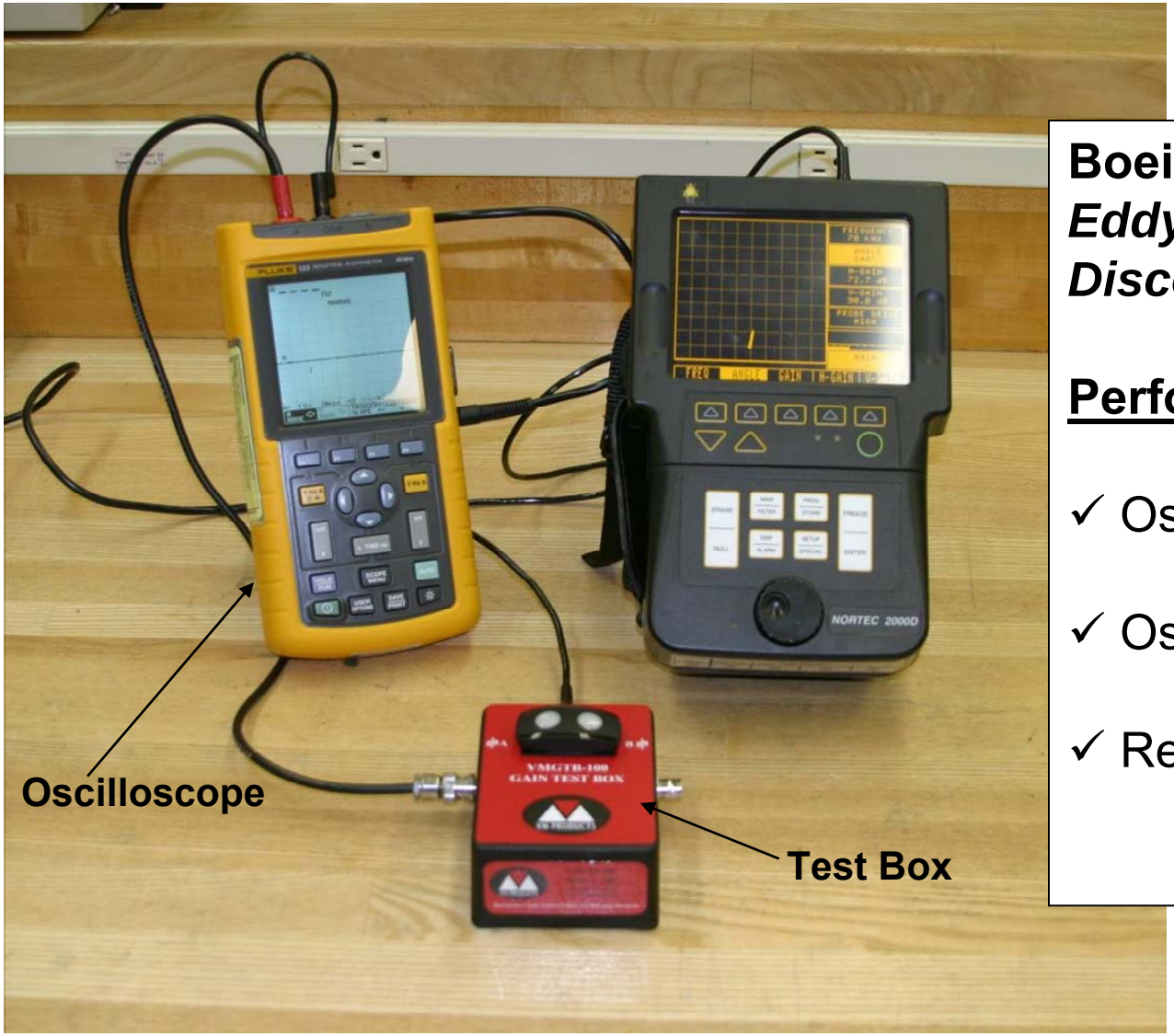
Eddy Current Instrument Performance Testing



Boeing Standard <u>BSS 7048</u>
Eddy Current Inspection, Discontinuities

<u>Performance Parameters</u>

- ✓ Oscillator Frequency
- ✓ Oscillator Amplitude
- ✓ Receiver Linearity

Instrument Performance Results

Oscillator Frequency

	Requirement	101242	72073	61626	61624	61623	6162
Frequency	±20% Indicated Value	Meter Value (KHz)	Meter Value (KHz)	Meter Value (KHz)	Meter Value (KHz)	Meter Value (KHz)	Mete Value (KHz
100 Hz	80 - 120 Hz	99.87	99.85	99.80	99.83	99.90	99.90
500 Hz	400 - 600 Hz	499.50	499.40	499.20	499.30	499.20	499.2
1 MHz	0.8 - 1.2 MHz	1.00	1.00	1.02	1.00	1.01	1.00
5 MHz	4 - 6 MHz	4.99	5.00	5.02	4.99	5.00	4.99
10 MHz	8 - 12 MHz	9.98	9.98	9.99	9.99	9.98	9.98
12 MHz	9.6 - 14.4 MHz	11.98	11.98	11.99	11.98	11.99	12.00
	PASS/FAIL	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**

<2% Variation

Oscillator Amplitude

		Instrum					
		101242	72073	61626	61624	61623	61620	616
Mid	4.8 - 7.2 volts							
High	9.6 - 14.4 volts							
	PASS/FAIL							

Ocillator Variance Acceptable

MID: 5 - 6.4 volts

HIGH: 10 – 12 volts

Receiver Linearity

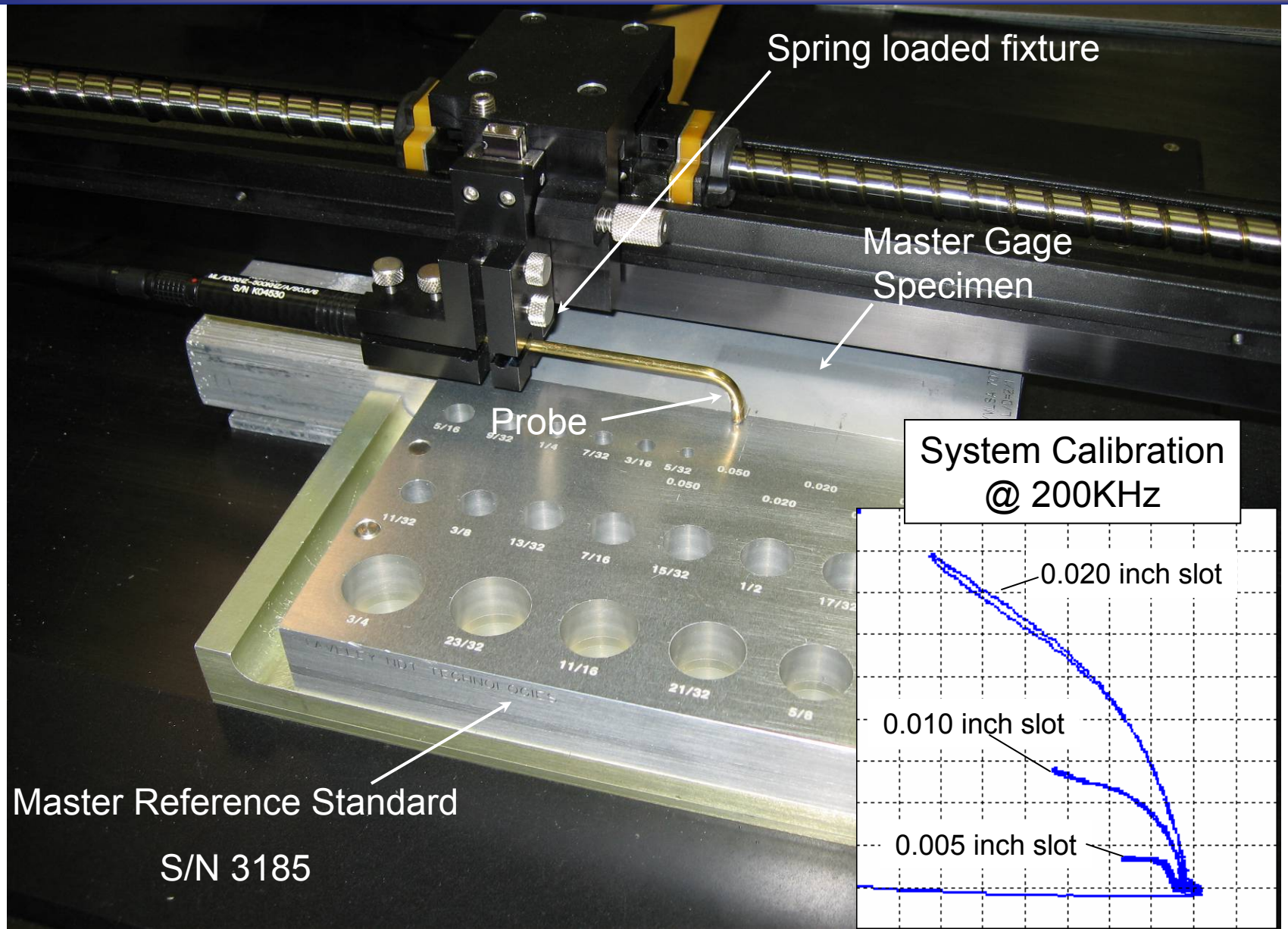
Sample Data

		Instrument S/N									
	Requirement	101242	72073	61626	61624	61623	61620	61619	61617	61616	6161
Gain (dB) @ 5 div	→	84.0	84.2	84.0	83.9	83.4	83.5	85.0	83.1	83.8	84.0
Set-up A-Coil	5 ± 0.5 div	5	5	5	5	5	5	5	5	5	5
-6dB B-Coil	2.5 ± 0.25 div	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
-20dB A-Coil	.5 div w/ no ovality	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
-20dB B-Coil	.5 div w/ no ovality	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	PASS/FAIL	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PASS**	**PAS**

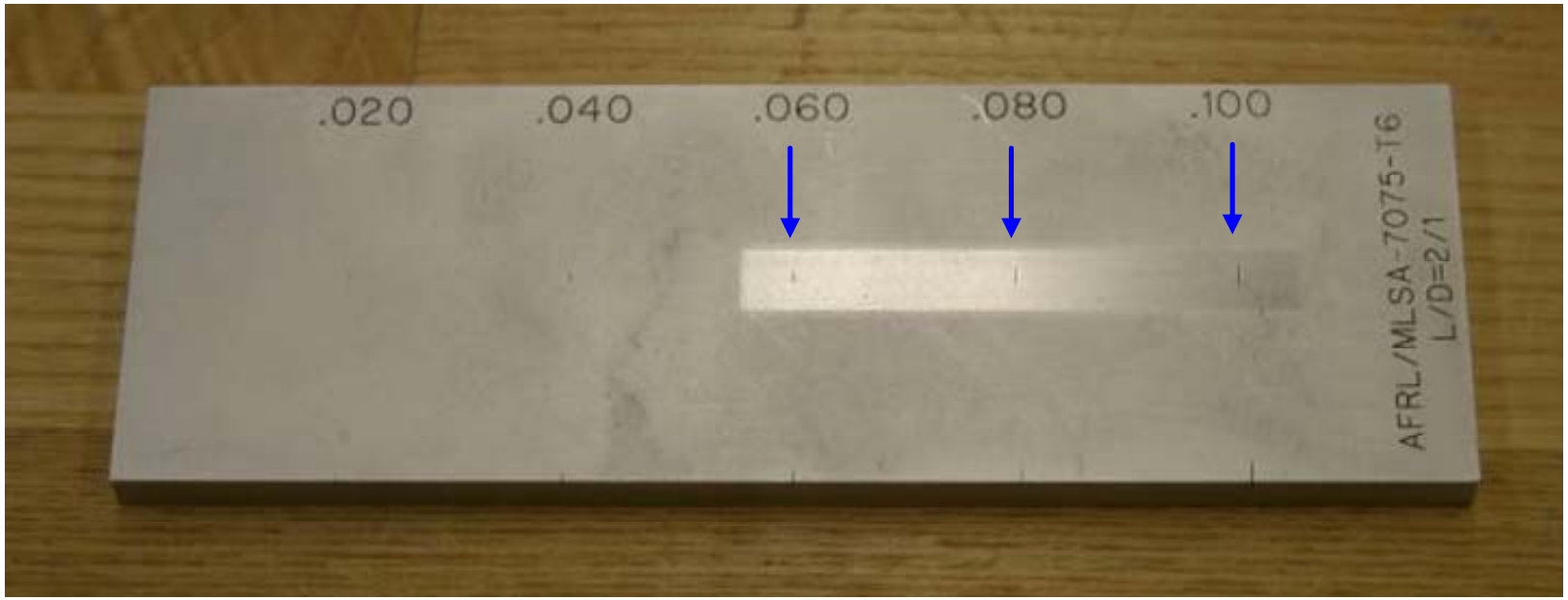
No Measurable Variation

Probe, Cable, Standard Performance Testing

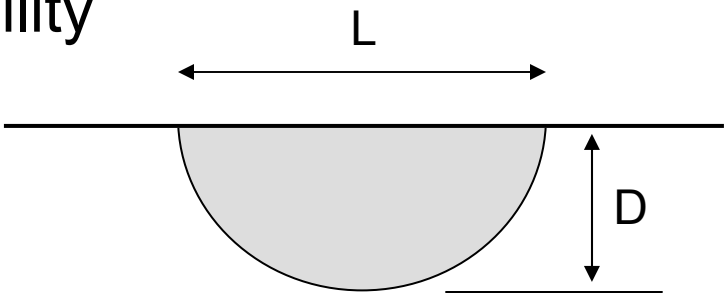
Probe, Cable, Standard Performance Testing
System Calibration



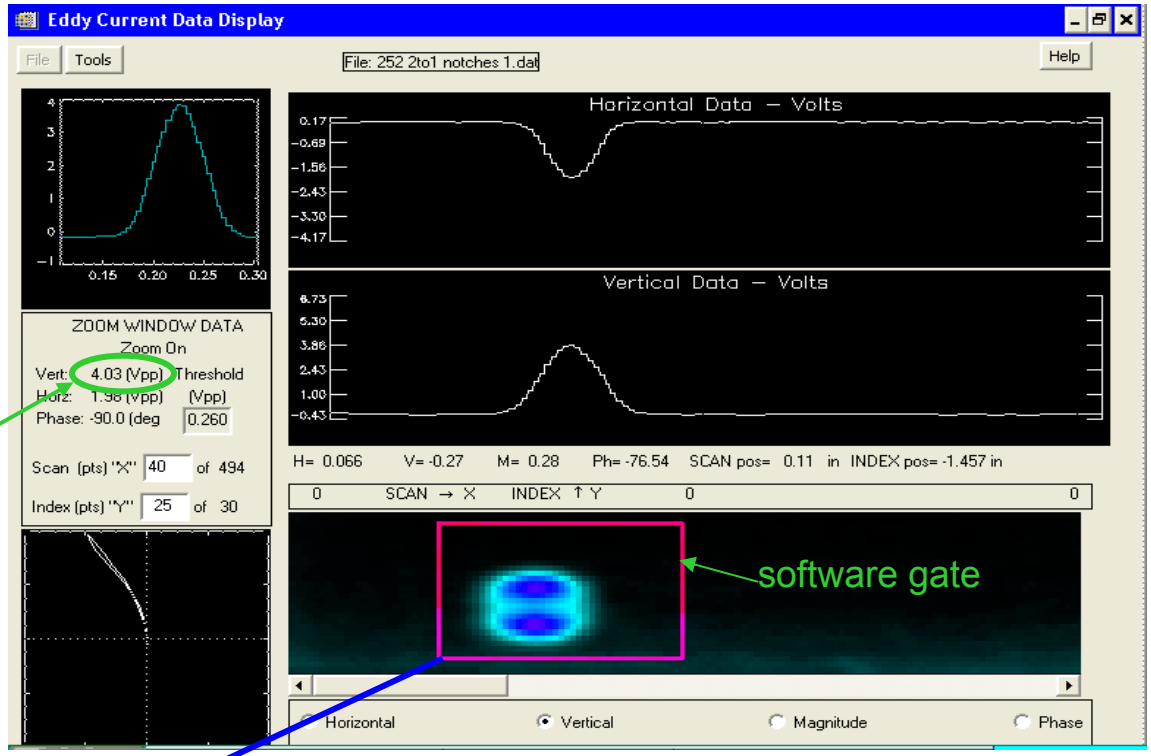
Target Flaws
Master Gauge



- EDM slots used to measure variability
  - Half-circle shape
  - 2:1 (Length:Depth) aspect radios

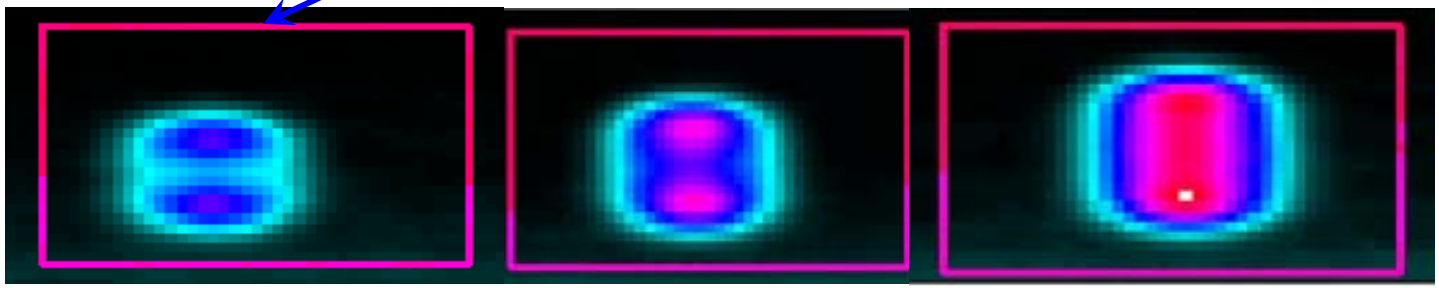


Automated Eddy Current C-scan



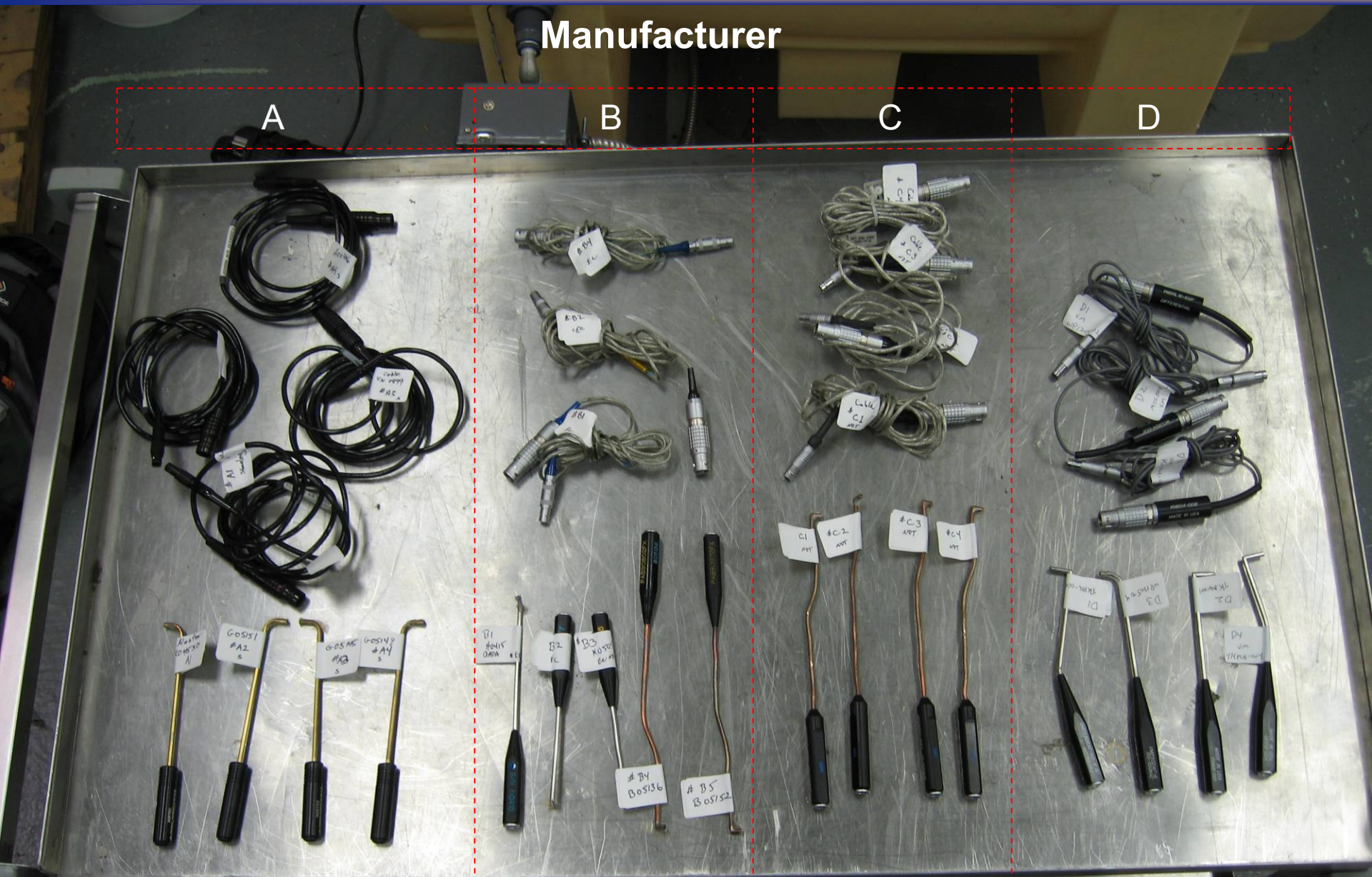
Peak Response

4.03 Volts (peak-to-peak)



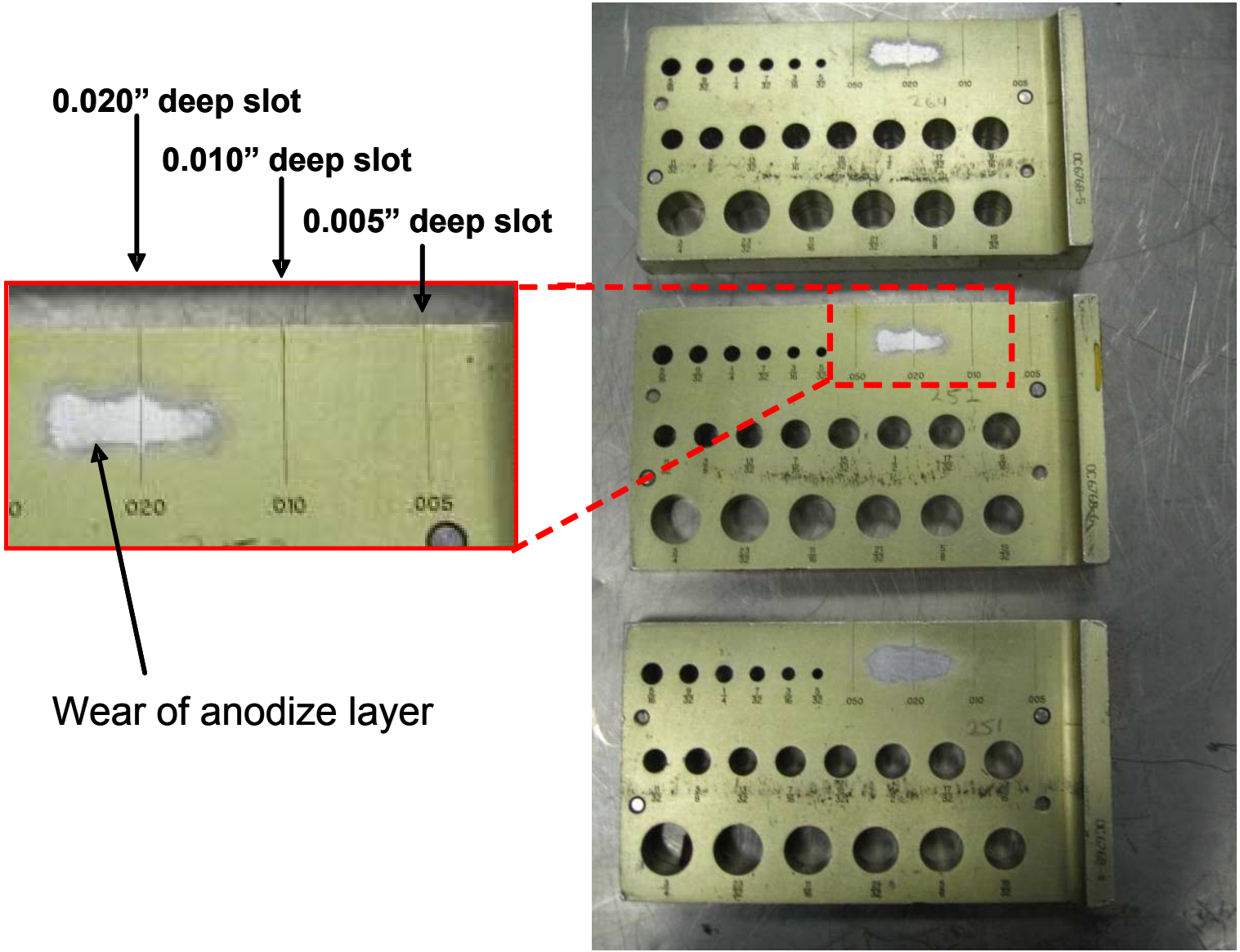
0.060 inch notch **0.080 inch notch** **0.100 inch notch**

Probe and Cable Sample Population



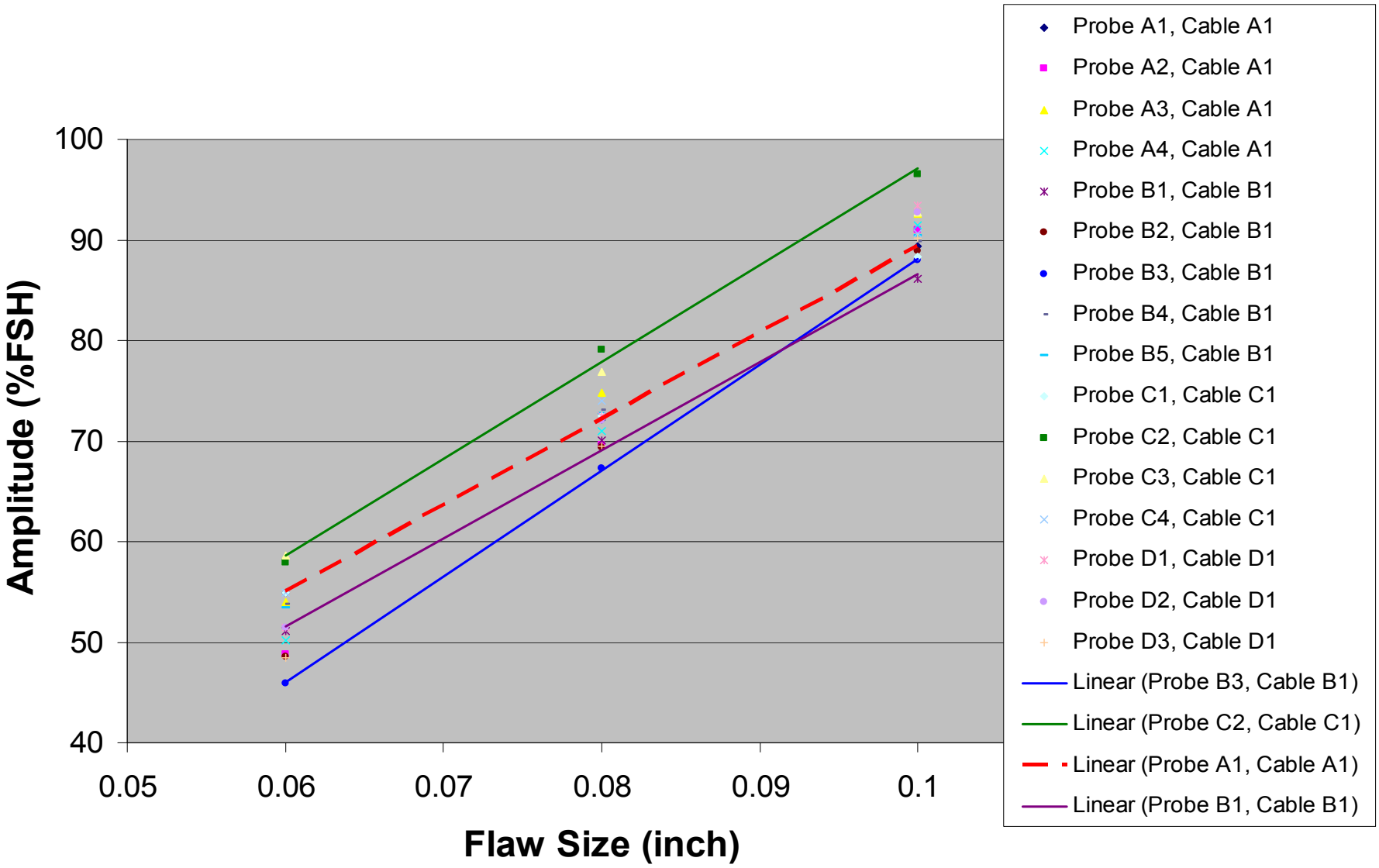
Reference Standards

Typical Examples (3 of 10)

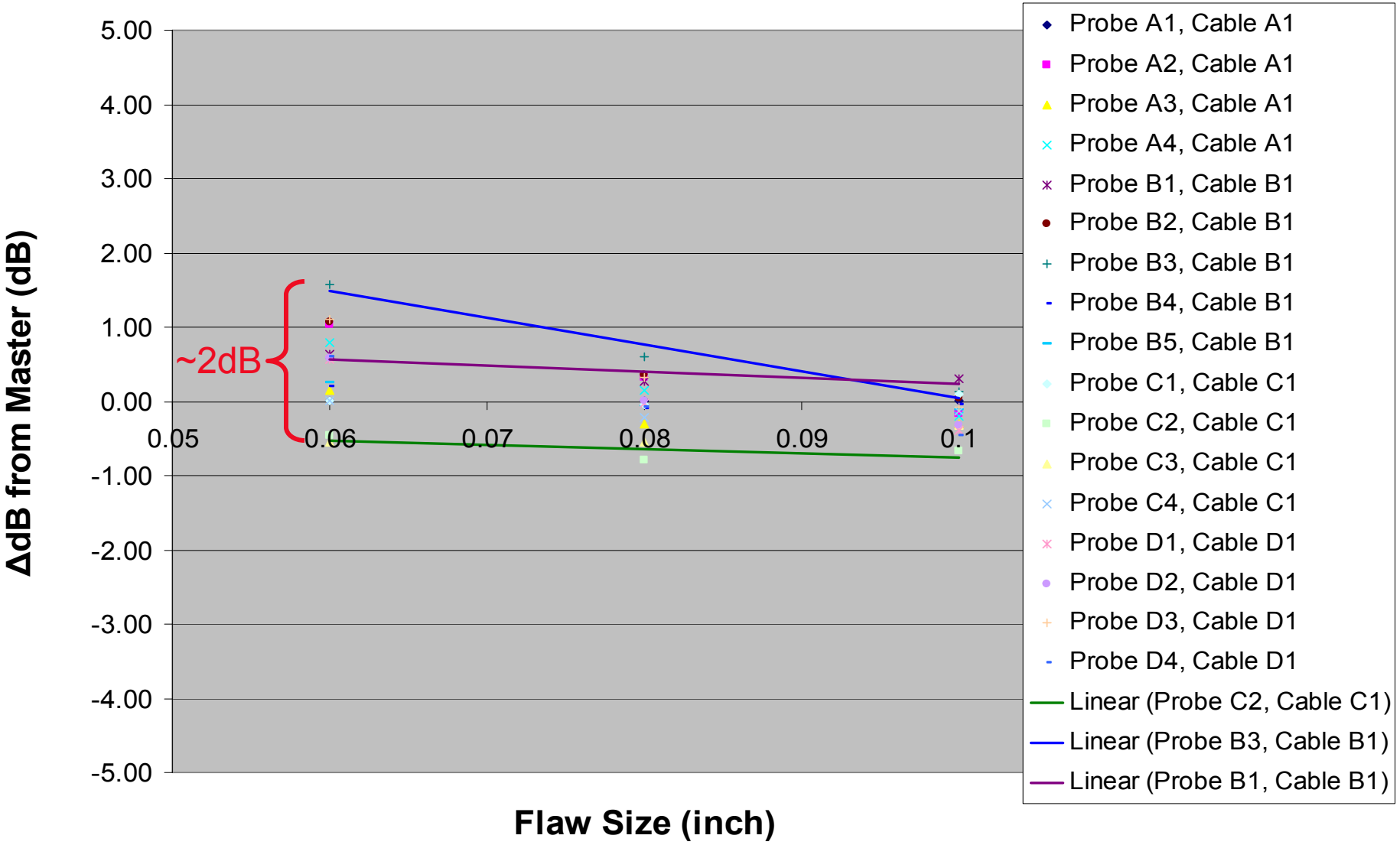


Probe, Cable, Reference Standard Performance Results

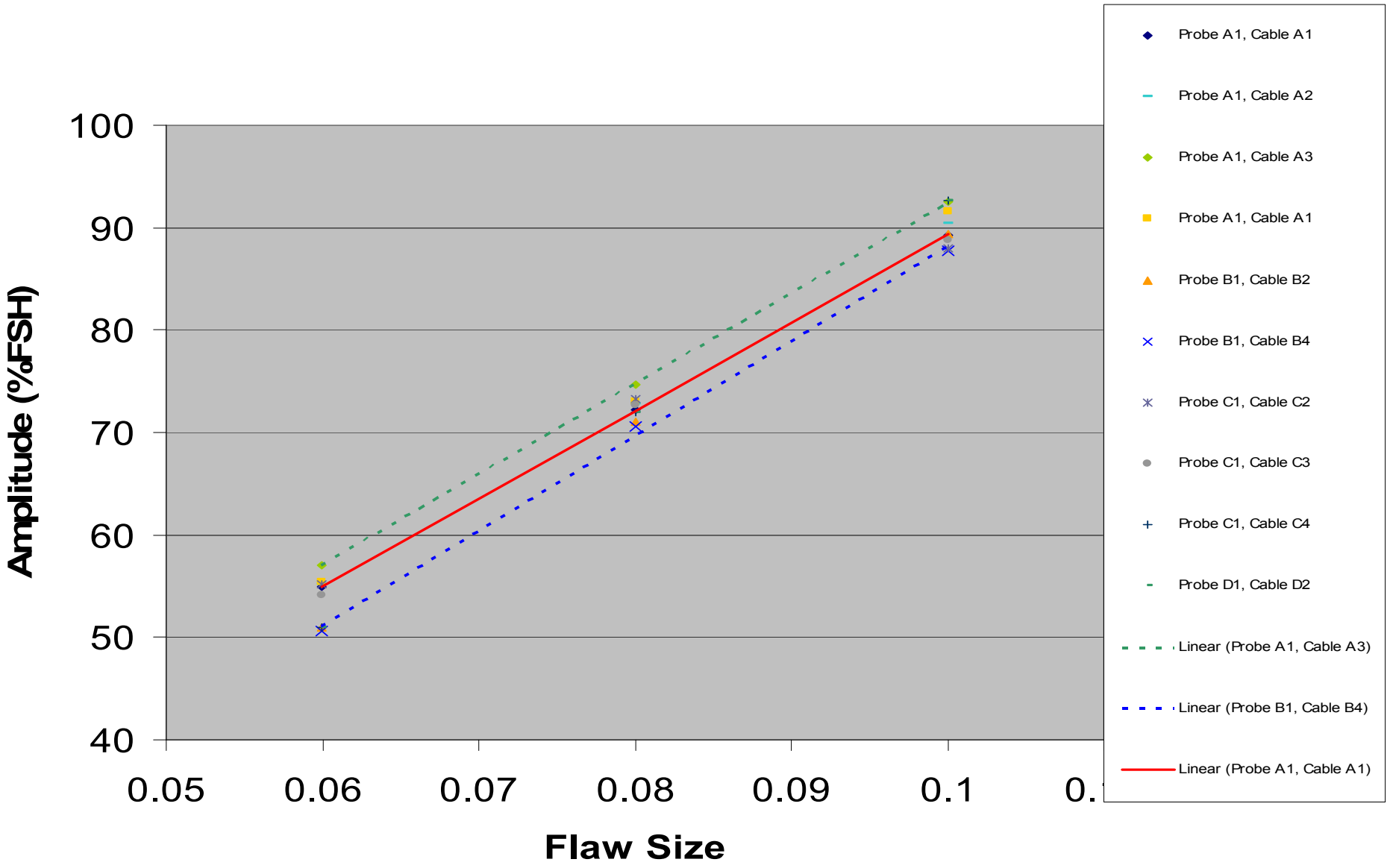
Probe Performance Variance Results



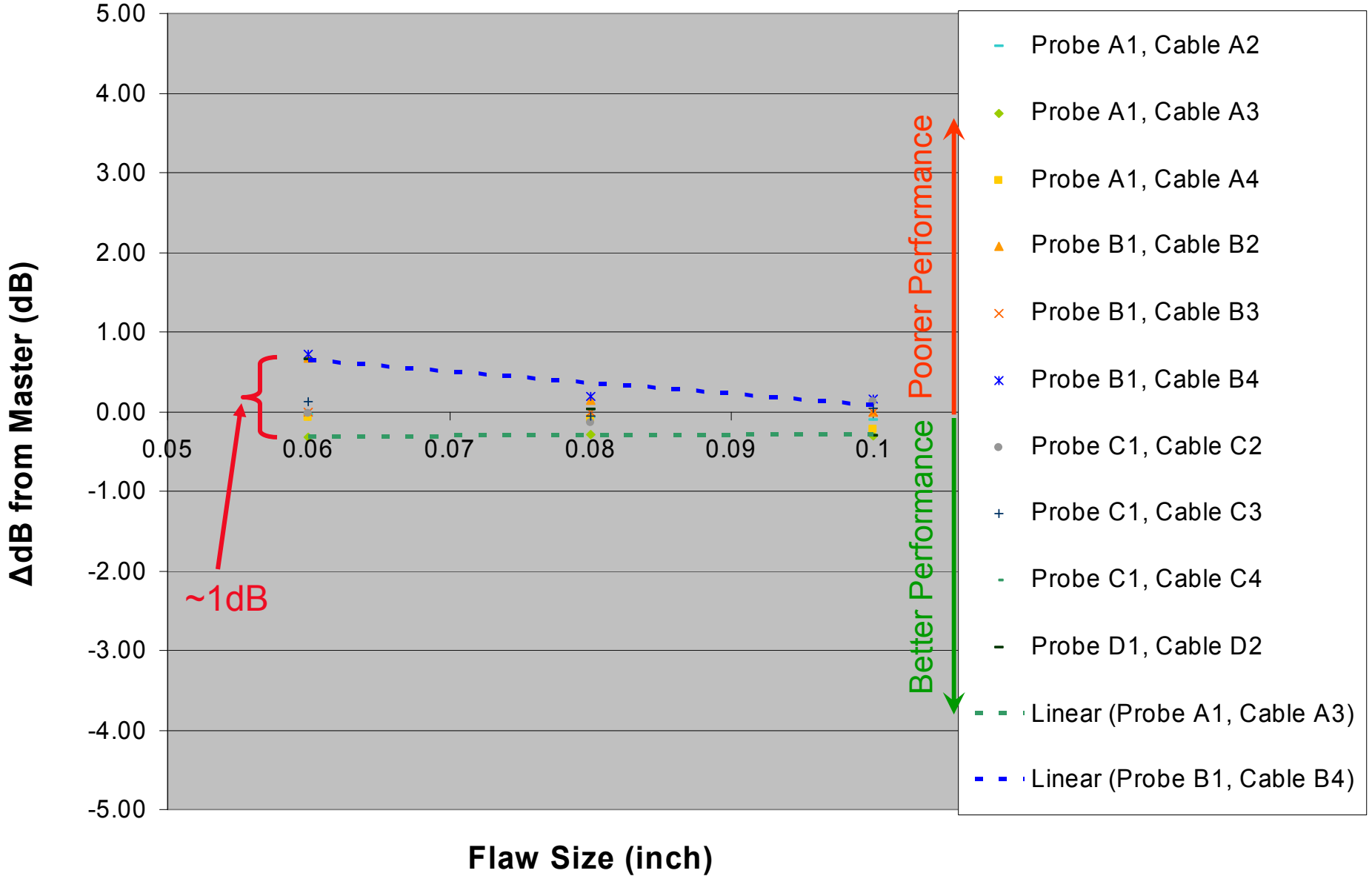
Probe - dB Variance Results



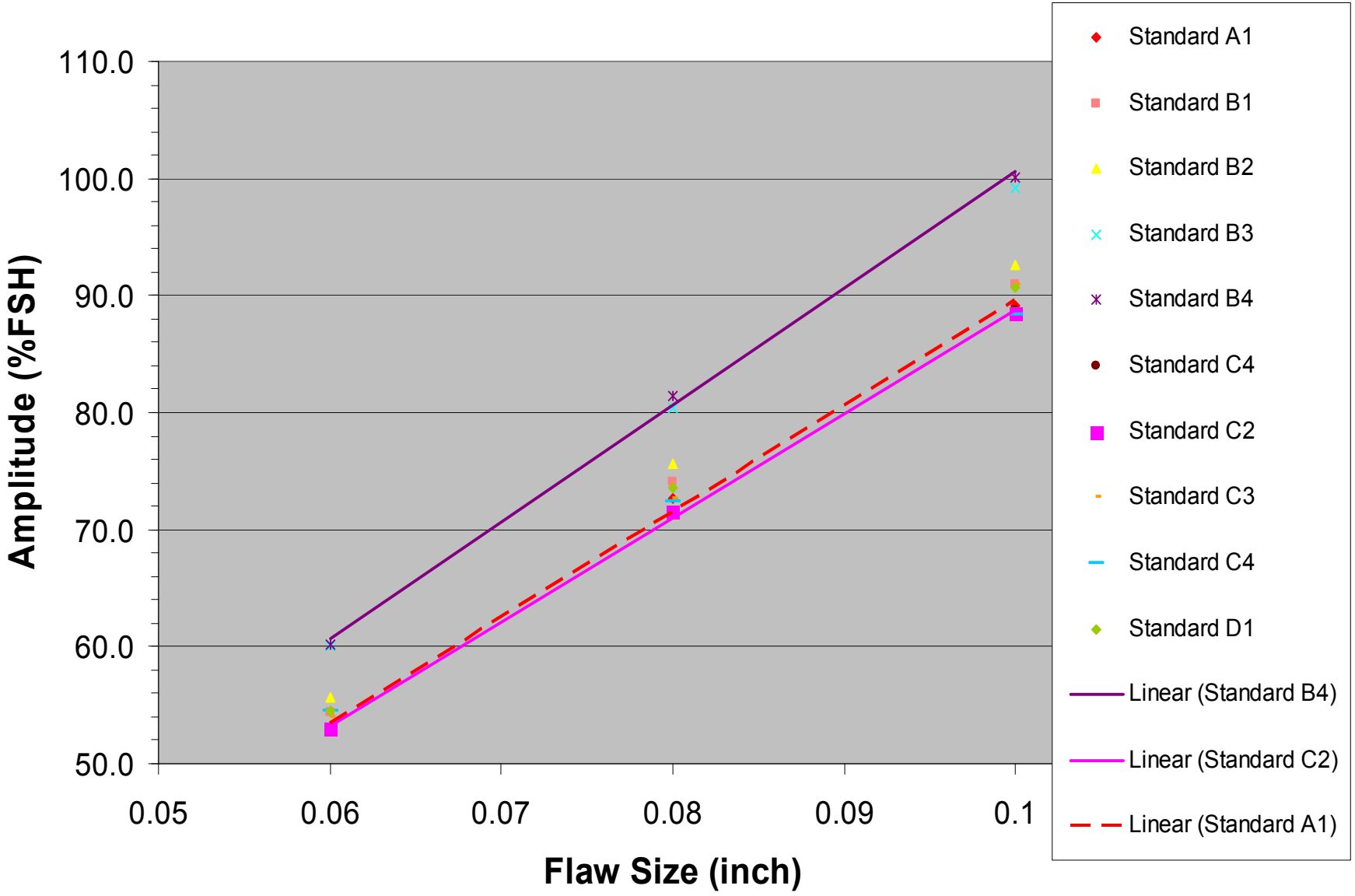
Cable Performance Variance Results



Cable - dB Variance Result

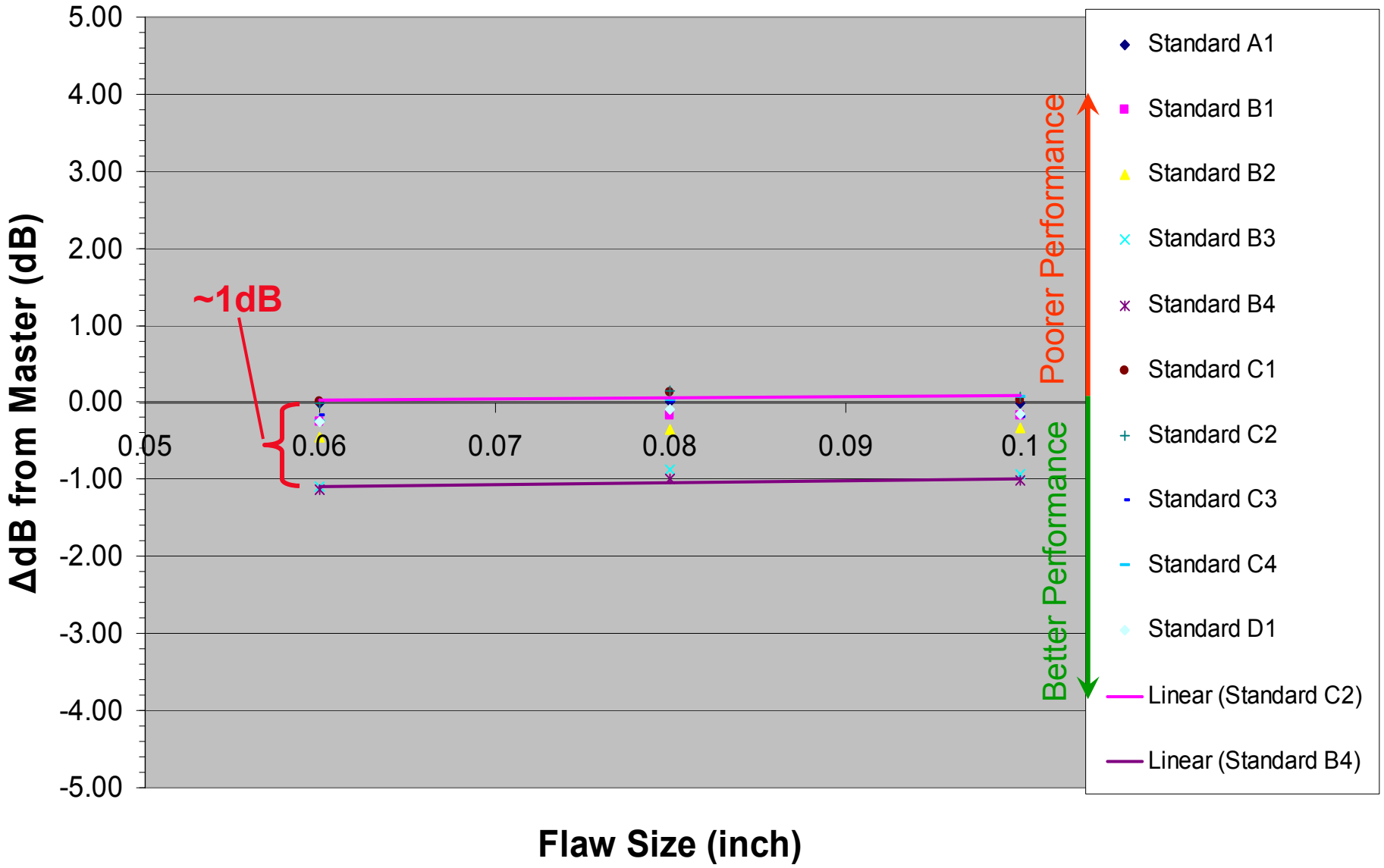


Reference Standard Performance Variance Results

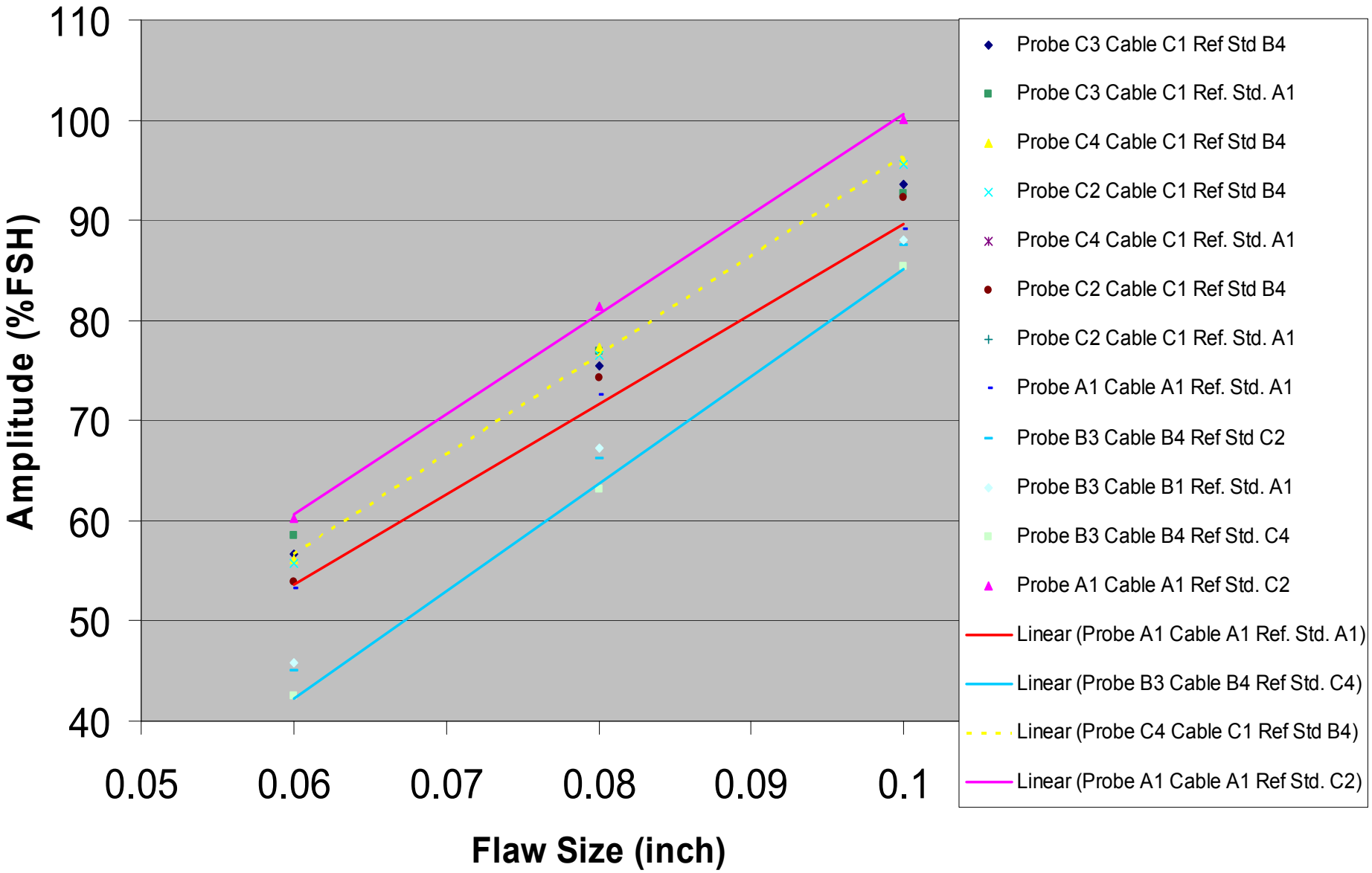


Reference Standard - dB Variance

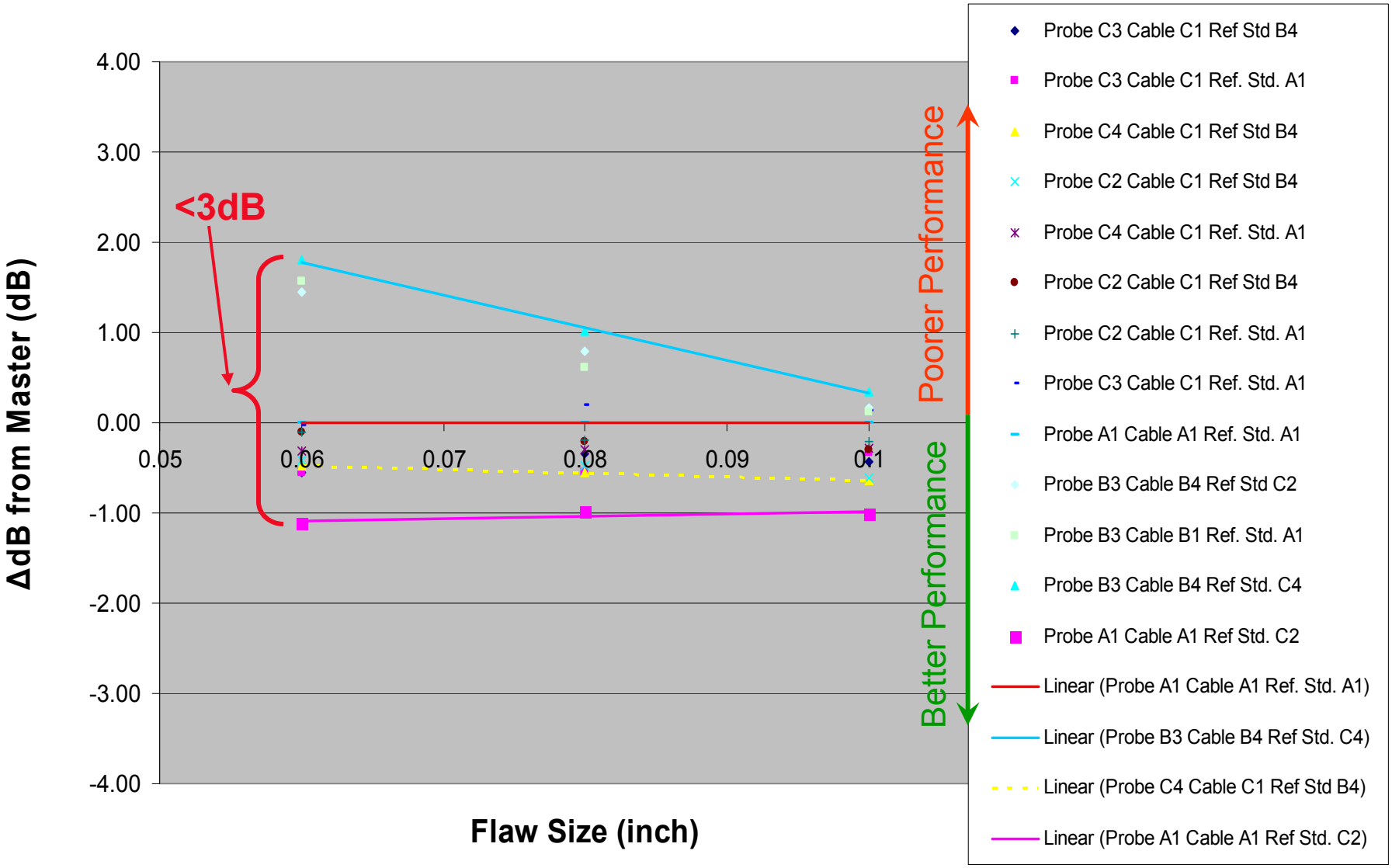
(ΔdB from Master)



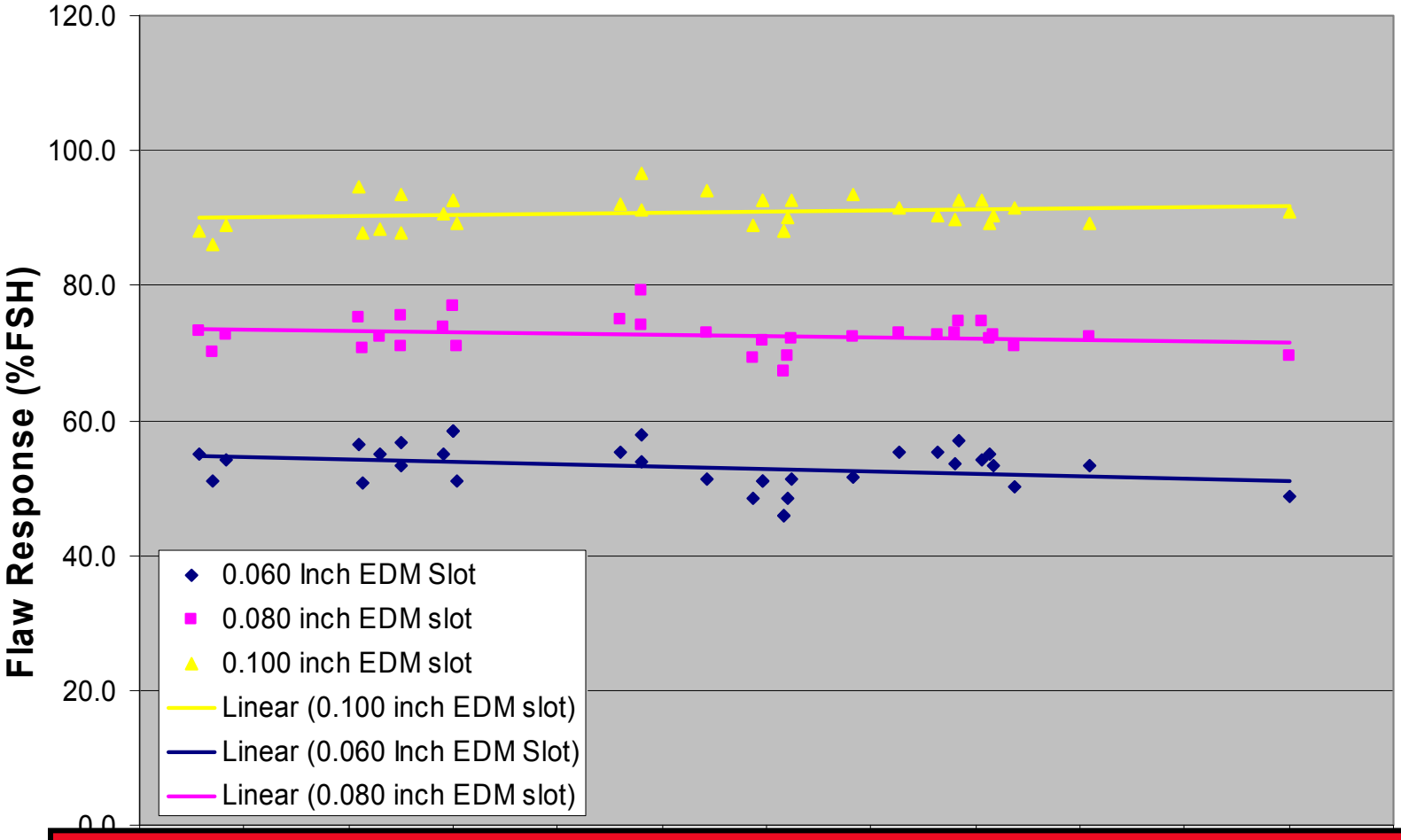
Extreme Combinations Performance Variance



Extreme Combinations - dB Variance



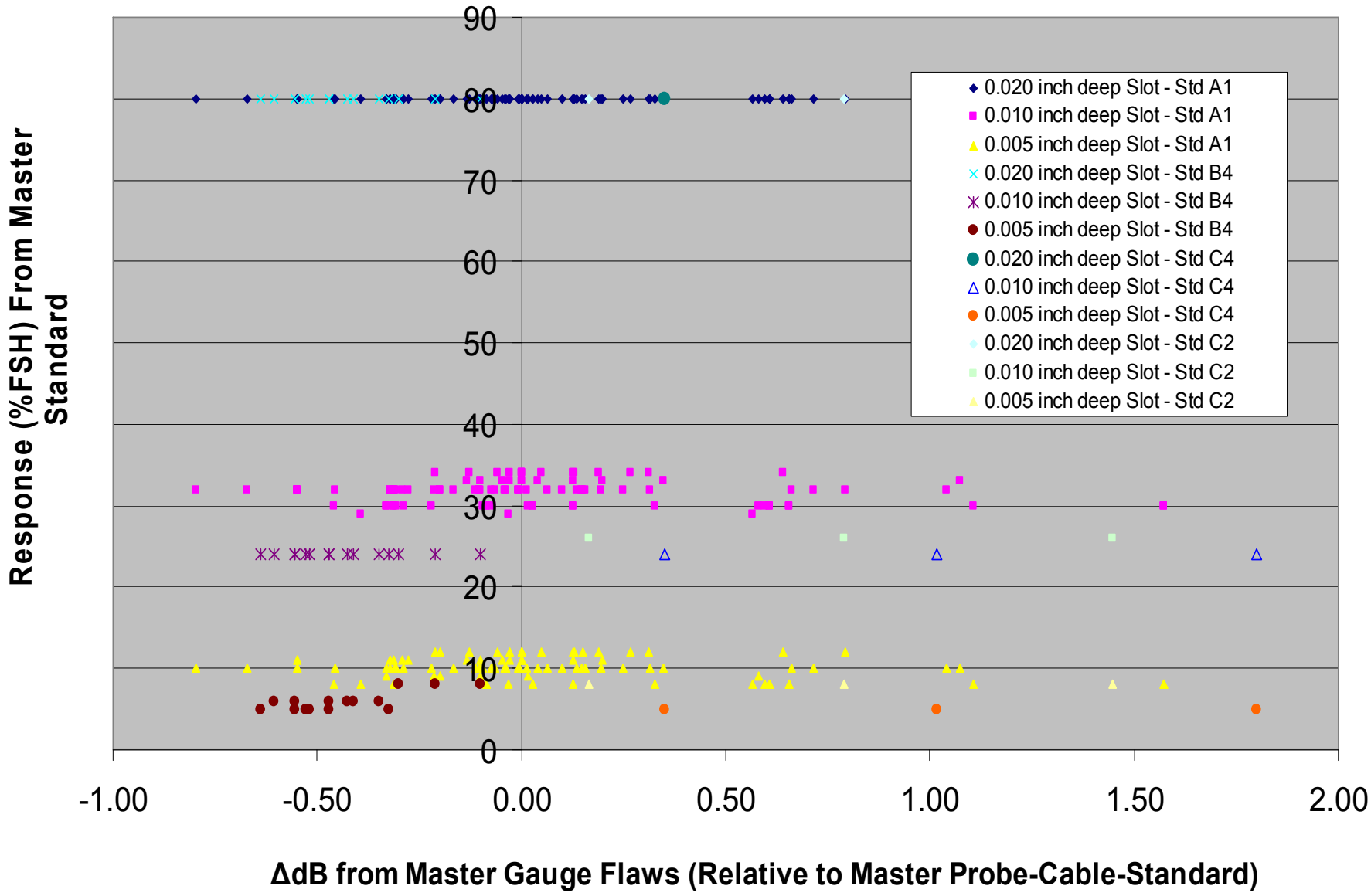
Flaw Response vs. Required Instrument Gain



No Correlation between Performance Variability and Required Calibration Gain

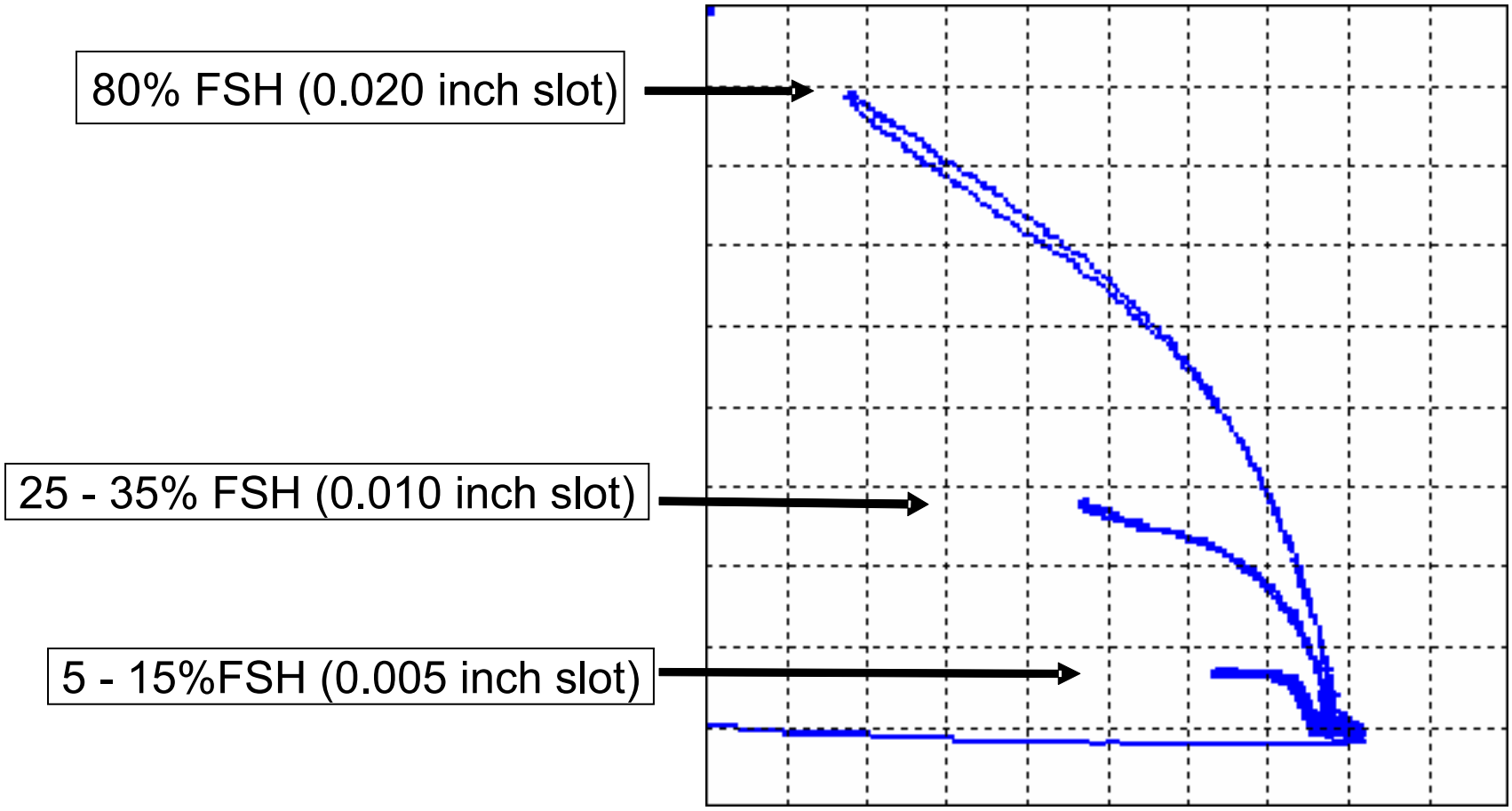
3-Point Cal. Response vs. dB Variance

(All Probe and Cable Combinations)

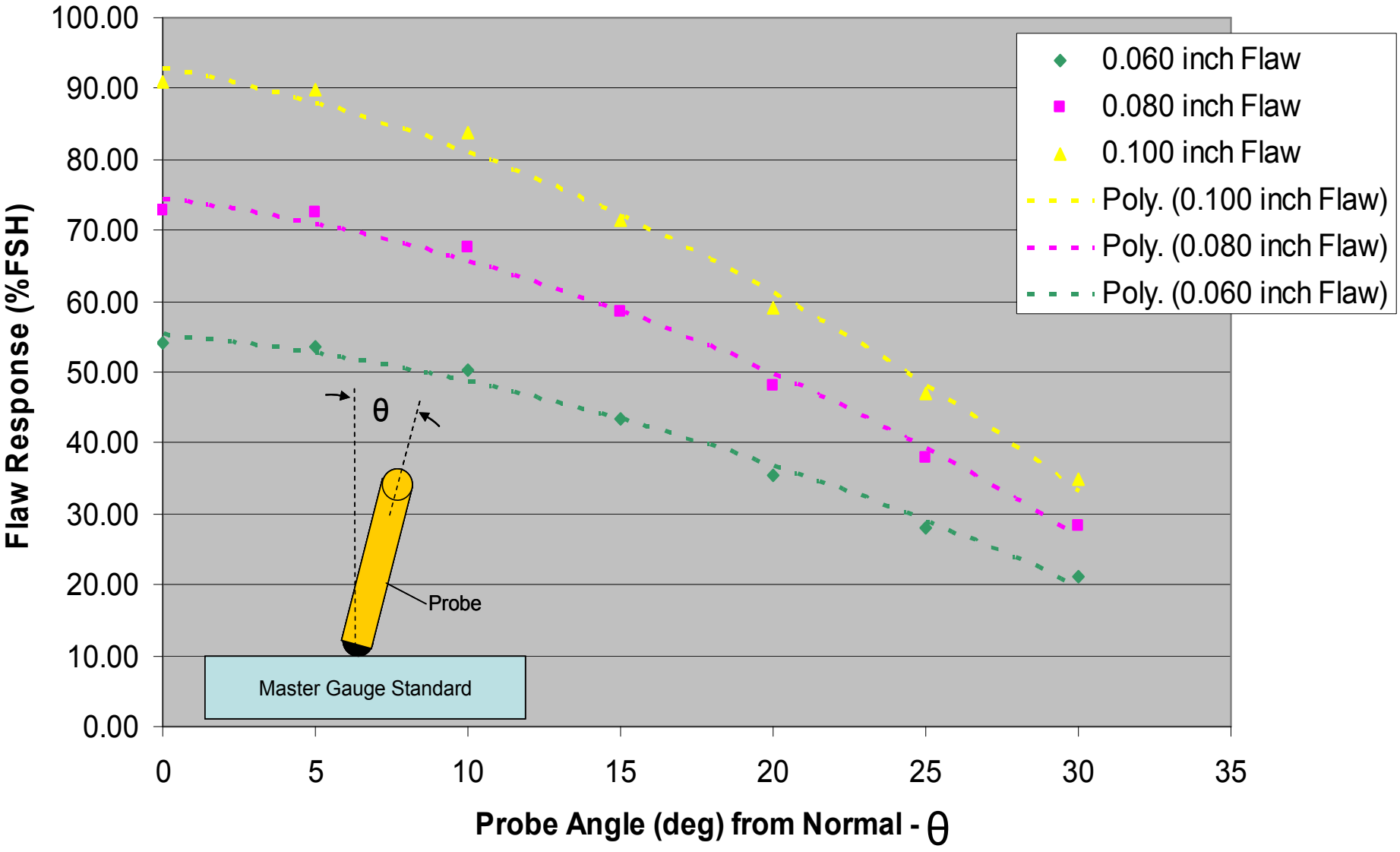


Surface Eddy Current Calibration

TO 33B-1-2

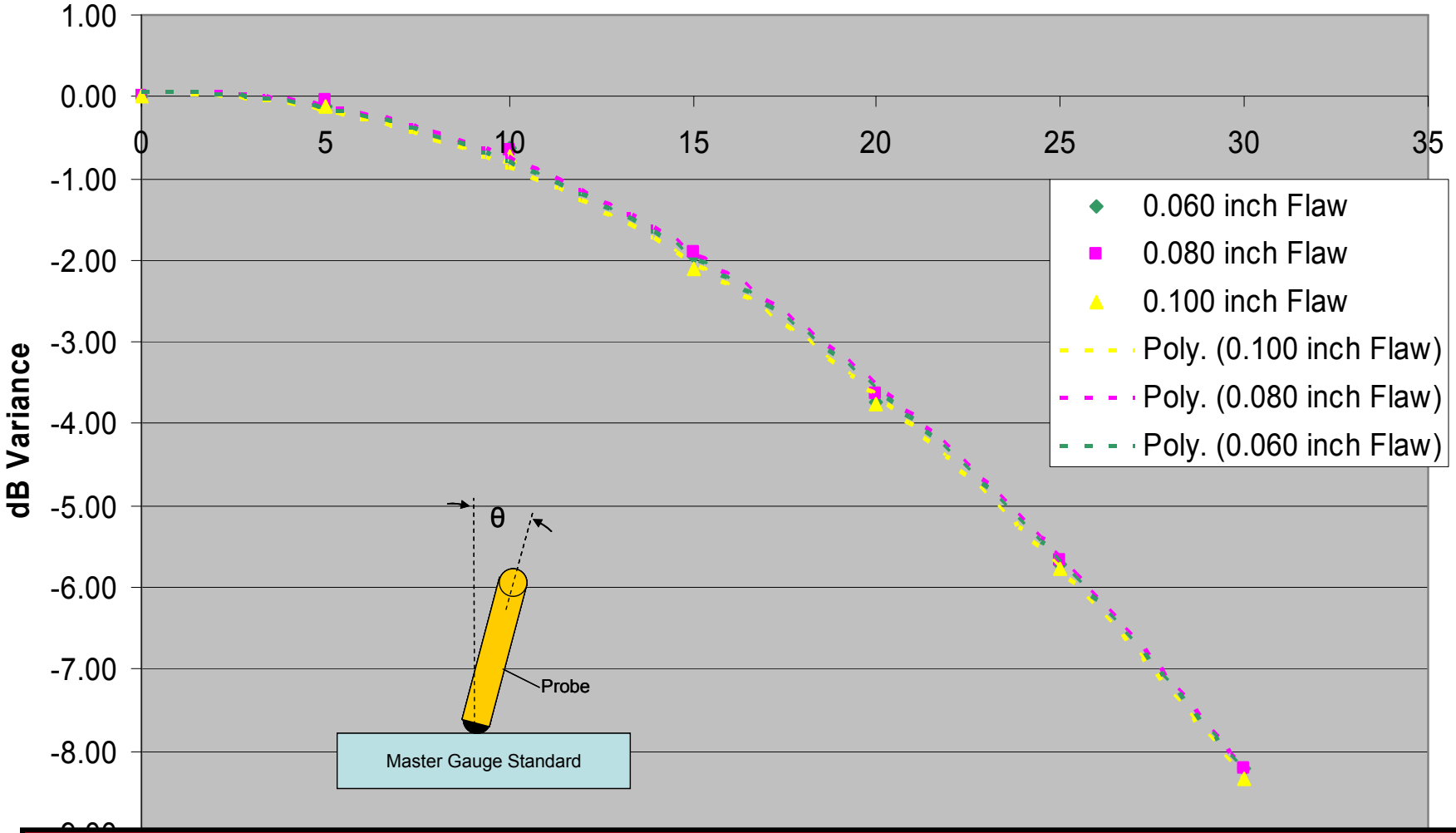


Performance Variance
Probe Angulation



Probe Angulation - dB Variance

(Signal Loss vs. Probe Angle)



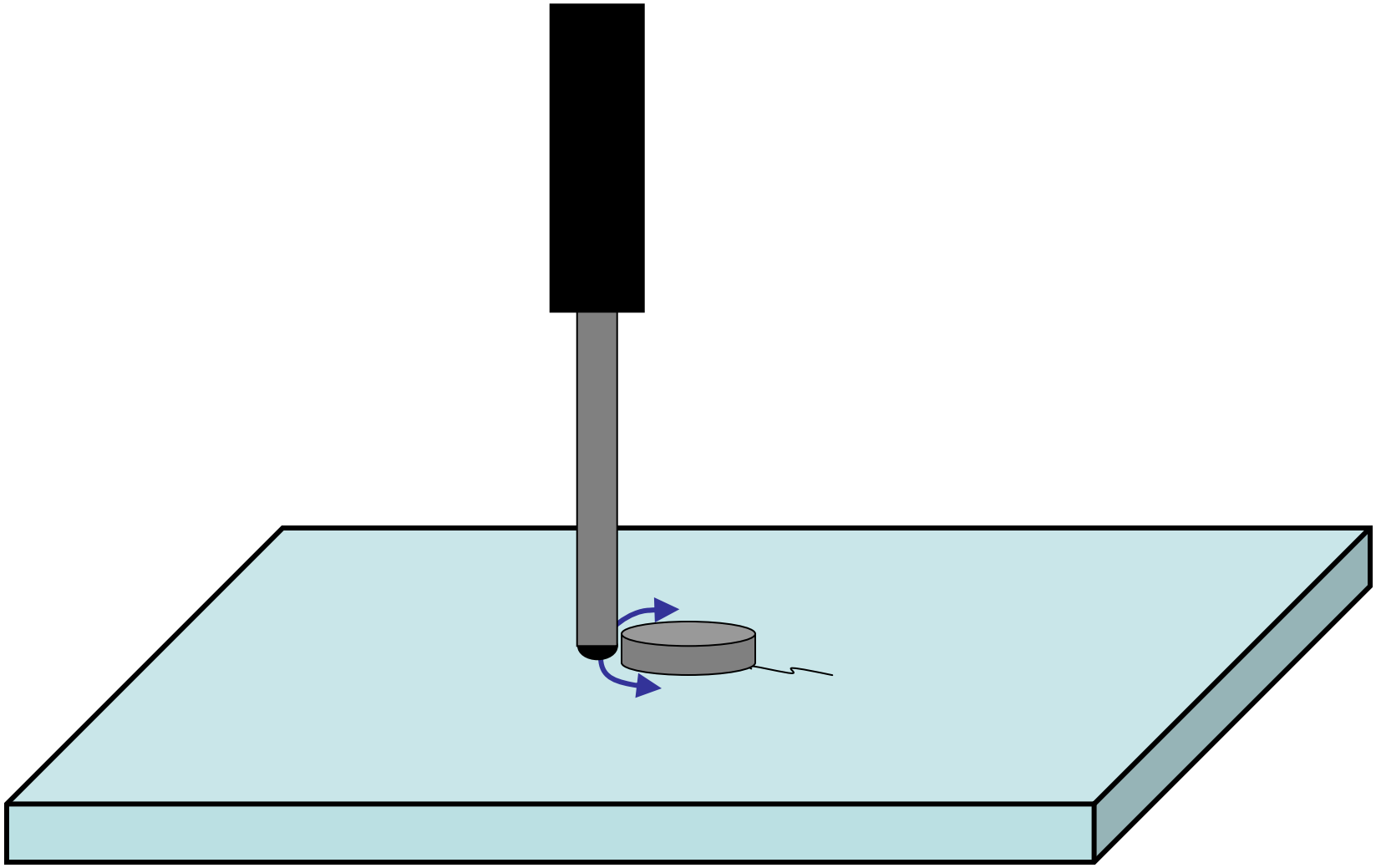
Indicates Human Factors Is Major Contributor to Performance Variance

Conclusions

- **Minimal instrument-to-instrument variation observed**
  - Oscillator Frequency Output nearly identical
  - Receiver Linearity nearly identical
- **Moderate variance noted in oscillator amplitude (drive voltage) observed; however….**
  - Well within acceptable range
  - Not a significant performance driver
- **Less than +/- 2dB response variance observe for all tested probe, cable, and reference standard combinations**
- **Probes most significant variable**
- **Worn standards (shallower slots) result in inspection at higher sensitivity**
- **Three point calibration/sensitivity check is valid approach to insure system control**
- **Results support human induced variance as dominant factor in manual scan eddy current inspection performance variability**

Reducing Inspection Variability

Example: EC Inspection Around Fasteners



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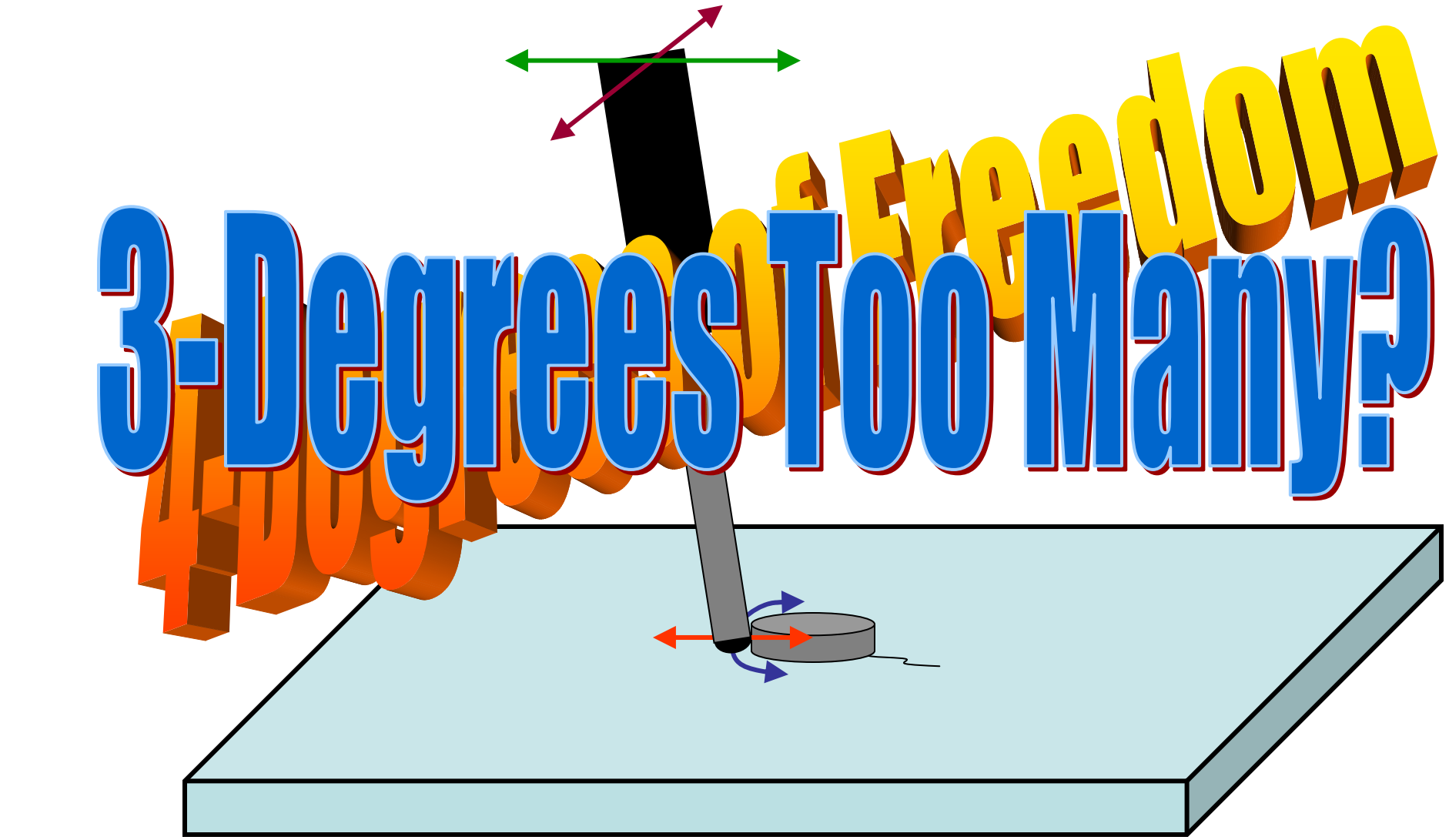

Reducing Inspection Variability

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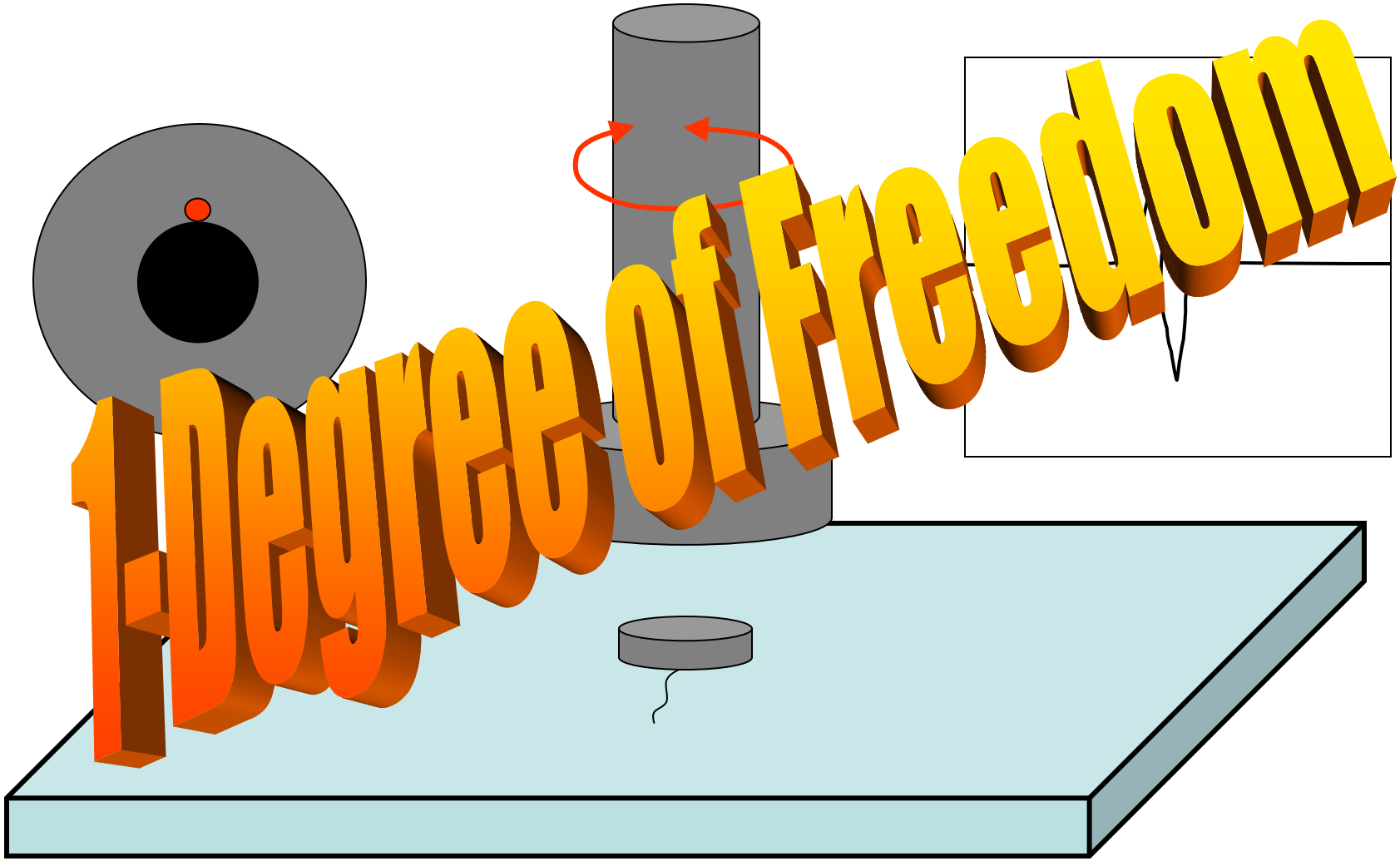
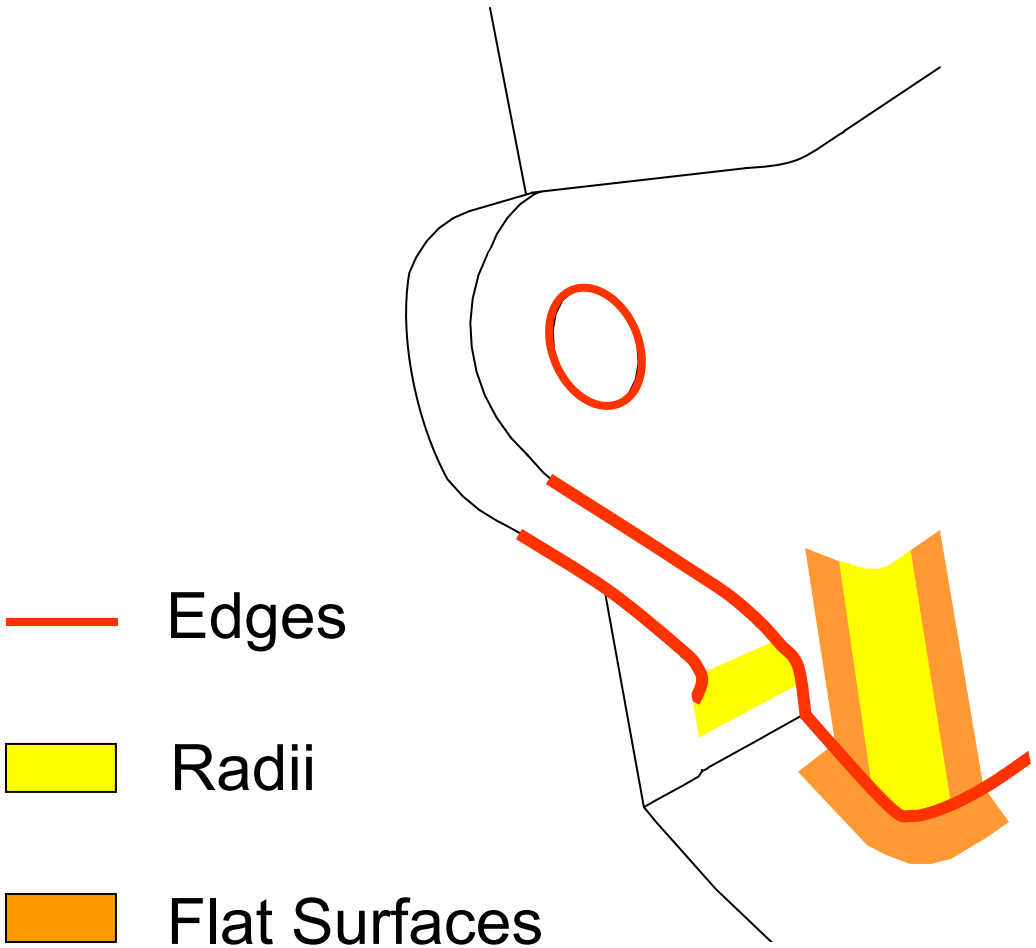


Approach: Geometry Classification

Design Probes to Reduce Scan Variability




questions?