



Determination of True Position, of a Threaded Hole, Using a Coordinate Measuring Machine

*Tony Bryce
Sandia National Laboratories*

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States
Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND -2005-6648P



Agenda

■ *Introduction*

- *ASME Y14.5-2009 Requirements*

■ *Problem*

- *Curved or Irregular Surfaces*

■ *Tests*

- *Evaluation of Various Methods*

■ *Conclusion*



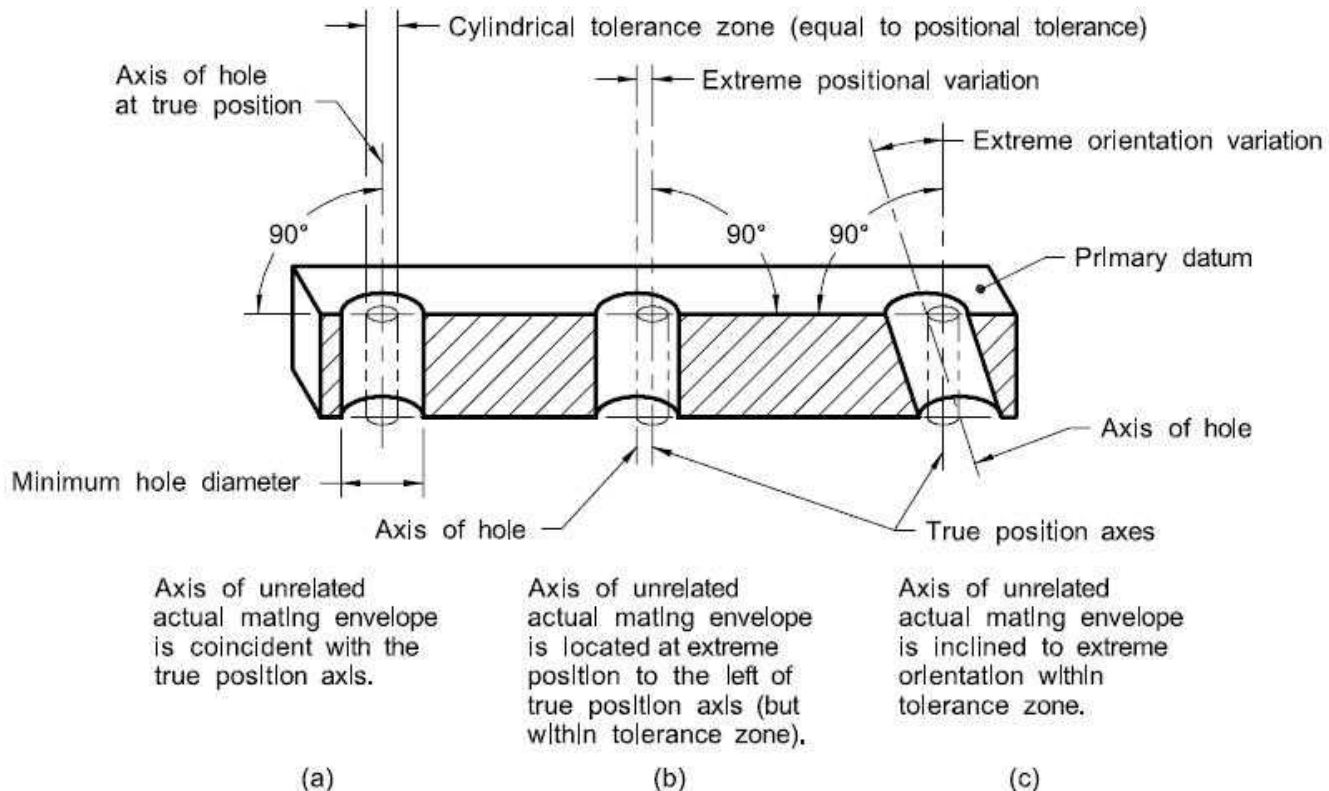
How should the position be established?

■ ASME Y14.5-2009

- Section 2.9

- *“Each tolerance of orientation or position and datum reference specified for a screw thread applies to the axis of the thread derived from the pitch cylinder.”*

Requirements per ASME Y14.5M-2009



Note that the length of the tolerance zone is equal to the length of the feature, unless otherwise specified on the drawing.

7.3.3.1

6.2



Coordinate Measuring Machine (CMM) Methods

■ *Probing a threaded/cylinder gage*

- *Issues*

- *\$ - Cost of gage*
- *Inconvenience of installing (time = money \$)*
- *Establishing pitch cylinder*

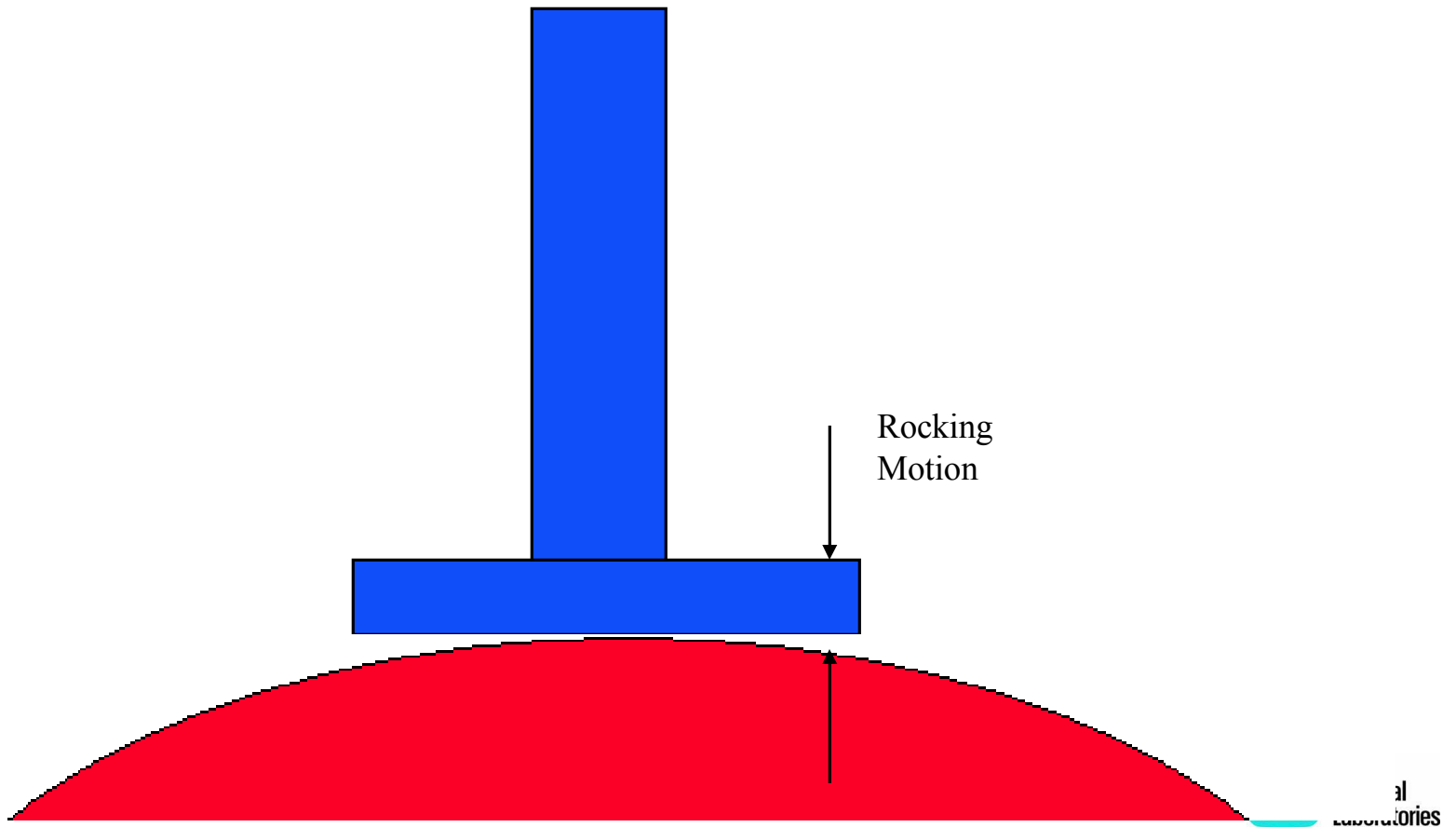
■ *Direct probing of the thread form*

- *Issues*

- *Chips, burrs*
- *Proper establishment of the pitch cylinder*

Problem

- *Standard cylinder gage is influenced by the surface the hole is located on.*



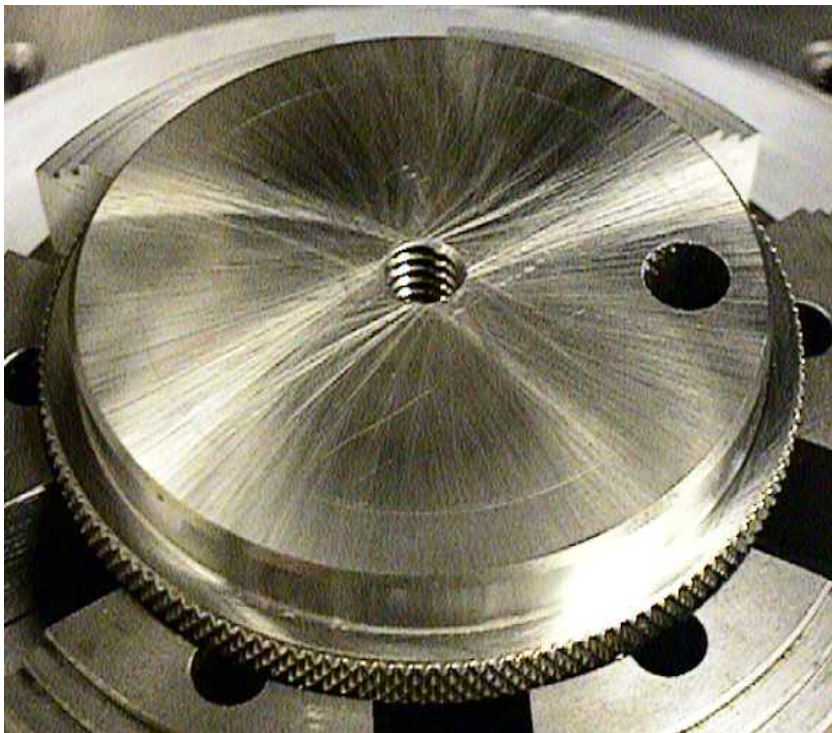


Initial Tests

- *Evaluate commonly used techniques*
- *Perform R & R tests using various techniques on a nominally flat surface*
 - *Test pieces having a 2 inch outside diameter with 1/4"-20 UNC thread in center*



Test Pieces



Various Types Plug Gage



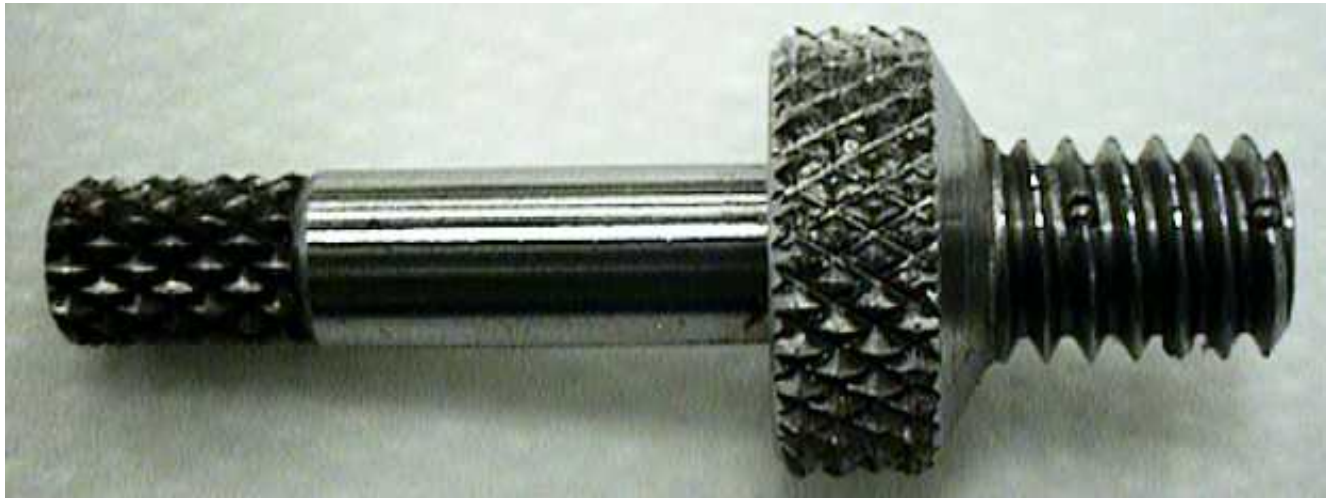
Split Thread Gage



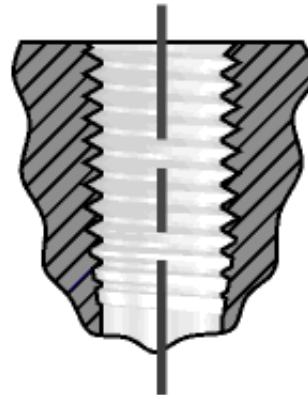
Tapered Thread Gage



Expanding Ball Gage



Expanding Ball Gage





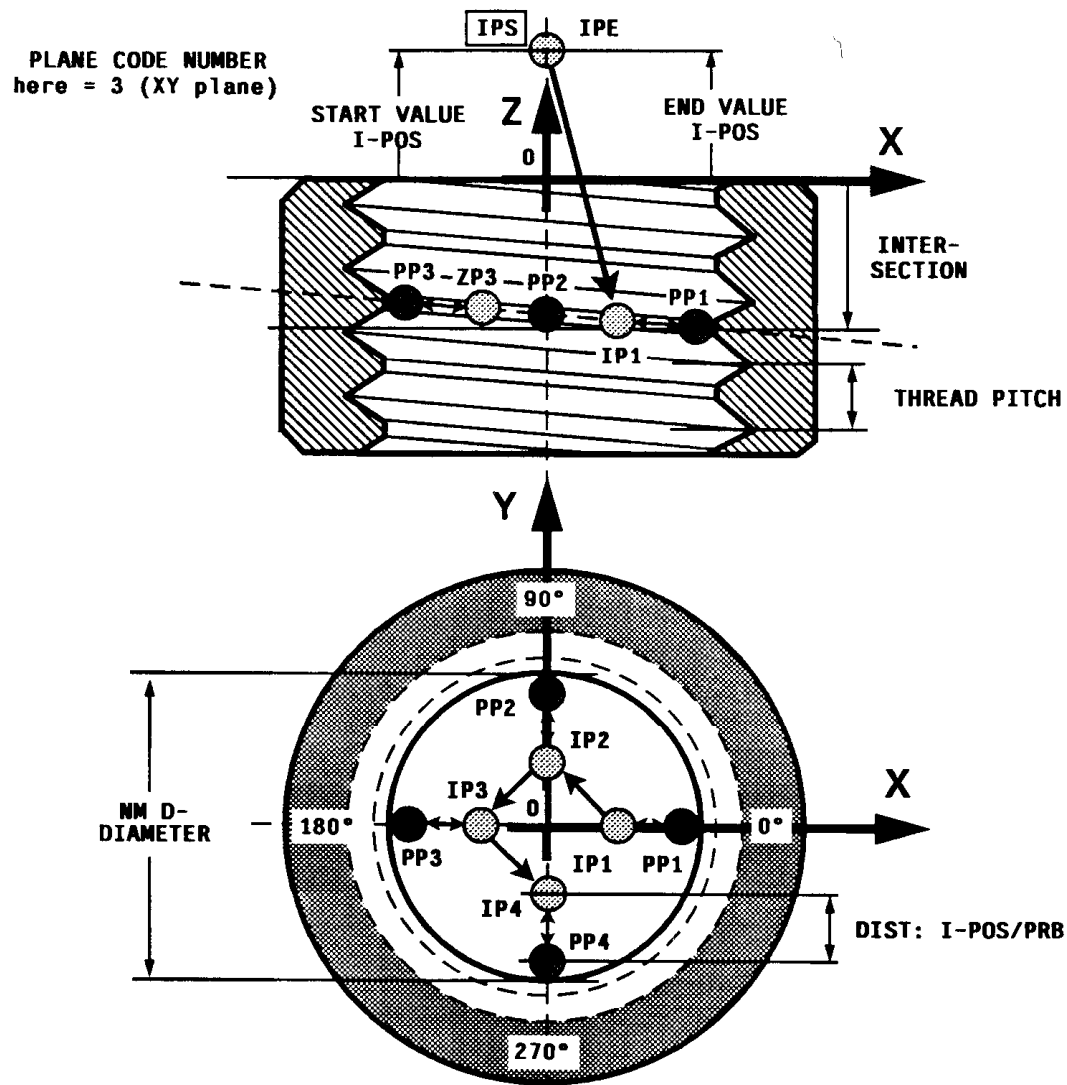
R&R Test Parameters

- *Establish intersection points of cylinder axis with Datum A (top surface) and at $-0.5''$ below Datum A*
- *Record X & Y position at both intersection points*
 - *Should show repeatability of not just Datum A location, but of the cylinder orientation (tilt).*

Typical CMM Setup



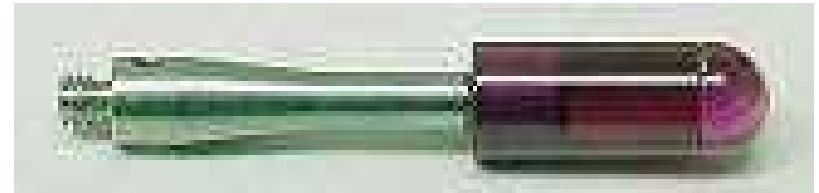
Direct Probing Technique



Direct Probing using Cylinder Probe

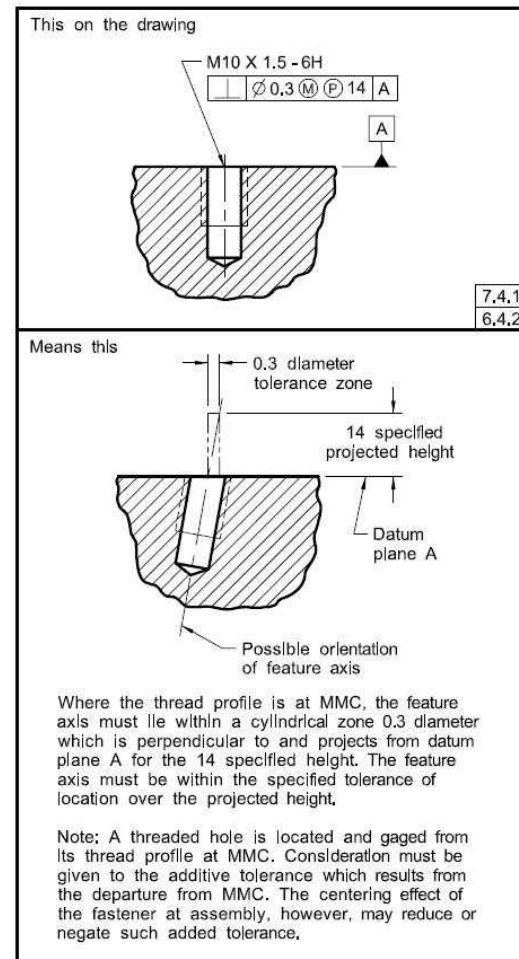
■ *Issues*

- *Taking a 3D requirement and making a 2D measurement*
- *Assuming many characteristics of the thread form*



Maximum Material Condition Issues

- *How is MMC applied?*
 - *Additive Tolerance “Bonus”*
 - *Centering Effects?*



Reprinted from ASME Y14.5-2009, by permission of The American Society of Mechanical Engineers. All rights reserved. No further copies can be made without written permission.



CMM's Used & Specifications

- *Zeiss Prismo (9/12/7)*
 - *3D = 0.000113 inches*
- *Zeiss Contura (7/10/6)*
 - *3D = 0.000097 inches*
- *Zeiss UPMC 550 (CAA)*
 - *3D = 0.000058 inches*

Zeiss Prismo CMM



Zeiss Contura CMM



Zeiss UPMC 550





Test Results – Steel Test Piece

	Axis	Datum A - Z Axis Zero			Projected 0.5 inches Z Axis		
		Deviation	Std. Dev.	TP Result	Deviation	Std. Dev.	TP Result
Standard Straight Gage	X	-0.00011	0.00002	0.0003	-0.00017	0.00003	0.0005
	Y	-0.00011	0.00001		-0.00017	0.00006	
Split Gage	X	-0.00016	0.00002	0.0003	0.00029	0.00037	0.0006
	Y	-0.00001	0.00002		-0.00011	0.00007	
Tapered Gage	X	-0.00017	0.00013	0.0004	-0.00029	0.00007	0.0009
	Y	-0.00010	0.00007		-0.00037	0.00030	
Expanding Ball Gage	X	0.00004	0.00002	0.0004	0.00029	0.00021	0.0006
	Y	-0.00019	0.00005		-0.00001	0.00021	
Direct Thread Probing	X	0.00043	0.00103	0.0009	0.00094	0.00059	0.0020
	Y	-0.00017	0.00001		0.00034	0.00045	

Results In Inches



Test Results – Aluminum Test Piece

	Axis	Datum A - Z Axis Zero			Projected 0.5 inches Z Axis		
		Deviation	Std. Dev.	TP Result	Deviation	Std. Dev.	TP Result
Standard Straight Gage	X	-0.00082	0.00002	0.0027	-0.00088	0.00007	0.0033
	Y	0.00110	0.00002		0.00141	0.00063	
Split Gage	X	-0.00018	0.00004	0.0027	-0.00061	0.00039	0.0031
	Y	0.00132	0.00005		0.00140	0.00010	
Tapered Gage	X	-0.00047	0.00004	0.0024	-0.00106	0.00053	0.0031
	Y	0.00113	0.00018		0.00112	0.00019	
Expanding Ball Gage	X	0.00029	0.00016	0.0024	-0.00061	0.00087	0.0027
	Y	0.00117	0.00006		0.00120	0.00016	
Direct Thread Probing	X	0.00080	0.00005	0.0016	0.00002	0.00064	0.0003
	Y	0.00004	0.00010		0.00014	0.00015	

Results In Inches



Conclusions

- *No significant difference seen between gage methods.*
- *No significant difference seen between gage methods and direct probing.*
- *Further testing & analysis needed to determine best practice.*



Questions?

August 11, 2009

Mr. E.A. "Tony" Bryce
Technical Team Leader
Sandia National Laboratories
PO Box 5800
Albuquerque, NM 87185

Subject: Copyrighted Material

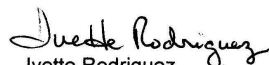
Dear Mr. Bryce:

In response to your e-mail dated August 10, 2009, ASME will grant you permission to reproduce excerpts from the material listed below:

ASME Y14.5-2009
Figure 6-11 (Page 104)
Figure 7-8 (Page 113)

as requested to be used in your presentation to be given at the North American Coordinate Metrology Association (NACMA) Conference. As is customary, we ask that the source document and ASME be fully acknowledged. **"Reprinted from ASME Y14.5-2009, by permission of The American Society of Mechanical Engineers. All rights reserved". No further copies can be made without written permission.** If you have any questions do not hesitate to contact me.

Sincerely,


Ivette Rodriguez
Systems Administrator
rodriguezi@asme.org
(212) 591-8482

/IR



Appendix *“Test Data”*



Test Results – Steel Test Piece

Results In Inches

Contura

		Datum A		Projected -0.5"	
Jo-Plug		Position	Std. Dev.	Position	Std. Dev.
	X	-0.00009	0.00003	-0.00019	0.00001
	Y	-0.00012	0.00002	-0.00020	0.00001
Tru-Pos					
	X	-0.00016	0.00002	0.00050	0.00003
	Y	-0.00002	0.00001	-0.00015	0.00003
CL Flex					
	X	-0.00002	0.00019	-0.00033	0.00019
	Y	-0.00014	0.00014	-0.00054	0.00014
Multi-Ball					
	X	0.00002	0.00006	0.00041	0.00002
	Y	-0.00019	0.00003	0.00012	0.00008
PCM					
	X	-0.00015	0.00002	0.00060	0.00001
	Y	-0.00015	0.00002	0.00060	0.00001



Test Results – Steel Test Piece

Results In Inches

Prismo

		Datum A		Projected -0.5"	
Jo-Plug		Position	Std. Dev.	Position	Std. Dev.
	X	-0.00013	0.00005	-0.00013	0.00002
	Y	-0.00010	0.00002	-0.00010	0.00004
Tru-Pos					
	X	-0.00014	0.00002	-0.00014	0.00001
	Y	-0.00003	0.00002	-0.00003	0.00003
CL Flex					
	X	-0.00022	0.00014	-0.00021	0.00022
	Y	-0.00002	0.00015	-0.00002	0.00024
Multi-Ball					
	X	0.00005	0.00008	0.00004	0.00003
	Y	-0.00024	0.00004	-0.00025	0.00006
PCM					
	X	0.00162	0.00001	0.00162	0.00001
	Y	-0.00017	0.00001	-0.00018	0.00017



Test Results – Steel Test Piece

UPMC 550

Results In Inches

		Datum A		Projected -0.5"	
Jo-Plug		Position	Std. Dev.	Position	Std. Dev.
	X	-0.00011	0.00002	-0.00019	0.00001
	Y	-0.00012	0.00002	-0.00020	0.00001
Tru-Pos					
	X	-0.00017	0.00001	0.00050	0.00003
	Y	0.00001	0.00001	-0.00015	0.00003
CL Flex					
	X	-0.00026	0.00009	-0.00033	0.00019
	Y	-0.00014	0.00007	-0.00054	0.00014
Multi-Ball					
	X	0.00004	0.00006	0.00041	0.00002
	Y	-0.00014	0.00003	0.00012	0.00008
PCM					
	X	-0.00018	0.00001	0.00060	0.00001
	Y	-0.00018	0.00001	0.00060	0.00001



Test Results – Aluminum Test Piece

Results In Inches

Contura

		Datum A		Projected -0.5"	
Jo-Plug		Position	Std. Dev.	Position	Std. Dev.
	X	-0.00084	0.00016	-0.00088	0.00010
	Y	0.00107	0.00005	0.00107	0.00002
Tru-Pos					
	X	-0.00022	0.00005	-0.00094	0.00008
	Y	0.00137	0.00005	0.00149	0.00027
CL Flex					
	X	-0.00046	0.00025	-0.00140	0.00028
	Y	0.00098	0.00026	0.00101	0.00034
Multi-Ball					
	X	0.00011	0.00020	-0.00089	0.00016
	Y	0.00112	0.00010	0.00138	0.00008
PCM					
	X	0.00085	0.00002	-0.00033	0.00002
	Y	-0.00006	0.00001	0.00032	0.00001



Test Results – Aluminum Test Piece

Results In Inches

Prismo					
		Datum A		Projected -0.5"	
Jo-Plug		Position	Std. Dev.	Position	Std. Dev.
	X	-0.00082	0.00007	-0.00082	0.00007
	Y	0.00111	0.00006	0.00214	0.00007
Tru-Pos					
	X	-0.00018	0.00003	-0.00018	0.00012
	Y	0.00129	0.00005	0.00129	0.00012
CL Flex					
	X	-0.00043	0.00037	-0.00045	0.00044
	Y	0.00133	0.00029	0.00135	0.00041
Multi-Ball					
	X	0.00037	0.00019	0.00036	0.00014
	Y	0.00116	0.00013	0.00118	0.00011
PCM					
	X	0.00075	0.00002	0.00075	0.00001
	Y	0.00003	0.00005	0.00004	0.00008



Test Results – Aluminum Test Piece

Results In Inches

UPMC 550

		Datum A		Projected -0.5"	
Jo-Plug		Position	Std. Dev.	Position	Std. Dev.
	X	-0.00081	0.00017	-0.00095	0.00007
	Y	0.00112	0.00013	0.00101	0.00005
Tru-Pos					
	X	-0.00013	0.00009	-0.00071	0.00006
	Y	0.00128	0.00005	0.00140	0.00006
CL Flex					
	X	-0.00051	0.00027	-0.00134	0.00027
	Y	0.00107	0.00033	0.00101	0.00040
Multi-Ball					
	X	0.00041	0.00017	-0.00131	0.00013
	Y	0.00124	0.00014	0.00106	0.00016
PCM					
	X	0.00079	0.00003	-0.00037	0.00001
	Y	0.00015	0.00009	0.00005	0.00004