SAND2008-6450C

News from Length/Mass/Force at PSL

IMOG Meeting

October 7-9, 2008

Meghan Shilling
Hy D. Tran

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.

Primary Standards Lab

- Provides guidance/consultation for DOE NNSA standards & calibration programs (and other activities) per D&P Manual
- Length/Mass/Force Metrology Lab:
  - Hy D. Tran, project leader
  - Meghan Shilling, technical staff
  - Orlando Espinosa, technologist (length & force)
  - Ben Casados, technologist (mass)
- Technologists have 60 + yrs aggregate experience; staff have advanced degrees in engineering

Capabilities

- PSL has accreditation from NVLAP (ISO 17025) in various scopes
- Mass capability to calibrate OIML E-2 level
- Force by deadweight to 1000 lbf (4448 N); by comparison to load cells to 100000 lbf (444.8 kN)
- Gauge blocks to 100 mm mastered by interferometry, then, mechanical comparisons for customers. Comparisons in a paired design (two PSL masters with two customer sets)
- Gaging balls, thread wires; roundness; surface finish; all by comparison

Leitz PMM-C Infinity

- New coordinate measuring machine acquired with funds from NIST
  - Leitz PMM-C Infinity (MPE_E = (0.3 + L/1000) μm per ISO 10360:2).
- Equipment arrived June 2008
- Acceptance testing finished September 2008

Sandia National Laboratories

M48 Leaves

Sandia National Laboratories

New Base

Sandia National Laboratories

Putting it Together

Sandia National Laboratories

New Leitz PMM-C Infinity

Sandia National Laboratories

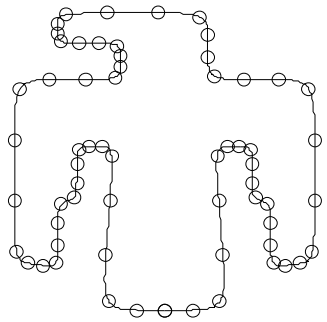
LMF News

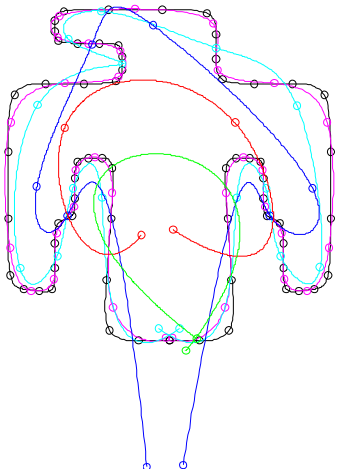
- NVLAP audit September 30 – October 2
- Maximo replaced Benchtop on August 5th
  - Handles recalls, certificate generation, billing
  - Electronic copy is now our official copy
  - Have been some transition problems

R&D at LMF

- Hybrid artifact for qualification of vision-probing machines (such as OGPs), funded by SNL LDRD program project completed 9/20/2007, looking to license.
- Metrology (non-contact & on-machine); funded by LANL pit mfg programs
  - Evaluate COTS on-machine systems
  - Evaluate capabilities of optical CMM probes
- Optimization of sampling strategies; funded by SNL LDRD (2008-2010)
- "Quantification of Uncertainty in Machining Operations for On-Machine Acceptance"; funded by SNL LDRD (Only Q4 2008)

Optimization of Sampling Strategies





- "Determination and Optimization of Spatial Samples for Distributed Measurements"
- 3 yr program (2008-2010)
- Desired end result is a recommended practice for selection of points when evaluating complex geometries
- Working with Xiaoming Huo from Georgia Tech (wavelet/statistics expert)
- Current work is on determining points and resultant confidence levels for lines and curves.

Sandia National Laboratories

Quantification of Uncertainty in Machining Operations for On-Machine Acceptance

- Establish a Machining Accuracy Ratio
- Analogous to TUR/TAR (Test Uncertainty/Accuracy Ratio)
- Determine a margin from established machine capability and acceptable consumer risk

- For example:
  - Form analysis=0.0006” (0.015 mm)
  - Desire MAR=5:1 (from quantitative consumer risk assessment)
  - If drawing callout shows form = 0.003”, accept the feature without further inspection

Form Error Estimate

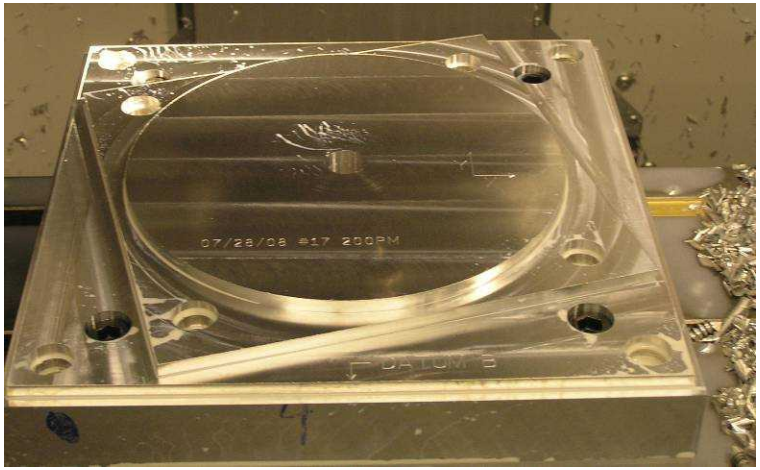
- **Thermal effects estimate: 2°C,**

$$\Delta CTE = 10 \text{ ppm}$$

  - **Estimate 0.00016” (0.004 mm)**
- **Geometry effects, from calibration data:**
  - **Estimate combined error motions 0.00055” (0.014 mm)**
- **Cutter and workpiece effects**
  - **Estimate combined effects 0.00008” (0.002 mm)**
- **Combined form error:** $\sqrt{\left(\sum \varepsilon_i^2\right)}$
  - **0.00058” (0.015 mm) (95% level of confidence)**

Sandia National Laboratories

Results



- **Machined 20 circle-diamond-square parts**
- **Expected form performance of 0.00058”, obtained average form 0.00030” to 0.00056”**
- **Dimensional evaluation of average 8.000” diameter is 8.001”; attributable to tool diameter**
  - **Tool tolerance is +0.000”/-0.001”; expected contribution is 2×0.00058”=0.00116”**

Geometry Evaluated	Feature	Average Measured Form (in)
X-axis straightness	2-D Line 3 (horiz)	0.00030
Y-axis straightness	2-D Line 4 (vert)	0.00051
X-Y straightness	2-D Line 5 (angled)	0.00056

Sandia National Laboratories

Other News

- Hy is on NCSLI Dimensional committee. There is a draft recommended practice on CMM calibration; contact Hy for a copy (should be treated as OUO/Proprietary)
- Hy is organizing a regional metrology meeting in Albuquerque, potentially early 2009. The focus will be on dimensional metrology.
- Ed Pritchard at Modus Metrology is organizing a round robin for high precision (roughly defined as MPE_E fixed term 1 micrometer or less) CMMs. Contact Hy to get on the round robin list.

Hy Tran – (505)844-5417, hdtran@sandia.gov