CAL LAB

THE INTERNATIONAL JOURNAL OF METROLOGY

3 Bar Versus 2 Bar Universal Calibrating Machines Comparison Test

The Effects of Loading Pad Hardness on the Calibration Results of Force Transducers

Using Robotic Comparators in Mass Calibration

10 Things to Know About Achieving ISO/IEC 17025 Accreditation

2016
APRIL
MAY
JUNE

Electric Current Measurement

DS Series Current Transducers

±300A to ±8000A, high accuracy for Power Analyzers and improved performance for Power Amplifiers

- Very high absolute amplitude and phase accuracy from dc to over 1kHz
- Low signal output noise
- Low fluxgate switching noise on the pimary
- Enhanced electrostatic shielding to increase rejection of primary dV/dt coupling
- Increased operating temperature range
- Reduced mechanical dimensions
- Options: Voltage Output Signal; Calibration Winding
- Amplitude and Phase measurement to 300kHz included with each head

DS200

DS2000

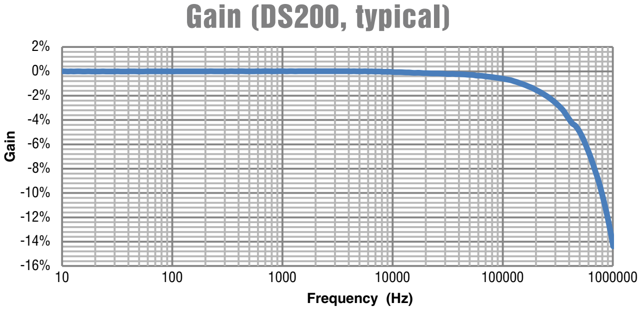
	DS200	DS600	DS2000	DS5000
Primary Current, rms	200A	600A	2000A	5000A
Primary Current, Peak	±300A	±900A	±3000A	±7000A
Turns Ratio	500:1	1500:1	1500:1	2500:1
Output Signal (rms/Peak)	0.4A/±0.6A†	0.4A/±0.6A†	1.33A/±2A†	2A/±3.2A†
Overall Accuracy	0.01%	0.01%	0.01%	
Offset	<20ppm	<10ppm	<10ppm	<5ppm
Linearity	<1ppm	<1ppm	<1ppm	<1ppm
Operating Temperature	-40 to 85˚C	-40 to 85˚C	-40 to 85˚C	0 to 55˚C
Aperature Diameter	27.6mm	27.6mm	68mm	150mm

Bandwidth Bands for Gain and Phase Error	DS200			DS600			DS2000			DS5000	
	<5kHz	<100kHz	<1MHz	<2kHz	<10kHz	<100kHz	<500Hz	<1kHz	<10kHz	<5kHz	<20kHz
Gain (sensitivity) Error	0.01%	0.5%	20%	0.01%	0.5%	3%	0.01%	0.05%	3%	0.01%	1%
Phase Error	0.2˚	4˚	30˚	0.1˚	0.5˚	3˚	0.01˚	0.1˚	1˚	0.01˚	1˚

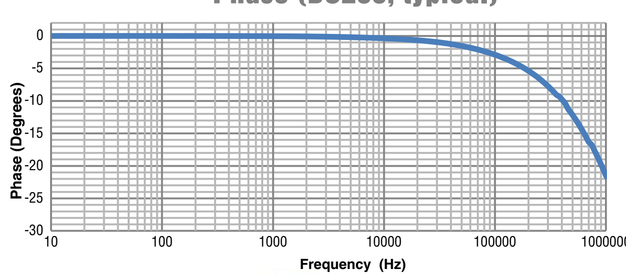
† Voltage Output options available in ±1V and ±10V

Gain / Phase

Gain (DS200, typical)



Phase (DS200, typical)



DSSIU-4 for Multi Channel Systems

4-channel Transducer Interface Unit and Power Supply improved performance for Power Amplifiers

- Power and Signal connections for up to four Current Transducer heads
- Heads may be mixed (e.g.: One DS2000 Head and three DS200 Heads)

DSSIU-4

Volume 23, Number 2

CAL LAB
THE INTERNATIONAL JOURNAL OF METROLOGY
www.callabmag.com

FEATURES

DEPARTMENTS

ON THE COVER: Hygrometer calibration using the Model 1200 Two-Pressure Humidity standard at Thunder Scientific located in Albuquerque, NM. Thunder Scientific, a NVLAP accredited calibration laboratory, is celebrating 50 years in the business of humidity metrology this year.

CALENDAR

UPCOMING CONFERENCES & MEETINGS

Jun 21-23, 2016 North American Custody Transfer Measurement Conference. San Antonio, TX. The conference will include all types of custody transfer measurement in addition to ultrasonic meter measurement. You will be able to hear speakers discuss a wide variety of fluid measurement issues and potential solutions. http://www.ceesi.com/SanAntonio2016.

Jun 22-23, 2016 METROAEROSPACE. Florence, Italy. 3rd IEEE International Workshop on Metrology for Aerospace is designed to raise the interest of a wide group of researchers, operators and decision-makers from metrology and aerospace fields, by presenting the most innovative solutions in this field from the scientific and technological point of view. http://www.metroaerospace.org/.

Jun 27-28, 2016 14th IMEKO TC10 Workshop on Technical Diagnostics – Milan, Italy. "New Perspectives in Measurements, Tools and Techniques for system's reliability, maintainability and safety." Forum where people involved with technical diagnostics, from different specialized areas, may compare their experiences and present solutions for actual and further requirements. http://www.imekotc10-2016.deib.polimi.it/

Jul 10-15, 2016 Conference on Precision Electromagnetic Measurements (CPEM). Ottawa, Canada. Hosted by the National Research Council of Canada, this biennial conference is the premier international forum for the exchange of information on precision electromagnetic measurements. http://www.cpem2016.com.

Jul 24-28, 2016 NCSL International Workshop & Symposium. Saint Paul, MN. The theme of this year's event is "Measurement Accuracy and the Impact on Society." http://www.ncsli.org.

Aug 9-10, 2016 Standards for Microbiome Measurements Workshop. Gaithersburg, MD. NIST & NIH. This workshop will seek input on defining reference materials, reference data and reference methods for microbiome community measurements. http://www.nist.gov/mml/microbiome-standards.cfm.

Oct 12, 2016 Strategic Automation Leadership Conference. Reasearch Triangle Park, NC. Hosted by the International Society of Automation (ISA) and Beamex, Inc., this event will showcase the latest insights, trends and best practices for process plant operators seeking to improve calibration quality, safety, accuracy and profitability. https://www.isa.org/strategicautomation2016/.

CAL LAB
THE INTERNATIONAL JOURNAL OF METROLOGY

ISSN No. 1095-4791

EDITOR'S DESK

Spring

Our friend Dave Nebel passed away on April 18th at the age of 78. Dave was actively involved in the metrology community well after his career days. Cal Lab Magazine knew Dave through his incredible volunteer activities with the National Conference of Standards Laboratories (NCSL International). As Cal Lab Solutions, we also knew Dave through his old USAF PMEL buddies. His enthusiasm for the measurement community and his companionship will be missed.

❧

The Measurement Science Conference (MSC) at Disneyland in Anaheim this past March was a refreshing change from previous years. The venue layout flowed much better in a smaller footprint and the tutorial and speaker lineup was excellent. I overheard attendees remark that attendance was especially strong—people filled out each of the speaker luncheons to capacity, even until the end when exhibitors typically bail and attendees disappear into the park with their families.

I get to see and talk with our advertisers while at the shows, but more and more we exchange the 'nod' as they are busy with tutorials and talking with customers. So we follow up with emails and that's where coming home from a conference is like Christmas, with paper submissions in my inbox! As a result, in this spring issue, we have an article from Morehouse Instrument Company comparing repeatability and reproducibility results of 2 bar versus 3 bar universal calibrating machines, "3 Bar Versus 2 Bar Universal Calibrating Machines Comparison Test."

Coincidentally, the National Institute for Standards of Egypt also contributed an article on force, investigating "The Effects of Loading Pad Hardness on the Calibration Results of Force Transducers."

And switching gears, Mettler Toledo contributed an article on mass, "Using Robotic Comparators in Mass Calibration," while "10 Things to Know about Achieving ISO/IEC 17025 Accreditation," was contributed by the American Association for Laboratory Accreditation (A2LA).

Happy Measuring,

Sita Schwartz

CALENDAR

SEMINARS: Analytical

Jul 24, 2016 T11 - Analytical Forensic Metrology. St. Paul, MN (NCSLI Workshop & Symposium). This 1/2 day tutorial provides a basic introduction to chemical metrology and its relevance to the many facets of the overall analytical measurement process in quantitative forensic analysis. http://www.ncsli.org.

Jul 25, 2016 T18 - Effective Calibration Interval Analysis. St. Paul, MN (NCSLI Workshop & Symposium). This tutorial targets the fundamental concepts and practices upon which to establish, evaluate, or modify systems and procedures to start or revive an effective manual or automated interval analysis system. http://www.ncsli.org.

SEMINARS: Dimensional

Jun 6-7, 2016 Hands-On Gage Calibration and Repair. Houston, TX. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Jun 9-10, 2016 Hands-On Gage Calibration and Repair. Oklahoma, OK. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Jun 6-8, 2016 Dimensional Measurement Training. Level 1 – Measurement User. Coventry, United Kingdom. NPL. A three day training course introducing dimensional metrology, the importance of good measurement practice and the right measurement behaviours. http://www.npl.co.uk/

Jun 13-16, 2016 Dimensional Measurement Training. Level 2 – Measurement Applier. Coventry, United Kingdom. NPL. A four day training course building on the knowledge and measurement principles gained through the Level 1 training course. http://www.npl.co.uk/

Jun 21-23, 2016 Hands-On Gage Calibration. Aurora (Chicago), IL. Mitutoyo Institute of Metrology. The Hands-On Gage Calibration course is a unique, active, educational experience designed specifically for those who plan and perform calibrations of dimensional measuring tools, gages, and instruments. http://www.mitutoyo.com/support/mitutoyo-institute-of-metrology/.

CALENDAR

Jun 23-24, 2016 Hands-On Gage Calibration and Repair. Bloomington, MN. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Jul 4-6, 2016 Dimensional Measurement Training. Level 1 – Measurement User. Coventry, United Kingdom. NPL. A three day training course introducing dimensional metrology, the importance of good measurement practice and the right measurement behaviours. http://www.npl.co.uk/

Jul 11-12, 2016 Hands-On Gage Calibration and Repair. Hartford, CT. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Jul 12-14, 2016 Hands-On Gage Calibration. Aurora (Chicago), IL. Mitutoyo Institute of Metrology. The Hands-On Gage Calibration course is a unique, active, educational experience designed specifically for those who plan and perform calibrations of dimensional measuring tools, gages, and instruments. http://www.mitutoyo.com/support/mitutoyo-institute-of-metrology/.

Jul 14-15, 2016 Hands-On Gage Calibration and Repair. Cleveland, OH. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Jul 24, 2016 T7 - Geometric Dimensioning & Tolerancing (GD&T) Basics Workshop. (NCSLI Workshop & Symposium). A basic introduction to the concepts of GD&T as defined in ASME Y14.5. Both the 1994 and 2009 standard will be covered. This course is suitable for those individuals needing a basic understanding of the concepts related to 2D drawings and CAD model definition. http://www.ncsli.org.

Jul 25, 2016 T17 - Intermediate Dimensional Metrology. St. Paul, MN (NCSLI Workshop & Symposium). This one-day tutorial will be an overview of important techniques and concepts not covered in books and classes. Each concept will be presented with examples of how the techniques make measurements more accurate, and in some cases, more efficient. http://www.ncsli.org.

Aug 2-4, 2016 Hands-On Gage Calibration. Aurora (Chicago), IL. Mitutoyo Institute of Metrology. The Hands-On Gage Calibration course is a unique, active, educational experience designed specifically for those who plan and perform calibrations of dimensional measuring tools, gages, and instruments. http://www.mitutoyo.com/support/mitutoyo-institute-of-metrology/.

CALENDAR

Aug 4-5, 2016 Hands-On Gage Calibration and Repair. Billings, MT. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Aug 8-9, 2016 Hands-On Gage Calibration and Repair. Portland, OR. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Aug 11-12, 2016 Hands-On Gage Calibration and Repair. San Francisco, CA. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Aug 15-16, 2016 Hands-On Gage Calibration and Repair. Los Angeles, CA. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Aug 18-19, 2016 Hands-On Gage Calibration and Repair. Las Vegas, NV. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Sep 7-8, 2016 Hands-On Gage Calibration and Repair. Blaine, MN. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Sep 21-22, 2016 Hands-On Gage Calibration and Repair. Kansas City, KS. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

SEMINARS: Electrical

Jul 11-14, 2016 MET-101 Basic Hands-on Metrology. Everett, WA. Fluke Calibration. This course introduces the student to basic measurement concepts, basic electronics related to measurement instruments and math used in calibration. http://us.flukecal.com/training/courses/MET-101.

CALENDAR

Jul 25, 2016 T13 - So You Think You Know DC Resistance and Current Measurements. St. Paul, MN (NCSLI Workshop & Symposium). This one-day tutorial will cover a resistance range from 1 μΩ to 100 TΩ, and current ranges from 1 mA to 1000A. http://www.ncsli.org.

Sep 7-9, 2016 Instrumentation for Test and Measurement. Las Vegas, NV. Technology Training, Inc. (TTI). To give students enough applications information that they can select optimum transducer, amplifier, recording and readout devices to assemble a system for routine measurements of environmental and dynamic phenomena. http://www.ttiedu.com/.

Sep 26-29, 2016 MET-301 Advanced Hands-on Metrology. Everett, WA. Fluke Calibration. This course introduces the student to advanced measurement concepts and math used in standards laboratories. http://us.flukecal.com/training/courses/MET-301.

Oct 3-6, 2016 MET-101 Basic Hands-on Metrology. Everett, WA. Fluke Calibration. This course introduces the student to basic measurement concepts, basic electronics related to measurement instruments and math used in calibration. http://us.flukecal.com/training/courses/MET-101.

SEMINARS: Flow & Pressure

Jul 24, 2016 T4 - Pressure Metrology. St. Paul, MN (NCSLI Workshop & Symposium). This full day tutorial covers all the fundamental challenges of calibrating pressure instruments. http://www.ncsli.org.

Sep 19-23, 2016 Principles of Pressure Calibration. Phoenix, AZ. Fluke Calibration. A five day training course on the principles and practices of pressure calibration using digital pressure calibrators and piston gauges (pressure balances). http://us.flukecal.com/Principles-of-Pressure.

Oct 17-21, 2016 Advanced Piston Gauge Metrology. Phoenix, AZ. Fluke Calibration. Focus is on the theory, use and calibration of piston gauges and dead weight testers. http://us.flukecal.com/Advanced-Piston-Gauge-Metrology.

SEMINARS: Force & Torque

Jul 24, 2016 T10 - Force Calibration. St. Paul, MN (NCSLI Workshop & Symposium). This tutorial will cover applied force calibration techniques and will include live demonstrations using secondary standards to exhibit potential measurement errors made in everyday force measurement. http://www.ncsli.org.

Jul 25, 2016 T20 - Fundamentals of Torque Calibration. St. Paul, MN (NCSLI Workshop & Symposium). An overview of torque standards including ASTM-E2428 and BS7882, uncertainty of torque calibration standards, Type A and B uncertainty analysis, torque calibration equipment, calibration and testing of torque transducers, proper calibration techniques, error sources associated with torque calibration, and why proper torque measurement is more than just a traceable length and mass calibration. http://www.ncsli.org.

SEMINARS: General & Management

Jun 24, 2016 Root Cause Analysis and Corrective Action. Frederick, MD. A2LA. The RCA/CA course consists of presentations, discussions and exercises that provide participants with an in-depth understanding of how to analyze a system in order to identify the root causes of problems and to prevent them from recurring. http://www.a2la.org/training/index.cfm.

Jul 25, 2016 T14 - Application of Calibration Data in a Testing Lab. St. Paul, MN (NCSLI Workshop & Symposium). This tutorial will ask and answer the question: "What should you do with equipment calibration data after you get it?" http://www.ncsli.org.

Jul 25, 2016 T15 - Applying LEAN in a Calibration Laboratory Environment. St. Paul, MN (NCSLI Workshop & Symposium). This updated, hands-on, and practical interactive one-day tutorial provides participants with a basic knowledge of the history and principles of LEAN and how those principles can apply to a calibration laboratory environment. http://www.ncsli.org.

Jul 25, 2016 T16 - Auditing, Traceability, and Auditing Traceability. St. Paul, MN (NCSLI Workshop & Symposium). This one day tutorial examines the principles of auditing, the concepts of metrological traceability and the tools to apply auditing principles in demonstrating your organization's chain of traceability for its measurement results. http://www.ncsli.org.

Aug 18, 2016 Interactive Workshop: Best Calibration Practices. Houston, TX. ISA and Beamex. This workshop is designed to equip engineers and technicians in the field with strategies for improving daily maintenance processes and tasks. Tactics for strengthening accuracy and quality, while saving time and lowering risks will be taught by industry experts. https://www.isa.org/calibrationworkshop2016/.

Sep 21, 2016 Root Cause Analysis and Corrective Action. Indianapolis, IN. A2LA. The RCA/CA course consists of presentations, discussions and exercises that provide participants with an in-depth understanding of how to analyze a system in order to identify the root causes of problems and to prevent them from recurring. http://www.a2la.org/training/index.cfm.

Oct 5, 2016 Root Cause Analysis and Corrective Action. Frederick, MD. A2LA. The RCA/CA course consists of presentations, discussions and exercises that provide participants with an in-depth understanding of how to analyze a system in order to identify the root causes of problems and to prevent them from recurring. http://www.a2la.org/training/index.cfm.

SEMINARS: Industry Standards

Jun 6-7, 2016 Introduction to ISO/IEC 17025. Greenville, SC. ANAB. This course helps you understand and apply the requirements of the ISO/IEC 17025:2005 standard. You'll examine its origins and learn document control, internal auditing, proficiency testing, traceability, measurement uncertainty, and method witnessing. http://asq.org/training/introduction-to-iso-iec-17025_INTRO17.html.

Jun 6-8, 2016 ISO 17025 Testing. Los Angeles, CA. International Accreditation Service (IAS). Analysis of ISO/IEC 17025 standard, Management and Technical requirements for Testing and Calibration Laboratories, IAS Assessment process, Auditing techniques. http://www.iasonline.org.

Jun 6-12, 2016 ISO/IEC 17025 Lead Assessor Training. Greenville, SC. ANAB. Want to learn better audit practices using the ISO/IEC 17025 standard? This course will prepare you to meet technical demands of the standard while providing practical exercises to aid comprehension. http://www.asq.org/courses/iso-iec-17025-lead-assessor.html.

Jun 12-17, 2016 Assessment of Laboratory Competence. A2LA. Frederick, MD. This course is a comprehensive look at the ISO/IEC 17025:2005 requirements and a detailed approach to the assessment of a laboratory's competence. http://www.a2la.org/training/index.cfm.

Jun 22-23, 2016 Internal Auditing. A2LA. Frederick, MD. This 2-day training course practices the internationally-recognized approaches of ISO 19011:2011 to conducting effective internal audits. http://www.a2la.org/training/index.cfm.

Jun 24, 2016 Fundamentals of SOP Writing. A2LA. Frederick, MD. Using the ISO/IEC accreditation standards and information provided during the class, participants will review the basic concepts of procedure structure, content, and development; will practice developing Standard Operation Procedures, both technical and administrative. http://www.a2la.org/training/index.cfm.

Jul 18-20, 2016 ISO 17025 Testing. Chicago, IL. International Accreditation Service (IAS). Analysis of ISO/IEC 17025 standard, Management and Technical requirements for Testing and Calibration Laboratories, IAS Assessment process, Auditing techniques. http://www.iasonline.org.

July 19-21, 2016 Internal Auditing to ISO/IEC 17025. Alexandria, VA. ANAB. This course prepares an internal auditor to clearly understand technical issues relating to an audit. You'll learn how to more effectively collect audit evidence and report your findings. http://anab.org/training/.

July 24, 2016 Understanding ISO/IEC Requirements. St. Paul, MN (NCSLI Workshop & Symposium). Full-day tutorial will cover highlights of ISO/IEC 17025 requirements. http://www.ncsli.org.

Sep 19-20, 2016 Internal Auditing. A2LA. Indianapolis, IN. This 2-day training course practices the internationally-recognized approaches of ISO 19011:2011 to conducting effective internal audits. http://www.a2la.org/training/index.cfm.

Sep 21-22 ISO/IEC 17025:2055 and Laboratory Accreditation. Detroit, MI. A2LA. This course is an introductory look at ISO/IEC 17025 and its requirements for demonstrating the technical competence of testing and calibration laboratories. http://www.a2la.org/training/index.cfm.

Sep 22-23, 2016 Introduction to ISO/IEC 17025. Atlanta, GA. ANAB. Examine the ISO/IEC 17025:2005 standard's origins and learn practical concepts like document control, internal auditing, proficiency testing, traceability, measurement uncertainty, and method witnessing. http://asq.org/training/introduction-to-iso-iec-17025_INTRO17.html.

Sep 23, 2016 Fundamentals of SOP Writing. Detroit, MI. A2LA. Review the basic concepts of procedure structure, content, and development; practice developing Standard Operation Procedures. http://www.a2la.org/training/index.cfm.

Sep 28-29, 2016 ISO/IEC 17025:2055 and Laboratory Accreditation. Frederick, MD. A2LA. This course is an introductory look at ISO/IEC 17025 and its requirements for demonstrating the technical competence of testing and calibration laboratories. http://www.a2la.org/training/index.cfm.

Sep 30, 2016 ISO/IEC 17025: 2005 Advanced: Beyond the Basics. Frederick, MD. A2LA. This is an advanced course in the application of ISO/IEC 17025 requirements. http://www.a2la.org/training/index.cfm.

SEMINARS: Mass & Weight

Jul 24, 2016 Traceability, Operations, and Good Measurement Practices for Balances in an Analytical Environment. St. Paul, MN (NCSLI Workshop & Symposium). Designed for the beginner to advanced user of balances, calibration managers, quality managers, ISO/IEC 17025 assessors, and those wanting a better understanding of accurate weighing methods where analytical weighing is an integral part of operations. http://www.ncsli.org.

Oct 24-Nov 4, 2016 Mass Metrology Seminar. Gaithersburg, MD. NIST Office of Weights and Measures. This two-week, "hands-on" seminar incorporates approximately 30 percent lectures and 70 percent demonstrations and laboratory work in which the trainee performs measurements by applying procedures and equations discussed in the classroom. Successful completion of the Fundamentals of Metrology Seminar is a prerequisite for the Mass Metrology Seminar. http://www.nist.gov/pml/wmd/5386.cfm.

CALENDAR

SEMINARS: Measurement Uncertainty

Jun 14-15, 2016 Measurement Uncertainty (per ILAC P14 Guidelines). Boston, MA. WorkPlace Training. This workshop introduces basic measurement uncertainty and traceability concepts. The concepts taught are then put in practice by developing sample measurement uncertainty budgets. http://www.wptraining.com.

Jul 21-22, 2016 Uncertainty of Measurement. Chicago, IL. International Accreditation Service (IAS). Introduction to metrology principles, learn how to calculate UoM, many examples and practical exercises. http://www.iasonline.org.

Jul 24, 2016 T6 - Control Charts and Stability Analysis for Calibration Laboratory Reference Standards. (NCSLI Workshop & Symposium). This tutorial provides instruction on how to develop control charts for reference standards utilized in the calibration laboratory. http://www.ncsli.org.

Jul 25, 2016 T19 - Test Uncertainty. St. Paul, MN (NCSLI Workshop & Symposium). This tutorial will explore the test uncertainty concepts in ISO 14253-5, explain how it is beginning to impact dimensional metrology calibrations, and discuss how it may eventually impact all calibrations that involve verification to specifications. http://www.ncsli.org.

Sep 19-20, 2016 Introduction to Measurement Uncertainty. A2LA. Detroit, MI. Every effort is made to eliminate unnecessary complications, to apply The Guide to the Expression of Uncertainty in Measurement (GUM) at its simplest level and to take away the mystery associated with measurement uncertainty. http://www.a2la.org/training/index.cfm.

Sep 21-22, 2016 Measurement Uncertainty Advanced Topics. A2LA. Detroit, MI. The advanced course is designed to expand and extend the topics in the introductory course to include: metrology and accreditation, measurement uncertainty estimation, statistical methods for measurement uncertainty, applying the GUM, determining sensitivity and correlation coefficients , useful rules of thumb, satisfying the assessor, determining calibration intervals, guard-banding, risk, and the Z540.3 standard. http://www.a2la.org/training/index.cfm.

Oct 11-13, 2016 Introduction to Measurement Uncertainty. Everett, WA. Fluke Calibration. MET-302 Hands-On Metrology Statistics is a three-day course that will teach you how to develop uncertainty budgets and to understand the necessary calibration processes and techniques to obtain repeatable results. http://us.flukecal.com/training/courses/MET-302.

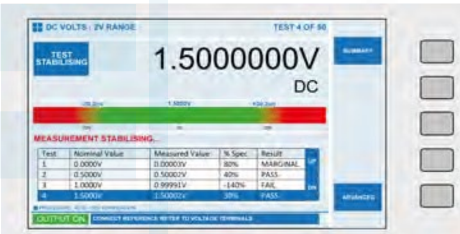
4010A

ADVANCED Multi-Product Calibrator

New Features ·VARIABLE RESISTANCE ·VARIABLE CAPACITANCE ·AC CURRENT TO 30kHz ·SCOPES TO 6GHz

CAPABILITIES

- AC/DC Voltage to 1025V
- AC/DC Current to 30A
- 2&4 Wire Resistance to 1G
- Capacitance to 10mF
- Inductance to 10H
- Frequency to 10MHz
- RTD/PRT Simulation
- AC/DC Power Calibration
- Oscilloscope Calibration



BUILT-IN CALIBRATION SOFTWARE

The 4010 incorporates user friendly software allowing the user to create, run, and store procedures without the need for a PC.

ADVANCED AUTO VALIDATION

The 4010 integrates a unique auto validation system. By connecting a precision multimeter, such as the Transmille 8081, the 4000 Series can perform a sequence of measurements for specific ranges and functions and produce a detailed report.

ADVANCED USER ASSISTANCE

Customized UUT connection diagrams or messages can also be loaded onto the system, to provide instrument specific wiring connection or calibration instructions to the user.

TRANSMILLE
Solutions In Calibration

+1(802) 846-7582
www. transmillecalibration.com

SEMINARS: Microwave

Jul 25, 2016 T23 - Microwave Measurement Basics. St. Paul, MN (NCSLI Workshop & Symposium). An introduction to the measurement concepts for microwave power and scattering-parameters will be covered. http://www.ncsli.org.

Jul 25, 2016 T25 - Microwave Power Sensor Calibration. St. Paul, MN (NCSLI Workshop & Symposium). This tutorial focuses on the calibration laboratory practice of calibrating RF Power sensors, using low-power coaxial sensors as the example. http://www.ncsli.org.

SEMINARS: Software

Jun 20-24, 2016 Basic MET/CAL® Procedure Writing. Everett, WA. Fluke Calibration. In this five-day basic MET/CAL procedure writing course, you will learn to configure MET/CAL software to create, edit, and maintain calibration solutions, projects and procedures. http://us.flukecal.com/software-training.

Jul 24, 2016 T27 - Introduction to Automated Calibration using Microsoft VB.NET®, C# and Metrology.NET®. St. Paul, MN (NCSLI Workshop & Symposium). During this 1/2 day tutorial, learn how to write and deploy automated metrology software using VB.NET and C#. Attendees will learn how to use the Metrology.NET tools to develop automation capable of running multiple calibrations on a single workstation. http://www.ncsli.org.

Jul 24-25, 2016 T1 - An Introduction to Instrument Control and Calibration Automation in LabVIEW™. St. Paul, MN (NCSLI Workshop & Symposium). This two-day tutorial will explore the LabVIEW environment, instrument control, data-logging, and measurement analysis applications. http://www.ncsli.org.

Aug 22-26, 2016 Basic MET/CAL® Procedure Writing. Everett, WA. Fluke Calibration. In this five-day basic MET/CAL procedure writing course, you will learn to configure MET/CAL software to create, edit, and maintain calibration solutions, projects and procedures. http://us.flukecal.com/software-training.

Oct 24-28, 2016 Advanced MET/CAL® Procedure Writing. Everett, WA. This five-day in-depth workshop is for experienced MET/CAL programmers who wish to enhance their procedure writing skills. Students will focus on the use of instrument communication with the IEEE, PORT, VISA, MATH and LIB FSCs, the use of memory registers in procedures, and will create a complex procedure using live instrumentation. http://us.flukecal.com/software-training.

SEMINARS: Temperature & Humidity

Jul 25, 2016 T21 - Fundamentals of Temperature Calibration. St. Paul, MN (NCSLI Workshop & Symposium). This segment is intended for those who are new to temperature calibration, or those who need to validate what they already know and get updated on current trends. http://www.ncsli.org.

Jul 25, 2016 T22 - The Humidity Calibration Tutorial. St. Paul, MN (NCSLI Workshop & Symposium). This tutorial will provide an overview of basic information regarding humidity definitions, dew point, frost point, and relative humidity. Participants will practice humidity calculations and conversions along with basic humidity uncertainty calculations using the HumiCalc with Uncertainty software. http://www.ncsli.org.

Jul 25, 2016 T24 - Advanced Topics of Temperature Calibration. St. Paul, MN (NCSLI Workshop & Symposium). This tutorial continues to build on the principles established in the Fundamentals of Temperature Calibration course. The objective of this course is to deliver the concepts needed to help a Metrologist or other calibration professional design an accredited temperature calibration process. http://www.ncsli.org.

Jul 25, 2016 T26 - Fundamentals of Radiation Thermometry Calibration. St. Paul, MN (NCSLI Workshop & Symposium). This presentation is an overview of the basic knowledge necessary to perform radiation thermometer calibrations. http://www.ncsli.org.

Sep 20-22, 2016 Practical Temperature Calibration Training. American Fork, UT. Fluke Calibration. http://us.flukecal.com/tempcal_training.

SEMINARS: Vibration

Jul 24, 2016 T12 - Dynamic Sensors & Calibration. St. Paul, MN (NCSLI Workshop & Symposium). This four-hour tutorial on vibration calibration will dive into calibration theory, standards, and methodology for dynamic sensors as well as explanations of different sensor types and the operational theories behind them. Target audience is beginner to intermediate level. http://www.ncsli.org.

Sep 19-21, 2016 Fundamentals of Vibration for Test Applications. Las Vegas, NV. Technology Training Inc. Covers topics associated with vibration and shock applications in order to enable course participants to acquire a basic understanding of the complex field of vibration and shock. http://www.ttiedu.com.

Visit **www.callabmag.com**
for upcoming metrology webinars!

Head to Head: Photonic Pressure Sensors vs. Mercury-Based Standard

When a team of researchers at NIST's Physical Measurement Laboratory (PML) first tested a new kind of pressure sensor two years ago, initial results showed it was faster and had higher resolution than the traditional, centuries-old mercury-based method for measuring pressure. The novel device, called the Fixed Length Optical Cavity (FLOC), works by detecting subtle changes in the frequency of light passing through a nitrogen gas-filled cavity about the size of a box of tissues.

Now the same research team has thoroughly vetted the FLOC against the U.S. mercury-based pressure standard, currently a world leader in pressure measurement. Their verdict: The photonic sensor performs better than expected and, in fact, outperforms the traditional mercury system at low pressure ranges. The work was carried out jointly by a team of NIST scientists from PML's Sensor Science Division and Engineering Physics Division.

"This is the biggest fundamental change to pressure measurement since the invention of the mercury manometer in 1643," says Jay Hendricks, PML's Thermodynamic Metrology Group Leader. "This breakthrough will enable development of smaller and smaller standards and possibly chip-scale primary pressure standards in the future. Additionally, this technique can cover up to nine decades of pressure, a task that currently requires six different primary standards."

Until now, the most reliable way to measure pressure has used a technique invented almost 400 years ago, involving a column of mercury whose height changes with pressure. But this type of device – called a manometer – is relatively slow, taking about a minute per measurement. It's also bulky. The current U.S. primary pressure standard is a mercury manometer 3 meters (about 10 feet) tall, that extends through the ceiling of the laboratory in which it is housed. Furthermore, manometers typically require mercury,* a toxin whose use is currently being phased out of products and manufacturing internationally.

The FLOC, by contrast, is mercury-free and consists of a chamber approximately 15.5 cm (about 6 inches) long by 5 cm (about 2 inches) square, a fraction of the size of the U.S. standard manometer. The device works by comparing the changes in optical path length between a pair of mirrors attached to two separate channels, one in vacuum and the other filled with ultra high-purity nitrogen gas.

"The length of each channel is measured by tuning the frequency of a laser so that a standing wave is set up between the mirrors," says PML's Jacob Ricker. Ricker explains that when gas is pumped into the nitrogen channel (i.e. as the gas pressure increases), it takes the light a longer time to bounce between the mirrors. So the effect they measure is the same as if the channel were being physically lengthened. (Changes in pressure do physically distort the channels slightly, but the researchers have measured and characterized this source of noise so they know what to expect.) The property of gas that changes the speed of light is known as the material's index of refraction.

With a change of pressure in the gas-filled channel, the frequency of the laser light bouncing around in that channel must change, too, in order to maintain a standing wave. The team has designed their system to compare this frequency change to the frequency of light in the vacuum channel, which remains the same. Measuring the changing frequency of the light in the gas-filled channel allows researchers to determine the gas' index of refraction, a quantity that lets them work out the pressure. (For more information about how the FLOC works, see "World's First Photonic Pressure Sensor Outshines Traditional Mercury Standard," [online at: http://www.nist.gov/pml/div685/grp01/102814-pressuresensor.cfm.])

To vet the new instruments' performance, Ricker hooked a FLOC and the manometer up to the same pressure source. But he couldn't flood both devices with the same sample of pressurized gas, because the FLOC relies on the ultra high-purity of their nitrogen gas for its accuracy. Instead, he connected the systems using a capacitance diaphragm gauge (CDG), a device that measures the difference between two pressures.

The head-to-head comparison and analyses show that the

Ricker holding a FLOC cavity with its two channels. The mercury manometer looms behind him. Credit: J.L. Lee/NIST smaller, faster FLOC – each measurement takes less than a second to perform – is more precise than the manometer at pressures below about 1 kilopascal (kPa, approximately 0.15 pounds per square inch).

Alas, pitting the newcomer against the reigning champion of pressure measurements still amounts to a "he said, she said," without additional checks in place. So the researchers built a second FLOC and tested all three instruments against each other.

They discovered that the FLOCs gave the same results to within about 1 part per million, while the disagreement between the manometer and either FLOC was up to twelve times worse. Furthermore, both FLOCs had a reproducibility and linearity of just 1 part per million at all pressures between 100 Pa and 100,000 Pa. (Linearity here means that the ratio of input to output is about the same at any pressure within that range.) And because both FLOCs were linear, the team was able to attribute the disagreement to nonlinearities in the manometer.

One reason for their excellent agreement? "We baked the FLOCs for two months at 373 K (100 degrees C) in a vacuum," says PML's Patrick Egan. "Heating helps speed up the curing process for the bonding** that was used to attach mirrors to the ends of each channel. Since the measurement of pressure in the FLOC comes from the measurement of length between the mirrors, it is very important that the mirrors are attached to the channels with high stability."

After this heat curing, the researchers saw a relative drift between the pair of mirrors on each channel of about 6 femtometers (million billionths of a meter) per hour – a tiny amount. "That's smaller than the nucleus of a gold atom," Egan says.

Although the team has beaten the manometer's accuracy at low pressures, their analysis reveals that, for measurements at pressures above 1 kPa, the FLOC is two times less accurate than the manometer. But that's not surprising, Egan says, since the FLOC's measurement of pressure depends on how accurately researchers can calculate the refractive index of nitrogen. And ironically, that calculation is limited by how accurately researchers can measure nitrogen's pressure with the best instrument they currently have: the mercury manometer.

So a long-term goal of the group is to create a new device to help them further shrink the FLOC's uncertainties.

"To do that, we have to measure the refractive index of nitrogen better than anything that's been done before," Egan says. "And that's what we're working on now."***

The immediate next phase however, Egan says, is to use the FLOCs alongside the manometer to calibrate customers' pressure gauges this summer. "That will be the first step on a road which departs from the three-and-a-half-century-old measurement tradition," he says.

— Jennifer Lauren Lee

* There is currently a global push to cut or phase out use

of mercury in products and manufacturing. See the United Nations Environment Programme's (UNEP) activities on mercury: http://www.unep.org/chemicalsandwaste/Mercury/tabid/434/Default.aspx.

** For more information about the bonding procedure, see "A Thin, Strong Bond for Vacuum Seal."

*** The FLOC is designed to be a workhorse pressure standard that uses the properties of nitrogen gas for accuracy. To make the FLOC more accurate than the manometer, the PML team must measure the refractive index of nitrogen at a pressure that is known more accurately than the mercury manometer can currently provide. To get this information, the team is building a device called the variable-length optical cavity (VLOC), a cousin of the FLOC that will employ helium gas instead of nitrogen. By using the much more complicated but potentially more accurate VLOC to gauge the pressure of nitrogen gas, the team will have the information it needs to push their FLOCs to outperform the mercury manometer at higher pressures.

Source: NIST PML Sensor Science Division, Thermodynamic Metrology Group, http://www.nist.gov/pml/div685/grp01/head-to-head-photonic-pressure-sensors-vs-mercury-based-standard.cfm (April 21, 2016).

NIST's Million-Pound Weight Stack Restoration is Complete

It's official: NIST's 4.45-million newton (equivalent to one million pounds-force) deadweight machine – the largest in the world – is back in one piece after a colossal 16-month effort to overhaul the system for the first time in 50 years.

The year-and-a-half-long saga involved dismantling, cleaning, restoring, and recalibrating about half of the stainless steel discs in the three-story stack of weights. It marked the first time the device had been taken apart since its original installation in 1965.

"This was an extremely complicated, time-consuming, labor-intensive operation with major risks and decisions at every turn," says Mass and Force Group Leader Zeina Kubarych. "From planning to teamwork and coordination, to risk mitigation and execution, this was a remarkable achievement and a success to be proud of.

"Perfectly orchestrated restoration of one of NIST's and the world's metrology treasures with no injury to personnel and no damage to property – a big weight off my shoulders!"

The deadweight system consists of a calibrated "T-shaped" lifting frame and a stack of 19 stainless steel discs about three meters in diameter (a little less than ten feet) when assembled. Their average mass is about 22,696 kg (just over 50,000 pounds) each.

Lab officials from NIST visited the machine this month, just a few days after the last bolts were torque-wrenched into place. They received a tour of the facility, which includes a control room above the weight stack and a hydraulic ram that moves the weights up and down.

At the event, Carl Williams, the Deputy Director of NIST's Physical Measurement Laboratory (PML), introduced and congratulated project leader Rick Seifarth, whose team orchestrated the refurbishment process and performed the calibrations of the larger masses. Seifarth's team includes PML's Kevin Chesnutwood and Sam Ho.

Force metrology customers who rely on this unique device include U.S. aerospace manufacturers, U.S. military laboratories, and several top-end commercial force calibration labs.

— Jennifer Lauren Lee

For more information about the restoration of NIST's million pounds-force deadweight machine, see "Restoration Begins on NIST's Million-Pound Deadweight Machine" and "Progress Report with Photos: Restoration of NIST's Million-Pound Deadweight Machine" on NIST's website at http://www.nist.gov/allnews.cfm.

Source: NIST PML Quantum Measurement Division, Mass and Force Group, http://www.nist.gov/pml/div684/grp07/nist-million-pound-weight-stack-restoration-is-complete.cfm (April 25, 2016).

PML restoration team and leadership in front of the newly refurbished million-pound weightstack. From left to right: Project Leader Rick Seifarth, Sam Ho, Kevin Chesnutwood, and Mass and Force Group Leader Zeina Kubarych. Credit: Jennifer Lauren Lee/NIST PML

In Memory of Dr. Bryan Kibble, 1938-2016

It is with great sadness that we announce that Dr. Bryan Peter Kibble passed away on Thursday 28 April 2016.

Dr. Kibble worked at the National Physical Laboratory (NPL) from 1967 to 1998 as an experimental physicist. He was instrumental in reshaping the International System of Units (SI), and is best known for his conception of the watt balance, one of the measurement approaches proposed for the redefinition of the kilogram. Dr. Kibble will be dearly missed by the international measurement community, with former colleagues citing his quiet and patient guidance, and praising his problem-solving skills.

Before NPL

Dr. Kibble was born in 1938 in Berkshire. He studied Physics at Wadham College, University of Oxford, where he was awarded a PhD in 1964 for research in atomic spectroscopy. Dr. Kibble continued his research as a Postdoctoral Fellow at the University of Windsor in Ontario, Canada, from 1965 to 1967, before joining NPL as a Senior Research Fellow in 1967.

Early impact on the SI units

Early in his NPL career, Dr. Kibble successfully measured the high field gyromagnetic ratio of the proton. This measurement, in conjunction with a similar low field measurement, indicated that there was a problem with the existing realisation of the ampere, the SI base unit of electrical current. At the time, the ampere was realised using the current balance, an instrument that was difficult to operate and that had a number of inherent limitations, which Dr Kibble was later to address.

Dr. Kibble also worked with Dr. Geoffrey Rayner on Coaxial AC Bridges and the calculable capacitor from which the SI definition of the unit of resistance, the ohm, could be established. In 1984, Dr. Kibble and Dr. Rayner compiled and published their research in the book, Coaxial AC Bridges

The imperfections of the current balance weighed on Dr. Kibble's mind and inspired him to conceive a new and improved instrument, the moving coil watt balance, which, together with the calculable capacitor realisation of the ohm, could replace the current balance.

The invention of the watt balance

In the early 1970s, Dr. Kibble had an idea for a measurement device that would supersede the current balance. He described his idea to Bob Cutkosky, a highly-respected experimental scientist visiting from the USA's National Institute of Standards and Technology (NIST). Cutkosky's response encouraged Kibble to proceed with the idea and also planted the seeds for similar developments in the USA, which were pursued by his friends Ed Williams and Tom Olsen.

In 1978, the Mark I watt balance was built at NPL with Dr. Ian Robinson and Ray Smith. The instrument was used to realise the ampere with greater accuracy than was possible with the current balance, and the results played a major role in setting the 1990 conventional values of the Josephson and von Klitzing constants, used today for electrical measurements throughout the world. In recognition of his work, Dr. Kibble was awarded the International Union of Pure and Applied Physics SUNAMCO Senior Scientist Medal in 1992.

Redefining the kilogram

The kilogram, the SI base unit of mass, is the last of the seven SI base units to be defined by a physical object. But in 2018, the kilogram will be redefined in terms of a natural constant, the Planck constant, the quantum of action in quantum physics.

In 1990, a second watt balance was built by Dr. Kibble, Ian Robinson and Janet Belliss at NPL. It was designed to operate in a vacuum and was intended to measure the Planck constant with sufficient accuracy to support the redefinition of the kilogram.

The watt balance compares the weight of a one kilogram mass to the electromagnetic force generated by the interaction of a current-carrying coil of wire and a magnetic field. Then, the same coil is moved with a measured velocity in the same field, and generates a measured voltage. The combination of these two parts enables the properties of the coil and magnet to be eliminated from the measurement and allows electrical power and mechanical power to be equated. Using the Josephson and quantum Hall effects, electrical power can be measured in terms of the Planck constant and time, allowing the watt balance to relate mass to the Planck constant and SI units of length and time. By changing the definition of the unit of mass within the SI to fix the value of the Planck constant, the last artefact standard in the SI – the platinum-iridium cylinder kept at the International Bureau of Weights and Measures (BIPM) in Paris - can be replaced and, by the additional fixing of the value of the elementary charge, the electrical units can return to the SI.

In 2014, Dr. Kibble and Dr. Robinson published new principles for building simple watt balance designs, making the instrument more accessible, and in 2014, Canada's National Research Council used the NPL Mark II watt balance to measure the Planck constant with sufficient accuracy for the redefinition. A fitting tribute to Dr. Kibble's visionary work, from 2018 watt balances should be used throughout the world to realise the kilogram definition.

An active retirement

Dr. Kibble retired from NPL in 1998, but continued to be active in the field. He worked on the Mark II watt balance and high-frequency standards and bridges at NPL, and became a guest worker at both the Physikalisch-Technische Bundesanstalt (PTB) and BIPM, where he played a key part in eliminating a number of unresolved problems with the measurement of the ac quantum Hall effect.

Dr. Kibble continued to be active on various international committees. In 2009, he won the IEEE Joseph F. Keithley Award in Instrumentation and Measurement and was invited to write a regular column for IEEE Instrumentation and Measurement Magazine. In 2010, he published a book with Jurgen Schurr and Shakil Awan, Coaxial Electrical Circuits for Interference-Free Measurements

Dr. Kibble gave his last talk at NPL on 17 March 2016, describing the invention and development of the watt balance to an audience of current and retired NPL staff, and members of the Institute of Physics and the British Society for the History of Science.

Find out more about watt balances at NPL at http://www.npl.co.uk/engineering-measurements/mass-force-pressure/mass/research/npl-watt-balance.

Source: National Physical Laboratory (NPL) News, http://www.npl.co.uk/news/in-memory-of-dr-bryan-kibble-1938-2016, accessed 6 May 2016.

Transcat Expands Presence in Southern California

ROCHESTER, NY, April 1, 2016 – Transcat, Inc. (NASDAQ: TRNS) ("Transcat" or the "Company"), a leading provider of accredited calibration and compliance services and value-added distributor of professional grade handheld test, measurement and control instrumentation, announced that effective April 1, 2016, it has acquired Excalibur Engineering, Inc. ("Excalibur"), a provider of calibration services, new and used test equipment, and product rentals for $7.35 million in cash.

Established in 1990, Excalibur serves the U.S. market out of its Irvine, California headquarters and Denver, Colorado office. With approximately $8 million in annual sales, Excalibur's comprehensive service offerings include calibration services with a concentration on high-end electronics including radio frequency ("RF") and microwave, and the rental and direct sales of both new and used test equipment. Approximately one third of the business is calibration service related.

Lee D. Rudow, President and Chief Executive Officer of Transcat, commented, "Excalibur has done an excellent job building a business with a first-rate reputation that is an outstanding strategic, operational and geographic fit with Transcat's business, as it enhances both our Service and Distribution segments on several levels. The major benefits of the Excalibur acquisition are that it:

- Further penetrates the Southern California market where we already have a strong organic presence giving us the opportunity for sales and cost synergies;
- Strengthens our position in the highly regulated life science and aerospace markets;
- Provides us with an established west coast platform to expand on the early success of our equipment rental business and provides the structure and experience to build a used equipment sales operation;
- Broadens several service capabilities, including a new comprehensive RF and microwave service offering; and,
- Fits well within our stated strategy of paying between four to six times a company's proforma annual EBITDA (earnings before interest,

income taxes, depreciation and amortization, and other income and expense)."

Concurrent with this transaction, Transcat expanded its borrowing capacity by adding a $10.0 million term note to its bank credit facility. The term note is a five year note with fixed principal payments plus interest. After funding the Excalibur transaction, the Company will have approximately $28.0 million in outstanding borrowings under its bank credit facility. Mr. Rudow reaffirmed that Transcat's balance sheet remains strong, with its total debt being less than two times its proforma Adjusted EBITDA (as defined in the bank credit facility agreement).

Source: http://www.transcat.com/media/pdf/20160401-TRNS-Excalibur-Acquisition-FINAL.pdf.

CAL-TOONS by Ted Green teddytoons@me.com

3 Bar Versus 2 Bar Universal Calibrating Machines Comparison Test

Henry Zumbrun
Morehouse Instrument Company

1. Introduction

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 versus 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. This paper 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 that **there is not a difference** between either type of UCM. The article compares a per point uncertainty analysis for each style 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.

2. The Test

A load cell was tested in both a new 3 bar Universal Calibrating Machine (UCM) that was manufactured by Morehouse, and a 2 bar UCM that was manufactured by Morehouse and used successfully by industry and government labs for 50-plus years. Both machines used the same design criteria and had a capacity of 100,000 lbf. To minimize variables, the test was performed using as much as the same instrumentation as possible:

- The same hydraulic ram was used with both UCMs.
- The same Morehouse Hydraulic Power Control and hoses were used with both UCMs.
- The same reference standard and loading adapters were used with both UCMs.
- The same load cell was used as the UUT with both UCMs. The UUT was a 100,000 lbf Shear Web Load Cell 100,000 lbf Model SW30 Load Cell.
- Two HBM–DMP 40s: The same one was used with the reference standard and the UUT with both UCMs.

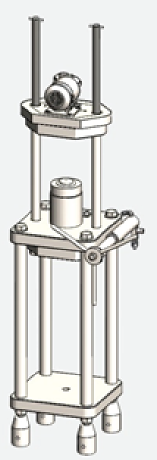


Figure 1. Design drawing of a Morehouse 2 Bar 100,000 lbf UCM.

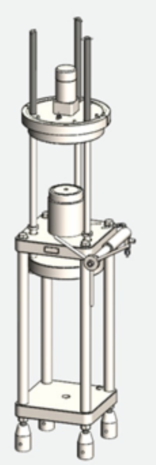


Figure 2. Design drawing of a Morehouse 3 Bar 100,000 lbf UCM.

3. The Reference Standard

A Morehouse Ultra Precision Load Cell calibrated using the Morehouse Force Calibration Laboratory's 120,000 lbf Dead Weight Primary Standard Force Machine was used as the reference standard. The measurement capability of the load cell was characterized using the following uncertainty contributors:

- Resolution of reference standard: 0.1 lbf
- ASTM E74 LLF (Converted to a pooled standard deviation): 2.471 lbf
- Resolution of UUT: 0.25 lbf
- Temperature effect on zero for both reference standard and UUT: 0.0015 % of rated output per 1° change in temperature
- CMC of 120,000 lbf Dead Weight Primary Standard Force Machine: 0.0016 %
- Repeatability, characterized per point (this is what varied between 2 and 3 bar UCM's)
- Stability was set to zero as the test between the UCMs was performed within a few days.

Figure 3. Morehouse 3 Bar 100,000 LBF UCM.

MODEL: ULTRA PRECISION
MOREHOUSE Load Cell, SERIAL NO. U-7660(HI)
100000.00 LBF Compression Calibrated to 100000.00 LBF
HBM DMP40 INDICATOR, SERIAL NO. 111320025

Calibration is in Accordance with ASTM E74-13
Ascending and Descending Compression DATA

Applied Load	Deflection Values Per ASTM Method 8.1B Interpolated Zero			Deviation From Fitted Curve			Values From Fitted Curve
	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	
LBF	mV/V	mV/V	mV/V	mV/V	mV/V	mV/V	mV/V
2000	-0.08120	-0.08119	-0.08119	-0.00001	0.00000	0.00000	-0.08119
10000	-0.40602	-0.40605	-0.40601	0.00000	-0.00003	0.00001	-0.40602
20000	-0.81206	-0.81210	-0.81207	0.00002	-0.00002	0.00001	-0.81208
30000	-1.21815	-1.21819	-1.21819	0.00002	-0.00002	-0.00002	-1.21817
40000	-1.62428	-1.62433	-1.62432	0.00003	-0.00002	-0.00001	-1.62431
50000	-2.03045	-2.03050	-2.03052	0.00005	0.00000	-0.00002	-2.03050
60000	-2.43667	-2.43674	-2.43677	0.00005	-0.00002	-0.00005	-2.43672
70000	-2.84291	-2.84300	-2.84302	0.00006	-0.00003	-0.00005	-2.84297
80000	-3.24914	-3.24920	-3.24925	0.00006	0.00000	-0.00005	-3.24920
90000	-3.65530	-3.65538	-3.65543	0.00008	0.00000	-0.00005	-3.65538
100000	-4.06136	-4.06149	-4.06152	0.00009	-0.00004	-0.00007	-4.06145

The following polynomial equation, described in ASTM E74-13 has been fitted to the force and deflection values obtained in the calibration using the method of least squares.

response = A0 + A1(load) + A2(load)^2 + A3(load)^3 + A4(load)^4

Where:
A0 1.26845873E-5
A1 -4.06037323E-5
A2 5.6929943E-14
A3 -5.8162163E-18
A4 4.1538608E-23

load = B0 + B1(response) + B2(response)^2 + B3(response)^3 + B4(response)^4

Where:
B0 3.11428743E-1
B1 -2.46282820E+4
B2 8.42042379E-1
B3 2.13472887E+0
B4 3.75551770E-1

The following values as defined in ASTM E74-13 were determined from the calibration data.
Lower Limit Factor, LLF 2.471 LBF

Figure 4. ASTME74 data for Morehouse reference standard.

4. 2 Bar Data

Repeatability

To test repeatability on the 2 bar UCM, 10 runs of 10 forces ranging from 10,000 lbf through 100,000 lbf were applied to the unit under test without rotation.

Runs 4 through 7 were used to calculate repeatability.

A per point uncertainty analysis using the Welch-Satterthwaite equation was performed using this data. The Welch–Satterthwaite equation is used to calculate an approximation to the effective degrees of freedom of a linear combination of independent sample variances, also known as the pooled degrees of freedom.

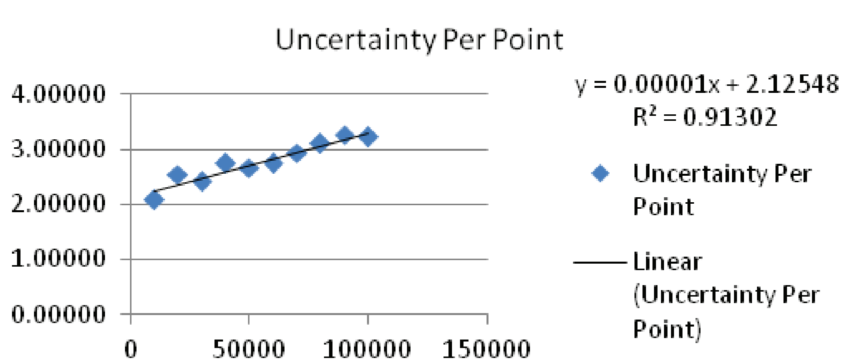
Reproducibility

To test reproducibility on the 2 bar UCM, 6 runs of 6 forces (5,000; 20,000; 40,000; 60,000; 80,000; 100,000 lbf) were applied to the unit under test during a rotational test. The unit under test was rotated 60 degrees on its primary axis between each run.

This data was calculated in accordance with section 8.3 of the ASTM E74-13a titled Standard Practice of Calibration of Force-Measuring Instruments for Verifying the Force Indication of Testing Machine. The ASTM Lower Limit Factor for the load cell in the 2 bar Universal Calibrating Machine was 5.332 lbf.

This and the repeatability test was repeated using the 3 bar UCM (Section 5).

Laboratory	Morehouse								
Parameter	FORCE	Range	10K-100K	Sub-Range					
Technician	HZ	Standards Used							
Date	12/21/2015								
Uncertainty Contributor	Magnitude	Type	Distribution	Divisor	df	Std. Uncert	Variance (Std. Uncert^2)	% Contribution	u^4/df
Reproducibility Between Techs		A	Normal	1.000	-1				
Repeatability Between Techs		A	Normal	1.000	0				
Repeatability	466.9004E-3	A	Normal	1.000	3	466.90E-3	218.00E-3	8.15%	15.8E-3
Standard Deviation	1.0296E+0	A	Normal	1.000	200	1.03E+0	1.06E+0	39.64%	5.6E-3
Resolution of UUT	250.0000E-3	B	Resolution	3.464	200	72.17E-3	5.21E-3	0.19%	135.6E-9
Environmental Conditions	1.5000E+0	B	Rectangular	1.732	200	866.03E-3	750.00E-3	28.05%	2.8E-3
Stability of Ref Standard	000.0000E+0	B	Rectangular	1.732	200	000.00E+0	000.00E+0	0.00%	000.0E+0
Ref Standard Resolution	100.0000E-3	B	Resolution	3.464	200	28.87E-3	833.33E-6	0.03%	3.5E-9
Miscellaneous Error									
Morehouse CMC	1.6000E+0	B	Expanded (95.45% k=2)	2.000		800.00E-3	640.00E-3	23.93%	
			Combined Uncertainty (u_c)=			1.64E+0	2.67E+0	100.00%	24.3E-3
			Effective Degrees of Freedom			294			
			Coverage Factor (k) =			1.97			
			Expanded Uncertainty (U) K =			3.22	0.00322%		
Slope Regression Worksheet									
	Applied	Run 1	Run 2	Run 3	Run 4	Average	Std. Dev.	Ref CMC	LBF
1	100000.00	99999.94	99999.69	99999.69	100000.68	100000	0.4669	0.0016%	1.6
Repeatability (Of Error)			Average Standard Deviation of Runs			0.466900			



Force Point	Expanded UNC
10000	2.09
20000	2.54
30000	2.40
40000	2.74
50000	2.67
60000	2.75
70000	2.94
80000	3.10
90000	3.27
100000	3.22

Figure 5. 2 bar 100K data point example. Expanded uncertainty 3.22 lbf.

5. 3 Bar Data

Repeatability

The identical test method used to test repeatability on the 2 bar UCM was used on the 3 bar UCM. To test repeatability on the 3 bar UCM, 10 runs of 10 forces ranging from 10,000 lbf through 100,000 lbf were applied to the unit under test without rotation.

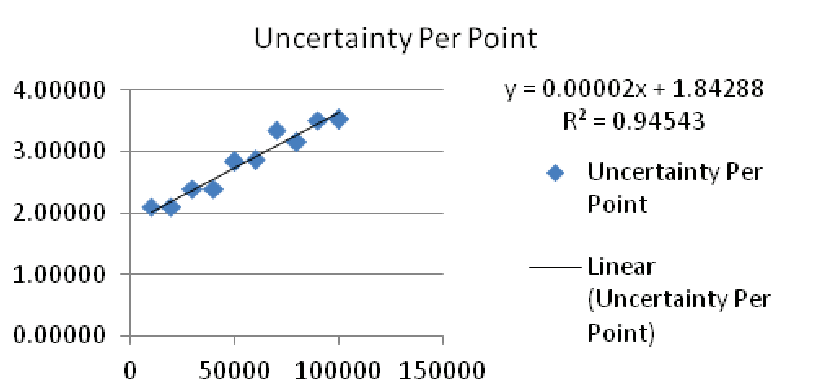
Runs 4 through 7 were used to calculate repeatability.

A per point uncertainty analysis using the Welch-Satterthwaite equation was performed using this data.

Reproducibility

The identical test method used to test reproducibility on the 2 bar UCM was used on the 3 bar UCM. To test reproducibility on the 3 bar UCM, 6 runs of 6 forces (5,000; 20,000; 40,000; 60,000; 80,000; 100,000 lbf) were applied to the unit under test during a rotational test. The unit under test was rotated 60 degrees on its primary axis between each run. This data was calculated in accordance with section 8.3 of the ASTM E74-13a titled Standard Practice of Calibration of Force-Measuring Instruments for Verifying the Force Indication of Testing Machine. The ASTM Lower Limit Factor for the load cell in the 3 bar Universal Calibrating Machine was 5.201 lbf.

Measurement Uncertainty Budget Worksheet									
Laboratory	Morehouse								
Parameter	FORCE	Range	10K-100K	Sub-Range					
Technician	HZ	Standards Used							
Date	12/21/2015								
Uncertainty Contributor	Magnitude	Type	Distribution	Divisor	df	Std. Uncert	Variance (Std. Uncert^2)	% Contribution	u^4/df
Reproducibility Between Techs		A	Normal	1.000	-1				
Repeatability Between Techs		A	Normal	1.000	0				
Repeatability	814.9853E-3	A	Normal	1.000	3	814.99E-3	664.20E-3	21.29%	147.1E-3
Standard Deviation	1.0296E+0	A	Normal	1.000	200	1.03E+0	1.06E+0	33.97%	5.6E-3
Resolution of UUT	250.0000E-3	B	Resolution	3.464	200	72.17E-3	5.21E-3	0.17%	135.6E-9
Environmental Conditions	1.5000E+0	B	Rectangular	1.732	200	866.03E-3	750.00E-3	24.04%	2.8E-3
Stability of Ref Standard	000.0000E+0	B	Rectangular	1.732	200	000.00E+0	000.00E+0	0.00%	000.0E+0
Ref Standard Resolution	100.0000E-3	B	Resolution	3.464	200	28.87E-3	833.33E-6	0.03%	3.5E-9
Miscellaneous Error									
Morehouse CMC	1.6000E+0	B	Expanded (95.45% k=2)	2.000		800.00E-3	640.00E-3	20.51%	
			Combined Uncertainty (u_c)=			1.77E+0	3.12E+0	100.00%	155.5E-3
			Effective Degrees of Freedom			62			
			Coverage Factor (k) =			2.00			
			Expanded Uncertainty (U) K =			3.53	0.00353%		
Slope Regression Worksheet									
	Applied	Run 1	Run 2	Run 3	Run 4	Average	Std. Dev.	Ref CMC	LBF
1	100000.00	100000.80	99999.08	100000.55	99999.57	100000	0.8150	0.0016%	1.6
Repeatability (Of Error)			Average Standard Deviation of Runs			0.814985			



Force Point	Expanded UNC
10000	2.10
20000	2.10
30000	2.40
40000	2.40
50000	2.84
60000	2.86
70000	3.36
80000	3.16
90000	3.52
100000	3.53

Figure 6. 3 bar 100K data point example. Expanded uncertainty 3.53 lbf.

FORCE APPLIED	2BAR CMC	%	3BAR CMC	%
10000	2.09	0.0209%	2.10	0.0210%
20000	2.54	0.0127%	2.10	0.0105%
30000	2.40	0.0080%	2.40	0.0080%
40000	2.74	0.0069%	2.40	0.0060%
50000	2.67	0.0053%	2.84	0.0057%
60000	2.75	0.0046%	2.86	0.0048%
70000	2.94	0.0042%	3.36	0.0048%
80000	3.10	0.0039%	3.16	0.0040%
90000	3.27	0.0036%	3.52	0.0039%
100000	3.22	0.0032%	3.53	0.0035%
STDEV	0.37		0.56	
AVG	2.77		2.83	

	2BAR LLF 5.332	2BAR LLF 5.332	3BAR LLF 5.201	3BAR LLF 5.201
FORCE APPLIED	MAX DIFF COUNTS	MAX DIFF LBF	MAX DIFF COUNTS	MAX DIFF COUNTS
5000	5	1.25	1	0.25
20000	15	3.75	11	2.75
40000	15	3.75	18	4.5
60000	24	6	23	5.75
80000	22	5.5	32	8
100000	40	10	37	9.25
STD DEV	12.13	2.69	13.44	3.04
AVG	18.05	5.08	18.17	5.10

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
2 BAR	9	25.62868	2.847631	0.090816
3 BAR	9	26.15768	2.906408	0.275684

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.015547	1	0.015547	0.084839	0.774586	4.493998
Within Groups	2.931997	16	0.18325			
Total	2.947544	17				

Figure 7. Data comparison using analysis of variance.
Note: The CMC % is better than 0.021 % through the Full Range.

6. Key Findings

Key Finding 1

The preliminary results on the 2 bar Universal Calibrating Machine showed better repeatability on 7 of 10 test points. The average calibration and measurement capability was higher on the 3 bar machine and there was more variation in the overall results on the 3 bar machine. On both machines, the Calibration and Measurement Capability (CMC) was 0.210 % or better throughout the full loading range. From 30 % of the measurement range and up, the CMC was better than 0.01 %. Adding a second reference standard of 30,000 lbf capacity, should allow a laboratory to maintain a CMC of better than 0.01 % from 10,000 lbf through 100,000 lbf.

Key Finding 2

The above data was compared using ANOVA analysis. Analysis of variance (ANOVA) is a collection of statistical models used to analyze the differences among group means and their associated procedures. ANOVA allows us to know if there is an agreement between the means of several groups. The average of the differences between the ASTM E74 predicted curve values and the individual 6 runs were statistically equivalent. The average difference was less than the resolution of the unit under test.

The ANOVA analysis in this article used a significance level (α) of 0.05. An Alpha of 0.05 indicates that a 5 % risk difference exists to get a sample that is not representative of the population. ANOVA analysis shows a p-value of greater than 0.05. This means we should fail to reject (accept) the null hypothesis that there is not a difference in repeatability and reproducibility between a 2 bar and 3 bar universal calibrating machines. When ANOVA was run on the maximum difference in counts between both machines, a P-value of 0.882407 was recorded. This high P-value indicates that there is a very high likelihood of obtaining similar averages by repeating this test. This further supports rejecting the null hypothesis and shows neither a 2 bar nor 3 bar machine offers an advantage over one another in regards to overall measurement uncertainty. However, the tare weight of the 3 bar system is 329 lbs, which is significantly higher than the 2 bar system at 206 lbs. This would mean a 2,000 lbf capacity load cell may not be able to be used as a reference standard in a 3 bar machine.

Key Finding 3

We ran a proficiency test between machines, which revealed En ratios of less than 1. This is further validation of the test results. Per APLAC PT 001, an En ratio is an internationally accepted method of judging the quality of each measurement result by calculating the error normalized with respect to the stated uncertainty. The highest En ratio was 0.454 at 20,000 lbf and we observed an En ratio of 0.000 at the 100,000 lbf test point.

Conclusion

This test has not found any statistically significant difference between a 2 bar or 3 bar UCM. When all aspects are considered, a 2 bar UCM will have the advantage as far as cost, lower tare weight, and easier calibration setups.

The test shows a 2 bar Morehouse UCM used with a Morehouse Ultra Precision Load Cell as a reference standard Capability below 0.02 % from 20 % through 100 % of the range. Adding a second load cell with a capacity of 20,000 lbf for use as a reference standard with the UCM would decrease the CMC and should allow better than 0.02 % CMCs at 4 % of full scale.

Note: The 3 Bar and 2 bar repeatability data is for one position only. This further demonstrates the need to do a reproducibility test and helps justify the use of ASTM E74 as the standard to quantify reproducibility of the UUT. When the load cell is rotated, the ASTM E74 predicted response values are in agreement.

References

[1] ASTM E74-13a, Standard Practice of Calibration of Force-Measuring Instruments for Verifying the Force Indication of Testing Machines, ASTM International, West Conshohocken, PA, 2013, www.astm.org.

[2] JCGM 100:2008 *Evaluation of measurement data — Guide to the expression of uncertainty in measurement.*

[3] APLAC PT 001 Issue No. 5, 03/08 APLAC Calibration Interlaboratory Comparisons, www.aplac.org.

Henry Zumbrun, Morehouse Instrument Company, York, PA, hzumbrun@mhforce.com.

Our TRANSCAT® Family of Companies has Expanded

More Locations - Greater Capabilities

Accredited Calibration Services, New Instrument Sales, Equipment Rental, and Analytical & Validation Services

Excalibur Engineering

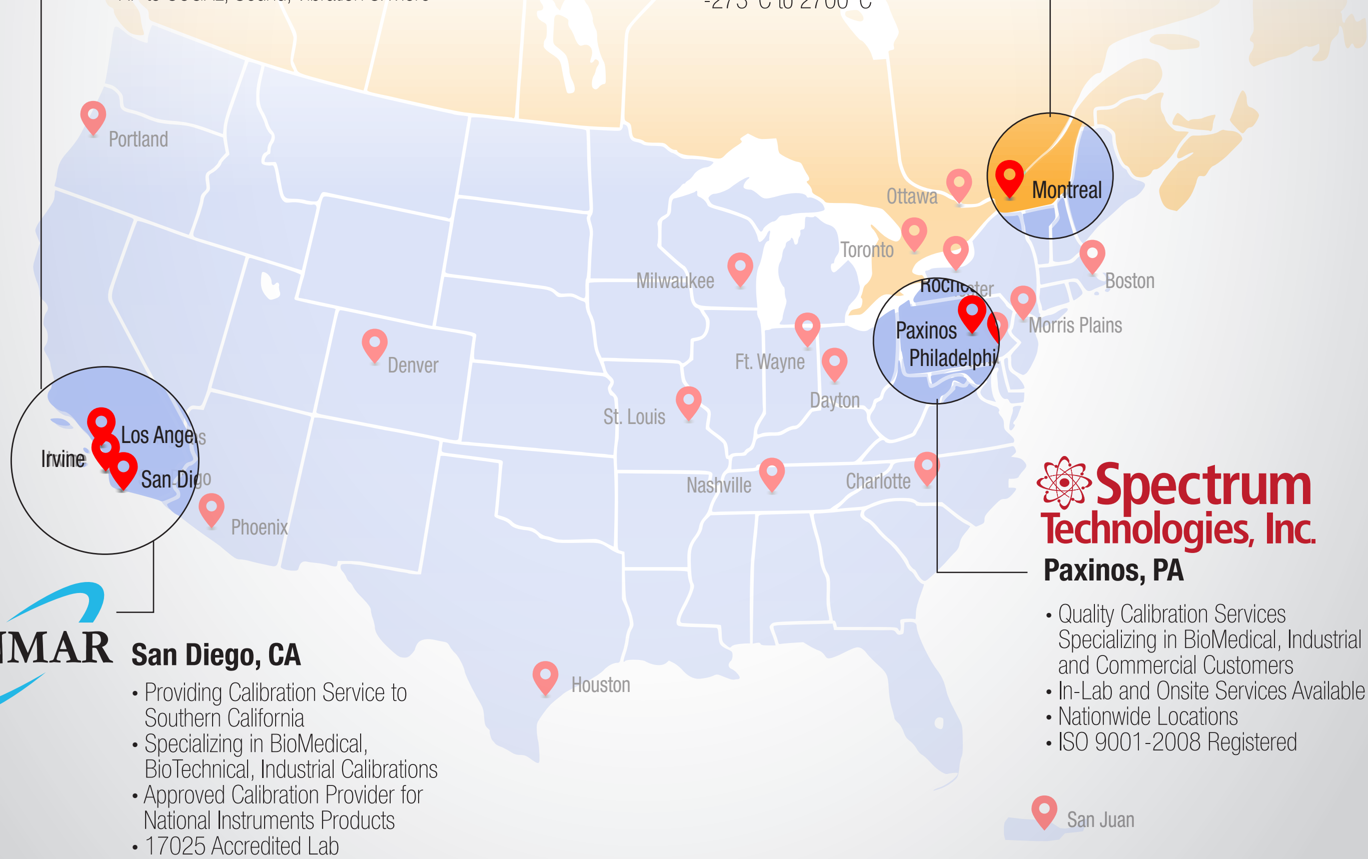
Irvine, CA

- Equipment Rentals Including: RF, Microwave, Power Analyzers and More
- New and Used Equipment Sales
- Accredited Calibration Services
- Equipment Repair
- Onsite Service Available
- RF to 50GHz, Sound, Vibration & More

DISPERSION
Laboratoire • Laboratory DIVISION • TRANSCAT CANADA

Montreal, Canada

Accredited Calibration Services Specializing in:
- Pipettes, Burettes, Syringes, etc.
- Precision Mass up to Class 1
- Balances and Scales
- Temperature Calibration from -273°C to 2700°C



Spectrum Technologies, Inc.

Paxinos, PA

- Quality Calibration Services Specializing in BioMedical, Industrial and Commercial Customers
- In-Lab and Onsite Services Available
- Nationwide Locations
- ISO 9001-2008 Registered

ANMAR

San Diego, CA

- Providing Calibration Service to Southern California
- Specializing in BioMedical, BioTechnical, Industrial Calibrations
- Approved Calibration Provider for National Instruments Products
- 17025 Accredited Lab

TRANSCAT®
Trust in every measure

For more information visit: **Transcat.com/contactus**
800-828-1470

The Effects of Loading Pad Hardness on the Calibration Results of Force Transducers

Ebtisam H. Hassan, R. Hegazy, Gouda M. Mahmoud
National Institute for Standards, Egypt

Common practice in the use of force proving instruments, such as load cells, has been to use loading pads to maintain the safety for the load cell from any defects that can be occurred due to direct contact between the force transducer body and the calibration standard machine and also in the event of accidental overload. The load cell manufacturer supplies these loading pads by a certain specified hardness and stiffness according to the load cell capacity. These loading pads may be lost and other loading pads, which are not of the same mechanical properties compared to the original ones, have to be used. Therefore, the aim of this study is to investigate the effect of changing the loading pads with different hardness values on the calibration results of the force transducers. The investigation shows that there are significant effects of the loading pad hardness on the results of calibration where the lower hardness pad results are lower than that for the higher hardness pad. This occurs due to the strain energy absorbed in the case of the lower hardness pad which tends to force losses and hence lower force applied on the under calibration force transducer and hence lower response of it.

1. Introduction

The load cell is a transducer to detect load which bears the load directly by the load cell itself. The load cell should be installed so that the load can be applied vertically to the load cell [1]. The top of the load cell is so spherical that bending moment or distortion is not applied to the load cell so the use of a spherical cap is recommended. The spherical cap is mounted to the top of a compression load cell for accurate transmission of compression loads (see Figure 1). In the case of tension load cell, a Rotary Attachment is used to ensure smooth load transmission by eliminating torsion during tension load measurements (see Figure 2) [2]. It's required for these loading pads, such as Spherical Cap and Rotary Attachment, to be rigid enough and have a sufficient hardness to perform the specified application [3,4]. In the case of losing these accessories, it is required to design and fabricate other alternative accessories similar to them. The aim of this research is to investigate the effects of hardness of these alternative accessories on the response of the under calibration load cells.

2. Experimental Work

The National Institute of Standards (NIS) of Egypt 50 kN dead weight standard machine with relative expanded uncertainty of ±0.002 was used. This machine is constructed to apply the calibration load values in 0.5 kN steps over the whole range of the compression. Two reference force transducers with capacities of 5kN and 10 kN and two samples with different hardness (171HV50 and 249HV50) were used to conduct this investigation.

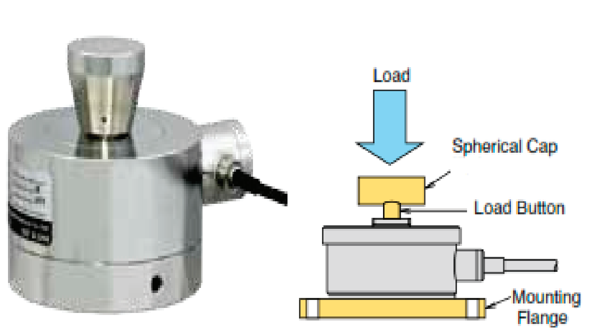


Figure 1. The spherical cap of the compression load cell.

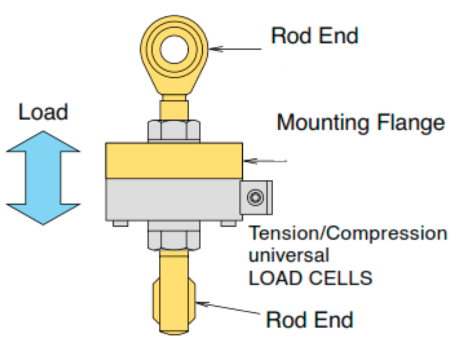


Figure 2. The rotary rod end of the tension load cell.

3. Procedure of the Investigation

The two force transducers were preloaded up to the maximum force and then calibrated in incremental procedures with steps 10 % up to 100 % of the force transducer capacity (Figure 3). These force transducers were calibrated three times for each in accordance with the relevant standard [5]; the first calibration was done using the normal loading cap, the second one was conducted using the 171HV50 loading cap, and the third was done using 249HV50. All of these calibrations were performed on the same procedure. The comparison of the results were done and relative error was calculated.

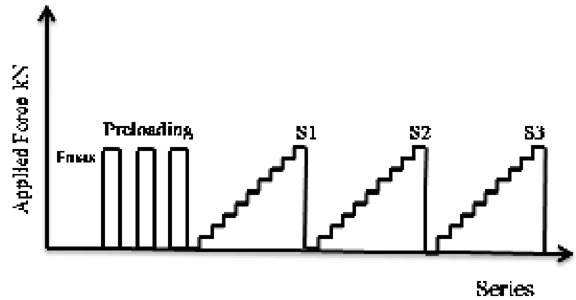


Figure 3. Schematic for the procedure of investigation for the force transducers.

Steps (N)	Normal cap (mv/v)	Top loading cap (mv/v)	Relative error (%)
1.0	0.400095	0.400085	0.0025
1.5	0.600172	0.60015	0.0037
2.0	0.800326	0.800304	0.0027
2.5	1.000501	1.000457	0.0044
3.0	1.200701	1.200681	0.0017
3.5	1.400935	1.400878	0.0041
4.0	1.601224	1.601145	0.0049
4.5	1.801541	1.8015	0.0023
5.0	2.001866	2.00178	0.0044

Table 1. The calibration results of 5 kN load cell using normal cap and 249 HV cap.

Steps (N)	Normal cap (mv/v)	Top loading cap (mv/v)	Relative error (%)
1.0	0.400065	0.400004	0.01525
1.5	0.600172	0.600082	0.01500
2.0	0.800326	0.800198	0.01600
2.5	1.000501	1.000350	0.01509
3.0	1.200701	1.200520	0.01508
3.5	1.400935	1.400683	0.01799
4.0	1.601224	1.600995	0.01430
4.5	1.801541	1.801276	0.01471
5.0	2.001866	2.001537	0.01644

Table 2. The calibration results of 5 kN load cell using normal cap and 171 HV cap.

Steps (N)	Normal cap (mv/v)	Top loading cap (mv/v)	Relative error (%)
1.0	0.200574	0.20057	0.00199
2.0	0.401155	0.401162	-0.00183
3.0	0.601731	0.60174	-0.00144
4.0	0.802299	0.802314	-0.00191
5.0	1.002821	1.002841	-0.00203
6.0	1.203312	1.203335	-0.00194
7.0	1.403745	1.403774	-0.00204
8.0	1.604136	1.604168	-0.00197
9.0	1.804437	1.804473	-0.00198
10.0	2.004682	2.004723	-0.00203

Table 3. The calibration results of 10 kN load cell using normal cap and 249 HV cap.

Steps (N)	Normal cap (mv/v)	Top loading cap (mv/v)	Relative error (%)
1.0	0.200574	0.20061	-0.01795
2.0	0.401155	0.401235	-0.02003
3.0	0.601731	0.601843	-0.01856
4.0	0.802299	0.802445	-0.01824
5.0	1.002821	1.00299	-0.01689
6.0	1.203312	1.203503	-0.01590
7.0	1.403745	1.403959	-0.01522
8.0	1.604136	1.604363	-0.01413
9.0	1.804437	1.804673	-0.01306
10.0	2.004682	2.004928	-0.01225

Table 4. The calibration results of 10 kN load cell using normal cap and 171 HV cap.

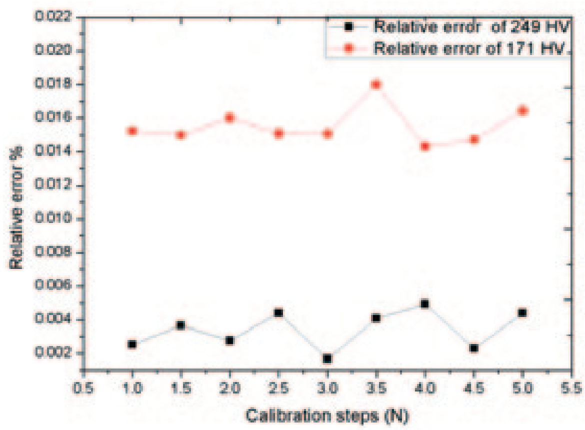


Figure 4. The effect of loading cap hardness on the calibration results of 5 kN.

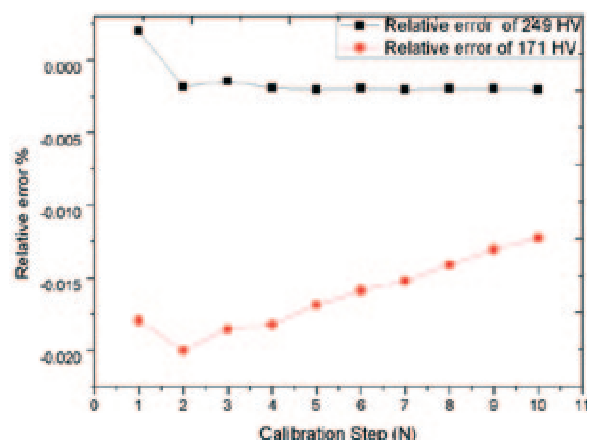


Figure 5. The effect of loading cap hardness on the calibration results of 10 kN.

4. Results and Discussion

After calibrating the two load cells in accordance with the previous section and relative error was calculated, the results of the investigation were summarized in the following tables and figures.

The figures and tables show there are significant effects of the loading cap hardness on the results of the load cell calibration where the lower hardness pad results are lower than that for the higher hardness pads; also, the nearest response to the reference response at normal cap was achieved at higher hardness.

5. Conclusions

It was concluded that relative error of force transducers with a lower hardness loading pad (171 HV) is larger than that for the force transducers with a higher hardness (249 HV) loading pad. The investigation shows that there are significant effects of the loading pad hardness on the results of the load cell calibration. The lower hardness pad results are lower than that for the higher hardness pad. This occurs due to the strain energy absorbed in the case of the lower hardness pad which tends to force losses and hence lower force applied on the under calibration force transducer and hence lower response of it.

References

[1] Dan Mihai Stefanescu, *Handbook of Force Transducers Principles and Components*, ISBN: 978-3-642-18295-2 (Print) 978-3-642-18296-9, 2011 Springer-Verlag Berlin Heidelberg.

[2] http://www.tml.jp/e/product/transducers/general/load_cell/loadcell_option.htm

[3] http://www.omega.co.uk/prodinfo/load-cells.htm

[4] J. C. Qiao1, Z. P. Xi2, H. P. Tang, J. Y. Wang and J. L. Zhu, "Compressive Property and Energy Absorption of Porous Sintered Fiber Metals" *Materials Transactions*, Vol. 49, No. 12 (2008) pp. 2919 to 2921.

[5] ASTM E74-13a, Standard Practice of Calibration of Force-Measuring Instruments for Verifying the Force Indication of Testing Machines, ASTM International, West Conshohocken, PA, 2013, www.astm.org.

Ebtisam H. Hassan, R. Hegazy, and Gouda M. Mahmoud (goudamohamed15@yahoo.com), National Institute for Standards (NIS), Tersa St. Haram Giza, Egypt.

Using Robotic Comparators in Mass Calibration

Mettler-Toledo AG

Calibrating a weight of unknown mass requires comparison to a known reference. It's not as simple as it sounds, however, particularly when manufacturing weights or establishing metrology standards. During manual calibration, everything from an operator's body heat to an open lab door can subtly shift results. Robotic mass comparators not only eliminate forces that disrupt weighing, they significantly improve processing speed—often with fewer personnel.

Determination of an unknown mass—whether for a single weight, or an entire set—can demand a great deal of time. Manual handling requires patience and experience to avoid negative human influences such as imprecise weight placement or not allowing long enough stabilization time. Environmental issues such as drafts, humidity, temperature changes and vibrations (such as those created by nearby machinery) can also skew results.

Additionally, the nanotechnology market is driving a trend towards microgram weights—weights of less than 1 mg—which is also challenging manual calibration techniques. These weights' miniscule size can make them very tricky to manipulate: loss of the weight itself becomes a very real possibility. Environmental issues can make manual calibration of these tiny weights even more problematic.

On the other hand, robotic systems allow acclimatization of weights to reduce environmental influence. They also ensure essential settling time, reduce abrasion so weights themselves maintain tolerance longer, and eliminate poor placement on the weighing-pan. Benefits like these are making well-designed robotic systems a valuable investment wherever an operator is faced with calibrating either the smallest weights or large numbers of weights of nearly any mass.

Uncertainty Improvements with Robotization

With the use of a robotic system, two main uncertainty contributors are improved significantly. The process uncertainty is improved with the increase of method repetitions, thus reducing the uncertainty contribution of the process variance. This factor improves the overall performance without compromising the efficiency, due to the fact that no personnel are required to be present.

For the smaller weights, a highly experienced calibration officer has the ability to reproduce placement of the weight within approx. 2 mm. However, due to the high accuracy design, a robotic system can achieve an overall system accuracy of ≤ 0.05 mm. This is 40 times more accurate than the operator and consequently the eccentricity uncertainty is reduced by the well-centered positioning.

A comparison of two models for a mass comparison of a 1 g E1 weight with the following definitions is represented in Table 1.

For dissemination, the off-center placement of the weights is mathematically corrected for eccentric load deviations by knowledge of the distance of the gravimetric centers of the weights and the distance from the perpendicular center of the weighing pan. This will further improve the eccentricity uncertainty contribution whilst enabling the dissemination with the placement of multiple weights with unequal nominal in the comparator without compromising the eccentricity influence. Overall the combined measurement uncertainty without the reference weight is improved by a factor of 3.8 for the robotic comparator method, with the added benefit of reduced labor cost. The efficiency is improved by factors, such as the robotic system does not require the continuous presence of staff and the test may be run throughout the night. In a higher workload environment, this increases efficiency whilst enabling higher measurement accuracies to be achieved.

Figure 1. Example of a robotic mass comparator.

A Strong Foundation

The first commercially available robotic system for weights calibration was introduced in 1999 as the result of a collaboration between METROTEC and Mettler-Toledo AG. A comparator balance produced the system's weighing accuracy, coupled with an XYZ robot to allow accurate picking and placing of the weights from the weight magazine. That initial install offered a regional UK calibration facility improved accuracy for smaller weights and provided the ability to handle weights from 1 mg up to 5 g at high throughput. Today, it is possible to handle weights as low as 50 µg (0.05 mg) on an automated robotic mass comparator.

The market served by robotic mass comparator technology has grown substantially. Robots have been improved, and systems with higher weights and larger magazine capacity have also been developed. At a basic level, however the principles that attended that first installation at the turn of the century remain unchanged.

Fundamental Accuracy

A robotic system consists of a cabinet that contains a weight magazine, a comparator balance, and a 3-axis robotic system. The robot, controlled by programmable software that executes the process, collects measured data and calculates relevant parameters for mass determination. To achieve required levels of weighing accuracy, the apparatus constantly measures cabinet atmosphere for temperature, humidity and pressure. This means that time can be allotted for acclimatization if weights kept in the weighing cabinet are a different temperature from the lab. Resulting air density calculations also assist with the buoyancy correction.

A full-range or window-range comparator can be used, depending on the required resolution and capacity of the robotic mass comparator. Window-range comparators are equipped with a counter-weight in equilibrium of the comparator's maximum load capacity: When smaller weights are measured, a dial weight is selected so that the dial weight plus the test weight is within the mass comparator's electrical weighing range, enabling maximum resolution and accuracy. A robotic comparator can actuate these dial weights automatically, allowing calibration of weights with different nominal values without human intervention. With a full range comparator, it is not necessary to have dial weights as every data point within the range is accessible for mass comparison.

Functionally, the robot processes the weights according to a programmed weighing regimen. The 3-axis robot moves to the weight magazine and picks up either a weight carrier or the weight itself. Then, it moves the unit to be measured towards the balance, the balance door opens, and the robot slowly and accurately places the weight onto the weighing pan for results calculation. This process is repeated until all weights in the magazine have been calibrated.

Parameter	Manual Comparator		Robotic Comparator	
	Value	Uncertainty	Value	Uncertainty
Eccentricity	0.2 µg	0.577 µg	0.2 µg	0.028 µg
Resolution	0.1 µg	0.041 µg	0.1 µg	0.041 µg
u Combined Comparator		0.579 µg		0.050 µg
u Air Buoyancy Correction		0.143 µg		0.143 µg
Low Load Repeatability	0.25 µg		0.2 µg	
Nominal Load ABA Repeatability	0.35 µg		0.35 µg	
Number of Weighing Schemes ABBA	2		10	
u Weighing Process		0.130 µg		0.058 µg
Combined Mass Uncertainty		**0.617 µg**		**0.162 µg**

Table 1. Manual versus robotic mass comparison of a 1 g E1 weight.

Accounting for Drift

By definition, mass comparators used for this type of activity have very high resolution. This means balance drift—or the slow change in the value of a measuring instrument's metrological indication—must be considered at all times.

In a robotic system, controller software automatically eliminates drift using either the ABA or ABBA method recommended by the International Organization of Legal Metrology (OIML). Accounting for drift guarantees higher accuracy in a well-designed robotic system.

The very nature of a robotic system means that it can be programmed to work during the night, by setting a time delay. Influences such as temperature fluctuation, vibration and drafts can be significantly reduced, thereby increasing the quality of the results

When considering all the benefits – drift elimination, environmental management/ acclimatization, the ability to program sufficient settling times, and the fact that automated handling reduces abrasion to ensure weights remain within tolerance longer—the robotic approach is generally understood to offer significant advantages over all but the most infrequent manual calibration processes.

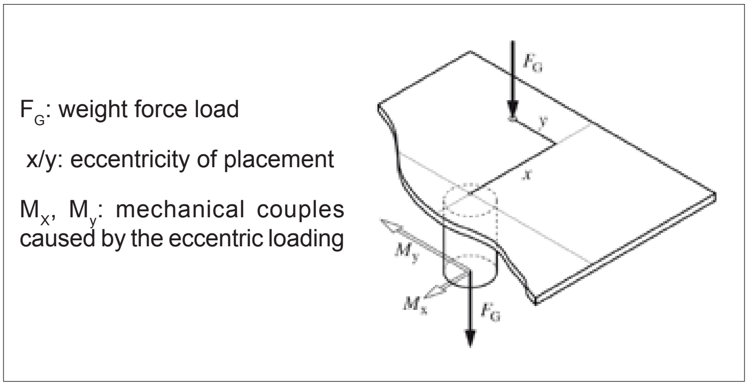


Figure 2. Graphical representation of eccentric load (corner load) error, which is dependent on load and distance from the center.

Figure 3. Robotic placement of wire weights on to the weighing pan using weight carriers with hooks.

Reducing Corner-Load Variance

Part of the overall Uncertainty budget which must be considered, is the error due to eccentric load placement, or corner load error. Asymmetrical placement of the center of gravity of the loaded mass causes this error. The eccentric load error increases with increasing load and distance from the center of the load receptor (Figure 2).

By comparison, it is extremely difficult with manual mass comparators for the technician firstly to place the weight concentrically, but secondly to continue doing this during the ABA or ABBA weighing series. Any small difference in physical weight placement will generate an error which will contribute to the overall Uncertainty Budget.

By contrast, it is simple with robotic mass comparators once adjusted properly, for the robot to place the weights in exactly the correct position, time after time. While efficient placement of the weight with the robotic arm is often enough to ensure reduced load variance, specialized instrumentation can go further to help prevent eccentric loading. For example, the clever design of the LevelMatic™ weighing pan (METTLER TOLEDO) helps balance users to avoid eccentric loads. The weighing pan design uses a combination of ball bearings and convex/concave weigh plates, which allow a weight lowered onto the weighing pan to essentially center itself. This makes any eccentricity error negligible.

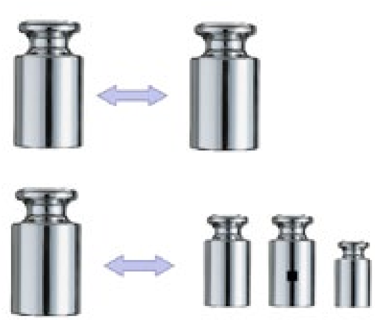
For wire weights, weight carriers with hooks carefully place the wire weight onto the weighing pan to allow the weight to find its center of gravity (Figure 3).

Calibrating Weight Sets and Weight Dissemination

Robotic systems also excel when calibrating weight sets. Weight set calibration is generally carried out in one of two ways. The "one vs. one" method requires a full reference weight set with all standard weights for accurate comparison. However, calibration of unknown masses can also be carried out by working "up" or "down" from just one reference. This is called dissemination.

1kg	1kg*	500g	500g C	200g	200g*	100g	100g C
A	B	-	-	-	-	-	-

1kg	1kg*	500g	500g C	200g	200g*	100g	100g C
-	-	A	-	B	B	B	-



"A" weight is the known reference
"B" weight is the unknown combination of test weights

Figure 4. Dissemination example: comparing the known nominal mass to unknown mass.

A combination of weight comparisons needs to be carried out, to compare the known nominal mass to unknown masses, in different combinations (see Figure 4).

A design matrix sets out the necessary combinations of comparisons of the known mass to combinations of unknown masses, and the results can then be evaluated (Table 2).

With robotic mass comparators, this matrix can be entered into, and saved within the control software (see Figure 5).

Dissemination can be time-consuming when performed manually, or even when using an automatic comparator. Often, weights must be stacked and specially-designed weighing schemes employed. This creates accuracy challenges: finding the center of gravity to reduce load variance is next-to-impossible when handling a group of weights with different nominal values.

A robotic system can handle a flexible weights dissemination scheme, however. Up to three weights can be loaded simultaneously onto the weighing pan with symmetrical placement eliminating load errors. Even if an asymmetric weighing scheme is chosen—for example, 5 g

1kg	1kg*	500g	500g C	200g	200g*	100g	100g C
A	B	-	-	-	-	-	-
A	-	B	B	-	-	-	-
	A	B	B	-	-	-	-
-	-	A	B	-	-	-	-
-	-	A	-	B	B	B	-
-	-	-	A	B	B	-	B
-	-	-	-	A	B	-	-
-	-	-	-	A	-	B	B
-	-	-	-	-	A	B	B
-	-	-	-	-	-	A	B

Table 2. Sample design matrix for dissemination.

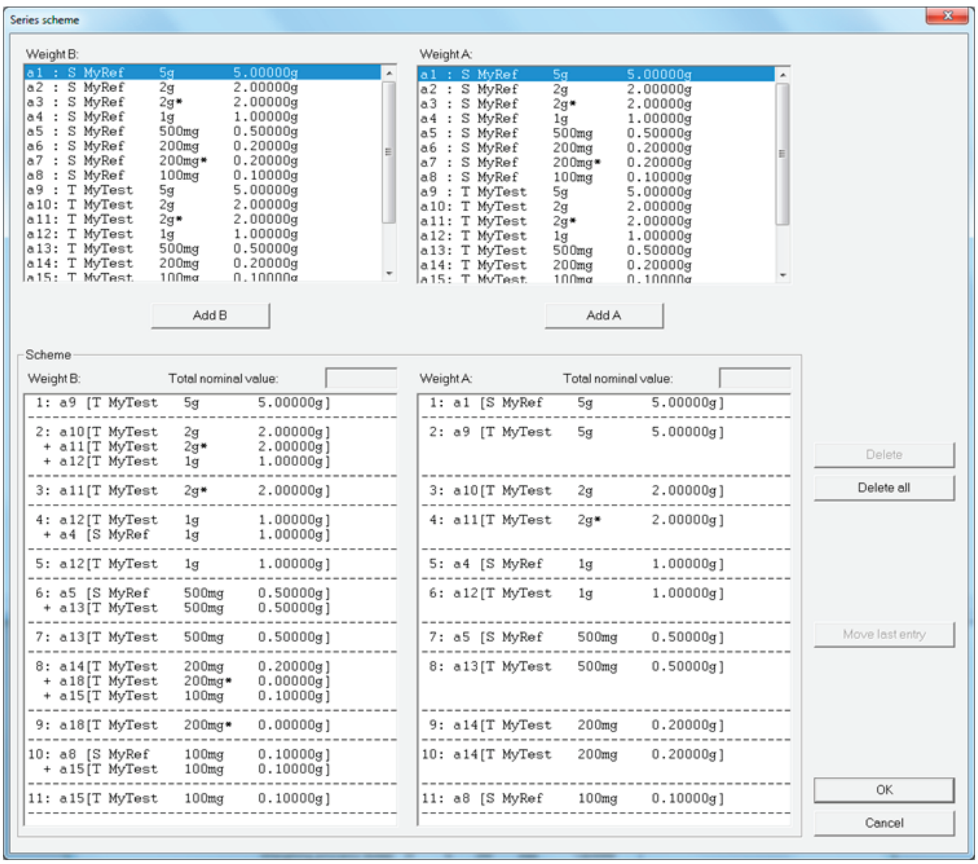


Figure 5. Dissemination sample design matrix in robotic mass comparator software.

Class	E_1	E_2	F_1	F_2	M_1, M_2, M_3
Minimum number of ABBA	3	2	1	1	1
Minimum number of ABA	5	3	2	1	1
Minimum number of $AB_1...B_n A$	5	3	2	1	1

Table 3. Minimum number of comparisons recommended as a function of class calibrated and comparison scheme used (Section C.4.3 - OIML R111).

vs. 3 g + 2 g—an automatic correction to the measurement value is made according to the determined value of the eccentricity error.

In summary, weight dissemination can be achieved and greatly simplified using robotic mass comparators. Human error is reduced, and highly accurate results obtained.

Handling Large Numbers

For operators charged with calibrating large numbers of masses, productivity is a concern that ranks almost as high as accuracy. Robotic systems have evolved over the years to ensure critical calibration tasks can be carried out accurately in less time.

A robotic system can maximize productivity by utilizing parameters and settings such as a pre-run check, which is an initial check of the loaded weight before measurement; history-specific pause for weights larger than 100g, which eliminates drift affecting difference between two weights when one has reached a higher temperature than the other due to elemental exposure; and start-delay, which for example allows acclimatization when weights in a magazine maintain a higher ambient temperature than the lab itself.

Setting a robotic system to carry out one pre-run check without recording data as part of the process can also help maximize productivity. This reduces the "first weighing effect" (drift) that is particularly noticeable after a change of nominal value. Depending on the class calibrated and the comparison scheme used, a minimum number of comparisons to be reported per group should also be chosen according to OIML recommendations (as shown in Table 3). This provides accuracy without requiring excessive numbers of measurements.

Ideal stabilization time will be evaluated by the technical expert who installs the system. However, integration time, or the number of seconds run after stabilization time has elapsed and during which the system records one measurement value per second with the average given as a measurement result, also needs to be established. This number should be set at no less than 5 to balance productivity concerns against those for accuracy.

Designed for Productivity

Over the years, robotic system design has also been improved to minimize handling. Some changes include processing weights with the same nominal values consecutively to eliminate switching of dial weights; optimization of magazine location to allow faster weight loading; and reduction of pre-run/centering time using "standard centering history": Centering and pre-run for standard weights used in many measurements can be skipped, saving valuable time.

As we continue to see smaller weights and enhanced productivity shift the landscape of weight manufacturing and standards setting, robotic systems—with their benefits of high throughput, reduced error potential, and enhanced accuracy—will continue to be optimized to meet the expectations of those who require robust, efficient mass comparator systems.

To download the free white paper, go to: http://www.mt.com/global/en/home/supportive_content/White_Papers/Mass_Calibration_Robotic.html?cmp=af_GLO_CalLab_LAB-WGH_WHP_RoboticMassComp_20160401.

10 Things to Know About Achieving ISO/IEC 17025 Accreditation

Rob Miller
American Association for Laboratory Accreditation (A2LA)

For organizations searching for options to differentiate their services, often times the most suitable way of achieving this is through accreditation to published standards such as ISO/IEC 17025. This outside evaluation based on internationally-recognized standards improves the organization's overall competitive advantage and showcases the commitment of the organization to quality and the integrity of the organization's output. Here are some things to bear in mind as you begin the accreditation process:

1) Recognize what accreditation is.

One of the first things to evaluate when considering accreditation is the difference between accreditation and certification or other commonly associated services. First, the organization should ask the question: "Is accreditation what is needed in my specific situation?" Registration and certification are often mistaken as equivalent to accreditation; however, these terms have distinct differences that should be noted. Accreditation refers to recognition given to an organization by an authoritative body. Accreditation is defined as a third-party attestation related to a Conformity Assessment Body (CAB) conveying formal demonstration of its competence to carry out specific conformity assessment tasks (ISO/IEC 17000). Accreditation can be granted to a variety of organizations, including laboratories, crime scene units, reference material producers and calibration providers. Accreditation is the most appropriate way to ensure an organization's competence to perform a specified task. Other frequently used terms include certification and registration – both of these are a third-party attestation that a product, process, service, or system complies with a defined set of requirements. Registration is a term frequently used to identify that an organization's Management System has been certified to meet a given set of requirements (such as ISO 9001 or 14001). These are often confused for accreditation, and an organization should consider whether or not they have need of attestation of their competence (accreditation), or attestation of compliance (certification).

2) Obtain a copy of the Standard.

Once the decision has been made to become ISO/IEC 17025 accredited, a copy of the Standard should be obtained. At this time, a thorough review of the Standard is imperative to gain familiarity with its requirements. The Standard itself is made up of five basic components including the Scope, Normative References, Terms and Definitions, Management Requirements and Technical Requirements. The most essential of these components, which your organization will need to ensure compliance with, are the Management and Technical Requirements. The Management Requirements are essentially associated with your laboratory's quality management system, whereas the technical requirements outline the elements that determine the correctness and reliability of the tests and calibrations your laboratory performs. Some organizations may choose to hire a consultant to help them understand the Standard and implement the requirements into their system. This is not a required step and should only be determined after reviewing the Standard and evaluating the time and resources available to achieve compliance to the requirements. A copy of the ISO/IEC 17025 standard may be purchased from the International Organization for Standardization (ISO) at www.ISO.org.

3) Investigate the need for training for you and your staff.

Another option to consider, although it is not necessary, is to obtain training for your laboratory personnel on the ISO/IEC 17025 standard itself. This can be done in-house or through a public venue and a variety of options may be found at www.A2LA.org/Training. Training can be done early on in the process to help laboratory personnel gain an understanding of the Standard and the overall goal of accreditation. Including all laboratory staff in a general ISO/IEC 17025 training course can assist in illustrating how every individual in the organization has a role in the accreditation process.

4) Begin the process of documentation.

Once you've reached this point, whether you are working independently or with a consultant, the next task should be to document all of your organization's policies, systems, programs, procedures and instructions to the extent necessary. This means that there should be objective evidence to demonstrate that the level of detail found in your documentation is adequate for producing the desired and required outcome. You are the best choice to complete this task as you are in the position of being most familiar with the organization's system. For this step, a consultant would be able to review the laboratory's procedures to ensure they are properly written and in compliance with ISO/IEC 17025, but they should only be used as a resource to provide guidance and recommendations. There are templates available to assist you in structuring your documentation. Examples of procedures may also be found on the Internet from other organizations who have been through the accreditation process, such as the US Food and Drug Administration (FDA) or United States Department of Agriculture (USDA). These may provide some insight as to what is expected in ISO/IEC 17025-compliant procedures. Preparing the documentation of your laboratory operations can be the most time-consuming step in this process and may take several months to complete.

5) Implement ISO/IEC 17025-compliant policies and procedures.

Once you have documented your policies and procedures and have ensured compliance with ISO/IEC 17025, you are now ready to begin implementation. This step can begin while the procedures are still being written, as this may help in determining if the procedures are adequate, detailed enough and appropriate for your system and processes. Once you are confident that all systems have been documented and implemented, you are ready for the next step.

6) Conduct an internal audit.

An internal audit must be conducted by a qualified internal auditor such as a "trained and qualified" member of the laboratory's staff or a contracted consultant. External third-party audits do not meet this requirement. There are no specific internal auditor training requirements specified in the ISO/IEC 17025 standard; therefore, further elaboration may be provided by the specific accreditation body chosen. The results of the internal audit should identify any gaps or weaknesses in the laboratory's system and determine if additional resources are needed in order to ensure compliance. Sufficient records must be kept of the internal audit results and any follow up actions taken. The outcome of the internal audit may help determine if the laboratory is, in fact, ready for an external assessment or if additional work is needed before applying for accreditation.

7) Perform a management review.

To fully comply with the requirements of ISO/IEC 17025 in order to seek accreditation, the lab must complete a management review in accordance with their documented procedure and pre-determined schedule as required by ISO/IEC 17025, Section 4.15. Although the Standard notes that a typical period for conducting the review is annually, there is no set requirement for the frequency of the review. The management review is to be conducted by the laboratory's top management which has the authority and resources necessary to make changes to any aspect within the laboratory. The lab will determine who these individuals are but they are typically those who hold positions such as President, Quality Manager, Technical Manager, etc.

8) Evaluate accreditation bodies.

Choosing an accreditation body is an important part of the process. Taking the time to evaluate each accreditation body's past performance, customer service and technical ability is imperative. Most importantly, you want to ensure that the accreditation body you choose is a signatory of the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement (MRA). Accreditation bodies that are ILAC MRA signatories are assessed by ILAC peer evaluators to determine compliance to specific requirements (ISO 17011) – similar to how laboratories are assessed to ISO/IEC 17025 requirements. Additional information regarding ILAC and its signatories may be found at www.ilac.org. A current list of the signatories to the ILAC Arrangement including scopes and dates of admission to the MRA are included in the Signatory Search section of the ILAC website mentioned above. You may also download a PDF version of the list of ILAC MRA signatories from the "ILAC MRA and Signatories" page of the ILAC website.

9) Apply for accreditation.

Once your systems have been implemented and you have completed the internal audit and management review, you are ready to apply for accreditation. After deciding which accreditation body you will use to obtain your accreditation, you are encouraged to ask specific questions related to the accreditation process. It is a good idea to develop familiarity with the accreditation body and their staff as they will likely have additional requirements and policies which must be implemented in addition to ISO/IEC 17025. They can also provide valuable customer service to assist on your journey through the accreditation process.

10) Market your accreditation.

Once accreditation is achieved, you may consider how you will ultimately benefit from the process of accreditation. One important factor is the understanding that this may be the differentiating factor that allows your organization to stand out from the crowd. Adherence to international standards such as ISO/IEC 17025 can improve your competitive advantage, yet still allow the flexibility needed to evolve. The end result of accreditation improves your organization's ability to make more informed decisions and help manage risk. We are acutely aware of the time and resources required to achieve and maintain this important attestation of your technical competence, so we encourage you to advertise and promote your accreditation at every opportunity.

Some of the most common ways in which accredited organizations promote their accreditation include:

- Press Releases
- Advertisements in Journals and Periodicals
- Tradeshow Displays and Handouts
- Flyers, Catalogs and Brochures
- Clothing
- Email blasts
- Letterhead
- Business Cards and Postcards
- Quotes, proposals and Solicitations
- Websites

There are many more possibilities that you could use to market your accreditation. If there are any questions or clarification needed, you can always contact your accreditation body to discuss any references to your accreditation that you wish to publish. You are encouraged to promote your accreditation to acknowledge the hard work put into achieving accredited status

The entire progression of becoming accredited - from initial thought to final accreditation - can be an involved and timely process. This should be expected as you are integrating, in most cases, a fresh ISO/IEC 17025-based quality management system into your laboratory's daily activities. ISO/IEC 17025 accreditation and the activities that support it should not be viewed as something additional to or separate from the laboratory's current process, but rather as a living, evolving complement to the way in which the laboratory operates. Compliance to the ISO/IEC 17025 standard can strengthen a laboratory's credibility and provide confidence in the data that is being reported.

Mr. Rob Miller is an Accreditation Manager and Program Manager at the American Association for Laboratory Accreditation (A2LA) and has been employed with A2LA since 2003. He manages the day to day operations for the Product Certification/Materials testing team that facilitates the assessment process for new and renewal organizations in the Mechanical, Chemical, Acoustics & Vibration, Thermal, Nondestructive, Electrical and Biology fields of testing. He is also responsible for the implementation/management of the Product Certification Accreditation Program (ISO/IEC 17065).

NEW PRODUCTS AND SERVICES

The New R&S RTO2000 Oscilloscope

Munich, February 23, 2016 -- Rohde & Schwarz presents the R&S RTO2000, the most compact lab oscilloscope for multi-domain applications. When using it to check advanced embedded designs, developers are able to analyze how sophisticated functional units such as power supplies, the processor system and the sensor technology interact. The R&S RTO2000 displays the correlations between time, frequency, protocol and logic analysis measurement results like no other oscilloscope can.

Via the analog input channels, the user simultaneously sees the signal in the time and frequency domain, and if desired, the spectrogram. Newly added functions such as peak list, max. hold detectors and the logarithmic display make frequency analysis even more efficient.

The new zone trigger enables the graphical separation of events in the time and frequency domain. Users can define up to eight zones of any shape. A trigger signal is activated when a signal either intersects or does not intersect the zone. This makes it especially easy to detect disturbances in the spectrum during EMI debugging or to separate read/write cycles of storage media in the time domain.

It is the first oscilloscope in this class to offer a memory of up to 2 Gsample. This is useful for the history function, which provides access to previously acquired waveforms at any time. A trigger timestamp allows time correlation. Users can view all saved signals and analyze them with tools such as zoom, measurement, math and spectrum analysis functions. Signal processing in the ASIC and intelligent memory management ensure smooth handling of long pulse and protocol sequences.

The new R&S RTO2000 oscilloscope also delivers outstanding performance. The high definition (HD) mode increases the vertical resolution to up to 16 bits, making signal details visible. The HD mode activates configurable lowpass filtering of the signal after the A/D converter. Users can trigger on all, even the smallest, signal details.

With one million waveforms per second, the R&S RTO2000 sets a new standard in this class of oscilloscopes. Users are able to quickly detect sporadic signal faults. The R&S RTO2000 provides high-speed analysis even when histogram and mask functions are active.

The optimized user interface makes the R&S RTO2000 very simple to operate. Thanks to the brilliant 12.1” capacitive touchscreen with gesture support and color-coded controls, users can easily configure the instrument for any measurement task. Users can customize the waveform display with SmartGrid. They can quickly access important tools on a toolbar and document measurement results and instrument settings at the press of a button. The app cockpit provides direct access to all available applications such as trigger and decoding functions, conformance and signal integrity tests, I/Q analysis and even customer-specific development tools.

For more information about oscilloscopes, visit: https://www.scope-of-the-art.com

GAGEpack Dashboard Feature

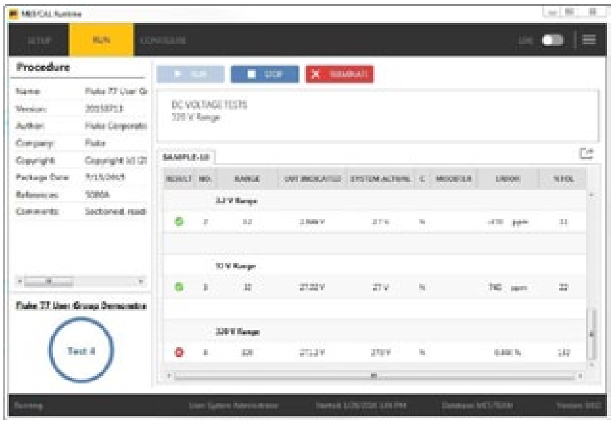
DAYTON—A powerful dashboard feature that provides a high-level overview for managers, technicians, and auditors is the “crown jewel” in the newest release of GAGEpack from PQ Systems, with an improved user experience that streamlines the gage management process.

GAGEpack is a powerful gage calibration solution that maintains complete histories of measurement devices, instruments, and gages. To guarantee timely calibration, the software provides a variety of new tools, including the dashboard feature, archiving capability, and precise accounting for audit trails.

The dashboard feature offers immediate access to summary information about gage inventory, historical events, and projected workload, improving efficiency and putting critical information at users’ fingertips. “Just as an airline pilot can determine a plane’s altitude and speed, the direction and velocity of the wind, fuel consumption, equipment condition, and terrain information by glancing at indicators, GAGEpack’s dashboard offers immediate access to information relevant to assuring accuracy and efficiency in measurement equipment,” says product manager Eric Gasper.

An archiving function in the newest release allows obsolete gages to be segregated from active gages, while retaining the associated data for reference and regulatory compliance. The auditing system offers a robust and precise accounting of all changes to gages and events.

PQ Systems is a privately-held company headquartered in Dayton, OH, with representation in Europe, Australia, Central and South America, Asia, and Africa, and customers in over 60 countries. For more than 30 years, the company has been helping businesses drive strategic quality outcomes by providing intuitive solutions to help manufacturers optimize process performance, improve product quality, and mitigate supply chain risk. www.pqsystems.com



Automating calibration procedures with MET/CAL can reduce the time to set up and run procedures by as much as 80 percent, helping calibration laboratory technicians get more done. (PRNewsFoto/Fluke Calibration)

Fluke Calibration MET/CAL Version 9 Simplifies Calibration Processes

EVERETT, Wash., April 12, 2016 /PRNewswire/ -- Fluke Calibration, a division of Fluke Corporation and certain of its affiliates, introduces version 9 of its MET/CAL® Calibration Management Software, the latest edition of the industry-leading application suite for calibration professionals who need to automate the calibration process and manage calibration assets efficiently and consistently. Automating calibration procedures with MET/CAL can reduce the time to set up and run procedures by as much as 80 percent, helping calibration laboratory technicians get more done.

MET/CAL 9 software has a new intuitive Runtime interface that is easier to use with features like:

- Drop down menus,
- Clean and visible prompts and results,
- A progress wheel that shows how much of the procedure has run, and
- Procedure details displayed throughout the run.

Version 9 also features a new and improved configuration format with check boxes and slide bars to simplify complex hardware configurations. Information is laid out in a simplified format and most changes do not require a restart of either the MET/CAL editor or Runtime.

MET/CAL is a software suite consisting of two applications: MET/CAL for automated calibration and MET/TEAM® for test and measurement asset management. The combination allows calibration professionals to automate calibration on test and measurement tools and equipment, including dc/lf, RF, and microwave instruments. The combination also allows users to easily create, edit, test, and document calibration procedures, and track asset information, including calibration and maintenance history and status, traceability, users, customers, and locations.

MET/CAL software users can obtain extended support through the MET/SUPPORTSM Gold support program. The annual membership program includes priority access for software support, free software upgrades, free access to more than 8,000 performance-tested MET/CAL procedures, and a 20 percent discount on training and database services.

To learn more about Fluke Calibration MET/CAL Calibration Software version 9 or download a free trial version, visit http://us.flukecal.com/metcal9.

Fluke, Fluke Calibration, MET/CAL and MET/TEAM are trademarks of Fluke Corporation.

Additel 780S Controller Series Provide an Accurate and Affordable Solution to 3,000 psi (200 bar)

Yorba Linda, Calif., April 15, 2016–Additel Corporation introduces their new ADT780S benchtop pressure controller with precision accuracy to 0.005% of reading + 0.005% FS and standard accuracy to 0.02% FS. The ADT780 configurations have the unique capability of generating pressure to 3,000 psi (200 bar) without the aid of a gas supply. By utilizing an electric pump this unit produces pressures to 1,000 psi (70 bar) and with an electric pump and gas booster to 3,000 psi (200 bar).

Each unit comes with one Intelligent Pressure Module configured to the many range offerings provided. Standard accuracy sensors are certified with a 1 year accuracy of 0.02% FS. The precision quartz-based sensors improve the one-year accuracy specification to 0.005% of reading + 0.005% FS.

The Additel 780S series offers two base ranges: to 1,000 psi (70 bar) and to 3,000 psi (200 bar). The base range establishes the maximum controlling range of the controller. Each configuration includes a control sensor in which is preselected to the range best suited for the application need. External and internal sensors can be used which allows for expanded range and accuracy capability in the future.

For more information visit www.additel.com. For information on Additel products and applications, or to find the location of your nearest distributor, contact Additel corporation, 22865 Savi Ranch Parkway, Suite F, Yorba Linda, CA 92887, call 1-714-998-6899, Fax 714-998-6999, email sales@additel.com or visit the Additel website at www.additel.com

About Additel

Additel Corporation is one of the leading worldwide providers of process calibration tools. Additel Corporation is dedicated to the design and manufacture of high-quality handheld test tools and portable calibrators for process industries in precision pressure calibration and test instrumentation. With more than 18 years in the industry, Additel has successfully developed Pressure Controllers, Portable Automated Pressure Calibrators, handheld Digital Pressure Calibrators, Documenting Process Calibrators, Multifunction Process Calibrators, Digital Pressure Gauges, and various Calibration and Test Pumps.

Hacker Crackdown

Michael Schwartz
Cal Lab Solutions, Inc.

I was recently on the road visiting my customers both new and old. During this trip I also wanted to check in with those customers we quoted but never got an actual purchase order from. I wanted to understand why they were not doing business with us. I wanted to gain a better perspective from their point. Maybe it would help us become a better company, service them better. But this trip turned out a little different. Instead I discovered many calibration labs don't understand many of the risks associated with employees and the software that can be found on their computers.

During one visit with a potential customer who expressed great interest in doing business with us in the past, I discovered they had chosen to hire an experienced programmer bringing all development in-house as opposed to outsourcing it. This wasn't a deal breaker by any means; I have several customers who have in-house developers. With them we tend to work on the very complex MET/CAL® procedures as well as building drivers and tools, so I shifted the conversation and the meeting went very well.

Later that afternoon, I visited the calibration lab, where their new programmer was showing me what he was working on related to automation. I was very impressed this programmer had some very well written procedures as well as a large library of procedures, something that would normally take years to accomplish. And therein was the problem, because he had only been working for this company less than one year. What he was showing me was all the software he had copied off the computer from the company where he worked before he came to this job. I watched him as he would open a procedure, and then quickly delete the name of the company information where the procedure was created.

This reminded me of the book *The Hacker Crackdown: Law and Disorder on the Electronic Frontier* by Bruce Sterling.* In it, the author describes bulletin board systems as the "life-blood of the digital underground" during the 1980's. But many boards existed for legitimate exchange of information as well. It just so happened that illicit data had been stored on computer systems unknown to those who owned and used them for business. Some of these people had equipment confiscated and were even charged and jailed.

Do you know what's on your company servers?

Then I remembered a different experience when I was onsite at a much larger customer's calibration lab where I witnessed an employee, "John," escorted out of the building. I remember talking to the technician earlier that day and thinking to myself "John seemed to be a really sharp tech." And as we all know in the metrology world, it is hard to find and keep good technicians. I was perplexed, why was John being fired on the spot—what did he do that was so offensive?

Later, I casually asked one of the managers about the incident. The answer was amazing: Earlier that week, John had copied some personal files up to the company's server from his thumb drive, and then copied them to another thumb drive because his workstation only had one USB port. The files were movies of significant enough size to catch the attention of IT who contacted his manager. He was warned at that time, "No personal files are to be copied onto any company computers." I was there for his second offense when he had copied a Word® document to the server—his homework for a class he had been taking—and they fired him on the spot!

I am not giving any legal advice here, but I think I know and understand why the company let John go on the spot without hesitation for what most people would consider a minor infraction. My takeaway was simple: Because the movies were more than likely stolen property, the company and their legal team knew the company was liable for possessing the stolen property on their servers. In the end, it didn't matter how good of a tech John was, he was not worth the risk of being in possession of stolen intellectual property (IP).

So those star programmers—the ones hired away from the competition—if they are really star programmers, they don't need the IP from their previous job. If that IP ends up on the company computers, then the company is at risk for legal litigation. It really doesn't matter how it got there or who put it there, because in the end a company is legally responsible for the actions of its employees. And all too often, it's a disgruntled ex-employee who reports the company for having illegal IP on company computers.

* *The Hacker Crackdown* was first published in 1992 and later digitized. MIT currently hosts a copy online at http://www.mit.edu/hacker/hacker.html. This book is a classic read for any techie.

September 12–15, 2016 | Disneyland® Hotel and Convention Center | Anaheim, California
AUTOTESTCON 2016
The world's premier automatic test conference brings together the military & aerospace automatic test industry and government & military acquirers and exhibit leading edge products and services.
IEEE-AUTOTESTCON 2016
The 2016 Technical Program includes over 100 papers that represent the interests of those participants presenting technical papers. The Program is complemented by more than 50 companies and DOD Agencies presenting a broad range of services, products and new innovations that are leading the way forward for the test industry.
Registration and additional information available at
http://www.autotestcon.com
Mission Assurance Through Advanced ATE
IEEE
Sponsored by
IEEE Aerospace and Electronics Systems Society,
IEEE Instrumentation and Measurement Society
Disneyland
© Copyright 2014 Raytheon Company. All rights reserved.