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

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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

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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 ¼”-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

PLANE CODE NUMBER
here = 3 (XY plane)

START VALUE
I-POS

Z
0

END VALUE
I-POS

INTERSECTION

THREAD PITCH

80°

180°

270°

DIST: I-POS/PRB

151x452
Direct Probing using Cylinder Probe

- Issues
  - Taking a 3D requirement and making a 2D measurement
  - Assuming many characteristics of the thread form
How is MMC applied?

- Additive Tolerance “Bonus”
- Centering Effects?
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

<table>
<thead>
<tr>
<th></th>
<th>Axis</th>
<th>Datum A – Z Axis Zero</th>
<th>Projected -0.5 inches Z Axis</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Deviation</td>
<td>Std. Dev.</td>
<td>TP Result</td>
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<tr>
<td><strong>Standard Straight Gage</strong></td>
<td></td>
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<td></td>
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<tr>
<td>X</td>
<td>-0.00011</td>
<td>0.00002</td>
<td>0.0003</td>
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<tr>
<td>Y</td>
<td>-0.00011</td>
<td>0.00001</td>
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<tr>
<td><strong>Split Gage</strong></td>
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<td>X</td>
<td>-0.00016</td>
<td>0.00002</td>
<td>0.0003</td>
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<tr>
<td>Y</td>
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<td><strong>Tapered Gage</strong></td>
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<td></td>
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<tr>
<td>X</td>
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<tr>
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<tr>
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</table>

Results In Inches
### Test Results – Aluminum Test Piece

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<th>Axis</th>
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<th>Projected -0.5 inches Z Axis</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Deviation</td>
<td>Std. Dev.</td>
</tr>
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<td><strong>Standard Straight Gage</strong></td>
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<tr>
<td>Y</td>
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<td>0.00010</td>
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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?