
2nd Annual
BiTS
CHINA 中国
September 13, 2016
Session 2
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Session 2

Frank Zhou
Session Chair

BiTS China

Socket Technology

"Study of Probe Pin Internal Resistance"

Takuto Yoshida - Test Tooling Solutions Group

"Monte Carlo Analysis for PoP Alignment"

DeXian (Frank) Liu - Smiths Connectors

"Conductive Elastomer vs Spring Probe: Performance & Application"

Jiachun (Frank) Zhou - Smiths Connectors

"Do Socket and Kits Design Matter for Die Cracking?"

Yuanjun Shi - TwinSolution Technology

Session 2
周家春
Session Chair

BiTS China

Socket Technology

"弹簧探针内部阻值的研究"

Takuto Yoshida - Test Tooling Solutions Group

"叠层封装测试插座设计中校直的蒙特卡洛分析法"

刘德先 — Smiths Connectors

"导电胶与弹簧探针技术的比较以及在半导体测试领域的性能与应用"

周家春（Frank）博士，刘德先 — Smiths Connectors

"测试插座和快速切换治具的设计对芯片碎片的影响"

施元军, 上海韬盛电子科技股份有限公司

BiTS 2016 China Burn-in & Test Strategies Workshop

Monte Carlo Analysis for PoP Socket Alignment

DeXian Liu（Frank)
Resty Querubin
Siang Soh
Smiths Connectors

BiTS China Workshop
Suzhou
September 13, 2016

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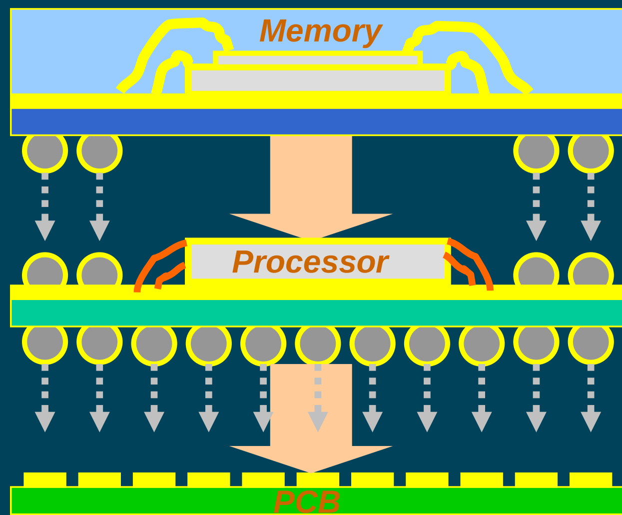
Basic: PoP Technology

PoP (Package on Package)

- A package technology to combine two discrete packages together vertically: a package on top of another
- Top package has fewer connectors than bottom package
- Package type: primarily BGA
- Top side of bottom package: BGA or LGA



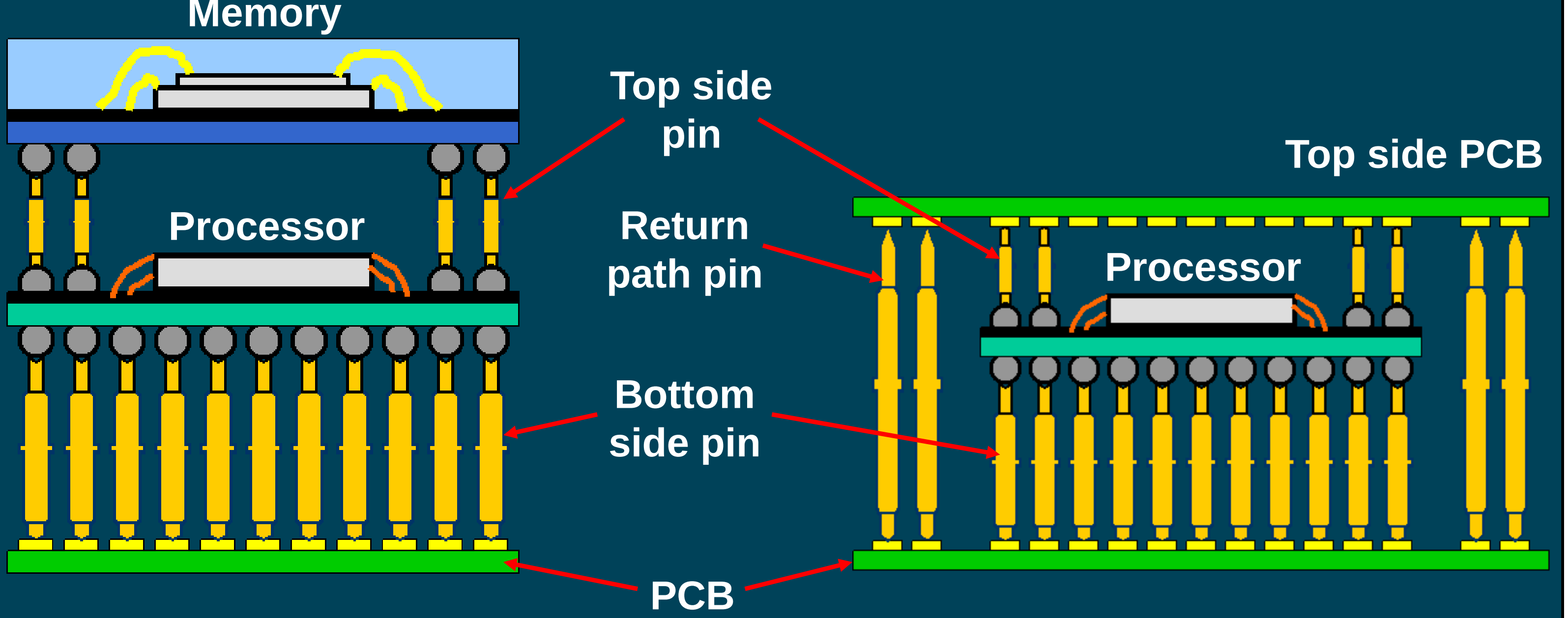
Basic: PoP Test Setup

Test Setup 1: Test Two Packages

- The memory (known good) and processor packages are tested in one setup (socket)
- Mostly for manual test only

Test Setup 2: Test Bottom Package

- Only processor package (bottom) is tested in one setup (socket)
- Both auto and manual tests

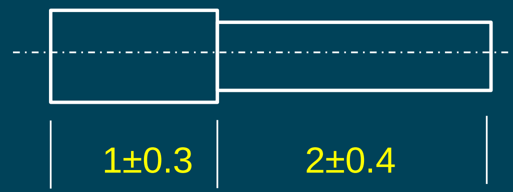


Why Tolerance Analysis?

- Design verification
- Optimize design for manufacturing feasibility
- Reduce manufacturing costs

Basic Tolerance Analysis

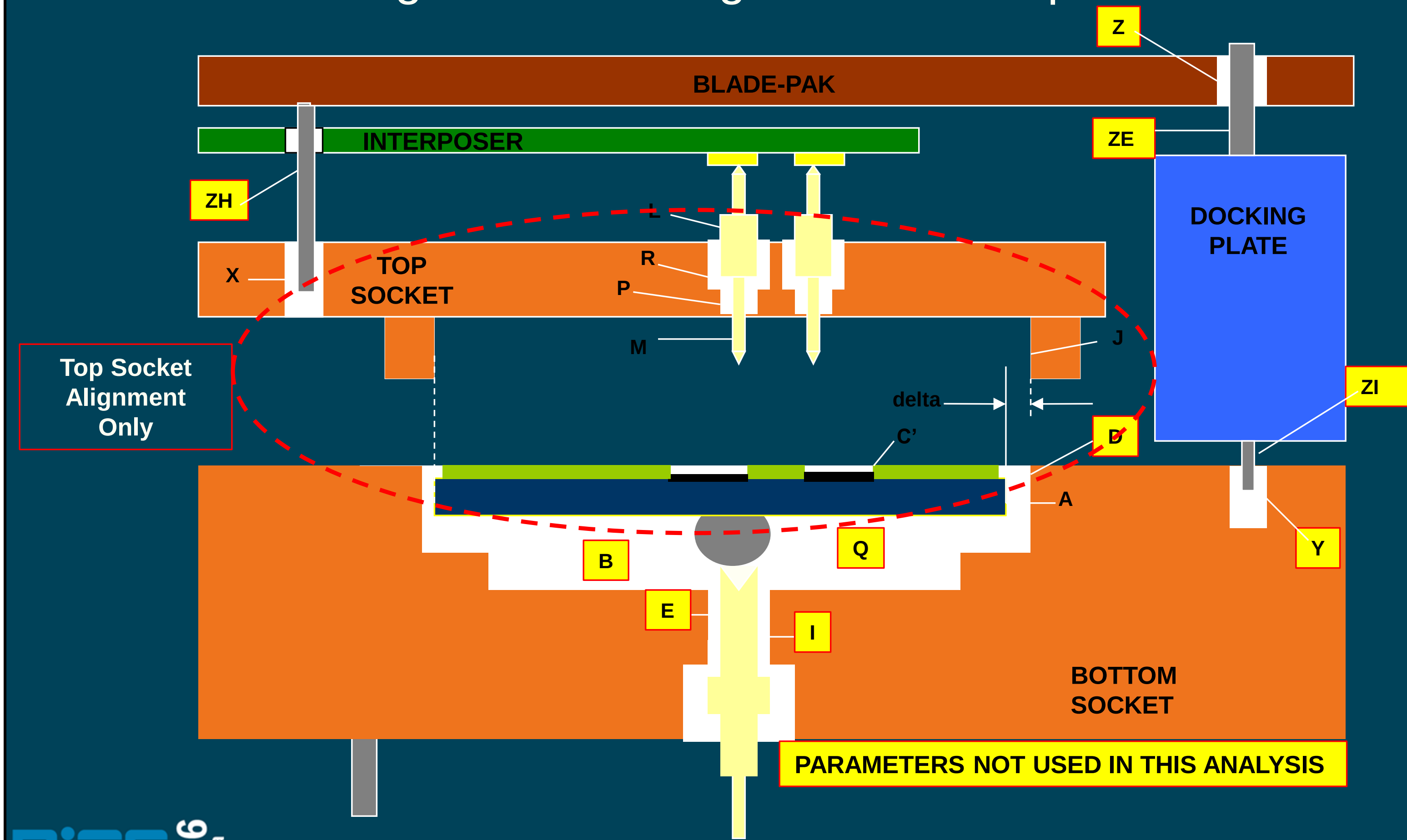
- **Worst Case Analysis (WC)**
- **Root Sum Squared (RSS or MRSS)**
- **Monte Carlo (MC)**



	Worse Case	**RSS**	**Monte Carlo**
Assumptions	1. Independent parameters required 2. Linear functions only 3. 6-sigma is assumed	1. Independent parameters required 2. Linear functions only 3. Normal distribution desired.	1. Dependent parameters are OK 2. Non-linear functions are allowed 3. Any (and mixed) distributions allowed
Limitation	One-or-Zero (like) (GO/NO-GO gauge) only	One-or-Zero (like) (GO/NO-GO gauge) only	Yield / Cpk / DPM can be computed
Applications	Early assessment where process distributions are unknown	Linear functions with normal input distributions	All linear or non-linear applications
Example	Max total = $(1+0.3) + (2+0.4) = 3.7$	RSS total = $1 + 2 + (0.3^2+0.4^2)^{0.5} = 3.5$	TBD

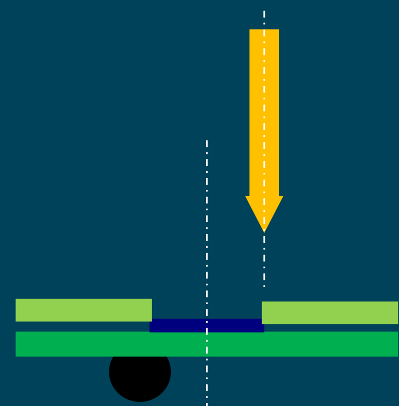
Schematic

Note: This is a generic drawing to define the parameters



Assumptions

- All normal input features have a Cp of 1
- This analysis focuses on the top socket alignment only
- Failure criteria below:
  - M-C’ Top Alignment Cpk
- Major parameters affected:
  - Package size tolerance
  - Package pad diameter
  - Package pad true position
  - Cavity true position
  - Cavity diameter



M-C’ PAD ALIGNMENT
(Edge of Pad to center of probe)

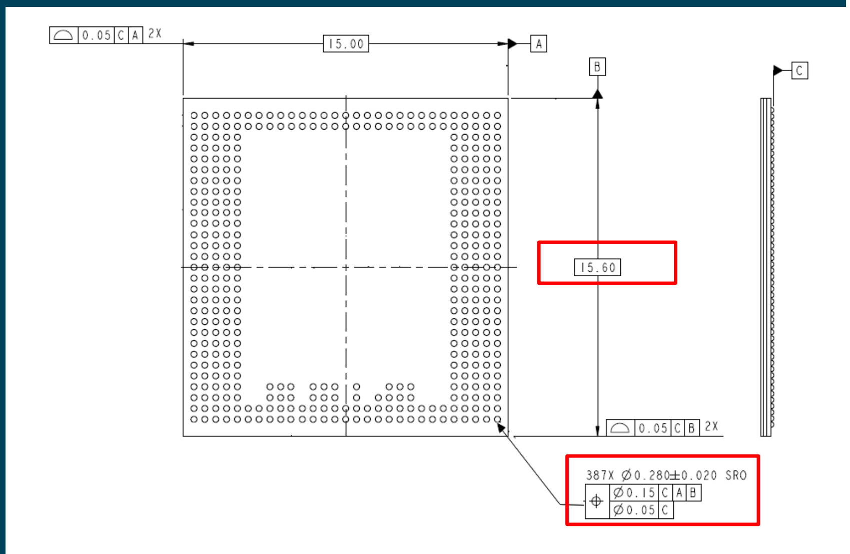
Schematic: Socket Structure / Package Information

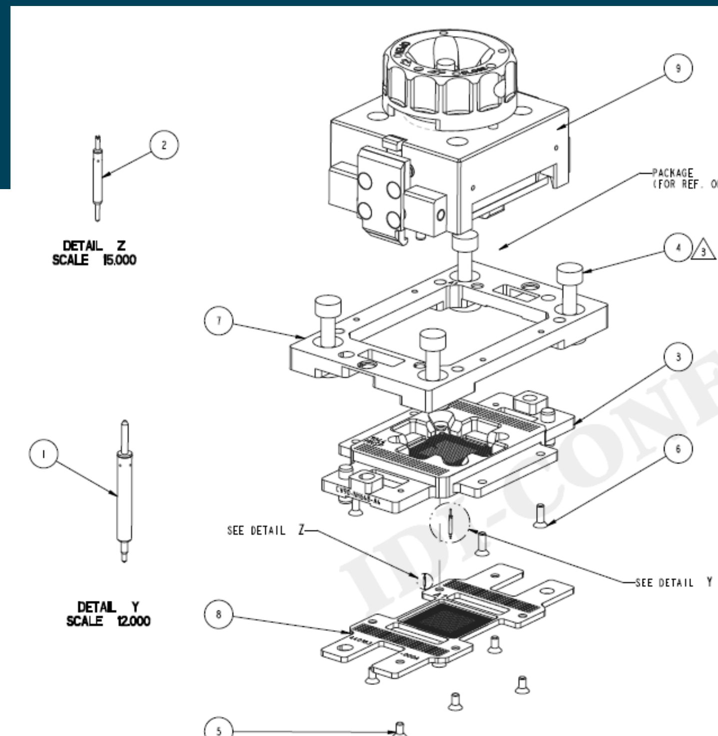
– **Outline Tolerance:** | ⌓ | 0.05 | C | A | | ⌓ | 0.05 | C | B |

– **Pad size and tolerance: Φ0.28±0.02mm**

– **Pad TP:**

⌖	Ø 0.15	C	A	B
	Ø 0.05	C		





Input: Design 1 + Current Package Spec (TP DIA .15)

Monte Carlo Tolerance Study **Application:** **PoP Device to Contactor**

Inputs: (219866-000) Autotest Current Design

Parameter	Dist.	Target	Min	Max	Tol. Range	Units	Notes
A X SIZE DEVICE	N	15.0000	14.9500	15.0500	0.1000	mm	Customer package specification
A Y SIZE DEVICE	N	15.6000	15.5500	15.6500	0.1000	mm	Customer package specification
C' POS POS DEVICE LGA PAD (SRO DIA) POS	L	0.0000	-0.0750	0.0750	0.1500	mm	Customer package specification
C' Ø SIZE DEVICE LGA PAD (SRO DIA)	N	0.2800	0.2600	0.3000	0.0400	mm	Customer package specification
J X SIZE TOP IC CAVITY	N	15.075	15.050	15.100	0.050	mm	440547-000 REV. D2
J Y SIZE TOP IC CAVITY	N	15.675	15.650	15.700	0.050	mm	440547-000 REV. D2
J X POS TOP IC CAVITY	N	0.0000	-0.0125	0.0125	0.0250	mm	440547-000 REV. D2
J Y POS TOP IC CAVITY	N	0.0000	-0.0125	0.0125	0.0250	mm	440547-000 REV. D2
L Ø SIZE PROBE 286-03 BODY DIAMETER (TOP SOCKET)	N	0.3100	0.3000	0.3200	0.0200	mm	623-0286-03
L POS POS PROBE 286-03 BODY DIAMETER (TOP SOCKET)	L	0.0000	-0.0300	0.0300	0.0600	mm	(calculated-movement L-R)
M Ø SIZE PROBE 286-03 DEVICE SIDE TIP DIA (TOP SOCKET)	N	0.1500	0.1400	0.1600	0.0200	mm	623-0286-03
M POS POS PROBE 286-03 DEVICE SIDE TIP DIA (TOP SOCKET)	L	0.0000	-0.0265	0.0265	0.0530	mm	(calculated-movement M-P)
P Ø SIZE HOLE IN TOP SOCKET FOR PROBE TIP DIA 286-03	N	0.1800	0.1670	0.1930	0.0260	mm	440547-000 REV. D2
P POS POS HOLE IN TOP SOCKET FOR PROBE TIP DIA 286-03	L	0.0000	-0.0100	0.0100	0.0200	mm	440547-000 REV. D2
R Ø SIZE CONTACTOR BODY HOLE FOR PROBE 286-03 (TOP SOCKET)	N	0.3500	0.3400	0.3600	0.0200	mm	440547-000 REV. D2
R POS POS CONTACTOR BODY HOLE FOR PROBE 286-03 (TOP SOCKET)	L	0.0000	-0.0250	0.0250	0.0500	mm	440547-000 REV. D2
X Ø SIZE TOP SOCKET HOLE FOR DOWEL ZH	N	1.5300	1.5170	1.5430	0.0260	mm	440547-000 REV. D2
X POS POS TOP SOCKET HOLE FOR DOWEL ZH	L	0.0000	-0.0250	0.0250	0.0500	mm	440547-000 REV. D2

Outputs from Monte Carlo Simulation:	
Number of simulations run	100000
(1) M-C' CONICAL TIP CHECK (286-03) (Edge of pad/Center of probe)	
MC DPM	1020.00
MC CPk	1.03
Sigma DPM	499.80
Sigma CPk	1.10

Input: Actual Measured Socket + Current Package Spec (TP DIA .15)

Monte Carlo Tolerance Study **Application:** **PoP Device to Contactor**

Inputs: (219866-000) Current Actual Measured Socket

Parameter	Dist.	Target	Min	Max	Tol. Range	Units	Notes
A X SIZE DEVICE	N	15.0000	14.9500	15.0500	0.1000	mm	Customer package specification
A Y SIZE DEVICE	N	15.6000	15.5500	15.6500	0.1000	mm	Customer package specification
C' POS POS DEVICE LGA PAD (SRO DIA) POS	L	0.0000	-0.0750	0.0750	0.1500	mm	Customer package specification
C' Ø SIZE DEVICE LGA PAD (SRO DIA)	N	0.2800	0.2600	0.3000	0.0400	mm	Customer package specification
J X SIZE TOP IC CAVITY	N	15.075	15.050	15.100	0.050	mm	440547-000 REV. D2
J Y SIZE TOP IC CAVITY	N	15.675	15.650	15.700	0.050	mm	440547-000 REV. D2
J X POS TOP IC CAVITY	N	0.0000	-0.0125	0.0125	0.0250	mm	440547-000 REV. D2
J Y POS TOP IC CAVITY	N	0.0000	-0.0125	0.0125	0.0250	mm	440547-000 REV. D2
L Ø SIZE PROBE 286-03 BODY DIAMETER (TOP SOCKET)	N	0.3100	0.3000	0.3200	0.0200	mm	623-0286-03
L POS POS PROBE 286-03 BODY DIAMETER (TOP SOCKET)	L	0.0000	-0.0300	0.0300	0.0600	mm	(calculated-movement L-R)
M Ø SIZE PROBE 286-03 DEVICE SIDE TIP DIA (TOP SOCKET)	N	0.1504	0.1450	0.1560	0.0110	mm	From Actual Measured Data
M POS POS PROBE 286-03 DEVICE SIDE TIP DIA (TOP SOCKET)	L	0.0000	-0.0157	0.0157	0.0313	mm	(calculated-movement M-P)
P Ø SIZE HOLE IN TOP SOCKET FOR PROBE TIP DIA 286-03	N	0.1724	0.1609	0.1763	0.0154	mm	From Actual Measured Data
P POS POS HOLE IN TOP SOCKET FOR PROBE TIP DIA 286-03	L	0.0000	-0.0100	0.0100	0.0200	mm	440547-000 REV. D2
R Ø SIZE CONTACTOR BODY HOLE FOR PROBE 286-03 (TOP SOCKET)	N	0.3500	0.3400	0.3600	0.0200	mm	440547-000 REV. D2
R POS POS CONTACTOR BODY HOLE FOR PROBE 286-03 (TOP SOCKET)	L	0.0000	-0.0239	0.0239	0.0477	mm	From Actual Measured Data
X Ø SIZE TOP SOCKET HOLE FOR DOWEL ZH	N	1.5300	1.5170	1.5430	0.0260	mm	440547-000 REV. D2
X POS POS TOP SOCKET HOLE FOR DOWEL ZH	L	0.0000	-0.0250	0.0250	0.0500	mm	440547-000 REV. D2

Outputs from Monte Carlo Simulation:	
Number of simulations run	100000
(1) M-C' CONICAL TIP CHECK (286-03) (Edge of pad/Center of probe)	
MC DPM	950.00
MC CPk	1.04
Sigma DPM	430.96
Sigma CPk	1.11

Input: Design 2 + New Package Pad (TP DIA .15)

Monte Carlo Tolerance Study **Application:** **PoP Device to Contactor**

Inputs: (219866-000) Autotest Design Change + New PKG SRO + PKG Ball Array TP DIA.15

Parameter	Dist.	Target	Min	Max	Tol. Range	Units	Notes
A X SIZE DEVICE	N	15.0000	14.9500	15.0500	0.1000	mm	Customer package specification
A Y SIZE DEVICE	N	15.6000	15.5500	15.6500	0.1000	mm	Customer package specification
C' POS POS DEVICE LGA PAD (SRO DIA) POS	L	0.0000	-0.0750	0.0750	0.1500	mm	Customer package specification
C' Ø SIZE DEVICE LGA PAD (SRO DIA)	N	0.2400	0.2200	0.2600	0.0400	mm	Changed from 0.28 +/-0.02 mm
J X SIZE TOP IC CAVITY	N	15.075	15.050	15.100	0.050	mm	440547-000 REV. D2
J Y SIZE TOP IC CAVITY	N	15.675	15.650	15.700	0.050	mm	440547-000 REV. D2
J X POS TOP IC CAVITY	N	0.0000	-0.0125	0.0125	0.0250	mm	440547-000 REV. D2
J Y POS TOP IC CAVITY	N	0.0000	-0.0125	0.0125	0.0250	mm	440547-000 REV. D2
L Ø SIZE PROBE 286-03 BODY DIAMETER (TOP SOCKET)	N	0.3100	0.3000	0.3200	0.0200	mm	623-0286-03
L POS POS PROBE 286-03 BODY DIAMETER (TOP SOCKET)	L	0.0000	-0.0300	0.0300	0.0600	mm	(calculated-movement L-R)
M Ø SIZE PROBE 286-03 DEVICE SIDE TIP DIA (TOP SOCKET)	N	0.1500	0.1400	0.1600	0.0200	mm	623-0286-03
M POS POS PROBE 286-03 DEVICE SIDE TIP DIA (TOP SOCKET)	L	0.0000	-0.0225	0.0225	0.0450	mm	(calculated-movement M-P)
P Ø SIZE HOLE IN TOP SOCKET FOR PROBE TIP DIA 286-03	N	0.1750	0.1650	0.1850	0.0200	mm	Changed from 0.18 +/-0.013 mm
P POS POS HOLE IN TOP SOCKET FOR PROBE TIP DIA 286-03	L	0.0000	-0.0100	0.0100	0.0200	mm	440547-000 REV. D2
R Ø SIZE CONTACTOR BODY HOLE FOR PROBE 286-03 (TOP SOCKET)	N	0.3500	0.3400	0.3600	0.0200	mm	440547-000 REV. D2
R POS POS CONTACTOR BODY HOLE FOR PROBE 286-03 (TOP SOCKET)	L	0.0000	-0.0250	0.0250	0.0500	mm	440547-000 REV. D2
X Ø SIZE TOP SOCKET HOLE FOR DOWEL ZH	N	1.5300	1.5170	1.5430	0.0260	mm	440547-000 REV. D2
X POS POS TOP SOCKET HOLE FOR DOWEL ZH	L	0.0000	-0.0175	0.0175	0.0350	mm	Changed from DIA.05 mm

Outputs from Monte Carlo Simulation:	
Number of simulations run	100000
(1) M-C' CONICAL TIP CHECK (286-03) (Edge of pad/Center of probe)	
MC DPM	8150.00
MC CPk	0.80
Sigma DPM	4455.11
Sigma CPk	0.87

Input: Design 2 + New Package SRO (TP DIA .08)

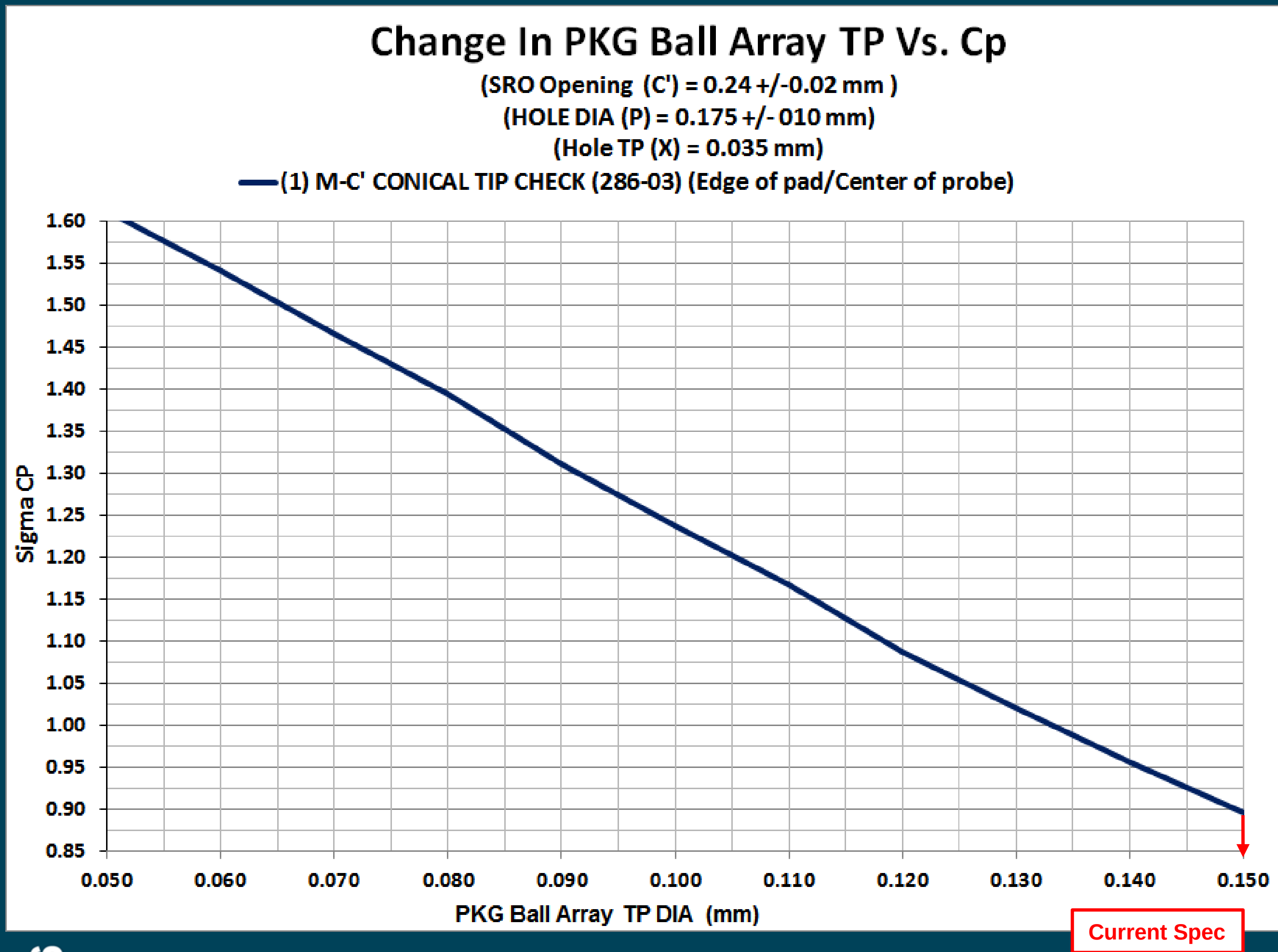
Monte Carlo Tolerance Study **Application:** **PoP Device to Contactor**

Inputs: (219866-000) Autotest Design Change + New PKG SRO + PKG Ball Array TP DIA.08

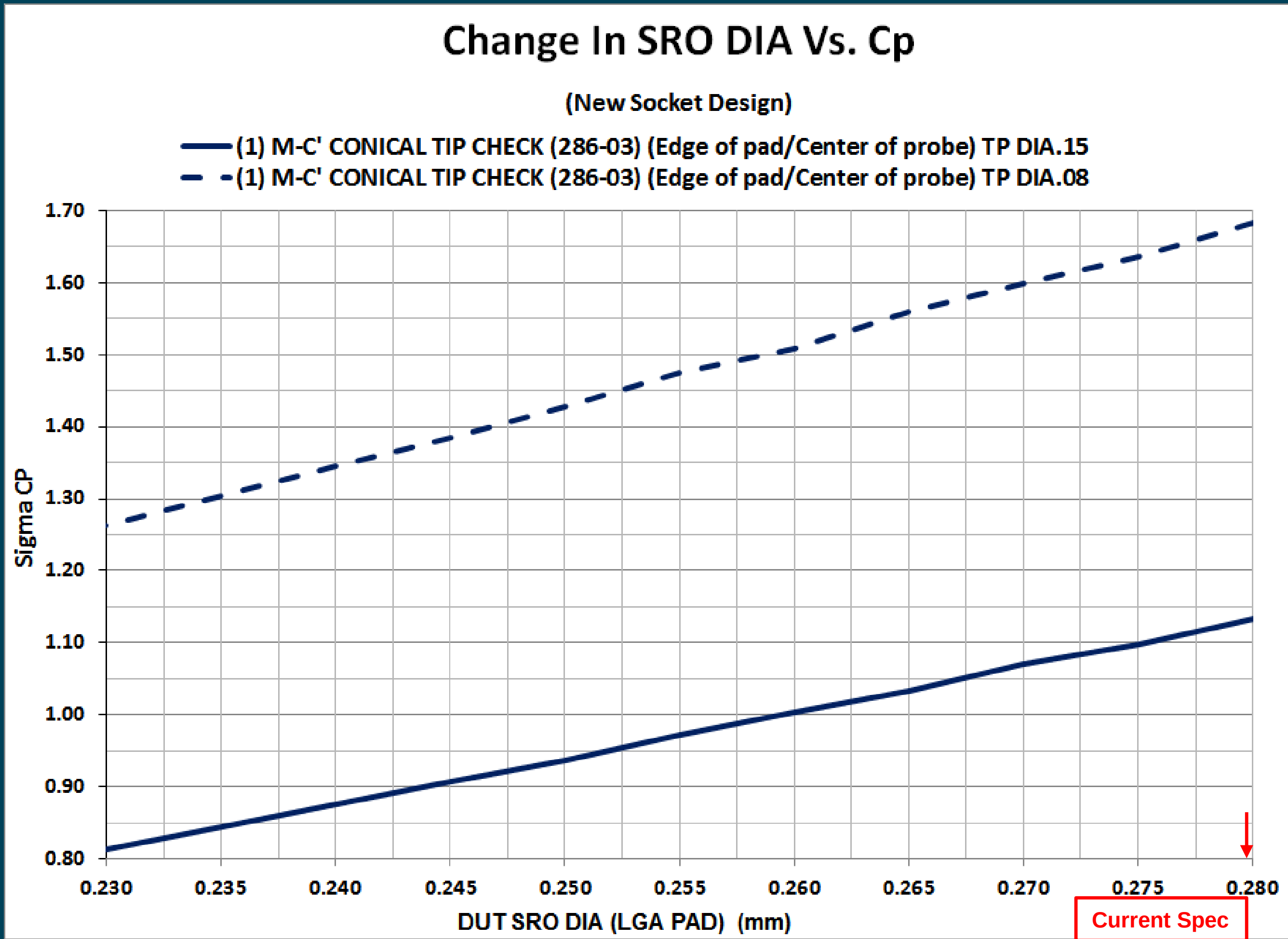
Parameter	Dist.	Target	Min	Max	Tol. Range	Units	Notes
A X SIZE DEVICE	N	15.0000	14.9500	15.0500	0.1000	mm	Customer package specification
A Y SIZE DEVICE	N	15.6000	15.5500	15.6500	0.1000	mm	Customer package specification
C' POS POS DEVICE LGA PAD (SRO DIA) POS	L	0.0000	-0.0400	0.0400	0.0800	mm	Changed from DIA.15 mm
C' Ø SIZE DEVICE LGA PAD (SRO DIA)	N	0.2400	0.2200	0.2600	0.0400	mm	Changed from 0.28 +/-0.02 mm
J X SIZE TOP IC CAVITY	N	15.075	15.050	15.100	0.050	mm	440547-000 REV. D2
J Y SIZE TOP IC CAVITY	N	15.675	15.650	15.700	0.050	mm	440547-000 REV. D2
J X POS TOP IC CAVITY	N	0.0000	-0.0125	0.0125	0.0250	mm	440547-000 REV. D2
J Y POS TOP IC CAVITY	N	0.0000	-0.0125	0.0125	0.0250	mm	440547-000 REV. D2
L Ø SIZE PROBE 286-03 BODY DIAMETER (TOP SOCKET)	N	0.3100	0.3000	0.3200	0.0200	mm	623-0286-03
L POS POS PROBE 286-03 BODY DIAMETER (TOP SOCKET)	L	0.0000	-0.0300	0.0300	0.0600	mm	(calculated-movement L-R)
M Ø SIZE PROBE 286-03 DEVICE SIDE TIP DIA (TOP SOCKET)	N	0.1500	0.1400	0.1600	0.0200	mm	623-0286-03
M POS POS PROBE 286-03 DEVICE SIDE TIP DIA (TOP SOCKET)	L	0.0000	-0.0225	0.0225	0.0450	mm	(calculated-movement M-P)
P Ø SIZE HOLE IN TOP SOCKET FOR PROBE TIP DIA 286-03	N	0.1750	0.1650	0.1850	0.0200	mm	Changed from 0.18 +/-0.013 mm
P POS POS HOLE IN TOP SOCKET FOR PROBE TIP DIA 286-03	L	0.0000	-0.0100	0.0100	0.0200	mm	440547-000 REV. D2
R Ø SIZE CONTACTOR BODY HOLE FOR PROBE 286-03 (TOP SOCKET)	N	0.3500	0.3400	0.3600	0.0200	mm	440547-000 REV. D2
R POS POS CONTACTOR BODY HOLE FOR PROBE 286-03 (TOP SOCKET)	L	0.0000	-0.0250	0.0250	0.0500	mm	440547-000 REV. D2
X Ø SIZE TOP SOCKET HOLE FOR DOWEL ZH	N	1.5300	1.5170	1.5430	0.0260	mm	440547-000 REV. D2
X POS POS TOP SOCKET HOLE FOR DOWEL ZH	L	0.0000	-0.0175	0.0175	0.0350	mm	Changed from DIA.05 mm

Outputs from Monte Carlo Simulation:	
Number of simulations run	100000
(1) M-C' CONICAL TIP CHECK (286-03) (Edge of pad/Center of probe)	
MC DPM	120.00
MC CPk	1.22
Sigma DPM	25.52
Sigma CPk	1.35

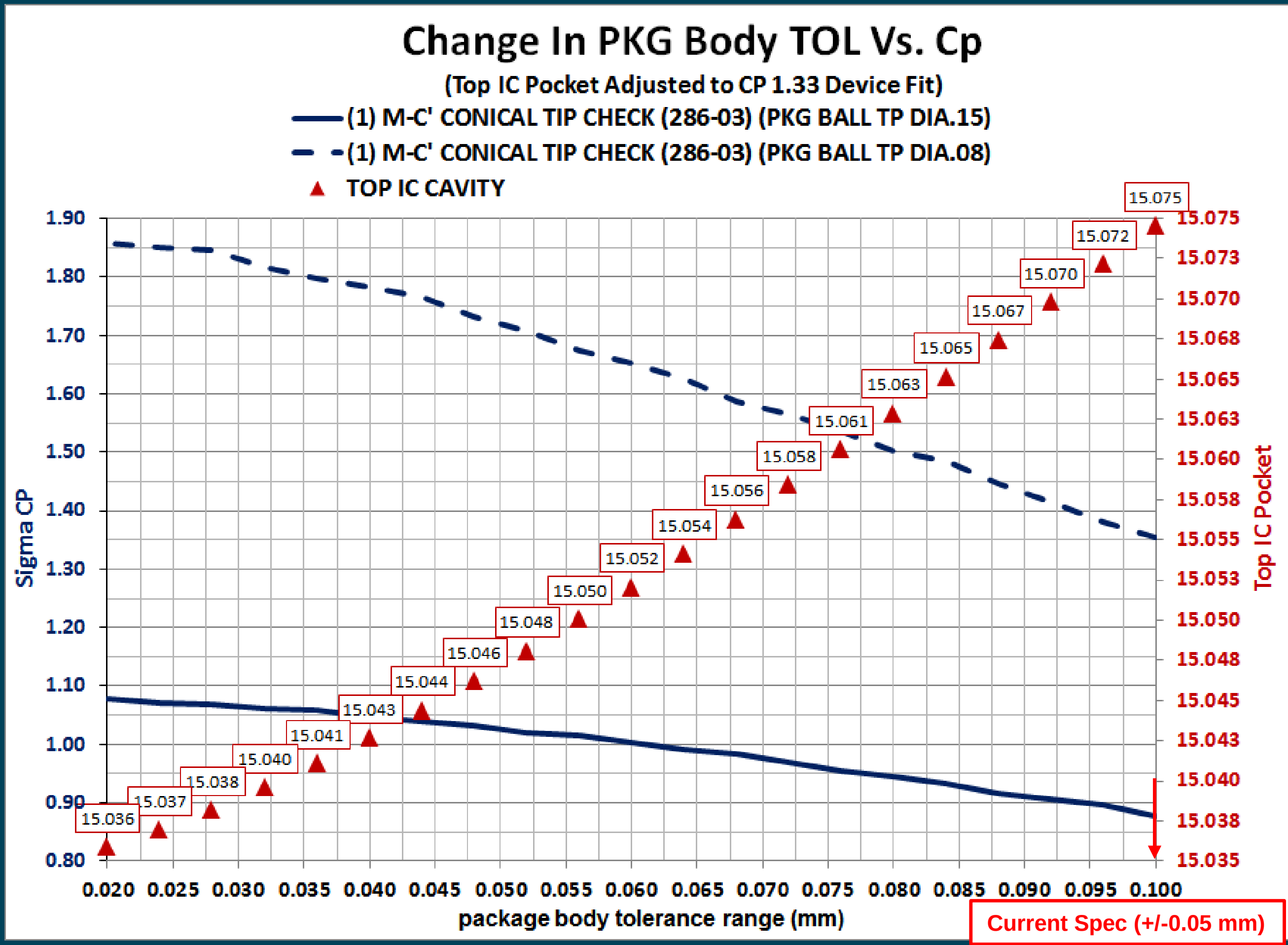
Output: Sensitive Graph-Change in Package Pad TP



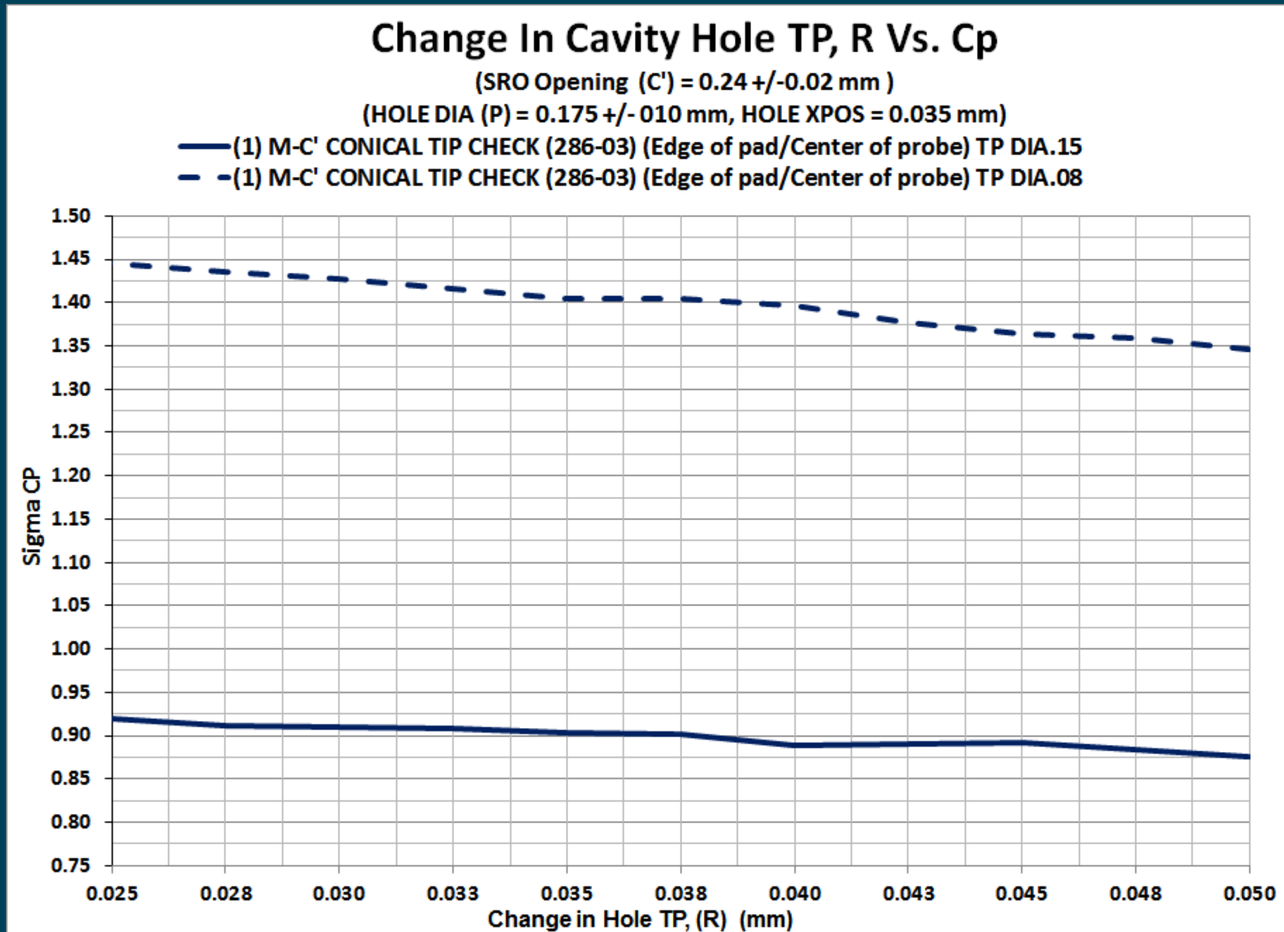
Output: Sensitive Graph-Change in Package Pad DIA



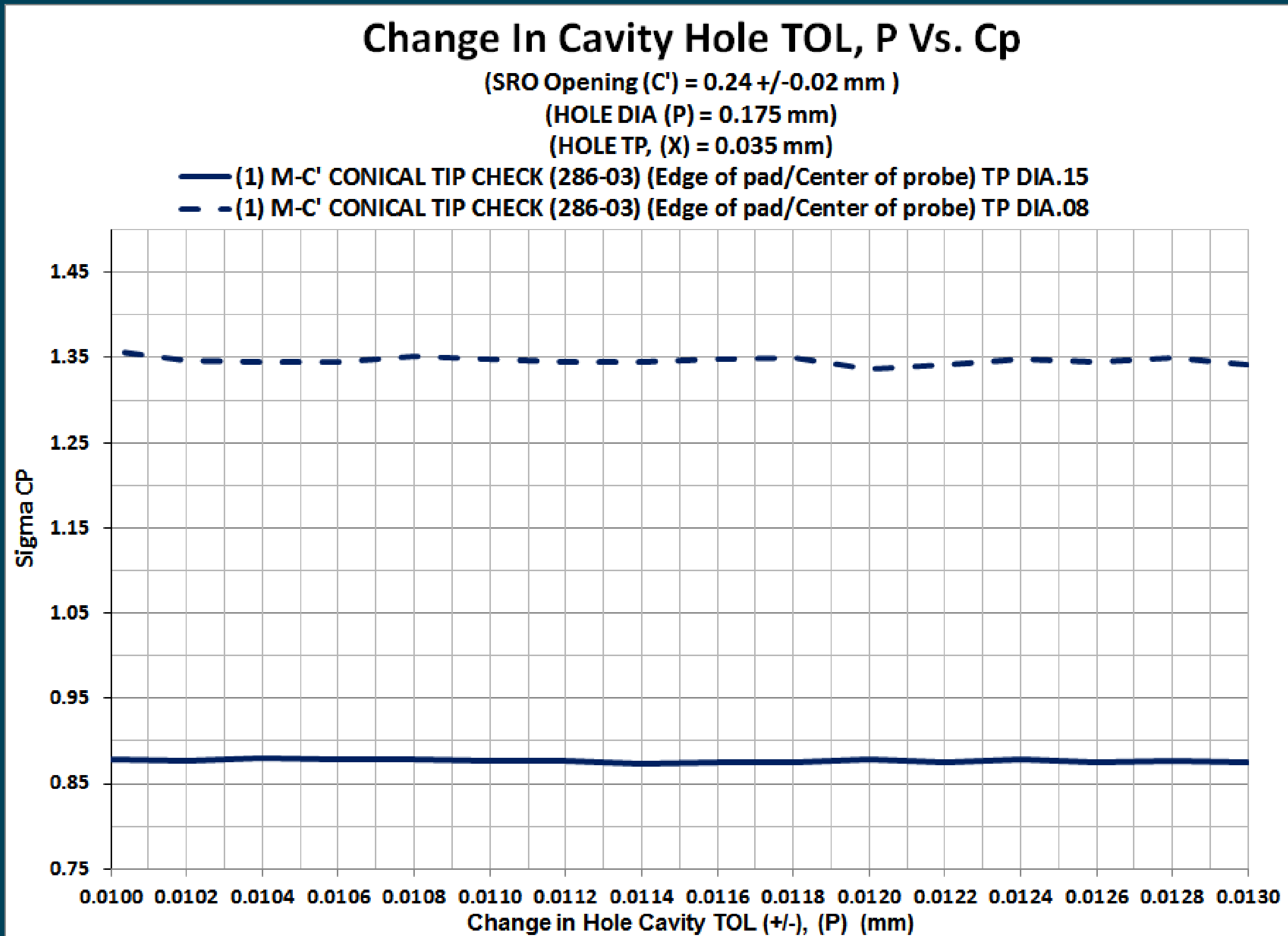
Output: Sensitive Graph-Change in Package Body TOL



Output: Sensitive Graph-Change in Cavity Hole TP



Output: Sensitivity Graph-Change in Cavity Hole TOL



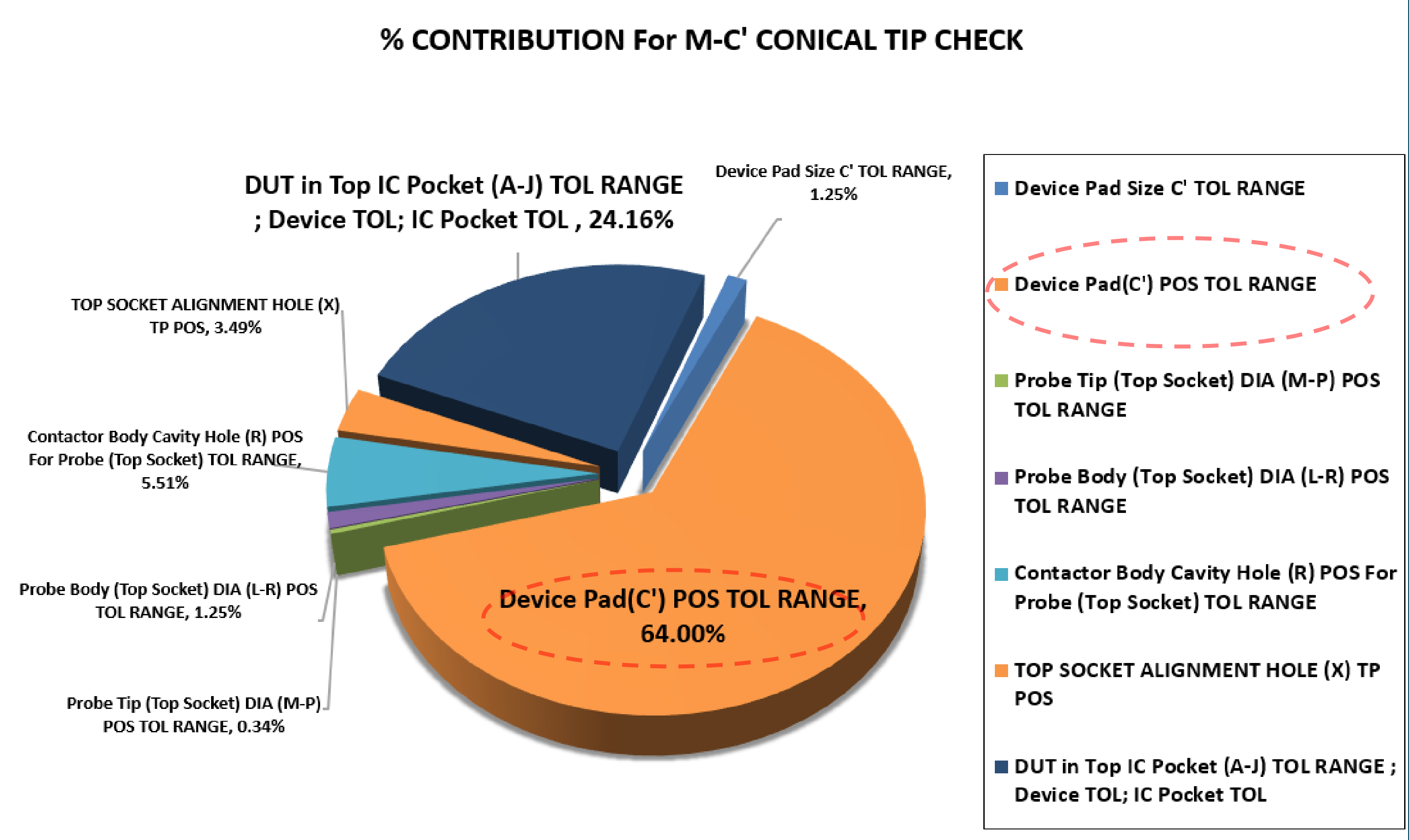
Results Summary

MC Top Alignment	Package spec TP diameter	Pad diameter (mm)	MC Cpk	Sigma Cpk
Design 1	0.15	0.28	1.03	1.10
Design 1	0.08	0.28	1.42	1.62
Actual measured socket	0.15	0.28	1.04	1.11
Actual measured socket	0.08	0.28	N/A	1.64
Design 1	0.15	0.24	0.78	0.85
Design 1	0.08	0.24	1.14	1.28
Design 2	0.15	0.24	0.80	0.87
Design 2	0.08	0.24	1.22	1.35

Reducing package pad true position diameter will get higher MC Cpk

Reducing pad diameter will get lower MC Cpk

Results: % Contribution For Design Change



Summary

- **Smiths Connectors has developed different Monte Carlo analysis models for different applications:**
  - Spring probe travel analysis
  - Spring probe pointing accuracy analysis
  - Contact alignment analysis
  - DUT / Lid / Heatsink travel analysis

- **The results for this analysis are primarily attributed to:**
  - Device pad true positon
  - Device outline tolerance