Morehouse Instrument Company

Issue 6: April, 2016

Force and Torque Calibration Quarterly

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A Message from the President

Welcome to our sixth Morehouse Instrument Company Newsletter. 2016 is off to an interesting start. We held our first SPC (Statistical Process Control) training class in February with our Force Uncertainty workshop and these were well received. We passed our A2LA audit with only one finding. The finding was on not having documented a specific process and we have since corrected the finding. We successfully presented a one hour presentation titled "Common Measurement Errors, and Challenges on CMC uncertainty for Force Measurements" at the A2LA technical forum and we are presenting "Measurement Traceability and Errors Related to Force Measurement" on April 13, 2016 at the NCSLI regional meeting at Exelon Power Labs in Coatesville, PA. It is not too late to register. Registration can be found here. We are developing free webinars on topics related to force and torque measurements.

We have been actively blogging about new topics regarding force verification systems, converting force to mass, and most recently we posted a blog about dual range calibrations. On first look, dual range force calibration on a load cell may save money on initial equipment purchase by having fewer load cells, but beware of the downside.

Read more at http://blog.mhforce.com

-Henry Zumbrun

2 Bar vs 3 Bar Universal Calibrating Machine (UCM)

Above: Solid Works Drawing created by our Mechanical Engineering Intern Michael Dutt.

There has been ongoing debate as to whether or not a hydraulic force machine that applies the force simultaneously to both the reference standard and the unit under test is more repeatable and reproducible when the force is applied and transferred with 3 bars vs 2 bars. The debate centers around alignment of the reference standard and the unit under test. There is no disagreement about the benefits of using a triangular configuration when using multiple load cells to weigh an object; however, there is a debate over any advantages that might be offered by using a 3 bar Universal Calibrating Machine (UCM) instead of a traditional 2 bar system. We wrote a paper that provides test results for repeatability and reproducibility for a 2 bar UCM and a 3 bar UCM, showing the null hypothesis to be correct and proving ***there is not a difference*** between either UCM. The paper compares a per point uncertainty analysis for each styles of machine using a Welch-Satterthwaite equation. Repeatability and reproducibility were examined using the same reference load cell, unit under test, hydraulic jack, Morehouse hydraulic power control, and HBM DMP40 indicators. Some of our key findings were the 2 bar UCM showed better repeatability on 7 of 10 points and the average CMC (Calibration and Measurement Capability) was higher on the 3 bar machine. When all aspects are considered, a 2 bar UCM will have the advantage as far as cost, lower tare weight, and easier calibration setups.

Click here to read the full paper

“If the Unit Under Test is to be used to calibrate other devices using both increasing and decreasing forces, the reference device, must be calibrated in both modes.”

Steps Recommended to Perform Calibration in Accordance with ASTM E74-13a

Stabilization

Allow UUT to come to room temperature. This can take 24 to 48 hours. Warm up Instrumentation – We recommend 20-30 minutes for electrical stabilization of the equipment.

Preparation

Select 10-11 Test points, if the UUT is to be used to calibrate other devices using both increasing and decreasing force, the reference device must be calibrated in both modes. The optimal selection of force points should be at least 21 (11 Increasing and 10 decreasing) Note: *Using an ascending calibration curve to calibrate a device in decreasing modes, can result in errors of 0.05 % and higher.*

There should be at least one calibration force for each 10% interval throughout the loading range, if the instrument is to be used below 10% of its capacity, a lower force should be applied. This low force must be greater than the resolution of the device multiplied by 400 for Class A or 2000 for Class AA devices. Note: *This means an applied force of 0 as the first test point is not allowable.*

“This low force must be greater than the resolution of the device multiplied by 400 for Class A or 2000 for Class AA devices”

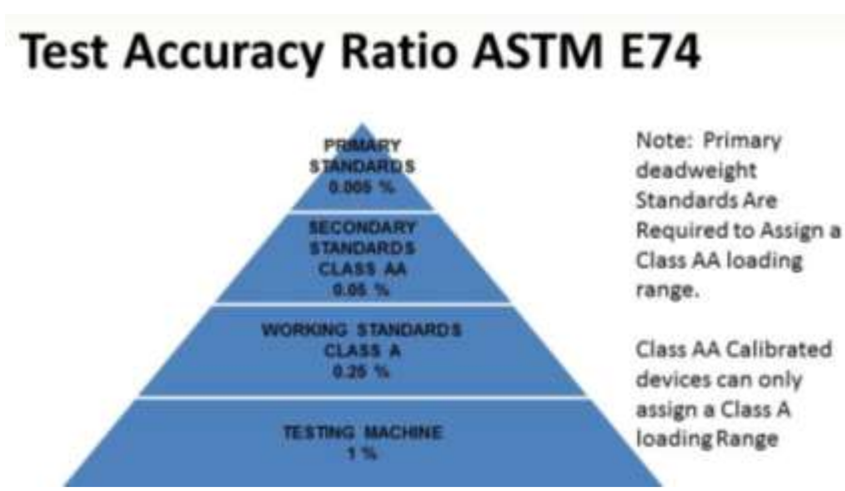


Figure above shows the various allowable errors at each level of the ASTM E74 Pyramid

Calibration Procedure

Fixture Unit Under Test (UUT) in Test Frame
Exercise UUT 2-4 times
Apply 1st series of forces (Run1)
Rotate the UUT 120 degrees if possible for run 2
Apply 2nd series of forces (Run2)
If UUT operates in compression and tension, switch to the other mode after finishing run 2, exercise, and repeat steps above. Note: *Morehouse will be posting a blog on load cell reversibility in the near future. The preliminary findings indicate there is not a statistically significant difference on a shear web type load cell by using this method versus compression and then tension loading.*

For Tension and Compression calibration, intersperse the loadings. Be sure to re-exercise the UUT prior to any change in setup.
Rotate the UUT another 120 degrees if possible for run 3
Apply 3rd series of forces (Run3)

Data Analysis

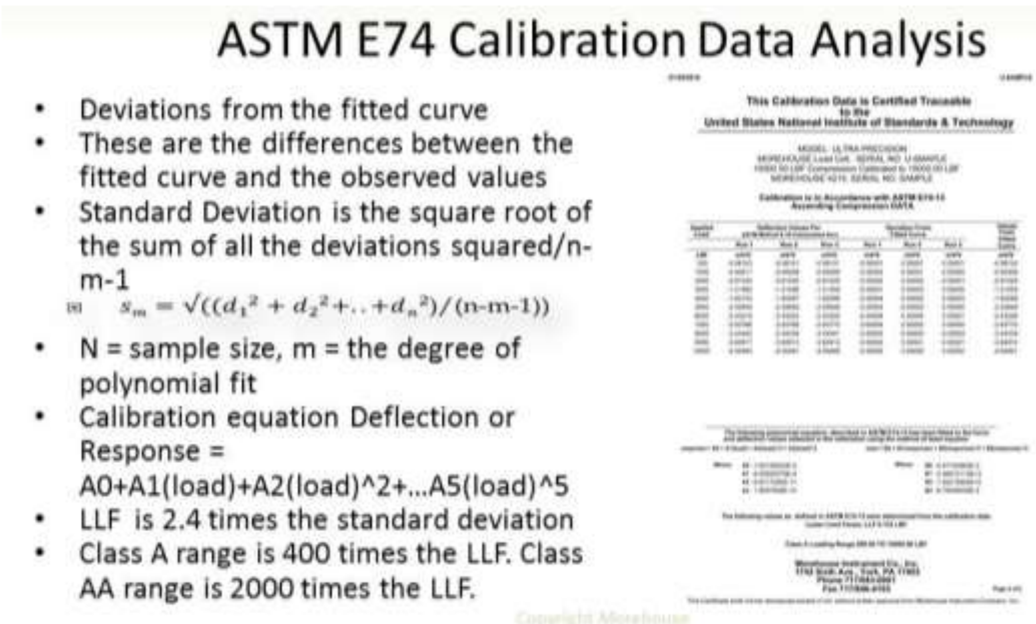
Deflection calculation Methods

Method B Deflection readings should be calculated as the difference between readings at the applied force and the average or interpolated zero force readings before and after the applied force readings. –NOTE: *Morehouse tested 46 instruments using Method A versus Method B. This paper was published in Cal Lab magazine (page 25). The conclusion: Method A will increase the LLF median value between 11.9% and 23.4%.*

Method A Deflection readings are calculated as the difference between the deflection at the applied force and the initial deflection at zero force.

Criteria for Use of Higher Degree Curve Fits
Resolution must exceed 50,000 counts
An F distribution test is used to determine the appropriate best degree of fit (instructions for this test can be found in the Annex A1 of the ASTM E74 Standard)

Criteria for Lower Load Limit
LLF = 2.4 * STD DEV – This corresponds to a 98.2 % Coverage Factor
Based on LLF or Resolution whichever is higher
Class A 400 times the LLF or resolution
Class AA 2000 times the LLF or resolution
NOTE: *Any instrument that is either modified or repaired should be recalibrated, and recalibration is required for a permanent zero shift exceeding 1.0 % of full scale.*



Calibration Interval Determination

Secondary Standards should be calibrated or verified annually to ensure that they do not change more than 0.032 % over the loading range. Instruments used as Class A devices (Typically used to calibrate testing machines) should be calibrated or verified annually to ensure that they do not change more than 0.16 % over the loading range. If the Calibration device is stable to within 0.16 % over the loading range, then the calibration interval can be 2 years as long as the UUT continues to meet the stability criteria.

"Secondary Standards should be calibrated or verified annually to ensure that they do not change more than 0.032 % over the loading range"

ASTM E74 Lower Load Limits Matter…

The Class A or Class AA loading range cannot be less than the first applied non zero force point

Per Section 8.6 of ASTM E74-13a, "*The loading range shall not include forces outside the range of forces applied during the calibration"*

Per Section 7.2.1 "*If the lower limit of the loading range of the device (see 8.6.1) is anticipated to be less than one tenth of the maximum force applied during calibration, then forces should be applied at or below this lower limit*"

"If the lower limit of the loading range of the device (see 8.6.1) is anticipated to be less than one tenth of the maximum force applied during calibration, then forces should be applied at or below this lower limit"

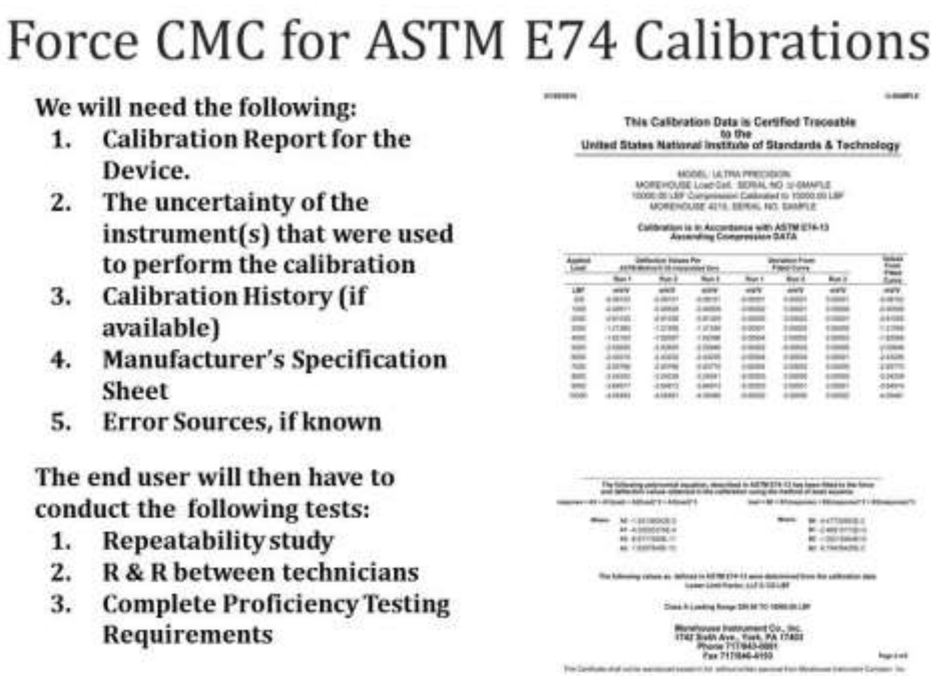
Zero cannot be a test point

Per Section 7.2.1 of ASTM E74-13a, *"In no case should the smallest force applied be below the lower limit of the instrument as defined by the values: 400 x resolution for Class A loading range & 2000 x resolution for Class AA loading range"*

Calibration and Measurement Capability (CMC) Spreadsheet for Force

Morehouse has developed an Excel spreadsheet to help those trying to figure measurement uncertainty, and how to calculate their Calibration and Measurement Capability (CMC).

This spreadsheet is setup for labs following the ASTM E74-13a standard. With slight modification, the uncertainty sheet could be used for instruments calibrated in accordance with another test method or standard.



Morehouse Measurement Uncertainty Calibration and Measurement Capability Worksheet

START ON THIS SHEET AND FILL IN ONLY LIGHT GREY BOXES

SECTION 1 DATA ENTRY			NOTE: ONLY ENTER INFORMATION IN LIGHT GREY BOXES
Laboratory	Morehouse		
Technician Initials	HZ		All information entered must converted to like units.
Date:	2/26/2016		This spreadsheet is provided by Morehouse Instrument Company
Range	1K-5 K		It is to be used as a guide to help calculate CMC
Standards Used Ref and UUT	Ref S/N U-7644 UUT S/N Test		
Resolution UUT	0.1	LBF	This is the resolution of the Unit Under Test you are Using for the Repeatability Study (What you are testing)
REFERENCE STANDARD INFORMATION			
ASTM E74 LLF *	0.231	LBF	* This is your ASTM E74 LLF Found on Your ASTM E74 Report. It will be converted to a pooled std dev (drop down for non ASTM)
Resolution of Reference	0.023	LBF	This should be found on your calibration report.
Temperature Spec per degree C %	0.0015%		This is found on the load cell specification sheet. Temperature Effect on Sensitivity, % RDG/100 F
Max Temperature Variation per degree C of Environment	1		During a typical calibration in a tightly controlled the temperature varies by no more than 1 degree C.
Morehouse CMC	0.0016%		This is the CMC statement for the range calibrated found on the certificate of calibration. Leave blank if entering Eng. Units
Miscellaneous Error	0.003	%	This can be creep, side load sensitivity or other known error sources. Enter and select Eng. Units or %
Conv Repeatability Data To Eng. Units	YES		

Ref Standard Stability / **Temperature Effect**

	FORCE APPLIED	Change From Previous %	Interporlated 0	Actual LBF	Temperature Effect 0.000015
1	300	0.0500%	0.15	0.15	0.0045
2	600	0.0500%	0.15	0.3	0.009
3	900	0.0500%	0.30	0.45	0.0135
4	1200	0.0500%	0.60	0.6	0.018
5	1500	0.0500%	0.75	0.75	0.0225
6	1800	0.0500%	0.90	0.9	0.027
7	2100	0.0500%	1.05	1.05	0.0315
8	2400	0.0500%	1.20	1.2	0.036
9	2700	0.0500%	1.35	1.35	0.0405
10	3000	0.0500%	1.50	1.5	0.045
11					
12					

Repeatability of UUT

	Applied	Run1	Run2	Run3	Run4	Average	Resolution	STD DEV	CONVERTED
1	300.00	300.5	300.5	300.6	300.6	300.55	0.998170022	0.05773503	0.05762937
2	600.00	600.9	600.8	600.8	600.8	600.825	0.998626888	0.05000000	0.04993134
3	900.00	901.1	900.9	901	901	901	0.998890122	0.08164966	0.08155904
4	1200.00	1201.3	1201.1	1201.2	1201.2	1201.2	0.999000999	0.08164966	0.08156809
5	1500.00	1501.4	1501.2	1501.4	1501.4	1501.35	0.999100809	0.10000000	0.09991008
6	1800.00	1801.4	1801.2	1801.3	1801.3	1801.3	0.999278299	0.08164966	0.08159073
7	2100.00	2101.4	2101.3	2101.4	2101.4	2101.375	0.999345667	0.05000000	0.04996728
8	2400.00	2401.4	2401.3	2401.4	2401.4	2401.375	0.999427411	0.05000000	0.04997137
9	2700.00	2701.4	2701.4	2701.3	2701.3	2701.35	0.99950025	0.05773503	0.05770617
10	3000.00	3001.2	3001.3	3001.4	3001.5	3001.35	0.999550202	0.12909944	0.12904138
11									
12									
						Avg Std Dev of Runs		0.07799573	0.07793211

Ref Laboratory Uncertainty Per Point / **MUST SELECT**

Force	%	Eng. Units	Conv %	Force	% or Eng.
300	0.0016%		0.000016	300	%
600	0.0016%		0.000016	600	%
900	0.0016%		0.000016	900	%
1200	0.0016%		0.000016	1200	%
1500	0.0016%		0.000016	1500	%
1800	0.0016%		0.000016	1800	%
2100	0.0016%		0.000016	2100	%
2400	0.0016%		0.000016	2400	%
2700	0.0016%		0.000016	2700	%
3000	0.0016%		0.000016	3000	%
	0.0016%		0.000016		%
	0.0016%		0.000016		%

Figure Above: Image of Morehouse CMC Worksheet.

Full instructions on how to use this spreadsheet can be found here.

If you are interested in calculating or need help with calculating your force CMC's Morehouse Developed a Calibration and Measurement Capability worksheet for instruments calibrated in accordance with the ASTM E74 standard. This sheet can be downloaded at: http://www.mhforce.com/s/cmc-calculations-for-force-measurements.xlsx

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NEW PRODUCT ANNOUNCEMENT

In Stock by April 22, 2016

Upcoming Events

June 13 & September 13, 2016 *Implementing Metrology and SPC concepts with MS Excel*, Instructor **Dilip Shah**

This one-day workshop prepares the metrology professional to apply the power of Microsoft Excel's mathematical and statistical tools to assist in managing the laboratory's Quality Management System, including Measurement Uncertainty. The class serves as a prerequisite for the Measurement Uncertainty workshop and reduces the amount of time spent learning both the Excel and Measurement Uncertainty estimation techniques at the same time.

June 14-15 & September 14-15, 2016 Applied Fundamentals of Force Calibration, Instructors **Henry Zumbrun (Morehouse)** and **Dilip Shah (E=mc^3 Solutions)**

This course will cover applied force calibration techniques and will include live demonstrations using secondary standards to exhibit potential errors made in everyday force measurements. The measurement errors demonstrated and discussed will include errors associated with improper alignment, use of different and/or incorrect adapter types, thread depth and thread loading. The course will cover the basics of measurement uncertainty and will provide the tools for anyone to be able to estimate Measurement Uncertainty for a Scope of Accreditation CMC or to report a customer's measurement uncertainty.

June 16-17, 2016 ISO/IEC 17025 Implementation, Instructor **Dilip Shah**

This 2-day workshop provides a general framework of tools for the laboratory seeking ISO/IEC accreditation. Attendees shall learn how to interpret the standard and what is required of the laboratory to successfully get accredited the first time.

Thank You and Future Newsletters

If you've made it this far, I would like to extend a giant "thank you" for reading our sixth newsletter.

Do you have a topic you would like to see covered, or would you like to submit a guest article for an upcoming newsletter?

Please feel free to contact us with topic suggestions, article proposals or feedback. We are continually looking to improve the content of our newsletter!

Please email any correspondence to hzumbrun@mhforce.com

Web Page Links:

Training Class
http://www.mhforce.com/customer-education

Morehouse CMC sheet instructions.
http://blog.mhforce.com/2015/11/measurement-uncertainty-calibration-and.html

The only force that moves us is
Quality Service & Satisfaction

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