SW Test Workshop

Semiconductor Wafer Test Workshop

Understanding the Probe Damage Risk thru Determination of Minimum Bond Pad Opening Capability of Different Prober and Needle Type Set-up

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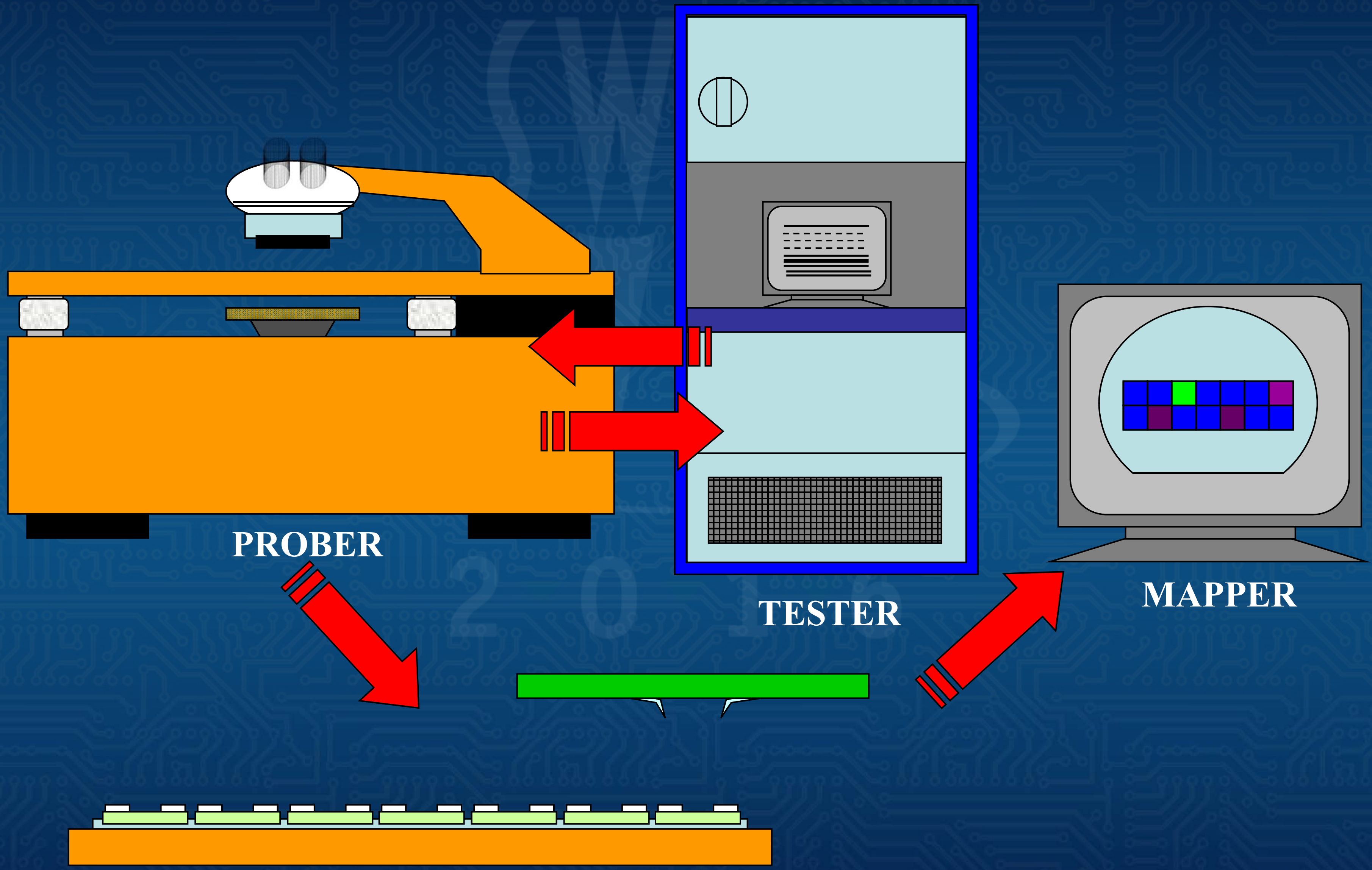
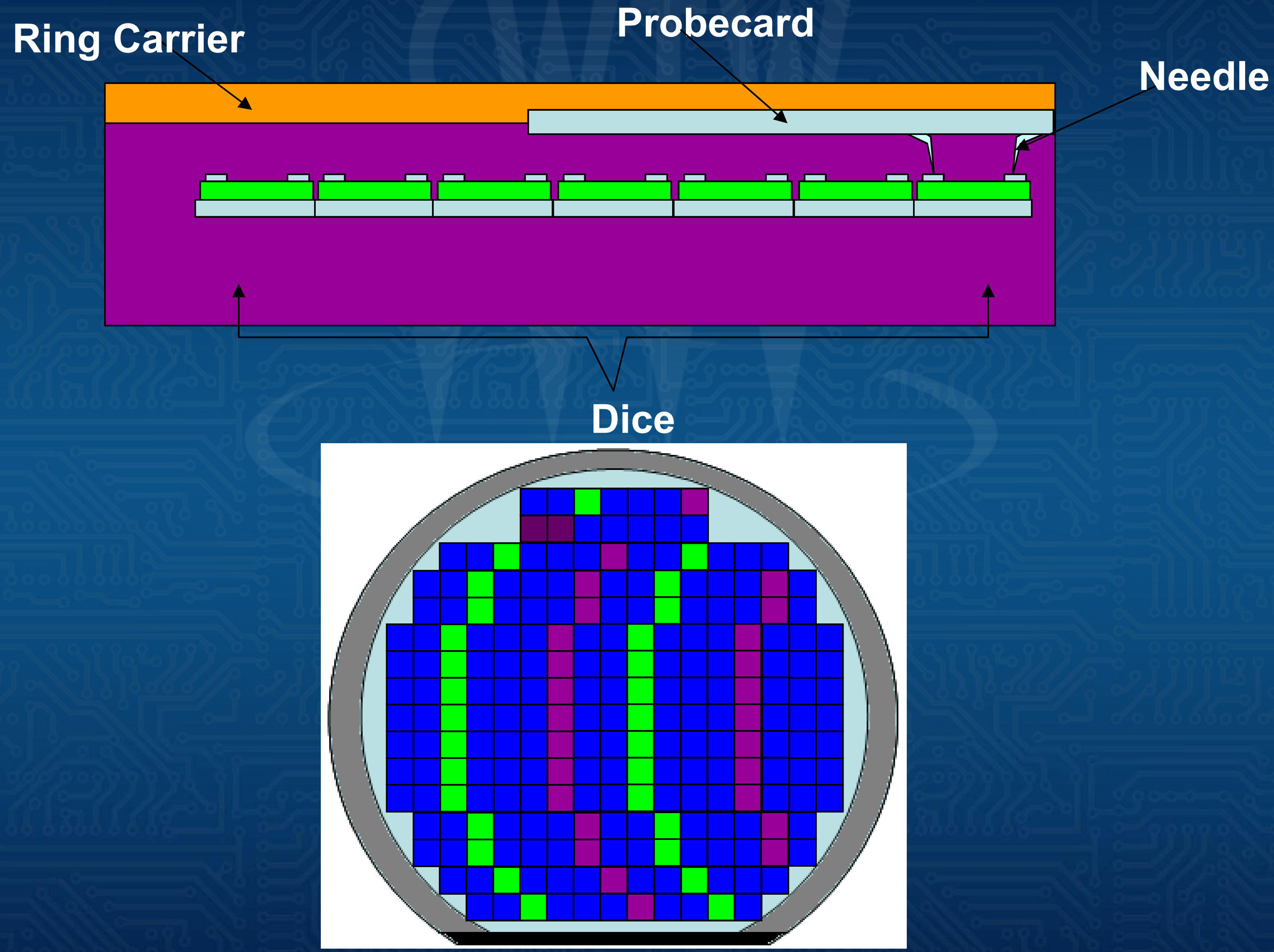
Introduction

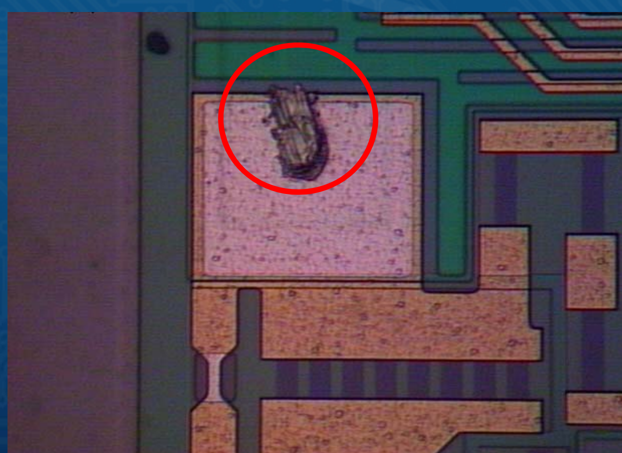


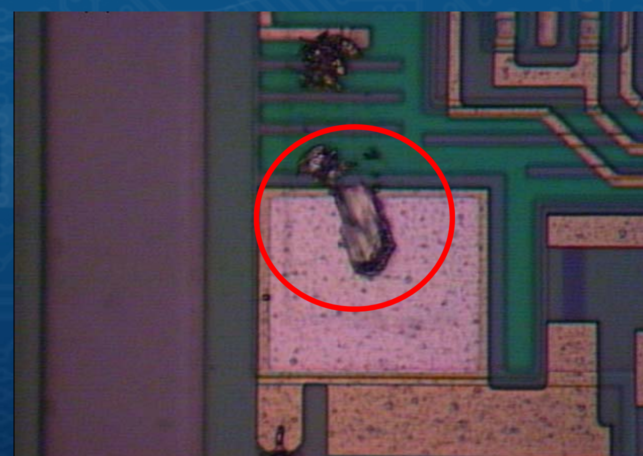
Introduction



Introduction

What happen when Probe Needle is off-center?



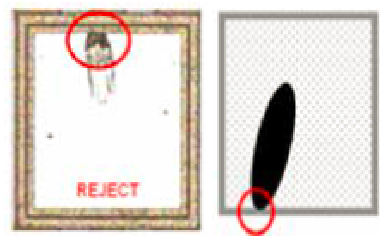
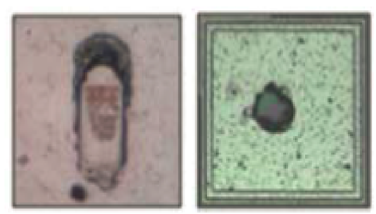


This will result to off-center probe-marks leading to Probe Damage.

Introduction

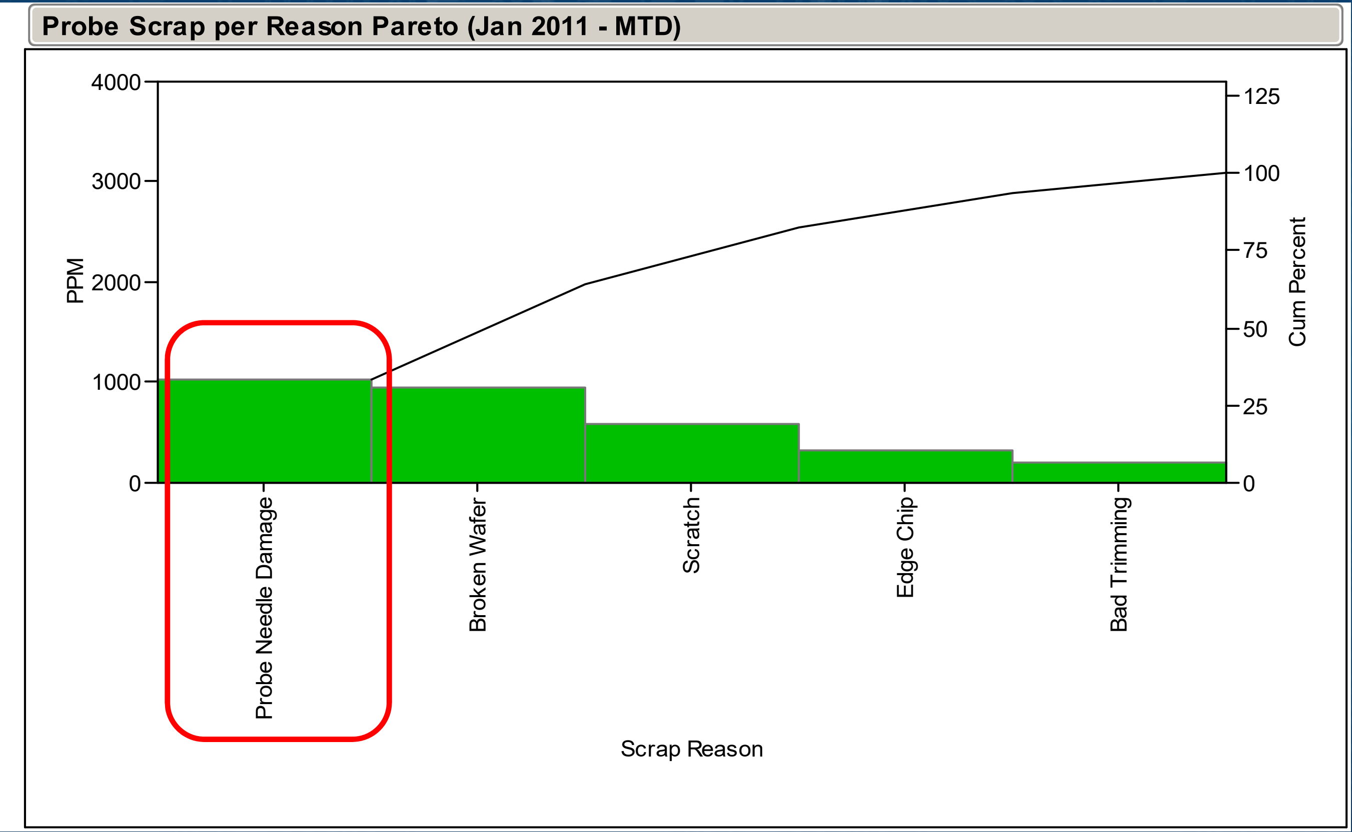
What is Probe Damage ?

- Is a phenomena when a part of a die specifically at the Pad Area such as Seal Ring or other metallization has been damage by the Probe Needle during Testing.
- Probe damage is the number one visual defect contributor at wafer sort process having a direct impact on yield and cycle time.

No	Defect visual aid	Remarks
1		Probe marks touching the seal ring of the bond pad
2		Expose oxide on the bonding pad

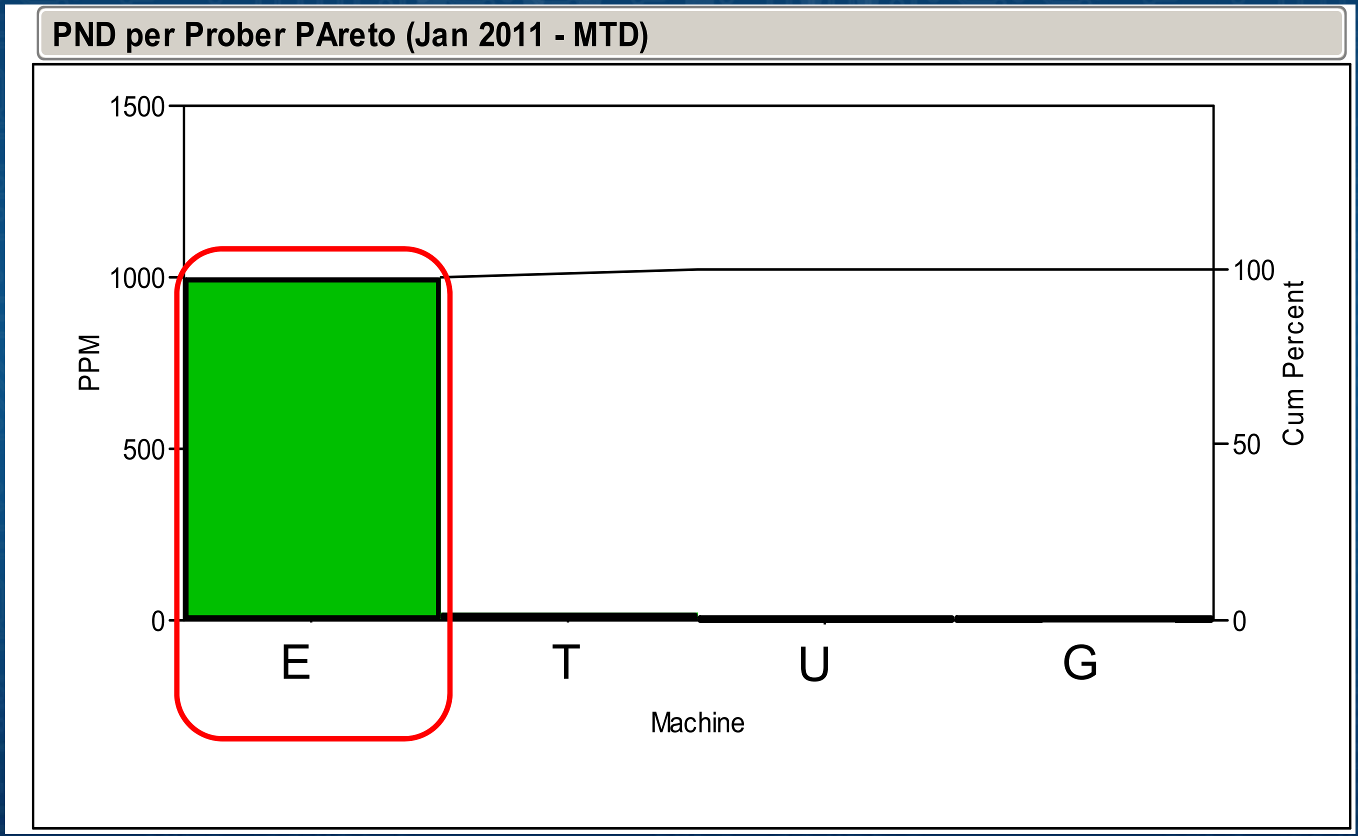
Introduction

At 1000 ppm, Probe Damage related to Probe Needle is on top of Pareto in terms of wafer scrappage reason.



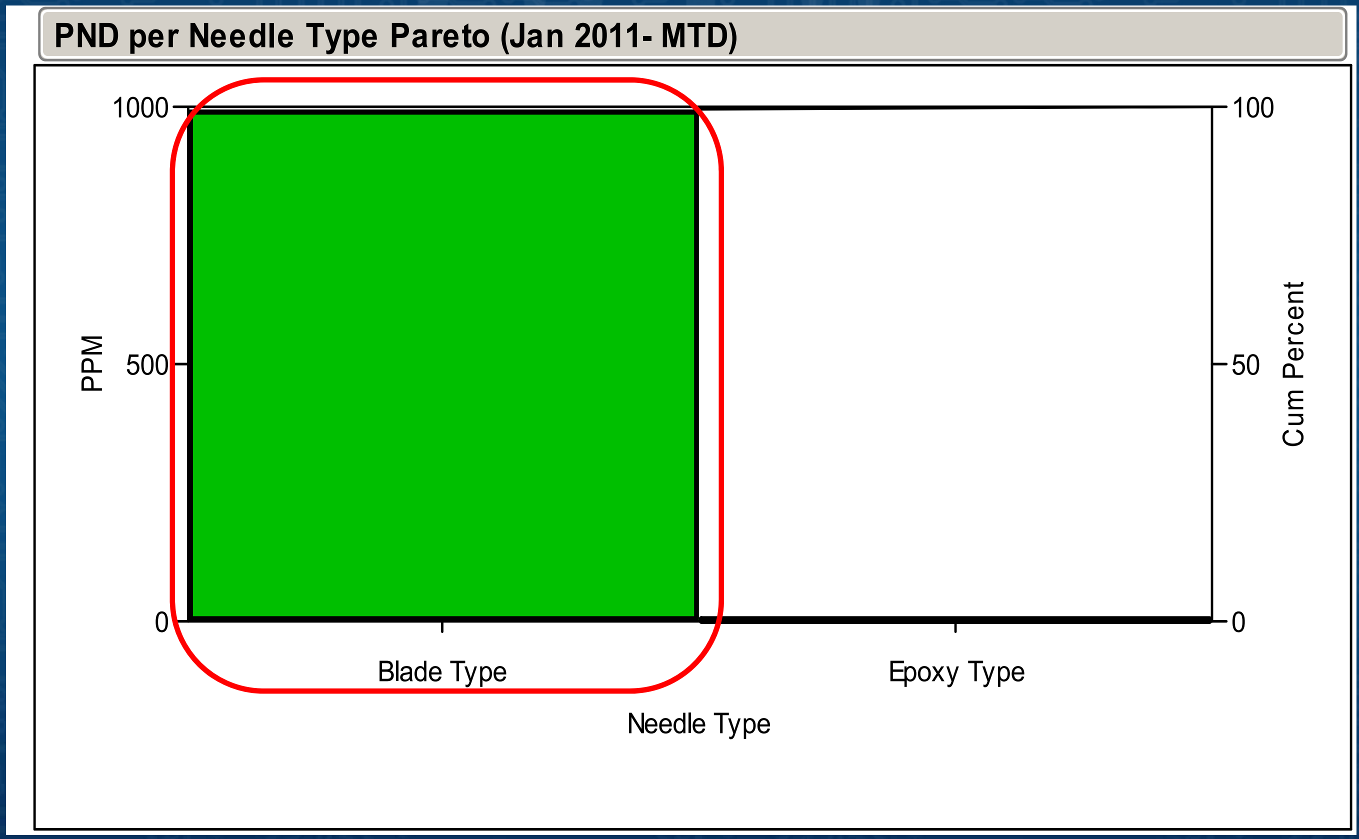
Introduction

100% of those 1000 ppm have been contributed by the Prober E which uses a Blade Type Needle for Probing.



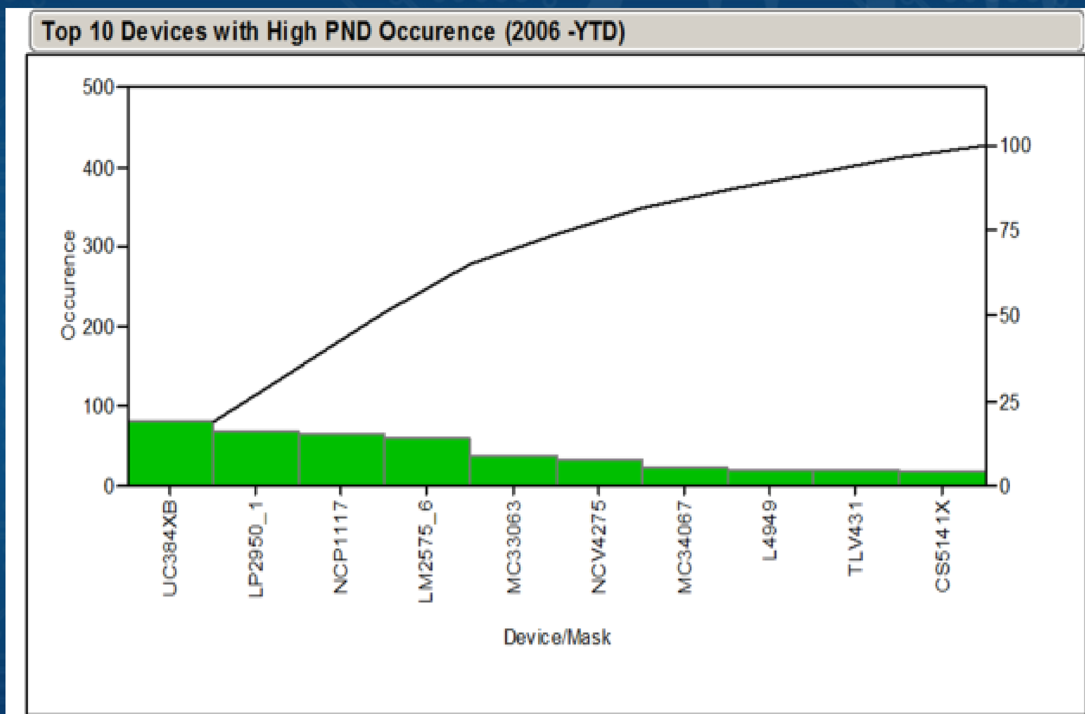
Introduction

100% of those 1000 ppm have been contributed by the Prober E which uses a Blade Type Needle for Probing.



Introduction

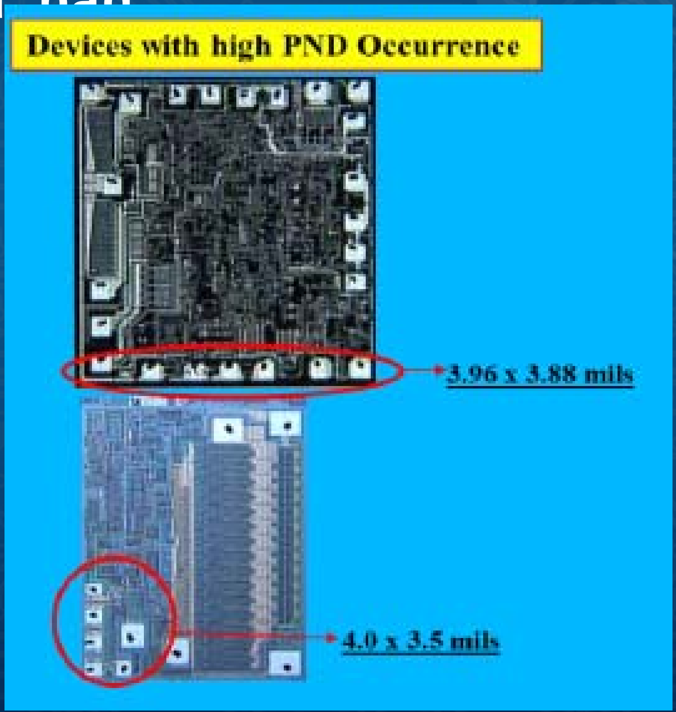
Further data stratification shown Top Devices with high Probe Damage Occurrence

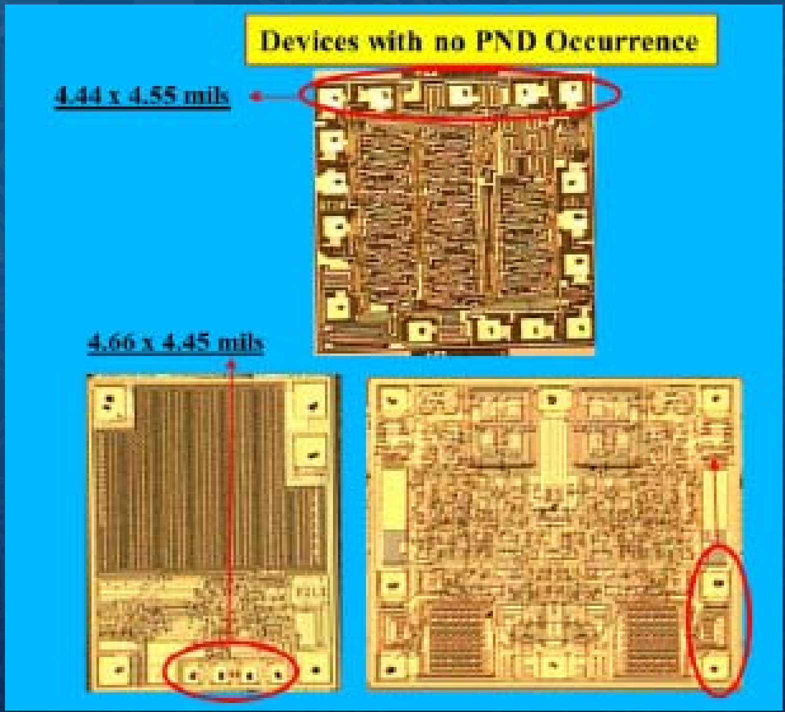


Mask Name	Total Occurrence	Small Pad Size	Big Pad Size
UC384XB	81	3.6 x 4.1 mils	4.2 x 4.2 mils
LP2950_1	69	3.5 x 4.0 mils	4.2 x 4.1 mils
NCP1117	66	4.1 x 3.4 mils	7.7 x 6.3 mils
LM2575_6	61	3.3 x 3.2 mils	7.6 x 7.3 mils
MC33063	39	3.4 x 4.0 mils	4.2 x 4.2 mils
NCP5331	36	3.4 x 3.4 mils	4.0 x 3.8 mils
NCV4275	32	3.7 x 3.6 mils	6.0 x 5.8 mils
NCP5422	24	3.6 x 3.5 mils	4.0 x 4.0 mils
MC34067	23	3.5 x 4.0 mils	4.3 x 4.1 mils
L4949	21	3.3 x 3.2 mils	4.8 x 4.4 mils
TLV431	19	3.1 x 3.1 mils	
CS5141X	17	4.3 x 4.1 mils	

Introduction

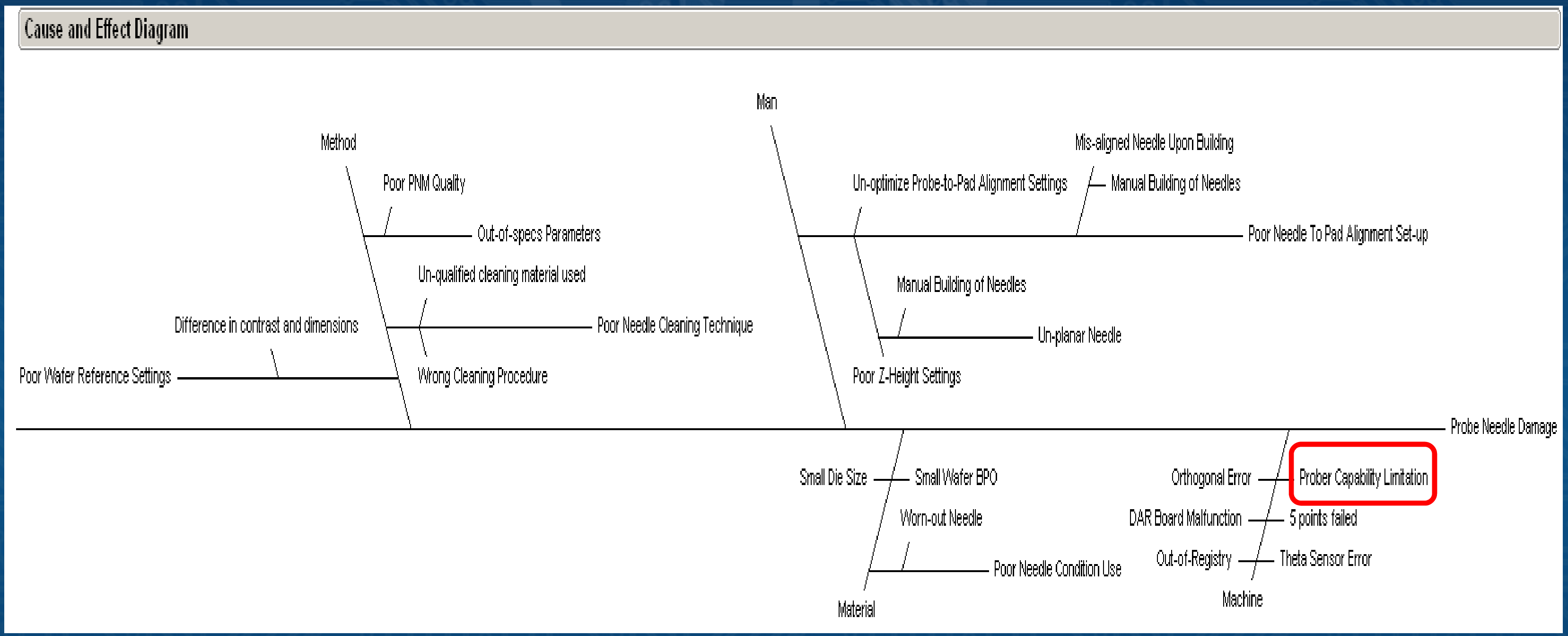
Devices with high PND occurrence have an average bond pad size less than 4 x 4 mils compared with devices with no PND occurrence. Initial assumption on high PND occurrence is due to Prober X when using blade type needle is not capable of probing devices with a minimum bond pad





Introduction

What are the causes Probe Damage ?



- Probe Capability limitation in terms of minimum bond pad opening has been identified as one of the many causes of Probe Damage on wafers.
- Smaller pad is high risk to Probe Damage.

Objective/Goals

- To determine the different minimum bond pad opening capability at Probe using different Prober and Needle Type.
- To assess the Probe Damage risk and come up with a solution to reduce the risk.

Methodology

- **Identify all possible Prober and Needle Type Combination.**
  - Block all the other factors that will serve as noises. This is to eliminate the un-necessary variation that will affect the overall accuracy of the study.

- **Create a Data Collection Plan**
- **Perform Data Analysis**
- **Perform Capability Study**
- **Risk Assessment**

Methodology

I. Old Prober Tandem with Blade Type Needle

II. Old Prober Tandem with Epoxy Type Needle

III. New Prober Tandem with Blade Type Needle

IV. New Prober Tandem with Epoxy Type Needle

V. New Prober Tandem with Vertical Type Needle

Methodology

Data Collection Plan:

1. Measure the Length X & Y value as shown in Figure 1. Perform measurements on dice illustrated in Figure 2.

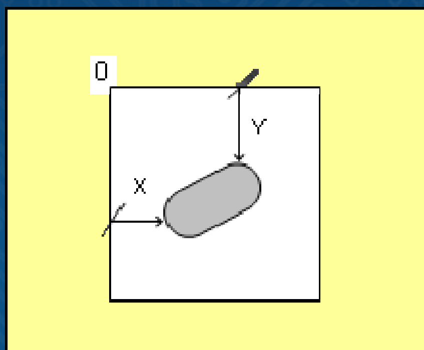
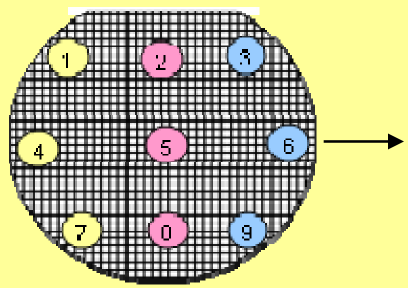


Fig 1



	Readings									
	1	2	3	4	5	6	7	8	9	sigma
X										#DIV/0!
Y										#DIV/0!

Fig 2

2. Repeat # 1 until 30 data sets is achieved.

Methodology

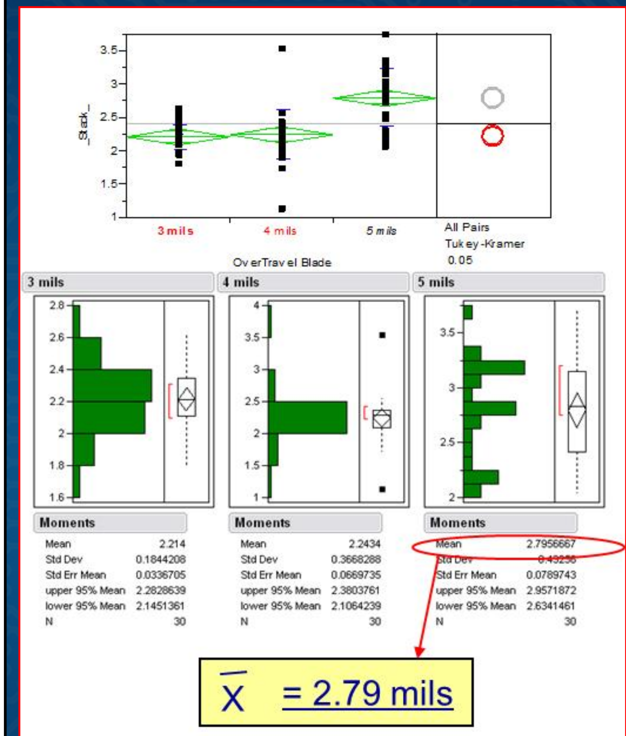
Computation of Minimum Bond Pad Capability using "Components of Variation" :

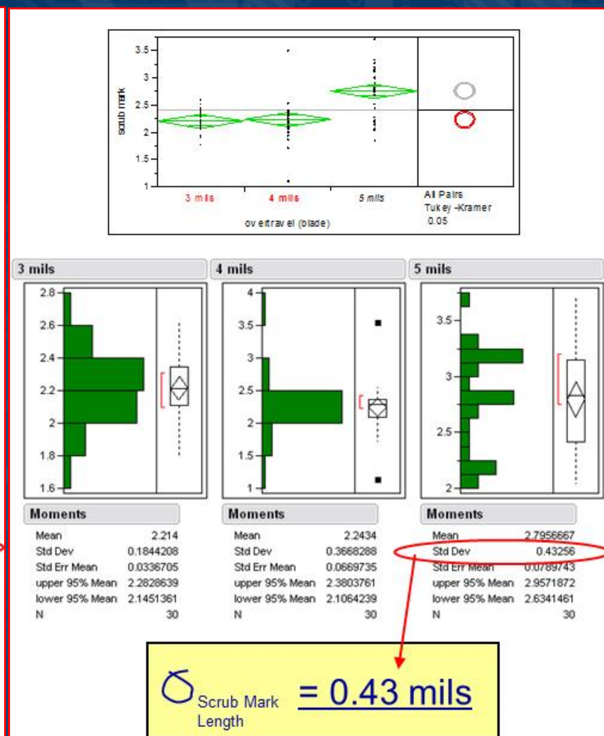
$$\underline{\textbf{Capability}} = \overline{X} + 3\sigma_{\text{Scrub Mark}} \quad ; \quad \sigma_{\text{Scrub Mark}} = \sqrt{\sigma^2_{\text{Scrub Mark Length}} + \sigma^2_{\text{Scrub Mark Placement}}}$$

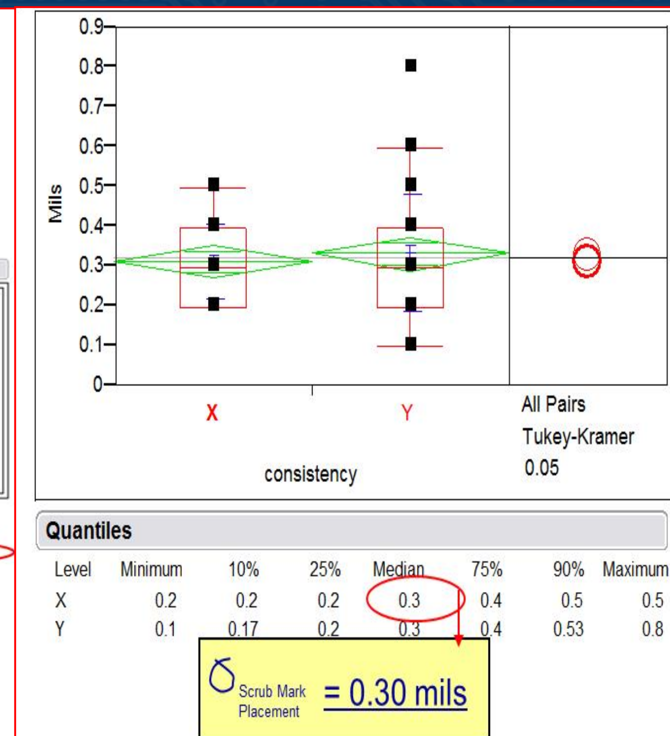
- $\overline{X}$: Average Probe Mark Length
- $\sigma_{\text{Scrub Mark}}$: Total Probe Mark Variance
- $\sigma^2_{\text{Scrub Mark Length}}$: Variance in Probe Mark Length
- $\sigma^2_{\text{Scrub Mark Placement}}$: Variance in Probe Mark Consistency

Capability Assessment Result

I. Old Prober Tandem with Blade Type Needle







Capability Assessment Result

I. Old Prober Tandem with Blade Type Needle

$$\text{Capability} = \bar{X} + 3\sigma_{\text{Scrub Mark}} \quad ; \quad \sigma_{\text{Scrub Mark}} = \sqrt{\sigma^2_{\text{Scrub Mark Length}} + \sigma^2_{\text{Scrub Mark Placement}}}$$

$$\text{Capability} = 2.79 + 3\sigma_{\text{Scrub Mark}} \quad ; \quad \sigma_{\text{Scrub Mark}} = \sqrt{(0.43)^2 + (0.30)^2}$$

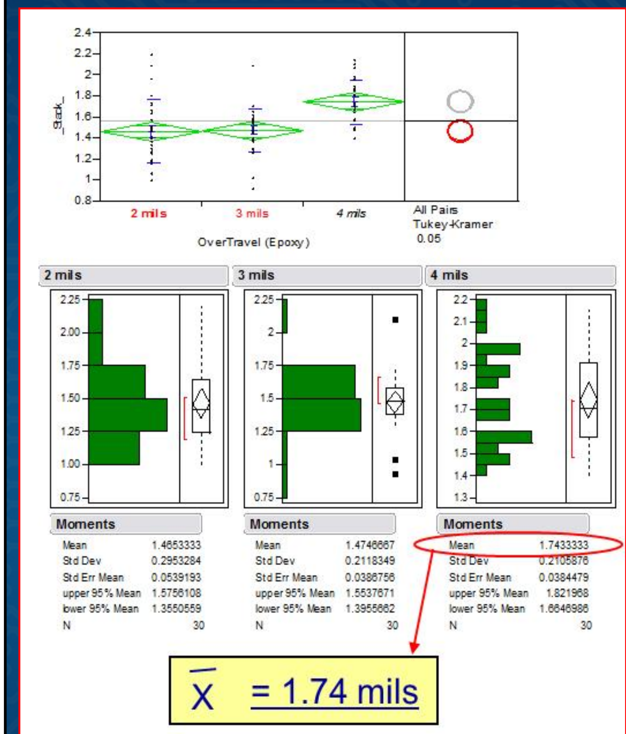
$$\text{Capability} = 2.79 + 3\sigma_{\text{Scrub Mark}} \quad ; \quad \sigma_{\text{Scrub Mark}} = 0.5264$$

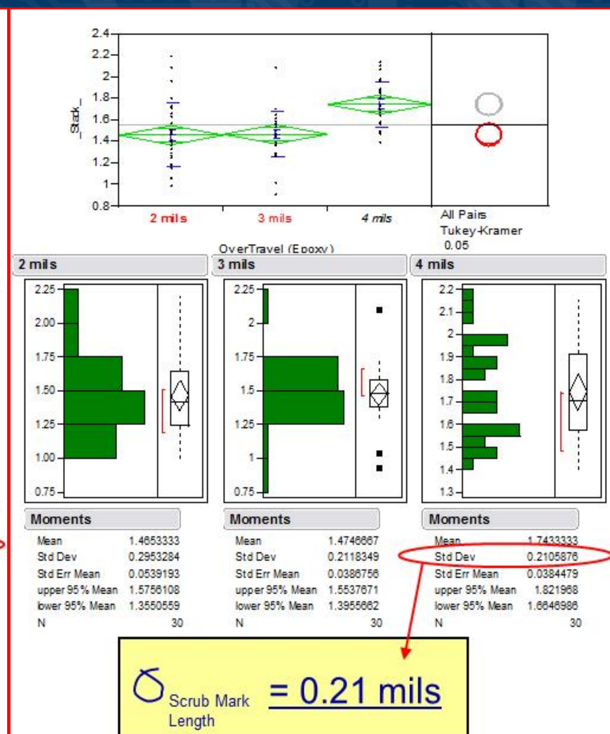
$$\text{Capability} = 2.79 + 3(0.5264)$$

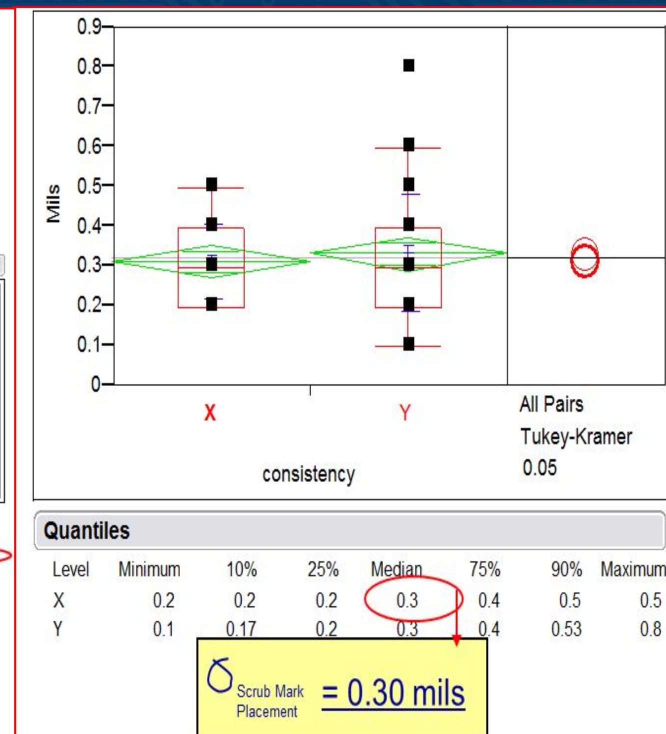
$$\text{Capability} = 4.37\text{mils} \approx 4.5\text{ mils}$$

Capability Assessment Result

II. Old Prober Tandem with Epoxy Type Needle







Capability Assessment Result

II. Old Prober Tandem with Epoxy Type Needle

$$\text{Capability} = \bar{X} + 3\sigma_{\text{Scrub Mark}} \quad ; \quad \sigma_{\text{Scrub Mark}} = \sqrt{\sigma^2_{\text{Scrub Mark Length}} + \sigma^2_{\text{Scrub Mark Placement}}}$$

$$\text{Capability} = 1.74 + 3\sigma_{\text{Scrub Mark}} \quad ; \quad \sigma_{\text{Scrub Mark}} = \sqrt{(0.21)^2 + (0.30)^2}$$

$$\text{Capability} = 1.74 + 3\sigma_{\text{Scrub Mark}} \quad ; \quad \sigma_{\text{Scrub Mark}} = 0.3665$$

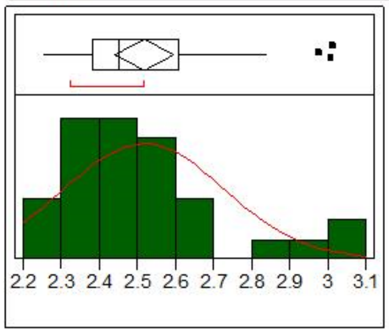
$$\text{Capability} = 1.74 + 3(0.3665)$$

$$\text{Capability} = 2.84 \text{ mils} \approx 3 \text{ mils}$$

Capability Assessment Result

III. New Prober Tandem with Blade Type Needle

Length



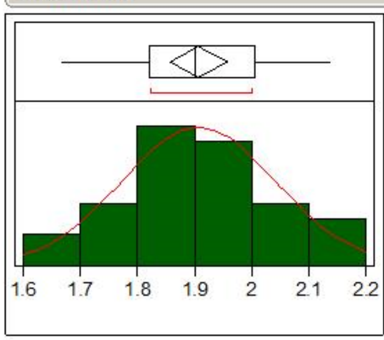
Normal(2.5181,0.2097)

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	2.5180959	2.4397914	2.5964003
Dispersion	σ	0.2097032	0.1670091	0.2819073

Placement



Normal(1.90753,0.13614)

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	1.9075273	1.8566901	1.9583645
Dispersion	σ	0.1361444	0.1084264	0.183021

Formula for Capability:

$Cp = \mu + 3\delta$; where $\delta = \sqrt{\delta_1^2 + \delta_2^2}$

Given Values:

μ = 2.51 mils
δ_1 = 0.21 mils
δ_2 = 0.14 mils

Computation for δ:

$\delta = \sqrt{\delta_1^2 + \delta_2^2}$
$\delta = \sqrt{0.21 \text{ mils}^2 + 0.14 \text{ mils}^2}$
δ = 0.25 mils

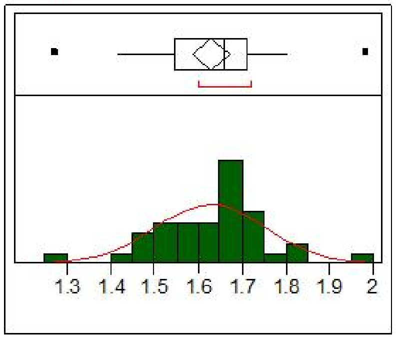
Computation for Cp:

$Cp = \mu + 3\delta$
Cp = 2.51 mils + 3 (0.25 mils)
Cp = 3.26 mils ≈ 3.5 mils

Capability Assessment Result

IV. New Prober Tandem with Epoxy Type Needle

Length



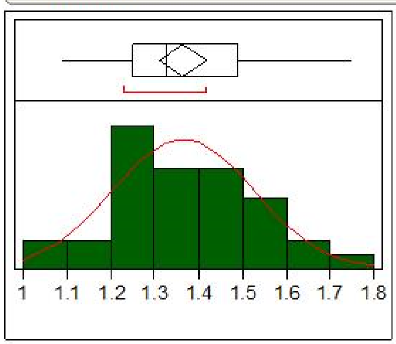
Normal(1.6298,0.12625)

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	1.6298004	1.5870839	1.672517
Dispersion	σ	0.1262491	0.1023983	0.1646841

Placement



Normal(1.36549,0.16028)

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	1.3654941	1.3112639	1.4197243
Dispersion	σ	0.1602779	0.1299985	0.2090726

Formula for Capability:

$Cp = \mu + 3\delta$; where $\delta = \sqrt{\delta_1^2 + \delta_2^2}$

Given Values:

μ = 1.63 mils
δ_1 = 0.13 mils
δ_2 = 0.16 mils

Computation for δ:

$\delta = \sqrt{(\delta_1^2 + \delta_2^2)}$
$\delta = \sqrt{0.13 \text{ mils}^2 + 0.16 \text{ mils}^2}$
δ = 0.21 mils

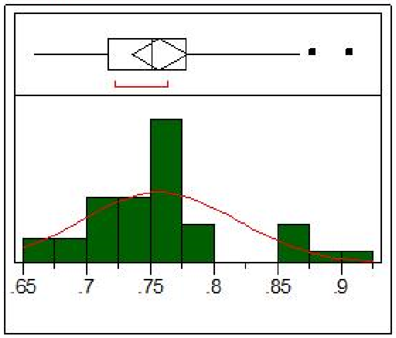
Computation for Cp:

$Cp = \mu + 3\delta$
Cp = 1.63 mils + 3 (0.21 mils)
Cp = 2.25 mils ≈ 2.5 mils

Capability Assessment Result

V. New Prober Tandem with Vertical Type Needle

Length



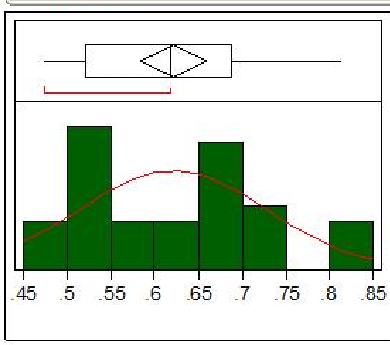
Normal(0.75732,0.06133)

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	0.7573235	0.7355771	0.7790699
Dispersion	σ	0.0613293	0.0493204	0.0811198

Placement



Normal(0.62113,0.10759)

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	μ	0.6211334	0.5829836	0.6592833
Dispersion	σ	0.1075903	0.0865229	0.1423089

Formula for Capability:

$Cp = \mu + 3\delta$; where $\delta = \sqrt{(\delta_1^2 + \delta_2^2)}$

Given Values:

$\mu = 0.76$ mils
$\delta_1 = 0.06$ mils
$\delta_2 = 0.11$ mils

Computation for δ:

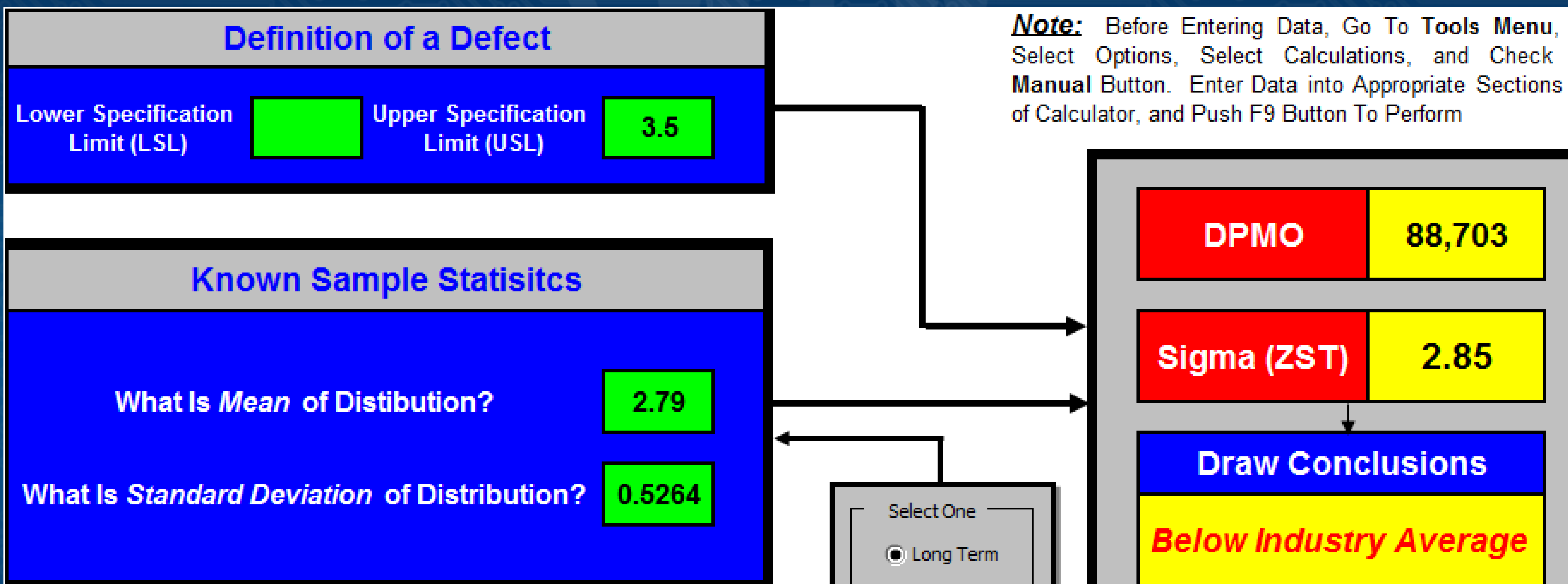
$\delta = \sqrt{(\delta_1^2 + \delta_2^2)}$
$\delta = \sqrt{0.06 \text{ mils}^2 + 0.11 \text{ mils}^2}$
$\delta = 0.13$ mils

Computation for Cp:

$Cp = \mu + 3\delta$
$Cp = 0.76 \text{ mils} + 3\,(0.13 \text{ mils})$
$Cp = 1.16 \text{ mils} \approx 1.5 \text{ mils}$

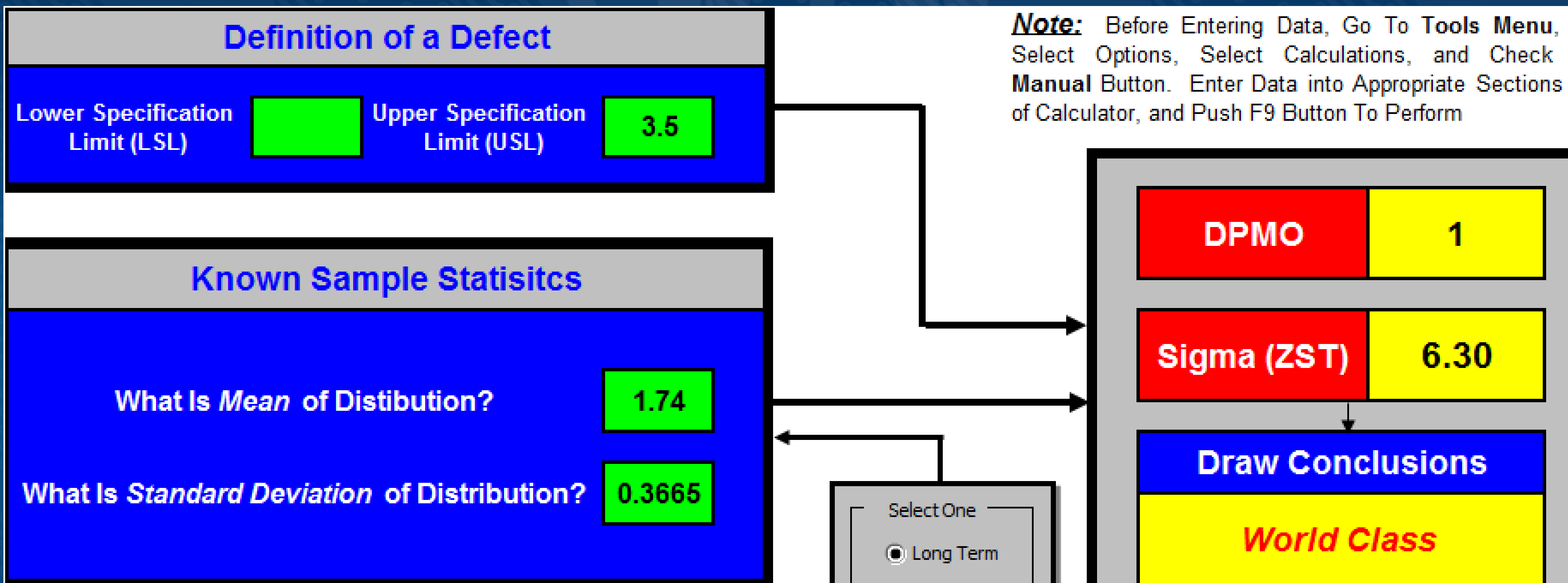
Sigma Assessment

I. Old Prober Tandem with Blade Type Needle



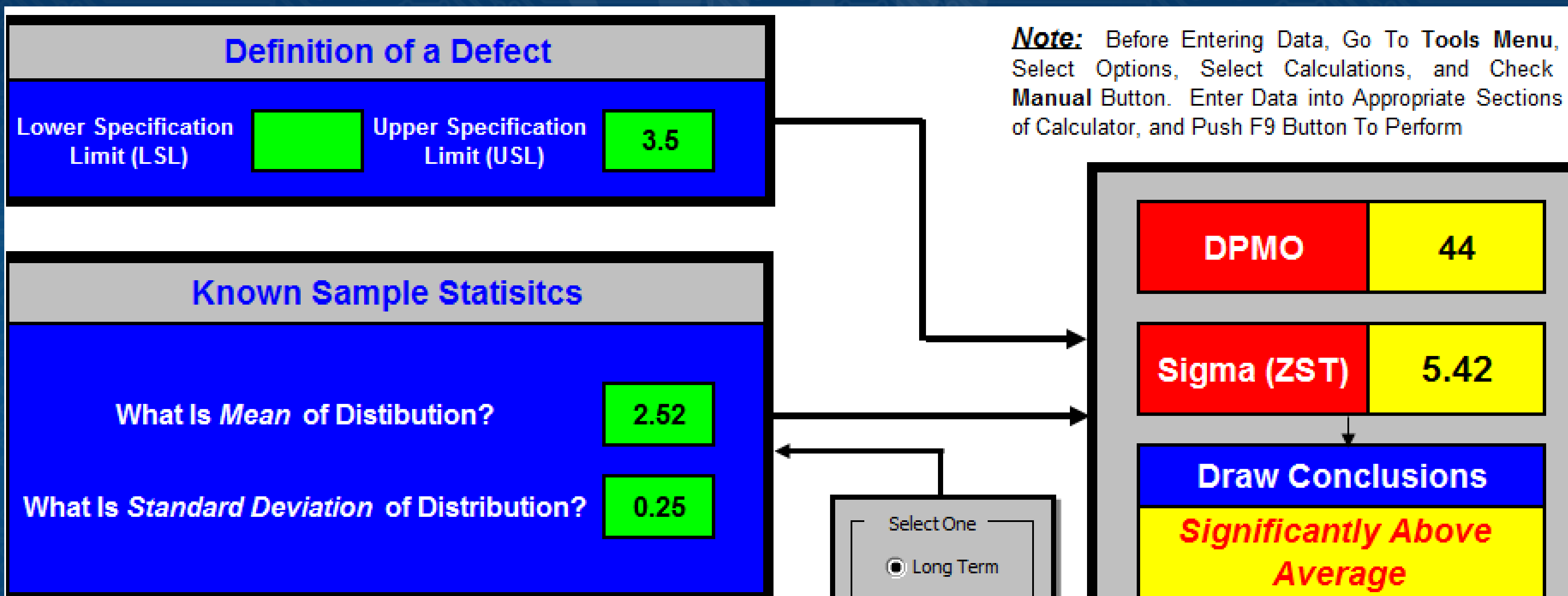
Sigma Assessment

II. Old Prober Tandem with Epoxy Type Needle



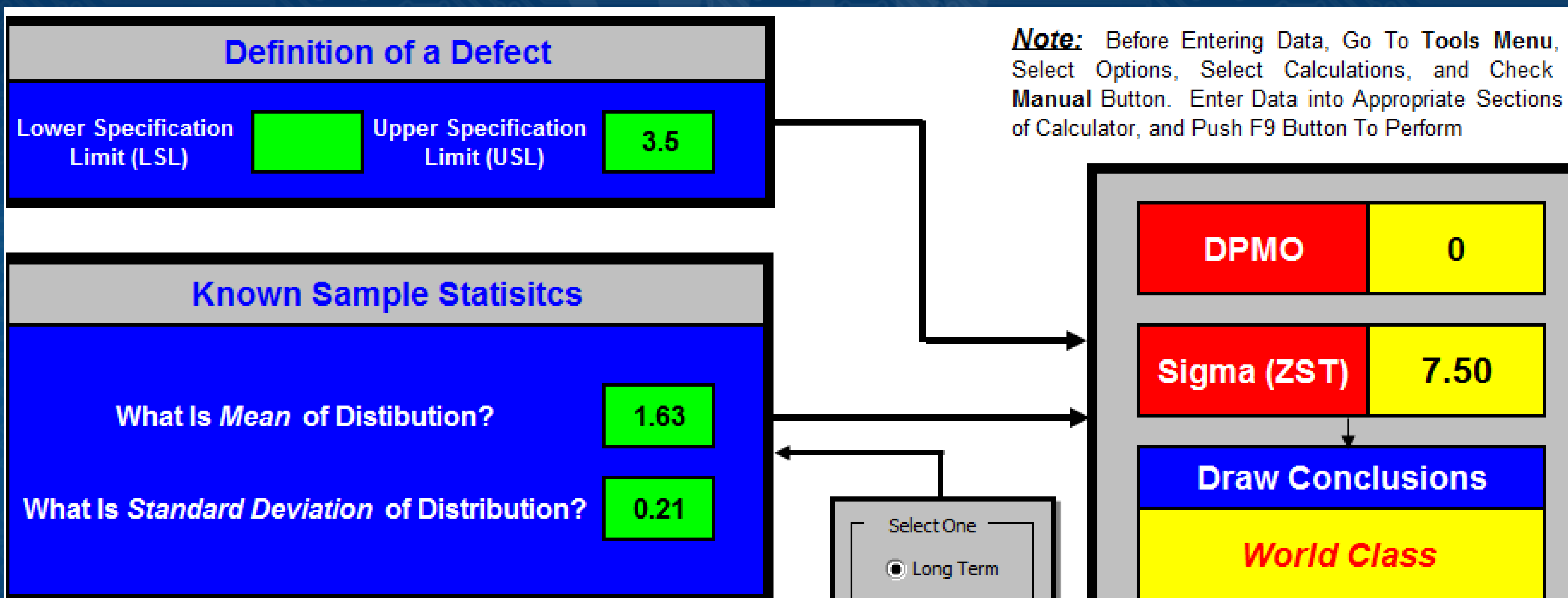
Sigma Assessment

III. New Prober Tandem with Blade Type Needle



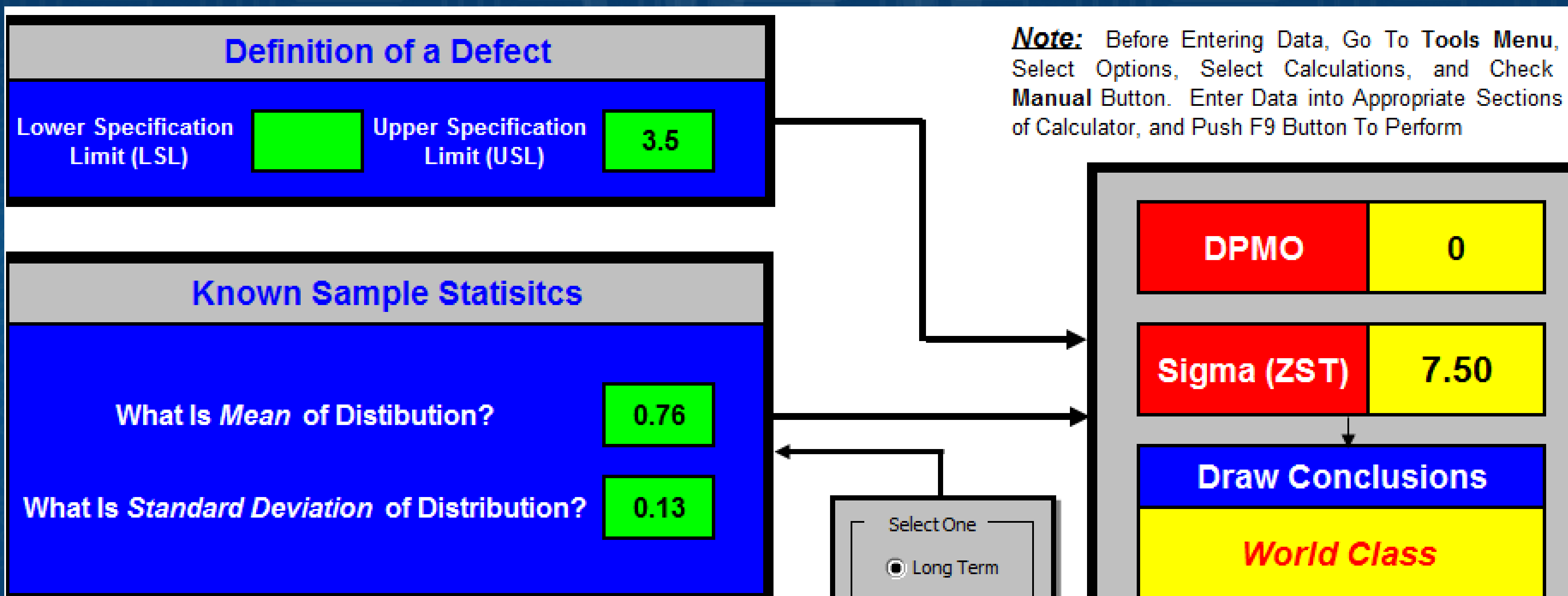
Sigma Assessment

IV. New Prober Tandem with Epoxy Type Needle



Sigma Assessment

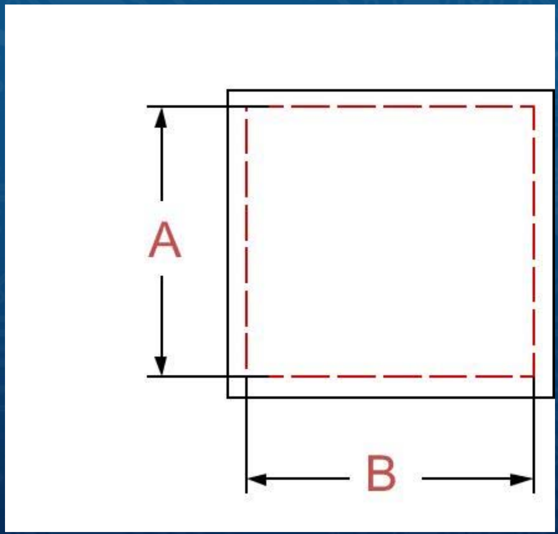
V. New Prober Tandem with Vertical Type Needle



Summary

Microsoft Excel Worksheet

Minimum Bond Pad Size Opening Capability							
Prober	**Needle Type**	**Probe marks Size (x)**	**3 Sigma (Placement and Length)**	**A**	**B**	**∑ - Level**	**DPMO**
Old	Blade Type (1.5 mils)	2.79 mils	1.6 mils	4.39 mils	4.39 mils	2.85	88703.00
	Epoxy Type (1 mil)	1.74 mils	1.1 mils	2.84 mils	2.84 mils	6.30	1.00
New	Blade Type (1.5 mils)	2.51 mils	0.74 mils	3.25 mils	3.25 mils	5.42	44.00
	Epoxy Type (1 mil)	1.63 mils	0.63 mils	2.25 mils	2.25mils	7.50	0.00
	Vertical Probe (2.5 mils)	0.9 mils	0.36 mils	1.27 mils	1.27 mils	7.50	0.00



Summary

Microsoft Excel Worksheet

Capability Study:

- ✓ Old Prober tandem with Blade Type needle minimum bpo = 4.39 mils.
- ✓ Old Prober tandem with Epoxy Type = 2.84 mils.
- ✓ New Prober tandem with Blade Type = 3.25 mils.
- ✓ New Prober tandem with Epoxy Type = 2.25 mils and for New Prober tandem with Vertical Probe = 1.27 mils.

Sigma Assessment:

- ✓ Old Prober tandem with Blade Type needle zigma = 2.85 which has an expected defect per million opportunity = 88703.
- ✓ Old Prober tandem with Epoxy Type needle zigma = 6.30 which has an expected dpmo = 1.
- ✓ New Prober tandem with Blade Type needle zigma = 5.46 which has an expected dpmo = 37.
- ✓ New Prober tandem with Epoxy Type or Vertical Probe zigma level = 7.5 which has an expected = 0.

Follow-On Work

- For new product development, Wafer Probe Equipment capability in terms of placement and stepping accuracy should be consider primarily. Current trend of technology causes the Die Size shrunk. BPO becomes smaller and smaller.

- Probe Technology should also be considered. A wide spread variety of Probe Technology such as Cantilever, Buckling Type, Cobra and Pogo can be chosen depending on the current process requirement and what the customer needs.

- MPCPS should be done on every New Product/Process. This is an anticipation of risk that prevents the issue during the Production Run that cost a lot. Solving the problem at the source is much cheaper.