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

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# Agenda

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## ■ *Introduction*

- *ASME Y14.5-2009 Requirements*


## ■ *Problem*

- *Curved or Irregular Surfaces*

## ■ *Tests*

- *Evaluation of Various Methods*

## ■ *Conclusion*



# *How should the position be established?*

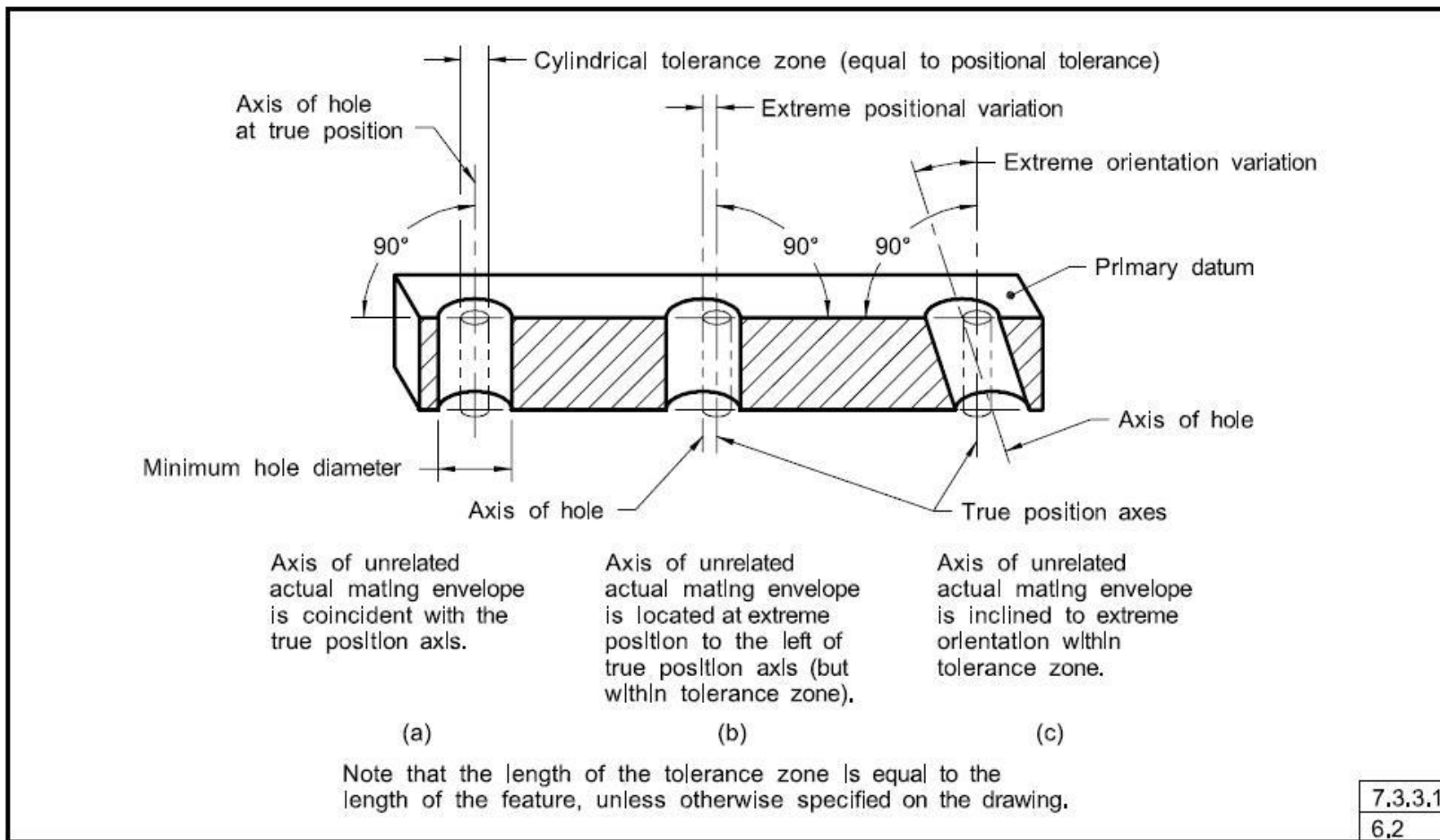
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## ■ ASME Y14.5-2009

- *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



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# *Coordinate Measuring Machine (CMM) Methods*

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## ■ *Probing a threaded/cylinder gage*

- *Issues*

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

## ■ *Direct probing of the thread form*

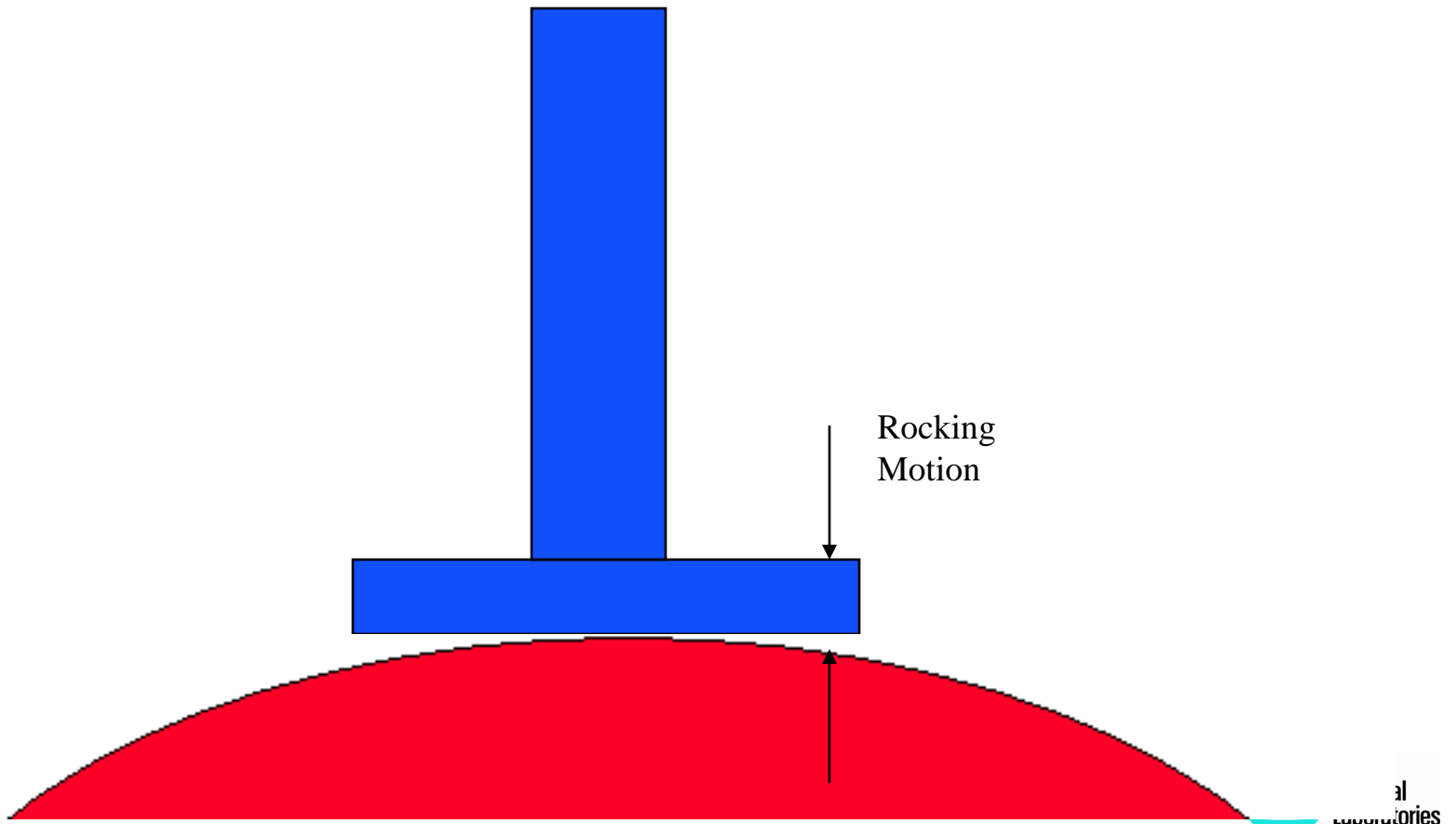
- *Issues*

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

# *Problem*

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





# *Initial Tests*

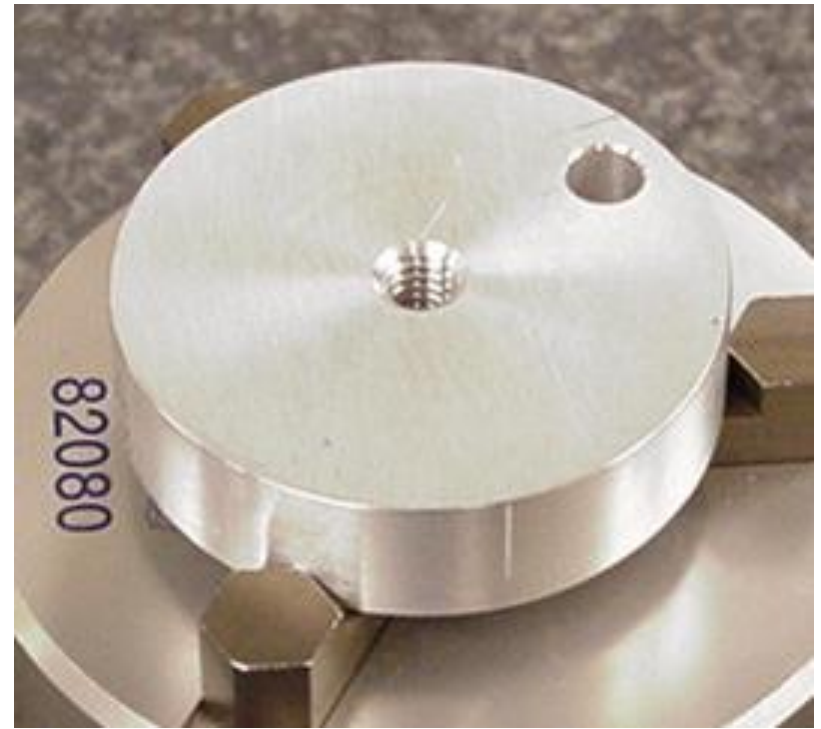
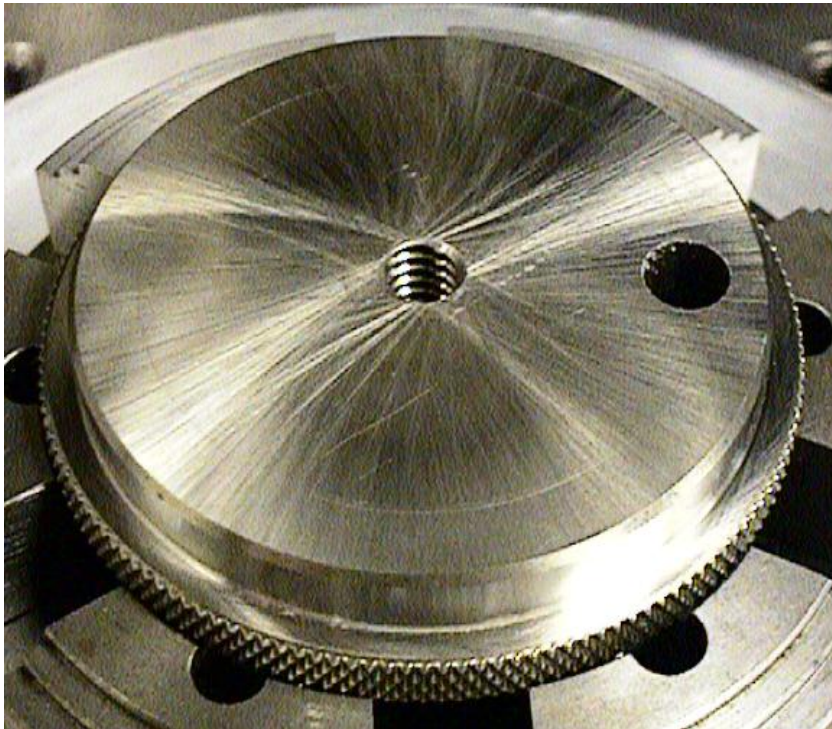
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- *Evaluate commonly used techniques*
- *Perform R & R tests using various techniques on a nominally flat surface*
  - *Test pieces having a 2 inch outside diameter with 1/4"-20 UNC thread in center*



# *Test Pieces*

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# *Various Types Plug Gage*

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# *Split Thread Gage*

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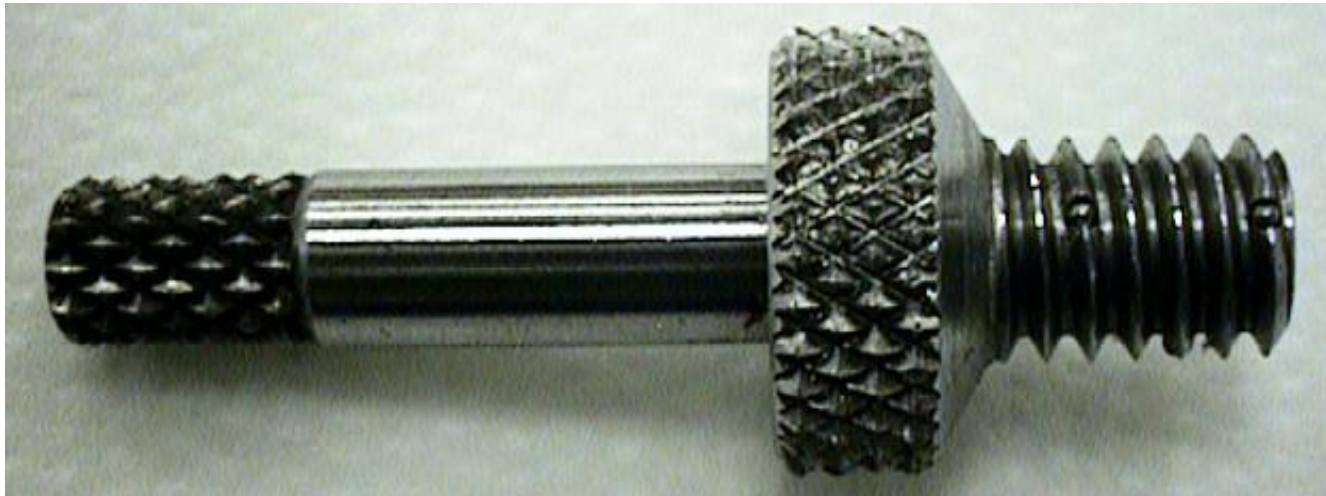
# *Tapered Thread Gage*

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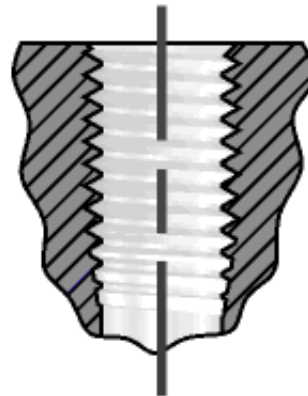


# *Expanding Ball Gage*

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# *Expanding Ball Gage*





# *R&R Test Parameters*

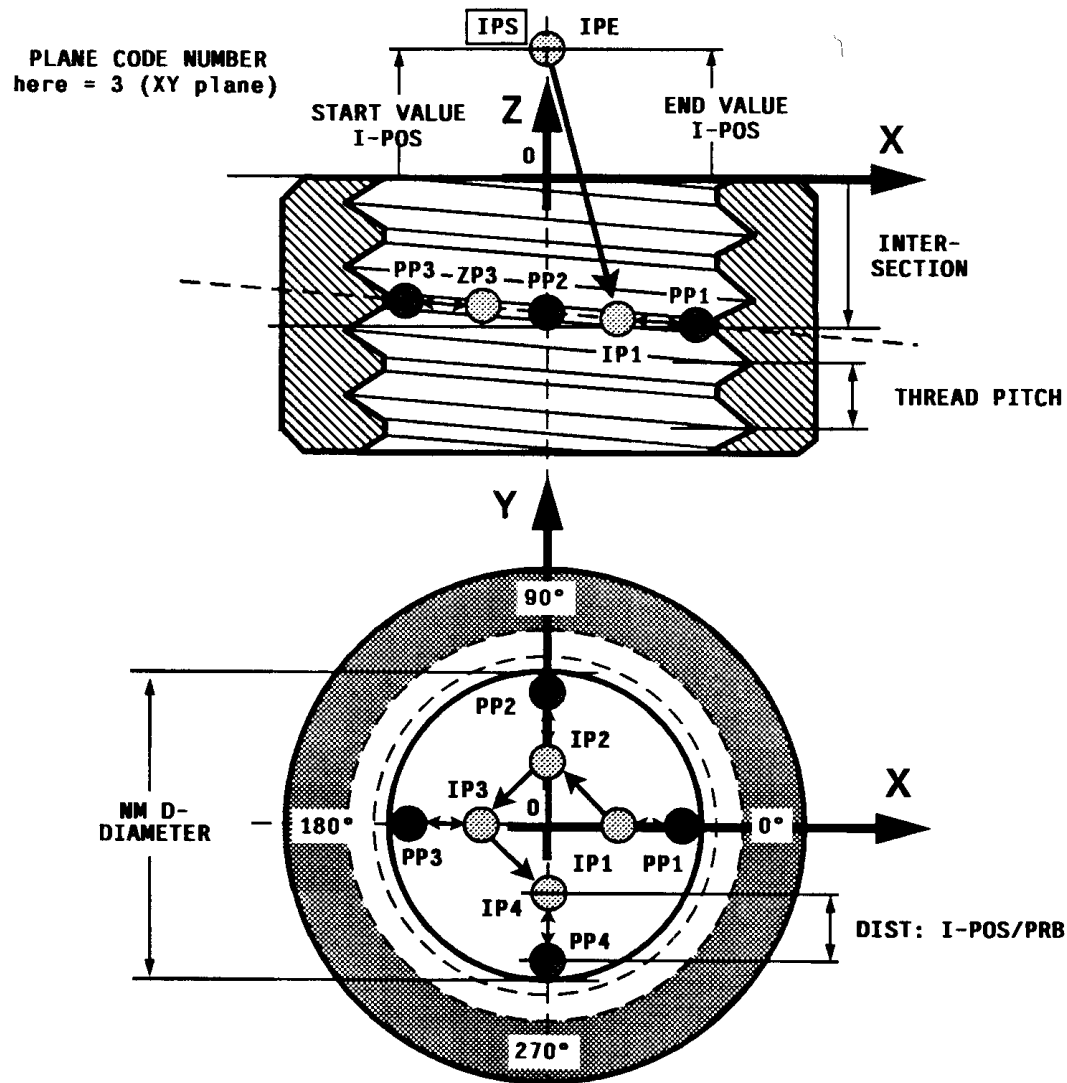
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- *Establish intersection points of cylinder axis with Datum A (top surface) and at  $-0.5$ " below Datum A*
- *Record X & Y position at both intersection points*
  - *Should show repeatability of not just Datum A location, but of the cylinder orientation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

# Typical CMM Setup



# Direct Probing Technique



# *Direct Probing using Cylinder Probe*

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## ■ *Issues*

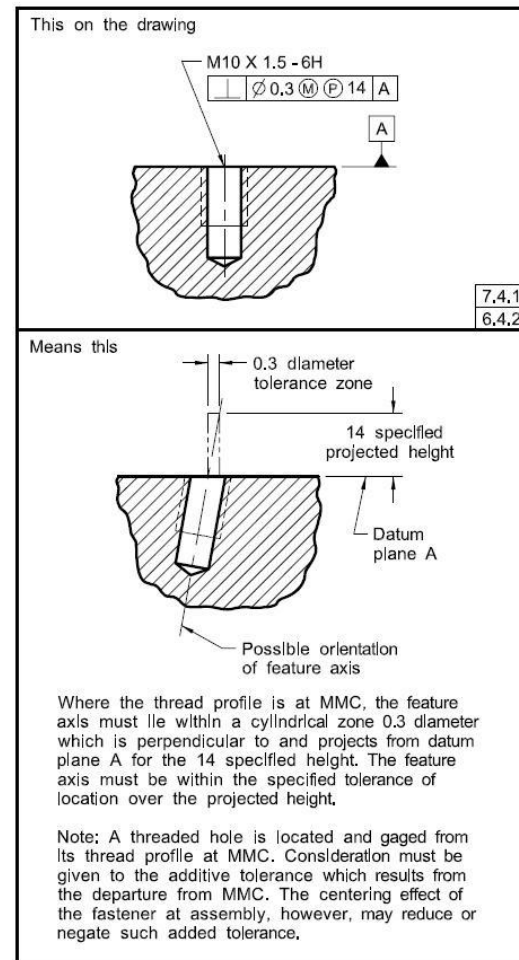
- *Taking a 3D requirement and making a 2D measurement*
- *Assuming many characteristics of the thread form*



# Maximum Material Condition Issues

## ■ How is MMC applied?

- Additive Tolerance “Bonus”
- Centering Effects?



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# *CMM's Used & Specifications*

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- *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*

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# *Zeiss UPMC 550*





# *Test Results – Steel Test Piece*

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

Results In Inches



# *Test Results – Aluminum Test Piece*

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

Results In Inches



# *Conclusions*

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- *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?*