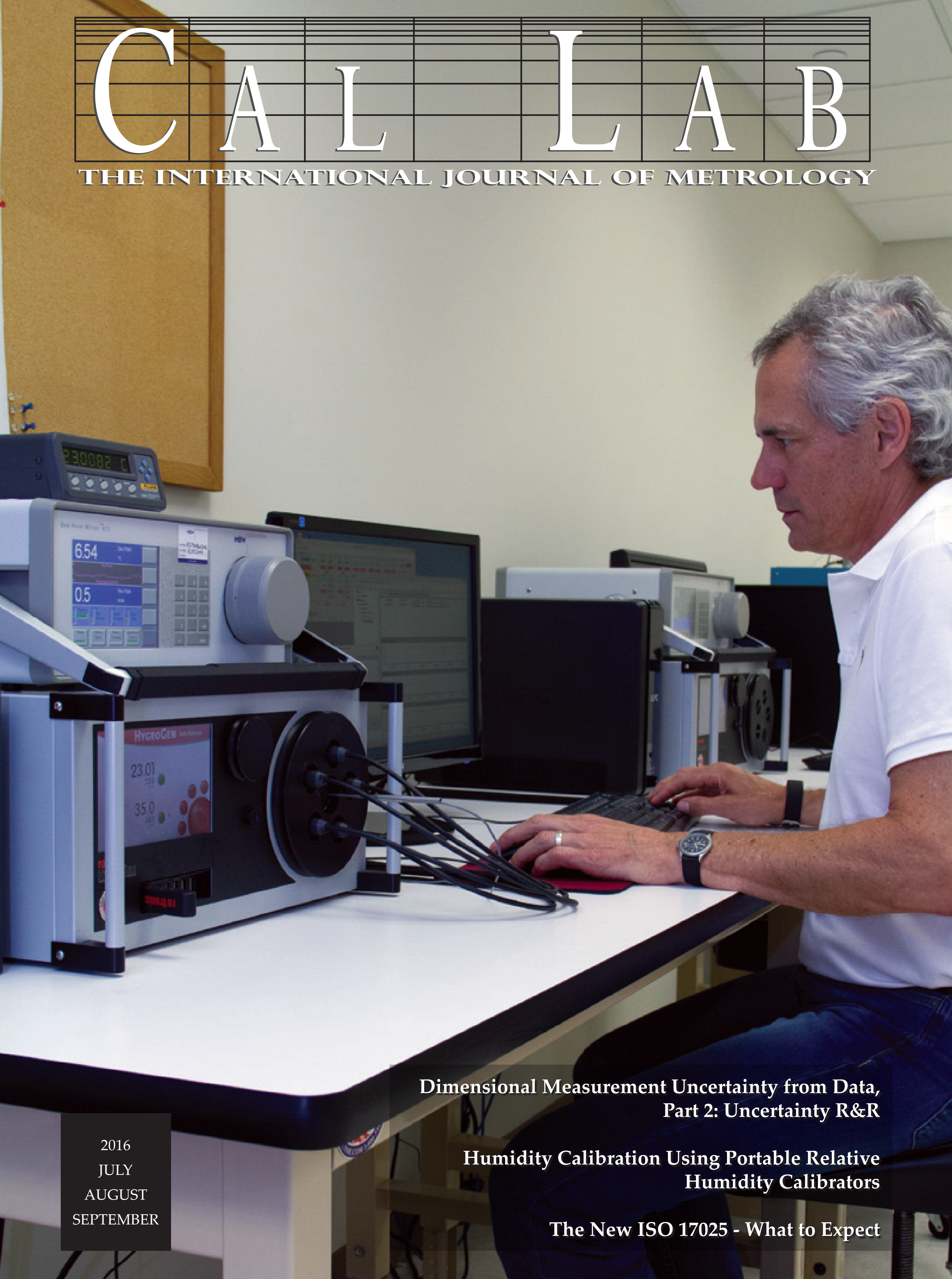
CAL LAB

THE INTERNATIONAL JOURNAL OF METROLOGY



Dimensional Measurement Uncertainty from Data, Part 2: Uncertainty R&R

Humidity Calibration Using Portable Relative Humidity Calibrators

The New ISO 17025 - What to Expect

2016
JULY
AUGUST
SEPTEMBER

Electric Current Measurement

DANISENSE

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

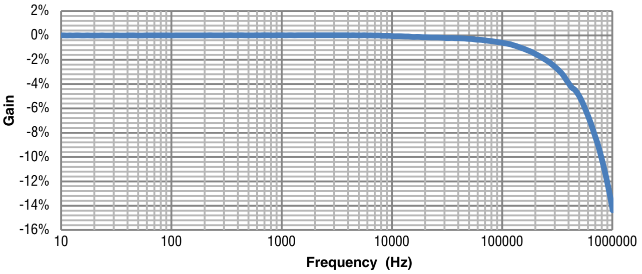
	DS200	**DS600**	**DS2000**	**DS5000**
Primary Current, rms	200A	600A	2000A	5000A
Primary Current, Peak	±300A	±900A	±3000A	±7000A
Turns Ratio	500:1	1500:1	1500:1	2500:1
Output Signal (rms/Peak)	0.4A/±0.6A†	0.4A/±0.6A†	1.33A/±2A†	2A/±3.2A†
Overall Accuracy	0.01%	0.01%	0.01%	
Offset	<20ppm	<10ppm	<10ppm	<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˚

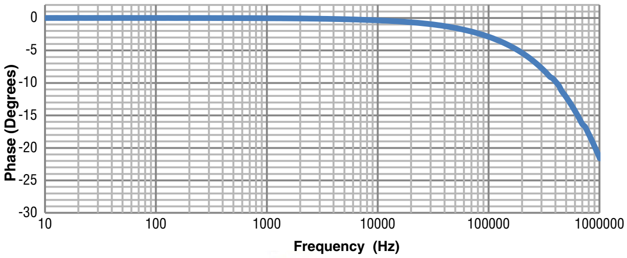
† Voltage Output options available in ±1V and ±10V

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 3

CAL LAB
THE INTERNATIONAL JOURNAL OF METROLOGY

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FEATURES

DEPARTMENTS

ON THE COVER: Humidity and temperature calibration using the Rotronic HygroGen HG2 humidity chamber, RH Systems 973 dew point mirror, and Fluke precision thermometer at the Rotronic Instrument calibration laboratory. Rotronic maintains a NVLAP accredited laboratory in Hauppauge NY. Rotronic recently celebrated 50 years since its founding in 1965.

CALENDAR

UPCOMING CONFERENCES & MEETINGS

Sep 7-9, 2016 21st IMEKO TC4 Symposium on Measurements of Electrical Quantities. Budapest, Hungary. The symposium covers the broad topics in measurement of electrical quantities and in related fields, with special track on analog-to-digital and digital-to-analog conversion. http://www.imeko-tc4-2016.hu/.

Sep 8-9, 2016 Nanotechnology for Instrumentation and Measurement Workshop (NANOfIM). Chemnitz, Germany. The workshop is supported by the IEEEE Nanotechnology Council and the IEEE Instrumentation and Measurement Society. http:// www.tu-chemnitz.de/etit/messtech/nanofim.

Sep 19-23, 2016 Simposio de Metrología. Santiago de Querétaro, México. Since its establishment, the Mexican Institute of Metrology, Centro Nacional de Metrología (CENAM) has provided support to the different sectors of society to meet their metrological needs in order to contribute to the welfare of the population and to increase the country's competitiveness. http://www.cenam.mx/simposio/.

Sep 26-28, 2016 T&M Conference. Gauteng, South Africa. The National Laboratory Association of South Africa (NLA-SA) Test & Measurement Conference will have various streamed presentations, interactive discussion sessions and tutorials for Laboratory Personnel (Management, Metrologists, Analysts, Technologists, Technicians), SHEQ Practitioners, Production/ Process Engineers, Students. http://www.home.nla.org.za/.

Sep 26-29, 2016 International Flow Measurement Conference, FLOMEKO 2016. Sydney, Australia. Hosted by the Metrology Society of Australasia, this event will bring together experts in flow and volume measurements from industry, metrology laboratories and national measurement institutes from all over the world. http://www.metrology.asn.au/flomeko2016/.

Oct 4-7, 2016 ISMQC – 12th International Symposium on Measurement and Quality Control. Florianópolis, Brazil. This year, the 12th edition of the ISMQC is promoted by two traditional IMEKO technical committees, TC14 "Measurement of Geometrical Quantities" and TC2 "Photonics", under the motto "Metrology and the Technological Innovation Process." http://ismqc2016.org.br/.

Oct 12, 2016 Strategic Automation Leadership Conference. Research 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. https://www.isa.org/strategicautomation2016/.

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Subscription fees for 1 year (4 issues)
$50 for USA, $55 Mexico/Canada,
$65 all other countries.
Visit **www.callabmag.com**
to subscribe.

Printed in the USA.

ISSN No. 1095-4791

EDITOR'S DESK

Goings On

We just got back from Saint Paul, Minnesota. It's a charming river city with Art Deco architecture, an extensive skyway, and small downtown park where the food trucks converge at lunchtime.

Our publisher had his booth set up on the exhibit floor of the NCSL International Workshop & Symposium at the RiverCentre in downtown Saint Paul, while I got to sneak in and out of different technical presentations. It's a great way to get a sampling of the different disciplines of metrology and learn something totally unexpected. The one thing that stood out strong this year at NCSL International was the excellent line-up of technical papers. Some exhibitors had just attended the Conference on Precision Electromagnetic Measurements (CPEM) which just wrapped up in Ottawa, Ontario… so much going on and so little time!

While the Measurement Science Conference (MSC) is held each year in southern California, NCSL International moves around the United States and has additional regional meetings throughout the US and internationally. Both conferences also hold yearly tutorial sessions—MSC in southern California and NCSLI along the east coast—so there's plenty of opportunity for anyone to soak up technical instruction. These tutorials are a great way to gain some knowlege and support these organizations at the same time.

In this issue, Ted Doiron of the Dimensional Metrology Group at NIST continues with part two of calculating measurement uncertainties—this time using Uncertainty Repeatability & Reproducibility—titled "Dimensional Measurement Uncertainty from Data, Part 2: Uncertainty R&R." Next, we have "Humidity Calibration Using Portable Relative Humidity Generators" by Michael Boetzkes, exploring key features of RH generators. And lastly, we have "The New ISO 17025 - What to Expect," the first of a series of ISO 17025 articles contributed by Dr. George Anastasopoulos of the International Accreditation Service (IAS), covering the upcoming changes as they unfold.

Happy Measuring,

Sita Schwartz

CALENDAR

UPCOMING CONFERENCES & MEETINGS

Oct 19-21, 2016 METROARCHAEO - International Conference on Metrology for Archaeology and Cultural heritage (TC4). Torino, Italy. https://www.imeko.org/index.php/homepage/coming-events.

Oct 23-28, 2016 ASPE Annual Meeting. Portland, OR. Featuring tutorials, technical paper presentations, poster sessions, a student challenge and mentoring session, commercial exhibits and technical tours covering: Controls and Mechatronics, Metrology Systems, Precision Design, Precision Manufacturing, Micro and Nano Technologies and Surface Characterization and Applications of Measurement Science. http://aspe.net/technical-meetings/31st-annual-meeting/.

Oct 25-28, 2016 34th International North Sea Flow Measurement Workshop. St. Andrews, UK. Among the Workshop presentations is a keynote address from the Flow Measurement Institute, looking at the current and future skills requirements that industry is now demanding from flow measurement professionals. http://www.tuvnel.com/site2/subpage/events_courses_training.

Nov 7-9, 2016 MATHMET 2016 - International Workshop on Mathematics and Statistics for Metrology. Berlin, Germany. PTB. The workshop will provide a forum for applied mathematicians, statisticians, and metrologists to present and discuss contemporary methods and challenges in applications of mathematical models and statistical data analysis to measurement science. http://www.ptb.de.

Nov 9-10, 2016 9th International Workshop on Analysis of Dynamic Measurements. Berlin, Germany. PTB. The workshop will bring together theoretical and practical expertise in the field of dynamic measurements. The main intention is to leverage the common mathematical and statistical theory in different metrological application areas, which is possible only in such an interdisciplinary forum. http://www.ptb.de.

SEMINARS: Dimensional

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 12-15 Dimensional Measurement Training: Level 2 – Measurement Applier. Coventry University, UK. A four day training course for those who have a good basic understanding of measurement principles gained through the Level 1 training course. Level 2 is applicable to all industrial sectors as a stand-alone qualification or as a building block for further NPL Dimensional Measurement Training Levels - 3 & 4. http://www.npl.co.uk/training.

Sep 12-15, 2016 Dimensional Measurement Training: Level 2 – Measurement Applier. Telford, UK. Hexagon Metrology. A four day training course for those who have a good basic understanding of measurement principles gained through the Level 1 training course. Level 2 is applicable to all industrial sectors as a stand-alone qualification or as a building block for further NPL Dimensional Measurement Training Levels - 3 & 4. http://www.npl.co.uk/training.

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.

Sep 27-30, 2016 Dimensional Measurement Training: Level 2 – Measurement Applier. Bristol, UK. INSPHERE Ltd. A four day training course for those who have a good basic understanding of measurement principles gained through the Level 1 training course. Level 2 is applicable to all industrial sectors as a stand-alone qualification or as a building block for further NPL Dimensional Measurement Training Levels - 3 & 4. http://www.npl.co.uk/training.

Oct 3-5, 2016 Dimensional Measurement Training: Level 1 – Measurement User. Telford, UK. Hexagon Metrology. A three day training course introducing measurement knowledge focusing upon Dimensional techniques. Applicable to all industrial sectors as a stand-alone qualification or as a building block to further NPL Dimensional Measurement Training Levels – 2 & 3. http://www.npl.co.uk/training.

Oct 6-7, 2016 Hands-On Gage Calibration and Repair. Dallas, 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.

Oct 10-11, 2016 Hands-On Gage Calibration and Repair. Indianapolis, IN. 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.

Oct 10-13, 2016 Dimensional Measurement Training: Level 2 – Measurement Applier. Telford, UK. Hexagon Metrology. A four day training course for those who have a good basic understanding of measurement principles gained through the Level 1 training course. Level 2 is applicable to all industrial sectors as a stand-alone qualification or as a building block for further NPL Dimensional Measurement Training Levels - 3 & 4. http://www.npl.co.uk/training.

Oct 13-14, 2016 Hands-On Gage Calibration and Repair. Pittsburgh, PA. 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.

CALENDAR

Oct 24-26, 2016 Dimensional Measurement Training: Level 1 – Measurement User. Coventry University, UK. A three day training course introducing measurement knowledge focusing upon Dimensional techniques. Applicable to all industrial sectors as a stand-alone qualification or as a building block to further NPL Dimensional Measurement Training Levels – 2 & 3. http://www.npl.co.uk/training.

Oct 25-27, 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/.

Nov 1-3, 2016 Dimensional Measurement Training: Level 1 – Measurement User. Telford, UK. Hexagon Metrology. A three day training course introducing measurement knowledge focusing upon Dimensional techniques. Applicable to all industrial sectors as a stand-alone qualification or as a building block to further NPL Dimensional Measurement Training Levels – 2 & 3. http://www.npl.co.uk/training.

Nov 8-9, 2016 Hands-On Gage Calibration and Repair. Chicago, IL. 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.

Nov 8-11, 2016 Dimensional Measurement Training: Level 2 – Measurement Applier. Telford, UK. Hexagon Metrology. A four day training course for those who have a good basic understanding of measurement principles gained through the Level 1 training course. Level 2 is applicable to all industrial sectors as a stand-alone qualification or as a building block for further NPL Dimensional Measurement Training Levels - 3 & 4. http://www.npl.co.uk/training.

Nov 15-16, 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.

Nov 22-24, 2016 Dimensional Measurement Training: Level 1 – Measurement User. Bristol, UK. INSPHERE Ltd. A three day training course introducing measurement knowledge focusing upon Dimensional techniques. Applicable to all industrial sectors as a stand-alone qualification or as a building block to further NPL Dimensional Measurement Training Levels – 2 & 3. http://www.npl.co.uk/training.

CALENDAR

SEMINARS: Electrical

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

Sep 19-22, 2016 Comprehensive Flow Measurement. Loveland, CO. CEESI. This course is applicable for senior technicians, engineers, and technical sales staff with experience using flow meters. Prerequisites: Extensive flow measurement experience or an engineering degree. A basic understanding of algebra, fluid mechanics, and thermodynamics is helpful. http://www.ceesi.com/events

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.

Nov 15-17, 2016 Principles and Practice of Flow Measurement Training Course. East Kilbride, UK. NEL. The course enables delegates to understand the issues surrounding flow measurement. It also provides the delegate with unbiased view of the various technologies available and the basic knowledge required to make informed choices. http://www.tuvnel.com/site2/subpage/events_courses_training

Nov 14-18, 2016 Gas Flow Metrology. Delft, The Netherlands. VSL Dutch Metrology Institute. This five day course focuses on the backgrounds of gas flow and energy measurement and the pitfalls that can be encountered in these measurements. http://vsl.nl/en/course-overview.

CALENDAR

SEMINARS: General & Management

Sep 12 - 13, 2016 Introduction to Measurement. Pretoria, South Africa. The National Laboratory Association (NLA). The main purpose of the course is to provide the knowledge and background required for the various discipline specific metrology courses that the NLA-SA presents, and increase awareness of measurement and establish a common frame of reference within the Southern Africa context. http://www.home.nla.org.za/

Sep 21, 2016 Root Cause Analysis and Corrective Action. Indianapolis, IN. A2LA. The Root Cause Analysis and Corrective Action (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 Root Cause Analysis and Corrective Action (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 17-20, 2016 Effective Cal Lab Management. Everett, WA. Fluke Calibration. Effective Cal Lab Management is ideal for anyone in a lead or supervisory position in a cal lab looking for ways to better communicate and manage personnel, and to bring about efficiency and customer satisfaction improvement. http://us.flukecal.com/training/courses/CLM-303.

Nov 15-17, 2016 Cal Lab Management; Beyond 17025 Training. Boca Raton, FL. WorkPlaceTraining. Does your lab manager have formal management training or experience? This course is designed for new lab managers or managers who would like a refresher or different perspective. http://www.wptraining.com/.

SEMINARS: Industry Standards

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. This course helps you understand and apply the requirements of the ISO/IEC 17025:2005 standard. You'll examine the origins of the standard, 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. 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.

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.

Oct 3-4, 2016 Internal Auditing. Frederick, MD. A2LA.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.

Oct 18-19, 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.

Oct 20, 2016 Fundamentals of SOP Writing. Frederick, MD. A2LA.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.

Oct 24-26 Internal Auditing to ISO/IEC 17025. Omaha, NE. 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. www.asq.org/courses/iso-iec-17025-internal-auditor.html.

Oct 24-26, 2016 ISO/IEC 17025 Lead Assessor Training. Omaha, NE. 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.

Oct 24-28, 2016 Assessment of Laboratory Competence. A2LA. San Diego, CA. 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.

Oct 31-Nov 4, 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.

Nov 14-16, 2016 Internal Auditing to ISO/IEC 17025. Bohemia, NY. ANAB (Hosted by Sartorius). 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/.

FALL TUTORIAL WORKSHOPS

Thursday, October 13, 2016

The Measurement Science Conference organizing committee invites you to join us in Irvine, California for the 2016 Fall Tutorial Workshops. Instructors from the pharmaceutical, aerospace, metrology and other industries will present the following full day technical programs covering specific disciplines of the measurement sciences. Courses are all inclusive with continental breakfast, lunch, snacks and parking. Course Fee: $695.00 per course.

COURSE INFORMATION

T01 Pipette Techniques

Instructors: Larry Newman, Thermo Fisher Scientific

Course covers fundamentals and techniques for accurate pipetting, proper setup, industry procedures, manufacturer specifications, and calibration methods of single and multichannel pipettes.

T02 Analytical Water Measurement (Multi-Parameter)

Instructors: Peter Noverini, BioVigilani, Paul Ferrell, Joseph Gecsey, Beckman

A number of analytical measurements help assure the quality of PW and WFI systems used in biopharmaceutical and medical devices industries. This session will cover most of these with reference to USP, EP and JP requirements. The instructors bring a wealth of practical knowledge on both existing methods and new technologies.

T03 Measurement Uncertainty Workshop

Instructor: Dr. Dennis Jackson, NSWC

The objective of this class is to provide you with the skills to create defendable measurement uncertainty budgets using a provided uncertainty analysis tool. The concepts to be covered in this class include: Managing Uncertainty Analysis, Measurement Error and Uncertainty Concepts, Tolerances and Specifications, Error Sources and Combined Uncertainties, Type A & B Uncertainty Calculations, Degrees of Freedom, Calibration Test Point Analysis and Measurement Equation Uncertainty.

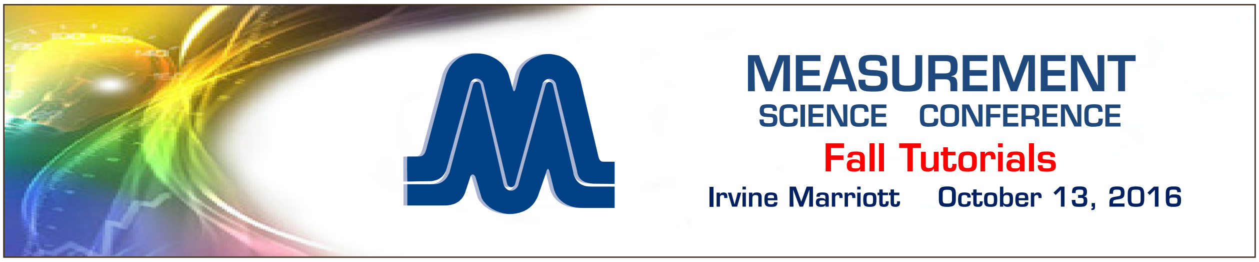
T04 Proficiency Testing & Inter-laboratory Comparisons

Instructor: Charles Ellis, National Association of Proficiency Testing

This tutorial will focus on the technical aspects of proficiency testing. The tutorial will prepare you to not only conduct a proficiency testing in accordance with ISO 17043, but prepare you for the in-depth statistical analysis requirements in ISO 13528.

Location: Irvine Marriott Hotel, 18000 Von Karman Ave, Irvine CA 92612

Register online: www.msc-conf.com **Information: 866 - 672 - 6327**



MEASUREMENT
SCIENCE CONFERENCE
Fall Tutorials
Irvine Marriott October 13, 2016

CALENDAR

Nov 16-17, 2016 ISO/IEC 17025:2055 and Laboratory Accreditation. Atlanta, GA. 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.

Nov 18, 2016 Fundamentals of SOP Writing. A2LA. Atlanta, GA. 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.

SEMINARS: Mass & Weight

Oct 24-Nov 4, 2016 Mass Metrology Seminar. Gaithersburg, MD. NIST Office of Weights and Measures. The Mass Metrology Seminar is a two-week, "hands-on" seminar. It 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.

SEMINARS: Measurement Uncertainty

Sep 19, 2016 Introduction to Measurement Uncertainty Training Course. Kuala Lumpur, Malaysia. NEL. This course is designed to impart a basic understanding of measurement uncertainty. Delegates will learn about the impact of uncertainty in industry, to identify important sources of uncertainty in measurement systems and receive practical guidance on the design of measurement techniques to minimize uncertainty. http://www.tuvnel.com/site2/subpage/events_courses_training

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 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/.

Oct 10 - 14, 2016 Uncertainty of Measurement - GUM (Physical). Pretoria, South Africa. The National Laboratory Association – South Africa annually presents various training courses which are designed to support both Calibration/Metrology and Testing Laboratories. These courses are presented by various experts in their field and provide an excellent base for both newcomers and more experienced laboratory practitioners. http://www.home.nla.org.za/.

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.

Oct 18-19, 2016 Introduction to Measurement Uncertainty. A2LA. Frederick, MD. 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.

Oct 20-21, 2016 Measurement Uncertainty Advanced Topics. A2LA. Frederick, MD. 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 24 - 28, 2016 Uncertainty of Measurement - GUM (Analytical). Pretoria, South Africa. The National Laboratory Association – South Africa annually presents various training courses which are designed to support both Calibration/Metrology and Testing Laboratories. These courses are presented by various experts in their field and provide an excellent base for both newcomers and more experienced laboratory practitioners. http://www.home.nla.org.za/

Oct 27-28, 2016 Fundamentals of Measurement Uncertainty. Omaha, NE. ANAB. Learn a practical approach to measurement uncertainty (MU) applications, based on fundamental practices. Hear about MU for both testing and calibration laboratories and understand the steps required, accepted practices, and the types of uncertainties that need to be considered by an accredited laboratory. http://asq.org/training/fundamentals-of-measurement-uncertainty_FMU.html.

Oct 31 - November 4, 2016 Uncertainty of Measurement - UoM (Physical). Pretoria, South Africa. The National Laboratory Association – South Africa annually presents various training courses which are designed to support both Calibration/Metrology and Testing Laboratories. These courses are presented by various experts in their field and provide an excellent base for both newcomers and more experienced laboratory practitioners. http://www.home.nla.org.za/.

Nov 14-15, 2016 Introduction to Measurement Uncertainty. A2LA. Atlanta, GA. 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.

Nov 16-17, 2016 Understanding & Evaluating Measurement Uncertainty. Teddington, UK. NPL. A two day training course on understanding and evaluating measurement uncertainty. The course includes an introduction to the philosophy behind the Guide to the expression of uncertainty in measurement (GUM) and the first Supplement to the GUM concerned with using a Monte Carlo method for uncertainty evaluation. http://www.npl.co.uk/.

CALENDAR

SEMINARS: RF Microwave

Oct 18-20, 2016 VNA Tools Course. Columbia, MD. Federal Institute of Metrology METAS (Switzerland). The primary focus is on the practical usage of the tool (http://www.metas.ch/vnatools). Theoretical aspects of the implementation will be discussed. The participants are asked to bring a laptop to the course and will directly learn how to use the software in the different steps of the vector network analyzer measurement process. Registration ends September 22nd. For more information visit: http://www.callabmag.com/?p=6610. To register, email: Juerg.Ruefenacht@metas.ch or Michael.Wollensack@metas.ch.

SEMINARS: Software

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.

Nov 7-11, 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.

SEMINARS: Temperature

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

SEMINARS: Vibration

Sep 19-21, 2016 Fundamentals of Vibration for Test Applications. Las Vegas, NV. Technology Training Inc. Course 116 covers a wide range of topics associated with vibration and shock applications in order to enable the course participants to acquire a basic understanding of the complex field of vibration and shock. http://www.ttiedu.com.

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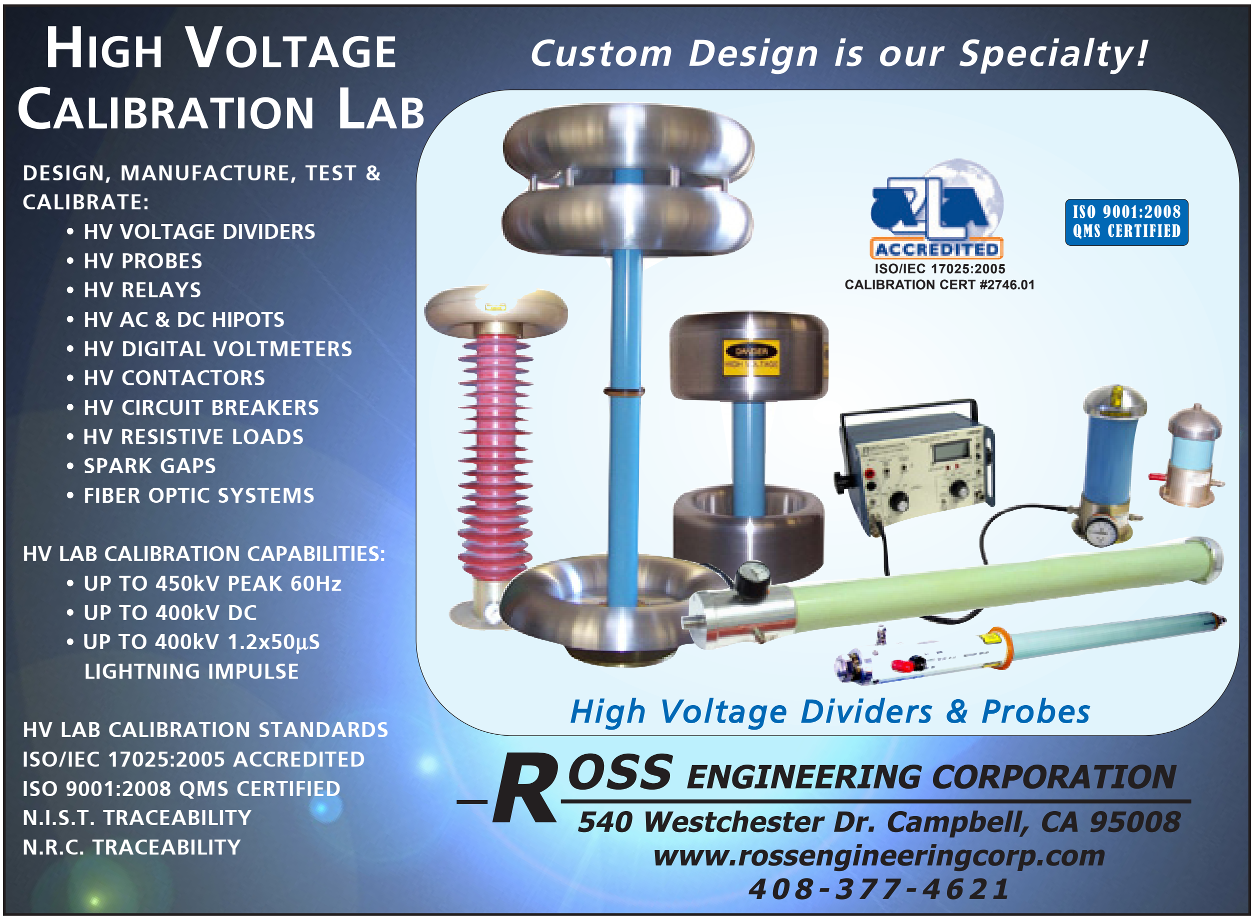


ONLINE & INDEPENDENT STUDY

AC-DC Metrology– Self-Paced Online Training. Fluke Training. Learn the basic concepts of ac/dc metrology, including the theory and application of thermal transfer standards to measure ac voltages and currents, definition of inductance and capacitance, and the measurement of impedance, admittance and immittance. http://training.fluke.com/Courses.htm.

ASQ CCT Exam Preparation Program. Learning Measure.This program contains courses that cover all aspects of the ASQ Certified Calibration Technician exam body of knowledge. http://www.learningmeasure.com/.

Basic Antenna Measurement Program. Learning Measure. This program covers concepts associated with basic antenna measurements. http://www.learningmeasure.com/.

Basic Dimensional Measurement Tools – Self Directed Learning. QC Training. With this program, workers will master the essentials of handling, applying and reading the most common gages on today's shop floors – from steel rules to micrometers and height gages. http://www.qcgroup.com/sdl/.

Basic Mass Computer-Based Training. NIST Weights and Measures Laboratory Metrology Program. Free download available in English and Spanish. http://www.nist.gov/pml/wmd/labmetrology/training.cfm.

Basic Measurement Concepts Program. Learning Measure. This program introduces basic measurement concepts, the SI system of units, and measurement uncertainty analysis. http://www.learningmeasure.com/programs.shtml.

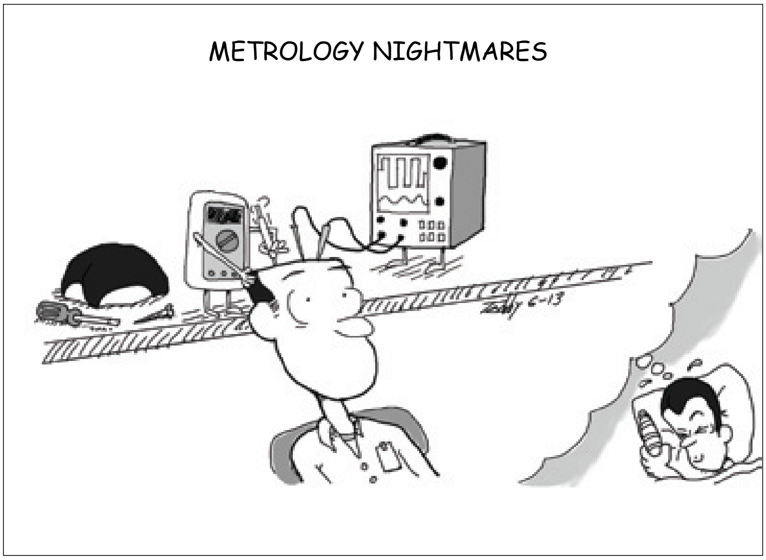
Basic RF & Microwave Program. Learning Measure. This is an introductory program covering the RF and microwave measurement field. http://www.learningmeasure.com/.

Certified Calibration Technician Certification Preparation - Web-Based. ASQ. This self-paced course covers the material you will see on the CCT exam. It includes a practice test based on the CCT Body of Knowledge. http://asq.org/training/catalog/delivery/self-paced.html.

Certified Calibration Technician – Self-study Course. J&G Technology has developed a self-study course to assist you in passing the ASQ CCT exam. http://www.jg-technology.com/selfstudy.html.

Certified Calibration Technician Prep – Online. QC Training. Using the same materials used in our 3-day classroom training, students prepare for ASQ"s examination for Certified Calibration Technician. http://www.qcgroup.com/online/.

CAL-TOONS by Ted Green teddytoons@icloud.com



Electronics for Non-Electronic Engineers – OnDemand Complete Internet Course. Technology Training, Inc. (TTI). To help participants to understand the concepts and terminology of electronics. http://www.ttiedu.com/.

Introduction to Measurement and Calibration – Online Training. QC Training. An easy to access, menu driven curriculum allows the learner to concentrate on the topics specific to their job requirements. For anyone taking measurements, new hires, students or a refresher for technicians. http://www.qcgroup.com/online/.

Introduction to Measurement and Calibration – Self-Paced Online Classes. Fluke Calibration. This course instructs the user on basic concepts of measurement and calibration. http://training.fluke.com/Courses.htm.

Introduction to Measurement and Calibration - Web-Based. ASQ. Satisfy the requirements for ISO 17025 and 16949, FDA,and FAA. You will learn skills including standardization, managing a metrology system, and units and instrumentation of measurements. http://asq.org/training/catalog/delivery/self-paced.html.

Introduction to Measurement Uncertainty – e-Learning Program by NPL. You will learn how risks are estimated enabling good decision-making in practical contexts, such as in manufacturing and regulation - maximise your efficiency and productivity. http://www.npl.co.uk/training.

Introduction to Metrology - e-Learning. NPL. This course has been designed to introduce metrology, the science of measurement, and explore its value for industry, the economy, science and society. http://www.npl.co.uk/training.

Instrumentation for Test and Measurement – OnDemand Complete Internet Course. Technology Training, Inc. (TTI). Course 163 presents basic information on selection, application, calibration and usage of modern measurement systems to measure electrical, environmental and dynamic phenomena. http://www.ttiedu.com/.

ISO/IEC 17025 Compliance. WorkPlace Training. This series includes 5 courses, 50 courseware hours. http://www.wptraining.com/.

ONLINE & INDEPENDENT STUDY

Measurement Uncertainty – Self-Paced Online Training. Fluke Training. Learn the fundamental concepts and how to successfully determine measurement uncertainty and quality improvement techniques. http://training.fluke.com/Courses.htm.

Measurement Uncertainty Analysis – Online Training. The QC Group. Targeted for calibration technicians, quality managers, engineers, quality technicians, and other users of uncertainty budgets. http://www.qcgroup.com/online/.

Metrology for Cal Lab Personnel – Self-Paced Online Training. Fluke Training. A general overview of metrology principles and practices; designed to help calibration laboratory personnel prepare for the American Society of Quality (ASQ) Certified Calibration Technician examination. http://training.fluke.com/Courses.htm.

Metrology Concepts. QUAMETEC Institute of Measurement Technology. This category contains courses designed to teach the basics that are needed for a well rounded understanding of Metrology. http://www.QIMTonline.com.

Metrology Concepts – OnDemand Complete Internet Course. Technology Training, Inc. (TTI). Provides a basic understanding of the wide range of activities encompassed by personnel working in standards and calibration laboratories. http://www.ttiedu.com/.

Precision Measurement Series Level 1. This series includes 14 courses, 100 courseware hours. WorkPlace Training, http://www.wptraining.com/.

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Precision Electrical Measurement – Self-Paced Online Training. Fluke Training. This course will increase your knowledge of terminology, concepts and procedures to help you become more proficient. http://training.fluke.com/Courses.htm.

Precision Dimensional Measurement – Online. QC Training. Advance your career with a low-cost, online course in precision dimensional measurement, tools and techniques. http://www.qcgroup.com/online/.

The Uncertainty Analysis Program. Learning Measure. This program covers all the courses concerning uncertainty and uncertainty analysis. http://www.learningmeasure.com/.

Vibration and Shock Testing. Equipment Reliability Institute. Power Point text and photo slides plus animations and video clips teach you about vibration and shock basics, control, instrumentation, calibration, analysis and sine and random vibration testing, as well as ESS, HALT and HASS. http://equipment-reliability.com/training/distance-learning/.

INDUSTRY NEWS

IAS Personnel Certification Body Accreditation under ISO/IEC Standard 17024 to be Recognized by PAC

The International Accreditation Service (IAS) is the first accreditation body globally to have its Personnel Certification Body (commonly abbreviated as ‘PCB’ or ‘Persons’) accreditation program recognized under the Pacific Accreditation Cooperation (PAC). This is a result of a detailed and stringent evaluation conducted by PAC evaluators in August 2015 that included a review of the IAS management system, witnessing of IAS assessors performing PCB assessments, and completing corrective actions raised by the PAC experts.

IAS will go on to achieve full signatory status of its PCB program when the (PAC) Multilateral Recognition Arrangement (MLA) is signed in June at the Joint PAC Plenary/APLAC General Assembly meetings in Taipei, Taiwan. The PAC recognition of IAS for accrediting personnel certification bodies enables IAS clients to enjoy global recognition and acceptance of their IAS-endorsed accredited personnel certifications.

PAC is one of the three major regional accreditation groups that operate within the framework of the International Accreditation Forum (IAF; www.iaf.nu). The other groups currently admitted under IAF are European Co-operation for Accreditation (EA) and InterAmerican Accreditation Cooperation (IAAC). PAC is a regional cooperation body formed by an association of accreditation bodies and other interested parties whose objective is to facilitate trade and commerce among economies in the Asia Pacific region. PAC promotes the international acceptance of accreditations granted by its accreditation body members, based on the equivalence of their accreditation programs.

The IAS Personnel Certification Body Accreditation Program is based on ISO/IEC Standard 17024 (2012) General requirements for bodies operating certification of persons and IAS Accreditation Criteria for Bodies Operating Certification of Persons (AC474 available on the IAS website http://www.iasonline.org/Personnel/docs.html). IAS accredits PCBs that certify personnel based on their professional competency and the program is managed by Dr. David Nelson, IAS Program Director, dnelson@iasonline.org.

Accreditation is a formal, independent verification that a program, institution, or company meets established quality standards and is competent to carry out specific conformity assessment tasks. Accreditation has been used for more than 50 years as the definitive means to evaluate organizations.

Accreditation by IAS demonstrates that personnel certification bodies have been assessed and found to be competent to certify personnel to serve national and international needs of governmental regulatory bodies and diverse industries concerned with personnel competency through the use of uniform standards, schemes and best practices. Accreditation also provides PCB’s with greater confidence that their certifications meet legal and technical requirements imposed by regulators and/or specifiers at global, national and local levels.

For more information about IAS accreditation programs, visit www.iasonline.org/.

NIST's Newest Watt Balance Brings World One Step Closer to New Kilogram

A high-tech version of an old-fashioned balance scale at the National Institute of Standards and Technology (NIST) has just brought scientists a critical step closer toward a new and improved definition of the kilogram. The scale, called the NIST-4 watt balance, has conducted its first measurement of a fundamental physical quantity called Planck's constant to within 34 parts per billion – demonstrating the scale is accurate enough to assist the international community with the redefinition of the kilogram, an event slated for 2018.

The redefinition–which is not intended to alter the value of the kilogram's mass, but rather to define it in terms of unchanging fundamental constants of nature–will have little noticeable effect on everyday life. But it will remove a nagging uncertainty in the official kilogram's mass, owing to its potential to change slightly in value over time, such as when someone touches the metal artifact that currently defines it.

Planck's constant lies at the heart of quantum mechanics, the theory that is used to describe physics at the scale of the atom and smaller. Quantum mechanics began in 1900 when Max Planck described how objects radiate energy in tiny packets known as "quanta." The amount of energy is proportional to a very small quantity called h, known as Planck's constant, which subsequently shows up in almost all equations in quantum mechanics. The value of h – according to NIST's new measurement – is $6.62606983\text{x}10^{-34}$ kg·m$_2$/s, with an uncertainty of plus or minus 22 in the last two digits.

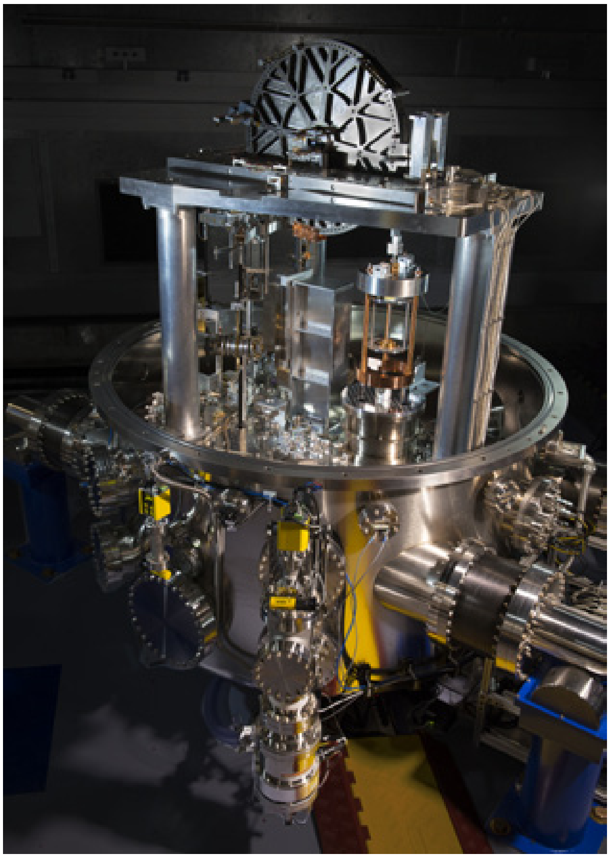
Accurate measurement of this tiny number is the key to retiring the physical kilogram, because it provides a way to equate mass with a particular amount of electric energy, which can be expressed as a function of h. If we know h precisely, we can build an electromagnet and measure exactly the amount of electric current it needs to lift a kilogram off the ground, and define the kilogram in terms of the current. Scientists are putting this idea to work in a device called the watt balance, which compares a physical mass with finely measured amounts of electricity (see this story for details of how watt balances work).

With enough accurate measurements of Planck's constant, scientists will eventually fix its value to a very high degree of precision, allowing highly accurate measurements of the kilogram. For scientists to agree on a new mass definition that relies on Planck's constant, however, there must be

solid evidence that we know h to great accuracy, so multiple countries—five to date—have built watt balances to make independent measurements that can be compared.

NIST's measurement, the first using its recently constructed NIST-4 watt balance, is good news because it is consistent with watt balance measurements from other countries and also because the amount of uncertainty in the measurement is far lower than the NIST team had hoped for. Both points imply that the international science community is on track to redefine the kilogram by its self-imposed 2018 deadline.

"This measurement was essentially a dry run," said NIST physicist Stephan Schlamminger. "We were hoping to achieve an uncertainty of within 200 parts per billion by this point, but we got better fast." For the redefinition to meet scientists' exacting standards, at least three experiments must produce values with a relative standard uncertainty of no more than 50 parts per billion, and one with no more than 20 parts per billion. All these values must agree within a statistical confidence level of 95 percent. The results also must be reconciled with the alternative "Avogadro" method, which involves counting the atoms in an ultra-pure sphere of silicon.


The NIST-4 watt balance has measured Planck's constant to within 34 parts per billion, demonstrating that the high-tech scale is accurate enough to assist with 2018's planned redefinition of the kilogram. Credit: J.L. Lee / NIST

Because Planck's constant is important for quantum electrical standards, the overall effort also will benefit electrical metrology, Schlamminger said. Fixing h's value will explicitly connect the quantum based standards for the ohm and the volt to the international system of units for the first time.

*D. Haddad, F. Seifert, L.S Chao, S. Li, D.B. Newell, J.R. Pratt, C. Williams, and S. Schlamminger. A precise instrument to determine the Planck constant, and the future kilogram. Review of Scientific Instruments. June 21, 2016. DOI: 10.1063/1.4953825.

Source: NIST Physical Measurement Laboratory, Quantum Measurement Division, June 21, 2016 (http://nist.gov/pml/div684/nist-newest-watt-balance-brings-world-one-step-closer-to-new-kilogram.cfm).

The Kibble Balance

The global metrology community has paid tribute to the late Dr. Bryan Peter Kibble, who worked at the National Physical Laboratory (NPL). Dr. Kibble's famous invention, the watt balance, is being renamed after him in a unanimous decision by the Consultative Committee for Units (CCU). Invented in the 1970s, the device measures the Planck constant in SI units enabling the redefinition of the SI unit of mass: the kilogram, which is proposed for 2018.

Kibble began working as a senior postdoctoral fellow at NPL in 1967 where he became interested in the SI unit of current, the ampere, which was then measured using a piece of equipment known as a current balance.

The accuracy obtainable using the current balance was limited and it was very difficult to use. To avoid these problems, Kibble invented a new way of linking the mechanical and electrical units. This watt balance, combined with a measurement of the SI ohm, produced more accurate measurements of the ampere. The watt balance is now named the Kibble balance.

Kibble continued to improve his invention, and a second model was built in 1990. In conjunction with quantum mechanical measurements of voltage and resistance, and measurements of the acceleration due to gravity, it was capable of accurately measuring the Planck constant. A worldwide consensus value of the Planck constant will be used to redefine the SI unit of mass: the kilogram.

Dr. Kibble worked tirelessly in his field until his death in April 2016, and his achievements were lauded by his peers as a pivotal steps for metrology. He was known for his gentle nature and patience as a teacher.

The formal redefinition of the kilogram is due to happen in 2018 and, though he is not alive to bear witness to it, Dr. Kibble's legacy will live on in metrology: a fitting tribute for a man who loved his work.

Read more about the Kibble balance by visiting online at: http://www.npl.co.uk/educate-explore/kibble-balance/.

Source: National Physical Laboratory (NPL) News, July 22, 2016 (http://www.npl.co.uk/news/kibble-balance-metrology-community-honours-late-dr-bryan-kibble).

METROLOGY.NET®

Have you ever asked yourself "why does nothing in metrology work together?" Why do we use a different piece of software from a different manufacturer in every area of our calibration lab? We at Cal Lab Solutions deem it possible to merge all of metrology into a unifying system.

Metrology.NET is Test Point Centric

The work of metrology is the process of collecting data points and calculating uncertainties. When all the data has been collected and the uncertainties calculated, the calibration is done. Thus, the heart of Metrology.NET is a test point.

The system was designed so that each data point could carry enough information about itself, and how it should be tested, that an external test engine could interrupt and measure it. But making it flexible enough that it could be used across all disciplines of metrology was the key. Metrology.NET solved this problem by adding a list of name value pairs. This data structure allows for more refined and detailed information to be added to each test point in every disciple.

Uncertainty Calculations

Across the board, no software calculates uncertainties better than Metrology.NET. Yes, that is a bold statement, but it is the first software to view uncertainty calculations as a post processing operation. The idea is simple; collect the measurement data and enough information about the test process and standards used so that another tool can calculate the uncertainties. Metrology.NET accomplishes this with its unique data format of name value pairs that are passed to the uncertainty calculator.

Metrology.NET also breaks uncertainty calculations up into two distinct parts: formula and inputs. This algebraic approach feeds the name value pairs from the test into the uncertainty calculator's formula. Using this structured data approach, formulas are created with a known set of optional and required inputs. The formulas can be simple or complex; all it needs is a set of name value pairs as an input and it will calculate uncertainties. Moreover, Metrology.NET stores every formula under revision control and the system can log all the name value pairs ever used in a calculation.

Automated Calibrations

Metrology.NET looks at automation from the test point outward. Though the technology is quite advanced, the vision is simple. Every calibration is simply a collection of data points that can be spread across the entire lab. Automation and equipment utilization are then maximized when all workstations can share the test point workload as opposed to the 1 work station 1 UUT method. If one station is busy, a second station can help with part or all of the workload—like in a distributed computing model.

One big difference in Metrology.NET is the UUT becomes a flexible driver, which allows engineers to automate horizontally as opposed to vertically. When an engineer creates a standard specific test process for sourcing volts DC in Metrology.NET, it is then useable on all UUTs that measure volts DC. This means it works on oscilloscopes, digital multimeters, etc. Metrology.NET allows calibration labs to support more UUTs with less code.

Manual Calibrations

Why have two systems—one for automated data collection and another for manual? This is twice the work for the developer. Metrology.NET seamlessly merges the two into one. And because it is iPad® and Android® compatible, users get all the advantages of mobile computing, including voice recognition and pen input for manual calibration.

For more information, visit:
http://www.metrology.net.

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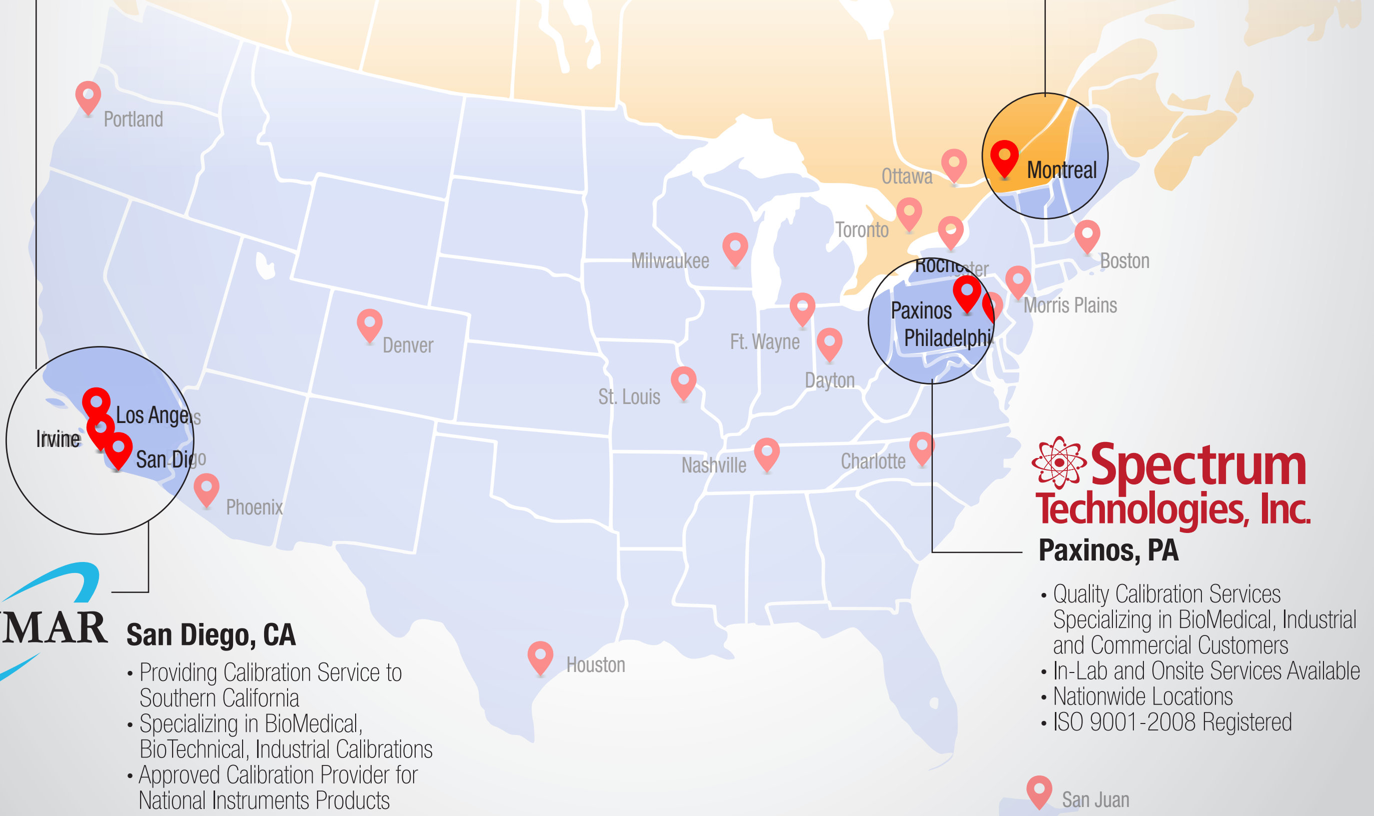

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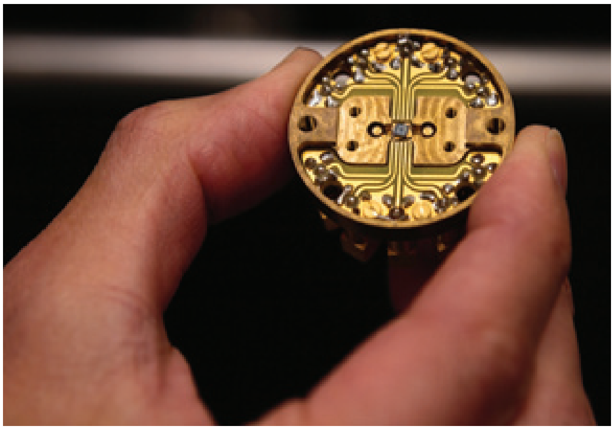
Record Speed Achieved with Single-Electron Pumps

The National Physical Laboratory (NPL), in collaboration with *NTT* (Nippon Telegraph and Telephone Corporation) in Japan, has measured silicon single-electron pumps with the highest speed and accuracy ever achieved, paving the way towards practical primary standards for electric current.

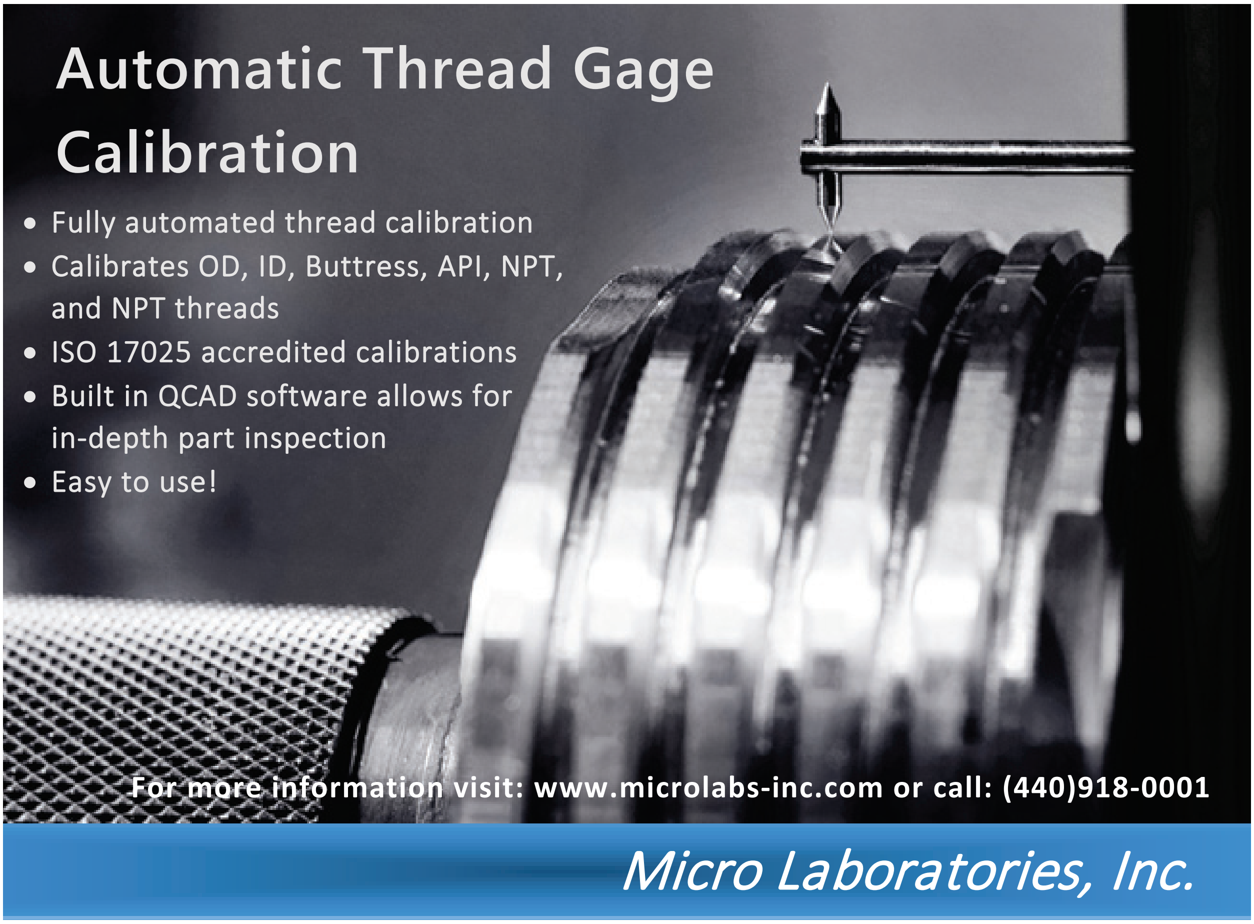
NTT's silicon nanodevice technology pushed the operating speed of the single-electron pumping frequency over 1 gigahertz (GHz), while the accuracy was verified to be better than one part per million using NPL's high-precision small-electric-current measurement system. The result was published in Applied Physics Letters*.

Single-electron pumps are tiny electronic devices that generate an electric current by moving individual electrons. These devices could be used as primary standards for the SI unit of electric current, the ampere. Presently, the definition of the ampere links it to the artifact kilogram, and there is no practical method to directly realize the ampere with the accuracy required for present-day electrical measurements.

The two key requirements of single-electron pumps are high accuracy and high speed. Because the electrical charge of each electron is very small, a huge number of electrons need to be pumped within a given time to produce a usable current. At the same time, the exact number of electrons pumped in each cycle needs to be known to obtain an accurate value of the current. The difficulty is that high-speed pumping tends to make devices operate less accurately. One way to overcome this and achieve more robust operation is



Credit: NPL.



to make the device very small, as this minimizes detrimental effects arising from energy fluctuations.

In the state-of-the-art silicon device fabrication facility at the NTT Basic Research Laboratories in Atsugi, single-electron devices were made with a 10-nanometre-scale silicon wire. These devices were found to operate at well over 1 GHz, a barrier that conventional single-electron pumps made from gallium arsenide-based materials have not been able to break without a significant loss in accuracy.

The test performed in a high-precision small-electrical-current measurement system, developed by NPL, confirms that these silicon devices can operate at 1 GHz with an accuracy better than one part per million. Even at 2 GHz, the accuracy was maintained at a level of 3 parts per million.

This is the first time that silicon single-electron pumps have been tested at such accuracy levels. In 2018, the worldwide metrology community plans to redefine four of the seven SI base units, including the ampere, in terms of fixed fundamental constants.

Ahead of the redefinition, single-electron pumps must be reliably tested to ensure that the current produced does not depend on the precise details of the experiment - for example, what material the device is made from. Instead, it should depend only on the elementary charge, one of fundamental constants of nature, and the frequency of operation, which can be determined to a very high level of accuracy using atomic clocks. Highly-accurate techniques to verify the performance of single-electron pumps, such as those being developed at NPL, are crucial in the international effort to prepare for the new SI ampere.

* G. Yamahata, S. P. Giblin, M. Kataoka, T. Karasawa, A. Fujiwara "Gigahertz single-electron pumping in silicon with an accuracy better than 9.2 parts in 10^7" *Applied Physics Letters* (2016).

Source: The National Physical Laboratory (NPL) News, http://www.npl.co.uk/news/record-speed-and-accuracy-achieved-with-single-electron-pumps.

Pulse-Driven AC Josephson Voltage Standard

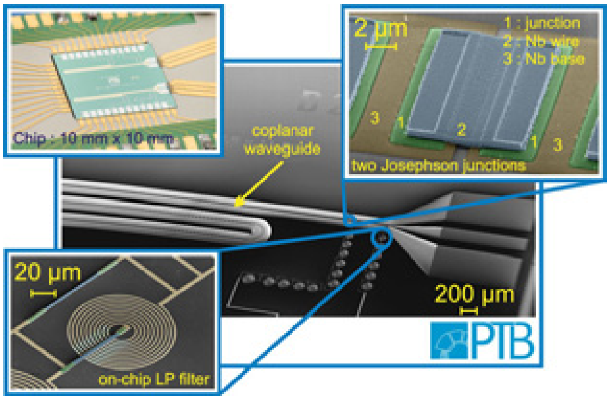
At PTB, the output voltage of a pulsedriven AC Josephson voltage standard has been significantly increased by using triple-stacked Josephson junctions, and by series connection of eight circuits with a total of 63 000 junctions; where previously obtained maximum output voltages were around an effective value of 300 mV, a standard value of 1 volt (important for metrological applications) has now been achieved for the first time. A precision comparison with an AC quantum voltmeter, at a frequency of 250 Hz, demonstrated an excellent agreement of (3.5 ± 11.7) nV/V. The increase obtained in the effective voltage opens up a range of new application possibilities.

Pulse-driven AC Josephson voltage standards make it possible to generate spectrally pure, arbitrary waveforms; for this reason, they are also referred to as Josephson Arbitrary Waveform Synthesizers (JAWS). They are based on series arrays of superconducting Josephson junctions of the kind manufactured in the Clean Room Center of PTB. In a complex multilayer thin-film process enhanced by PTB, a sequence of three layers (superconductor – normal conductor – superconductor) is used, of which the middle, very thin normal conductor layer of Nb_xSi_{1-x} weakly connects the two superconductor Nb layers. The extremely stable and reproducible deposition conditions allow layers of well-defined thickness to be manufactured. In this way, stacks of three Josephson junctions each – i.e., four Nb layers and three Nb_xSi_{1-x} layers in sequence – were manufactured with a high fabrication yield. On a single chip (10 mm · 10 mm), two circuits are integrated with a total of around 18 000 Josephson junctions (see image). The combination of eight JAWS circuits (i.e., four chips) resulted in a series connection of 63 000 Josephson junctions in total. By irradiating these JAWS circuits with a pulse signal in the GHz frequency range, sine waves are generated. The output voltage achieved was 1 volt and demonstrated outstanding spectral purity (signalto- noise ratio better than 120 dB).

An AC quantum voltmeter, also developed at PTB (see PTB News 2013/2), was used to check the accuracy of the sine waves generated in this way. This enabled a direct comparison of two different Josephson voltage standards, performed at 1 volt across the frequency range of 30 Hz to 1.5 kHz – the first such comparison in the world. The "quantum accuracy" of the new, pulse-driven 1-volt JAWS system was proven with an excellent agreement of (3.5 ± 11.7) nV/V at a frequency of 250 Hz.

The fact that an effective voltage of 1 volt can be generated opens up a wide range of new possibilities for applying JAWS in the field of electrical AC voltage metrology such as calibrating measuring instruments, analog-to-digital and digital- to-analog converters, AC/DC standards,

Source: PTB-News 2.2016 (https://www.ptb.de/cms/en/presseaktuelles/journals-magazines/ptb-news.html).



Top left: chip with two JAWS circuits (with a total of around 18 000 integrated Josephson contacts). Center: scanning electron microscope image of a JAWS circuit. Top right and bottom left: detailed enlargement of the circuit.

Dimensional Measurement Uncertainty from Data, Part 2: Uncertainty R&R

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While check standards will eventually give the most accurate uncertainty for a calibration procedure, the time and expense can be discouraging. Another common method, standard Gage Repeatability and Reproducibility study does not produce anything like the actual uncertainty. It is possible to force variation into the R&R and get a much more useful estimate of uncertainty. This process, which I call the Uncertainty R&R (UR&R), is described along with examples of actual studies made on a typical Universal Length Measuring instrument (ULM).

Introduction

As in the previous paper, "Dimensional Measurement Uncertainty, Part 1: Check Standards," we will start with the Guide to the expression of Uncertainty in Measurement (GUM) [1]. In the GUM there is a short and passing reference to a method for determining uncertainty that does not involve modeling, statistical analysis, and most of the other tools that are part of the GUM.

> **3.4 Practical considerations**
>
> 3.4.1 If all of the quantities on which the result of a measurement depends are varied, its uncertainty can be evaluated by statistical means. However, because this is rarely possible in practice due to limited time and resources, the uncertainty of a measurement result is usually evaluated using a mathematical model of the measurement and the law of propagation of uncertainty. [1]

The idea behind part one of this series is that check standards provide an excellent estimate of measurement process uncertainty. This has been the basic method used by the Dimensional Metrology Group for the last 40 years, and forms the key part in our Measurement Assurance Program [2,3,4].

After writing the paper [5], I prepared the presentation, and to add interest I compared how the check standards did a much better job of estimating the uncertainty than the standard GR&R study. In the Spring of 2015 the Dimensional Metrology Group offered its second Hands-on Workshop in Dimensional Metrology, and as part of the workshop the attendees did a series of experiments to determine the variation for each part of the uncertainty budget. By the time of my presentation, it was plain to me that an expanded R&R, like the one in the workshop, would give a better estimate of the uncertainty than even check standards unless you had data over a very long period.

Any method for finding the uncertainty of a measurement starts with a list of influence factors. The next step is to make a mathematical model of how the measurement depends on these factors. These models range from the very simple for typical calibration lab measurements to very sophisticated for NMI measurements. I will take these influences from the Generic Uncertainty Budget for Dimensional Calibrations [6].

1. Master Gage Uncertainty
2. Repeatability/Reproducibility
3. Thermal Factors
    a. Thermometer Calibration
    b. Temperature Variation Between Master and Customer Gage
    c. Uncertainty in Customer Gage Coefficient of Thermal Expansion (CTE)
4. Measuring Machine Scale Uncertainty
5. Elastic Deformation
6. Instrument Geometry
7. Customer Gage Geometry

This budget has been used for 20 years to determine the uncertainty of NIST dimensional calibrations, particularly special tests which have no check standards. For one of a kind measurements, we have found that in most cases the factors for each item of the budget can be estimated well because the operators have extensive experience with their machines, but in most cases there are some small experiments, similar to these that follow, needed to verify some of the more subtle error sources.

1. Master Gage Uncertainty

Most dimensional calibrations are made by comparison to master gages. Comparison measurements are generally simpler, faster, and often have uncertainties very near that of the master gages because the repeatability of a good comparator can be less than 20 nm. The NIST gage block comparators, for example, have 3 nm repeatability.

The best way to think about the comparison process is that you set the zero of the machine with the master gage and then measure the test gage. In this way you use a shorter section of the scale which makes the uncertainty from the scale smaller. Also, using a master with the same geometry reduces the effects of geometry errors in the machine.

In many cases, the uncertainty in the master gage is the dominant source of uncertainty. This is particularly true in calibrating ring gages. Master Gage variation is difficult to sample with check standards because master gages usually have long recalibration intervals. Using the same master gages will give a very consistent value of the slope of the calibration line, but the slope could be wrong. If you use different master gages with different sources of traceability, the residual errors in the master gage calibrations will average out and the average slope will be much more accurate. When gage block stacks are used (a common practice for ring gage calibration) the problem can become quite dangerous. In most labs, the common rule is that each wring adds about 25 nm to the uncertainty of the stack. This is unlikely to be true. The variation between gage block stacks is very dependent on the skill of the operator wringing the stack and the geometries of the blocks. I note that the specification of the variation in length of a small Grade 0 gage block is 120 nm, which is much larger than many estimate as the added uncertainty of wringing one block to a stack. To assess these sources of error, a number of master gages should be tested against each other, and in particular a number of gage block stacks using different blocks should be used.

In a short study, the variation from the master gage calibration can be examined by using different master gages that have completely different traceability paths. Using different gages calibrated by the same calibration lab may not provide enough variation because sources of variation like instrument geometry and thermal environment are not varied.

2. Repeatability

The most direct way to get the short term variability is to make a lot of measurements of a small gage. In the workshop, each of the 8 operators measured the difference in diameter of two cylinders 4 times giving 32 measurements over an hour. The repeatability was found to be 0.00035 mm and taken as the standard uncertainty.

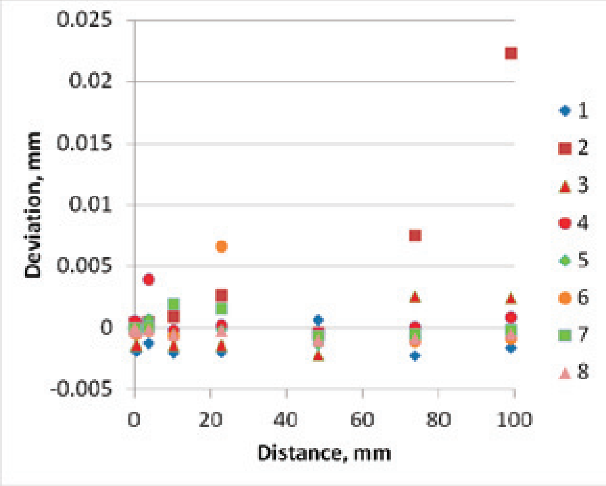

Figure 1. This graph shows the ULM calibration data, 7 distances measured by 8 different operators. The repeatability is taken from this data so that the dependence of the repeatability at long lengths can be estimated.

While this is a nice test for small distances, the repeatability of an instrument is commonly length dependent. For longer distances longer gages are needed. Since we have to calibrate the scale, which is really a number of measurements of gages that span the total travel of the instrument, we can use this data to get the length dependence of the repeatability. Figure 1 shows the calibration data taken by 8 operators using the same gage blocks.

There are a number of interesting things in this graph. The first thing that jumps out is that there are significant outliers. The standard deviation for all of the 8 operators together is only 0.0035 mm, and the major outlier is off by 6 standard deviations and is omitted from further analysis. It is a well-known effect that the prevalence of blunders goes up significantly as the number of observers gets larger. Some allowance must be made for this effect, but the source still should be checked by a re-measurement of the master gage. The gage calibration could be wrong.

This data effectively estimates the repeatability of 8 different operators using the same gage blocks. Analyzing the data in Figure 1, the standard deviation dependence on length is show in Figure 2 (on the following page).

The slope of the line is 0.00001 and we will take it as the length dependence of the repeatability. One point, at length 100 mm, has been omitted as an outlier. I have not used the repeatability of the small gage blocks as the zero-length repeatability because the data was taken over a long time period and is thus more like the intermediate precision or reproducibility. In its place, I use the repeatability of the small cylinders found in the first experiment, 0.00035 mm. Putting these components together we get an estimate of the repeatability of

$$U(\text{repeatability}) = 0.00035 + 0.00001 \times L \quad (L \text{ in mm}).$$

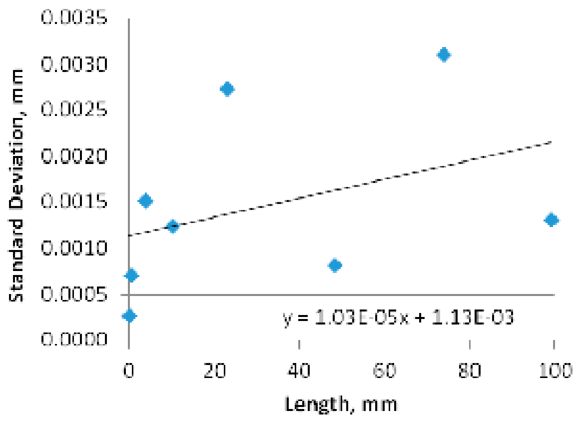

Figure 2. The repeatabilities of the scale data is quite variable but the slope is statistically significant, and is used for the length dependence of the measurement reproducibility.

In this exercise, one person manipulated the machine and two separate observers recorded the data. We have found that one person writing observations is very prone to error, mostly the loss of zeros. In general, the manual input of numerical data is surprisingly error prone, with error rates reported around 1% [7].

3. Thermal Influences

Temperature of the ULM: For most laboratories, the air temperature typically varies by about ±1 °C during any one hour period. The change in temperature of the gages and equipment is more complex depending on the size, mass and thermal diffusivity. Estimating the effects of these changes is very difficult. With check standard measurements made across the yearly weather cycle and the daily variation from the temperature controller the variation in temperature is part of the check standard data can give a very good estimate of the variation caused by thermal changes. The process can be sped up by changing the thermal environment around the ULM in various ways. Figure 3 shows the temperature changes that were recorded at various points on the measuring machine and gages during the first day of the workshop.

The conference room used for the workshop is a typical room and has no special temperature control. The ULM had about 10 thermometers mounted on different parts of the machine and the air temperature sensor was placed directly above the right contact assembly of the ULM. The record has basically 4 parts. The first part up to 10 AM had the attendees around the conference table watching a presentation of what they were to do and what should they expect as an outcome. The second part, up to noon the attendees began to make measurements using the machine for a basic repeatability experiment. At noon everyone went to lunch and the machine and room cooled, and after lunch measurement began and lasted to 5 PM, the end of the first day.

The different parts of the machine changed temperatures much like the room air but there were some significant differences of up to 0.5 °C between different parts of the machine. The giant spikes in the middle of the graph are accidental contact between the operator's hand and the thermometer.

Over the 3 days the variation in room temperature, variation of the temperature of the different parts of the ULM and gages provided an excellent simulation of what

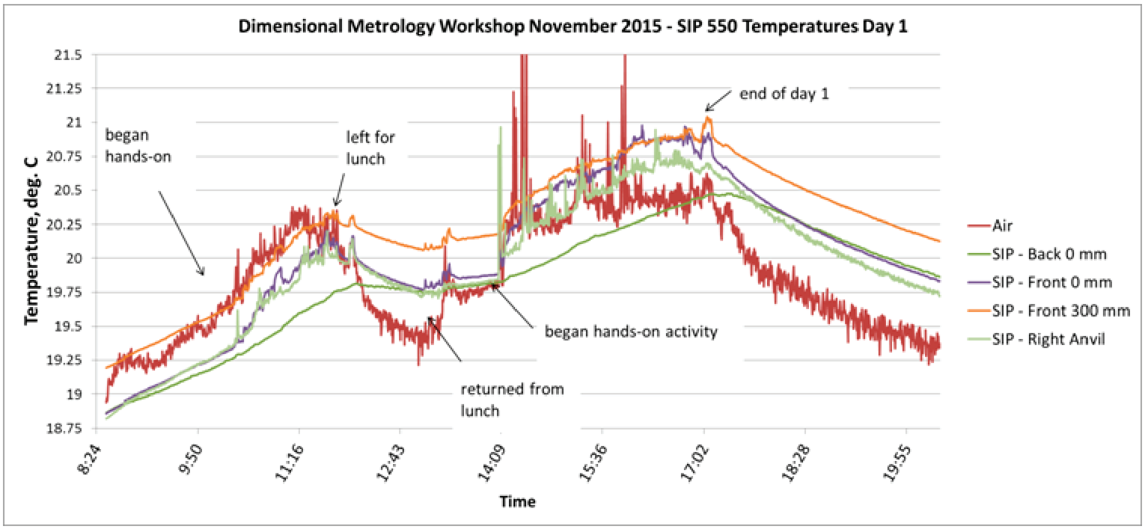

Figure 3. The graph shows the variation in the temperature of the ULM in various places and the air temperature near the contacts. The wide variation is, in this case, very good as the data is taken with wide variations in temperature and thermal drift are equivalent to long term changes found in the lab during a year.

might happen in a normal laboratory over time. In fact, the variation during the UR&R was probably much larger than occurs in most commercial labs, and the use of such a study to estimate the uncertainty from thermal sources seems justified.

The conclusion is that the data taken for the slope calculation really includes the repeatability of the instrument and many of the effects of the thermal environment, and thus we can use the data as an estimate of both of these two influence factors. The actual data is discussed in the next section.

CTE of Customer Gage: The experiment does not test all of the thermal errors. The final result of the calibration must be adjusted to the length the gage would have at 20 °C, the standard reference temperature. This means that any uncertainty in the coefficient of thermal expansion of the test and master gages must still be estimated. Most labs take 10% of the CTE as the uncertainty. This is a bit high for gage blocks, which are well studied, but probably low for parts.

Using a steel gage the nominal CTE is 11.5×10^{-6} and 10% is approximately 1.2×10^{-6}. If the room is ±1 °C, the uncertainty using a rectangular distribution is

$$u(CTE) = 0.69 \times 10^{-6} \times L.$$

Thermometer Uncertainty: Many labs have thermometers that only have integer degree resolution. This means when the calibration results are corrected to 20 °C there will be an uncertainty equal to the gage length, CTE, and thermometer uncertainty. We will assume the lab has a thermometer with resolution of 1 °C. Using a rectangular distribution we get a standard uncertainty of:

$$u(T) = 11.5 \times 10^{-6} \times 0.69 \times L = 6.9 \times 10^{-6} L.$$

Operator	Slope	stdev Slope
1	0.999993	0.000011
3	1.000028	0.000014
4	0.999995	0.000014
5	0.999994	0.000005
6	0.999989	0.000024
7	0.999992	0.000009
8	0.999993	0.000003
	Average Slope	Standard Deviation of Slope
	0.999998	0.000013

Table 1. Each operator used the same set of 7 gage blocks to calibrate the ULM scale. The average results were fairly consistent given the wide thermal changes during the measurements.

4. Comparator Scale

Each of the 8 attendees made a complete set of measurements of the same set of gages, repeating the first gage at the end to see what drift might have occurred during the calibration. The deviations from the corrected length of the master gages are in Table 1.

If we use regression to find the slope and uncertainty in the slope for all 8 operators' calibrations, we get an estimate of the standard uncertainty of the scale. Table 1 shows the results when operator 2's data is not used because of two obvious outliers.

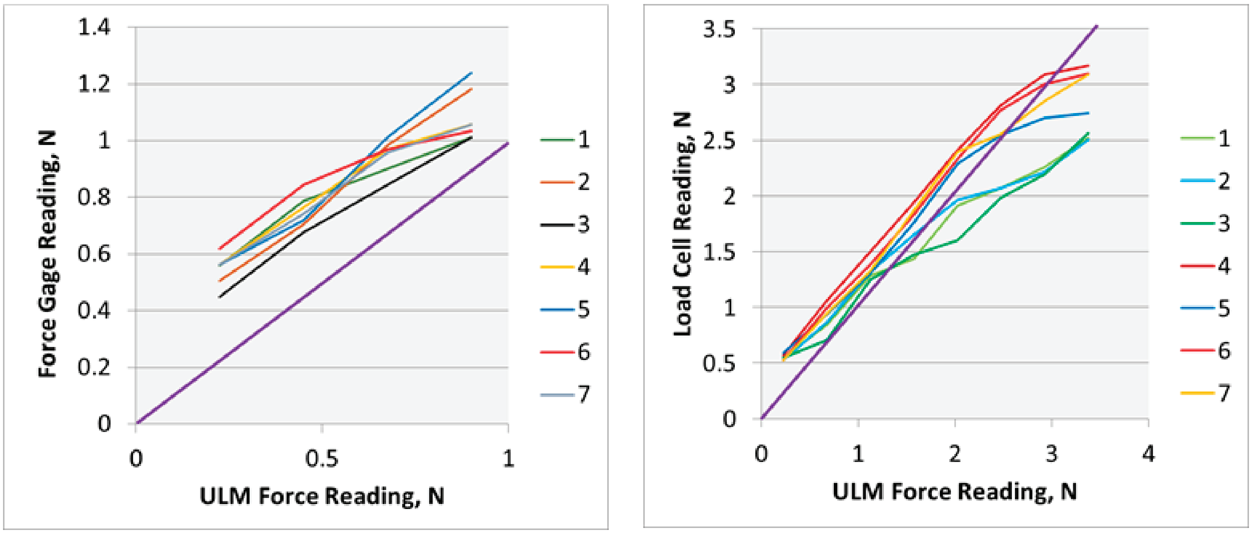

Figure 4. The force readout on the ULM was tested with two types of force gages by several operators. The graph to the right is from the electronic load cell.

We can use this analysis to document an uncertainty in the scale of the instrument to 13×10^{-6} (13 ppm).

$$U(\text{scale}) = 0.000013 \times L$$

From this data we see that the 8 data sets are reasonably alike except for three obvious outliers. Looking again at the deviation data in Figure 1, it is easy to see that the variation has little length dependence. The overall standard deviation of the data is 0.0017 mm, which is a reasonable result given the thermal environment.

5. Elastic Deformation

The primary deformation problems are the results of point contact. In the case of the ULM there is the obvious deformation of spherical gages between the flat anvils of the machine, but there can also be problems with the ULM attachments that give a spherical contact on both anvils. In either case, the deformation depends on the materials, the geometry of the contact, the geometry of the gage, and the force.

Most labs do not check on the force on their ULMs on a regular basis, and thus it is not a source of error that is found by check standards. In the workshop, each group checked the applied force with two different force gages: one dial gage and one digital load cell.

On the graphs of Figure 4 (previous page), the purple line is to provide a reference line so that the experimental slopes can be readily seen. The left figure is, unfortunately, typical of dial force gages that are used by inexperienced operators. The slopes are fairly close but there is a large zero error, indicating that there is some sort of hysteresis in the gage or none of the operators made zero corrections to their data. The results on the right are much better, if for no other reason than the system has a button that zeros the scale on demand.

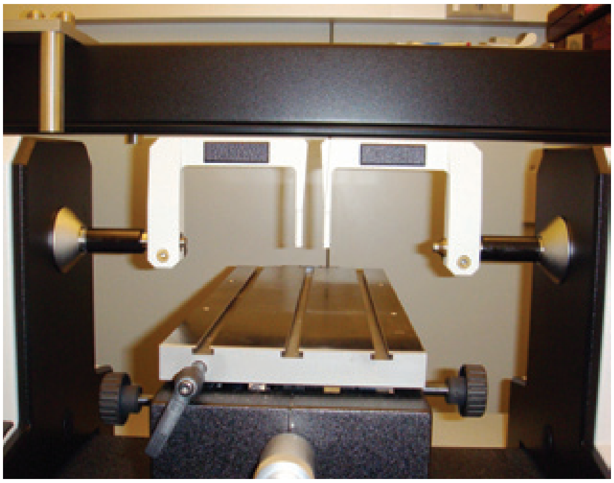

Figure 5. Most ULMs have accessories that mount on the contacts to measure the inside diameter of parts. Measurement of inside and outside diameters is the source of the word “Universal” in ULM. These attachments can bend significantly and the repeatability of the force is a critical property of the machine.

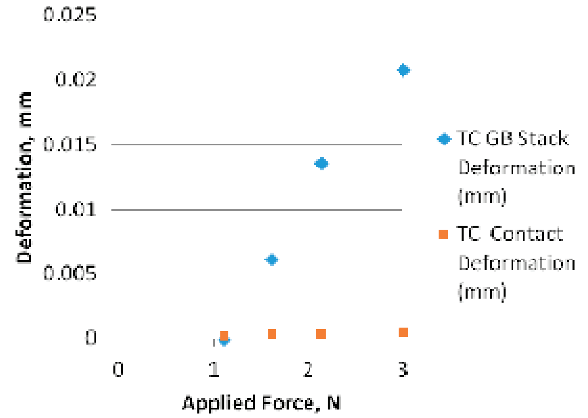

Figure 6. The TC contact deformation is the deformation of the part and contact spheres, which is small and can be calculated from standard equations. The top line is the overall deformation, dominated by the bending of the accessory fingers.

The average slopes for the two gages were 0.81 and 0.74. Even if the force reading can be corrected, there will still be an uncertainty in the measurement because of the 15% variation in the force calibration. If the force is not corrected, there will be two sources of uncertainty, in our case a 20% bias and 15% standard uncertainty from the slope calibration.

Even if the instrument is used as a comparator, comparing a sphere to a master sphere of the same size and material, there are errors caused by the non-repeatability of the force setting. As an example, gage blocks measured with the spherical contacts. On our ULM the contacts are ruby spheres that have diameters of 4 mm. With a standard contact force of 1 N the deformation of the steel/ruby is 0.476 µm and a 15% variation in force causes a 0.05 µm error.

There are worse cases that require large forces in the measurement, like the procedure to calibrate thread wires according to the defined procedure (ASME B89.1.17), that is, the wire is measured against a crossed cylinder of certain diameter and a specific force given by the standard. A 16 pitch wire, for example, is measured across a 0.75” (19 mm) cylinder at 2.5 lbs (11 N). There is considerable deformation and if the force is wrong by 10% there is an error in the diameter of the wire of 0.11 µm. This is a significant uncertainty because the tolerance on master wires is 0.5 µm.

Another serious problem involving the repeatability of the force produced by the ULM is in ring gages. Ring gages are measured with extensions to the main contacts of most ULMs. Figure 5 is a picture of our setup to measure rings.

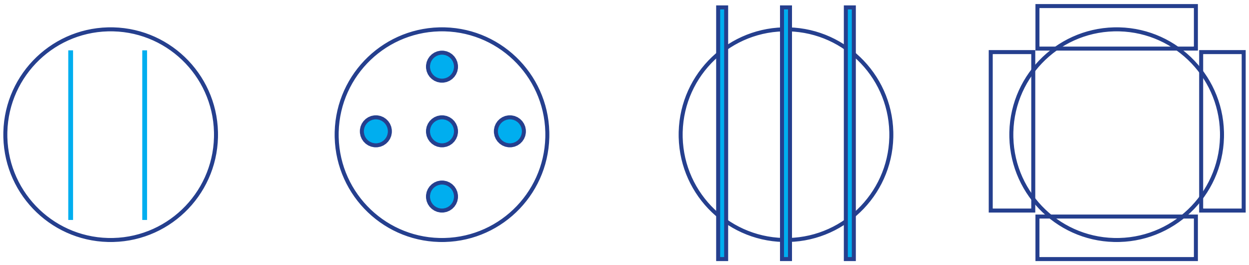

Figure 7. Four popular tests for parallelism/flatness are used; optical flat for fringe curvature, contact of ball along edges and center, moving a precision cylinder across the contacts, and checking a gage block along 4 directions at the edge of the contacts.

Most ring procedures compare the test ring against a master ring or a gage block stack. In either case, a change in the impressed force will give an error depending on the flexibility of the thin arms hanging down.

The ring gage attachments were tested with a steel ring gage and a tungsten carbide gage block stack. In each case, the force was ramped up from 4 N to 11 N and the apparent diameter was recorded. Figure 6 shows the results. If we were to ignore the bending of the instrument, the calculated deformation of the spherical contacts with the gage is shown as the nearly flat lines at the bottom of the graph. The slope of the diameter/force curve was found to be 0.012 mm/N at 1 N. This is quite large and it represents the bending of the contact arms. If the repeatability of the force is 10% at 1 N, this leads to an uncertainty of 0.0012 mm and will dominate the other sources of uncertainty.

For systems that automatically set the force, the repeatability might be better. For many machines the limitation is the operator precision reading the force gage on the instrument.

6. Instrument Geometry

The most obvious instrument geometry error source is the flatness and parallelism of the flat contacts. Many ULMs have contacts that are lapped in situ, and have no adjustment. This is good because of the general rule that if something is adjustable it will need adjustment very often. There are a number of ways to check the parallelism of micrometer contacts. The major ones are shown in Figure 7: optical parallels, a small sphere measured at different places on the contact, moving a cylinder across the contacts, and measuring a gage block that overlaps small areas at the edge of the contacts. This last test is difficult but it is the only one that can be used for large distances between the contacts.

The workshop measurements gave a flatness of 0.12 µm for the optical flat, 0.07 µm for the sphere, 0.15 µm for the cylinder and 1.00 µm for the gage block. While the gage block method seems to be a problem because it is difficult to hold or fixture a long gage block at the edge of the contacts, it is possible that it is not. As the tailstock of the ULM moves away from the other contact, for long gages, the motion can have pitch or yaw errors that would change the parallelism. For 5 mm contacts, a pitch or yaw error of 1” will rotate the moving contact out of parallel from the fixed contact by 0.025 µm. Figure 8 is a graph of another ULM in our lab.

Even at 100 mm, the pitch error will cause the contacts to be out of alignment by 0.050 µm. At the maximum extension of 300 mm the error would be 0.175 µm. In many cases this is not an ignorable error, and lower quality machines could have significant errors. This error motion is not part of the specifications of any ULM currently on the market and the size of the error is unknown.

7. Customer Gage Geometry

If the customer sends a sphere that is out of round by 10 µm, the measurement uncertainty from the other sources is probably negligible. You cannot make good measurements on poor gages. This source of error is invisible for check standards as it is to a GR&R, but by using “ordinary” gages in the UR&R it is possible to see some of the effects.

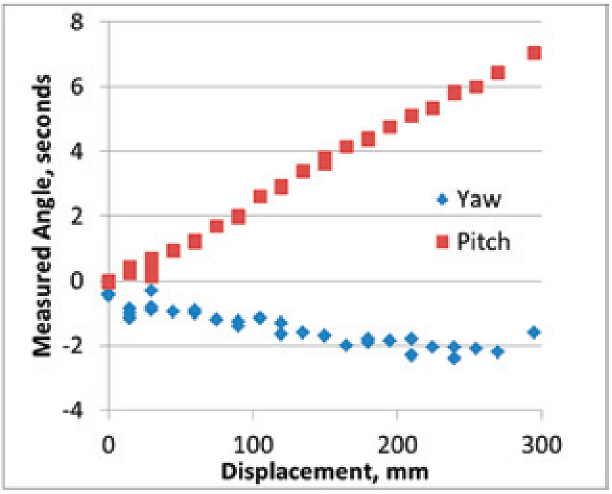

Figure 8. The pitch and yaw errors on most 1D measuring machines is unknown and not part of the instrument specification. Even very good machines can have significant errors. This graph shows the pitch and yaw of a state of the art ULM.

Uncertainty Source	Length Independent	Length Dependent
1. Master Gages	0.06 µm	$0.6 \times 10^{-6} \times L$
2. Repeatability	0.35 µm	$10 \times 10^{-6} \times L$
3. Scale		$13 \times 10^{-6} \times L$
4. Thermal Effects CTE Thermometer		 $1.2 \times 10^{-6} \times L$ $6.9 \times 10^{-6} \times L$
5. Instrument Geometry	0.07 µm	
6. Elastic Deformation	negligible for line contacts	

Table 2. Summary Table of Uncertainty Budget.

For example, it is best to do the UR&R with a good sphere—Grade 5 or better so that your uncertainty will not include customer gage effects—but if your customers routinely send in worse gages, the UR&R repeatability test can be repeated with typical gages and you will have information on both the ideal case for your best measurement capability and the higher uncertainty for typical spheres.

8. Uncertainty Budget

Summary of Uncertainty Budget for a cylinder measured at 21 °C (Table 2):

1. Master Gages: A search through accredited scopes showed that the lowest (k=2) uncertainties cluster around $0.12\ \mu m + 1.2 \times 10^{-6} \times L$.
2. Repeatability: We take the repeatability of the small cylinders as the zero length repeatability and the linear part we get from the scale calibration data, which was $0.00035\ mm + 10 \times 10^{-6} \times L$.
3. Scale: We use the data from 8 operators calibrating the scale, which is $13 \times 10^{-6} \times L$.
4. Thermal Effects: Since we are measuring away from 20 °C, we must use the CTE of the gage to correct our answer to the proper temperature. We take the variation in CTE of 10 % of the nominal CTE and using steel we get $1.2 \times 10^{-6} \times L$.

   Our thermometer reading also has uncertainty, the primary error at our temperature is the resolution. I assume that the lab has a thermometer with 1 °C resolution and gets a standard uncertainty of $6.9 \times 10^{-6} \times L$.
5. Instrument Geometry: This measurement is a cylinder and I take the parallelism results from the cylinder test, 0.07 µm.
6. Elastic Deformation: Negligible for line contacts.

To get the uncertainty over a range of diameters, we need to calculate the uncertainty for some small size gage and a large gage. The uncertainty for very small cylinders is only the length independent terms, which is 0.36 µm. We then calculate the uncertainty for a 100 mm cylinder (Table 3).

We now fit this data to a line of the form A+BL and get an expanded uncertainty of

$$\text{Uncertainty (k=2)} = 0.72\ \mu m + 33 \times 10^{-6} \times L \text{ (L in meters).}$$

Uncertainty Source	Length Independent, µm	Length Dependent, µm	Total, µm
1. Master Gages	0.06	0.060	0.12
2. Repeatability	0.35	1.0	1.35
3. Scale		1.3	1.3
4. Thermal Effects CTE Thermometer		 0.12 0.69	 0.12 0.69
5. Instrument Geometry	0.07		0.07
6. Elastic Deformation	negligible for line contacts		
Combined Standard Uncertainty			2.0
Expanded Uncertainty (k=2)			4.0

Table 3. Uncertainty of 100 mm cylinder.

Summary

The standard method to develop an uncertainty budget involves a list of known influence factors and a process to estimate the value of the error that could be contributed to the measurement uncertainty. Although there are many lists of possible influence factors, there remains the serious problem that human beings simply do not estimate very well. The problem is well documented and has spawned a moderately large branch of research into the subject [8, 9, 10].

The Uncertainty Repeatability and Reproducibility method is a hybrid method that uses experiments over a short period to estimate many of the sources of uncertainty and procedures from the GUM to estimate those that cannot be measured directly.

Acknowledgement

I would like to thank the Dimensional Metrology Group staff for their assistance with the Hands on Workshop. In particular I would like to thank Michael Braine for helping the attendees make the measurements in this report.

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Humidity Calibration Using Portable Relative Humidity Generators

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Metrology Consultant

Not too long ago, the RH calibration chambers which were appropriate for calibrating the high accuracy RH transmitters were limited to custom build chambers at the sensor manufacturer and a very small handful of commercially available units, none of which could be considered portable. As happens with all technologies, Relative Humidity generators have been developed and improved, reducing their size and making improvements to measurement uncertainties. When using the standard control sensors, these portable systems will often have uncertainties larger than laboratory based RH generators; however, these portable systems can often be improved upon by using external temperature and RH references. This paper will explore some of the key features which differentiate the different portable RH generators as well as look at examples of the uncertainty budgets for two systems, a portable generator using the internal sensors and the same generator using external references.

The performance of an RH calibration system breaks down into three major sections:

- How the generator adds or removes moisture from the air in the test chamber
- Control of the temperature of the test chamber
- Measurement of the relative humidity and temperature within the test chamber

Humidity Generation

Most RH generators, small enough to be considered portable, generate the RH set point in a similar manner. Air is constantly circulated within the test chamber of the instrument. A capacitive RH sensor is used to determine if the relative humidity of the test chamber is above or below the desired set point. If the RH is too high, then some of the air is passed through a drying cell which removes water vapor from the air before returning it to the test chamber. Conversely, if the RH is too low, the air is passed through a humidification cell to add moisture.

The drying cells in these chambers typically consist of a tube or chamber which contains a self-indicating silica gel or molecular sieve desiccant which absorbs the moisture from the air. The desiccant has a finite amount of moisture that it can absorb before it needs to be regenerated. Typically regeneration is performed in a separate oven and can take an hour or longer. The calibration ranges, the number of cycles expected and the model of RH generator selected can affect the amount of desiccant brought to a site. Small desiccant cells may require regeneration of the desiccant or new desiccant while onsite.

On the humidification process, there is more variance between the different generators. Water vapor is typically added to the air with 1 of these 3 methods:

1. The Bubbler: Water is bubbled through a volume of water. As the air passes through the water, the water evaporates, adding water vapor to the air.
2. High Surface Area Generator: Air is passed through a chamber which has a high surface area of liquid water. A common method for having a high surface area of water is to use a wet sponge or something similar.
3. Ultrasonic Generation: An ultrasonic transmitter is used to evaporate water from a water supply.

Regardless of humidification mode used, it is important to ensure that the water used in the chamber is free from contaminants. Distilled or deionized water is highly recommended in all cases.

Temperature Control

In a typical RH measurement, the temperature is not often given a high amount of consideration. The same is not true for RH calibration. Once an RH calibration system has come to equilibrium, the composition and the distribution of the water molecules in the air is considered to be uniform. Stated another way, the dew point or mixing ratio of the air will be uniform and without measureable gradients. The relative humidity, however, will vary by a function of the temperature gradients within the chamber and the temperature stability of the chamber.

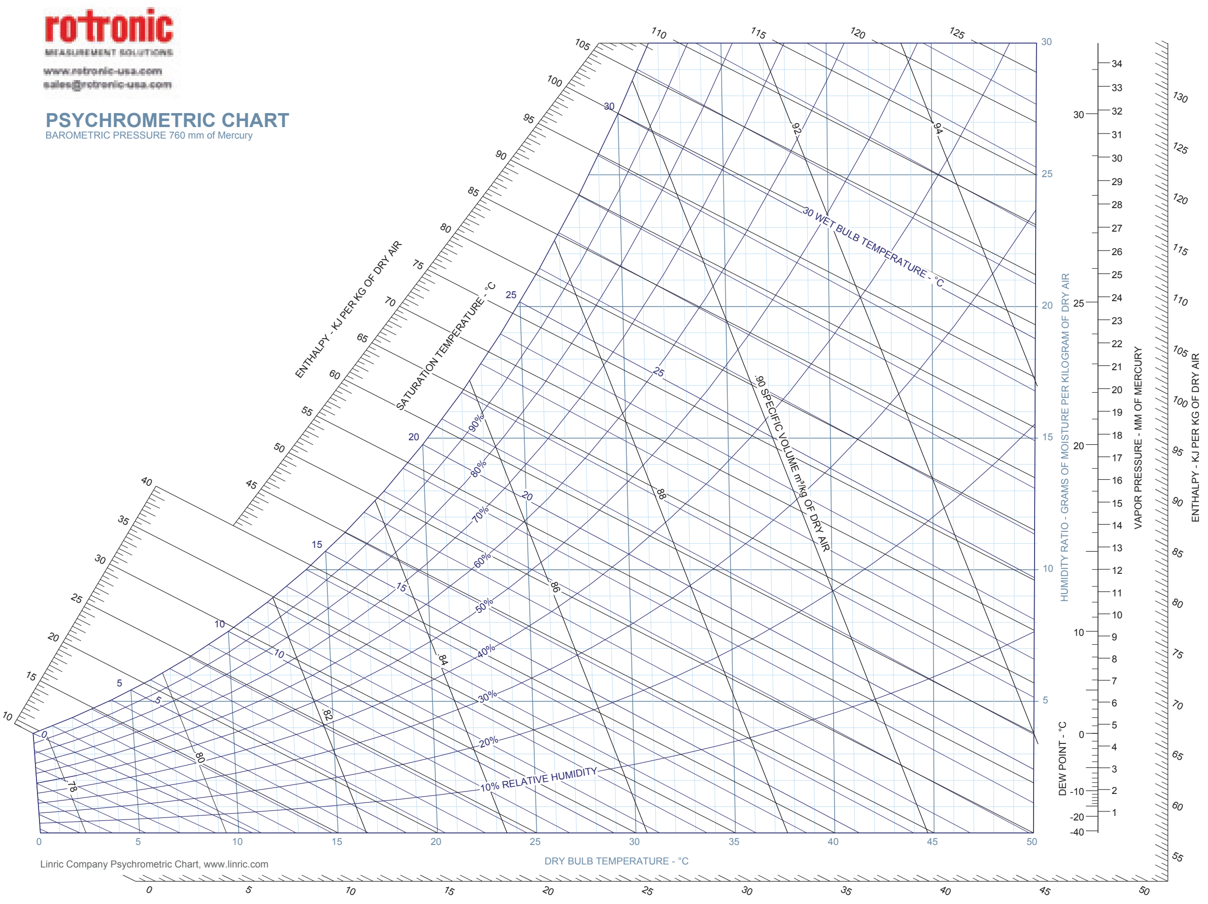

Figure 1. Psychrometric Chart

For relative humidity calibration it is critical to remember that it is a multicomponent parameter. A relative humidity value is incomplete without an accompanying temperature value. A measurement value of 50 %RH is meaningless without a temperature measurement. A corresponding temperature value is necessary to provide the information required to know how much water vapor the air can hold. This relationship is defined in the definition of relative humidity which is

$$\%RH = e / e_s * 100$$

where e is the water vapor content of the gas (water vapor partial pressure) and e_s is the maximum possible water vapor content of the gas at that same temperature (saturation vapor pressure).

Graphically, this relationship can be viewed on a psychrometric chart such as in Figure 1. For a fixed pressure and composition of a gas, as the temperature increases the relative humidity of that gas will decrease.

To see the impact that even small temperature changes have on the relative humidity value consider the following example.

A sample of air is known to have a relative humidity of 80.0 %RH at 22 °C. This corresponds to dew point of 18.39 °C. If this sample of air is heated by 0.1 °C the dew point of the air does not change remaining at 18.39 °C. The relative humidity of the air is now 79.5 %RH.

As this example illustrates, even a small temperature difference can have a significant effect on the relative humidity value. The effect varies according to the starting relative humidity and the temperature of the air.

Figure 2 shows further examples of the sensitivity of the relative humidity value to changes in temperature. As applied to a portable relative humidity generator Position 1 could be considered as the reference or control sensor of the generator and Position 2 could be the unit under test. The examples show gradients in the relative humidity which can quickly become some of the largest components of the uncertainty budgets.

Pressure (hPa)	Dew Point Temperature (°C)	Position 1		Position 2		Temperature Gradient (°C)	RH Gradient (%RH)
		%RH	°C	%RH	°C		
1013.25	18.39	80	22	79.5	22.1	0.1	-0.5
1013.25	34.71	75	40	75.4	39.9	-0.1	0.4
1013.25	-2.42	30	15	29.6	15.2	0.2	-0.4
1013.25	-8.71	10	25	10.1	24.8	-0.2	0.1

Figure 2. Effect of Temperature Gradients on RH values in air of constant composition. Temperature changes cause RH values to change while dew point temperature values remain constant.

In RH generators, temperature can be affected in three primary areas:

1. Temperature stability of the test chamber
2. Temperature gradients within the test chamber
3. Stem effect of the unit under test

Temperature stability of a portable RH generator is a function of the stability of the ambient temperature of the room where calibration is performed and the capabilities of the temperature control of the generator itself. Some portable RH generators do not have temperature controls and generate a relative humidity only at the ambient temperature. This condition leads to the uncertainty for temperature stability to be different for each different environment. RH generators without temperature controls present the problem of equilibration time. If the generator arrives onsite at a different temperature than the ambient condition where calibration is to be performed, equilibration can add several hours to the calibration process depending on the transportation conditions. Generators with temperature controls have the advantage of being able to generate a stable temperature in a shorter time period thus reducing the effect of any ambient temperature fluctuations.

Temperature gradients within the test chamber are minimized by moving the air within the test chamber itself with an internal fan. This is typically done in all portable RH generators regardless of whether or not the chamber includes temperature controls. The temperature gradients are primarily driven by temperature influences coming through the walls of the chamber. Some RH generators which have temperature control features have thermal guards within the test chamber to minimize the effects. Many generators, which do not have temperature controls, do not even have insulation around the RH test chamber. Such chambers rely on the thermal mass of the chamber to maintain a stable and uniform temperature.

The effect of temperature gradients on the overall uncertainty can be reduced through additional testing of an RH generator and careful setup of equipment. Temperature gradients can potentially be reduced through the use of a limited calibration volume within the test chamber.

The RH probe of the unit under test may also be introducing a temperature gradient into the chamber, especially if the entire probe cannot fit into the test chamber. When the RH probe is inserted through a port into the chamber a thermal pathway is created to the outside ambient environment creating what is called the stem effect. This is most noticeable when the calibration temperature differs significantly from the ambient temperature. As the temperature differential increases so does the temperature gradient along the length of the probe. Similar to temperature probe calibrations, when there is a large temperature differential between the calibration environment and the ambient conditions it is preferred to have as much of the RH probe inside the test chamber as possible to minimize any stem effect.

Temperature and RH Reference Measurements

The final element to consider is the device(s) providing the reference temperature and relative humidity readings. Often these are the largest contributors to the measurement uncertainty once the temperature effects are minimized. Portable RH generators can typically be used as provided from the manufacturer using the provided internal sensors. Many generators also allow external or secondary sensors, such as chilled mirrors, to be used as the reference.

Portable RH generators include temperature and RH sensors installed which are used to control the test environment. These same sensors are, typically, also used to provide the reference values from the chamber. It is common for these control sensors to be standard, commercially available probes which are available from many RH sensor manufacturers. As such, they often have the same uncertainty as many of the instruments that a user is calibrating in the field. Depending on the final use of the unit under test, the increase in the uncertainty may be an acceptable compromise to having a field calibration.

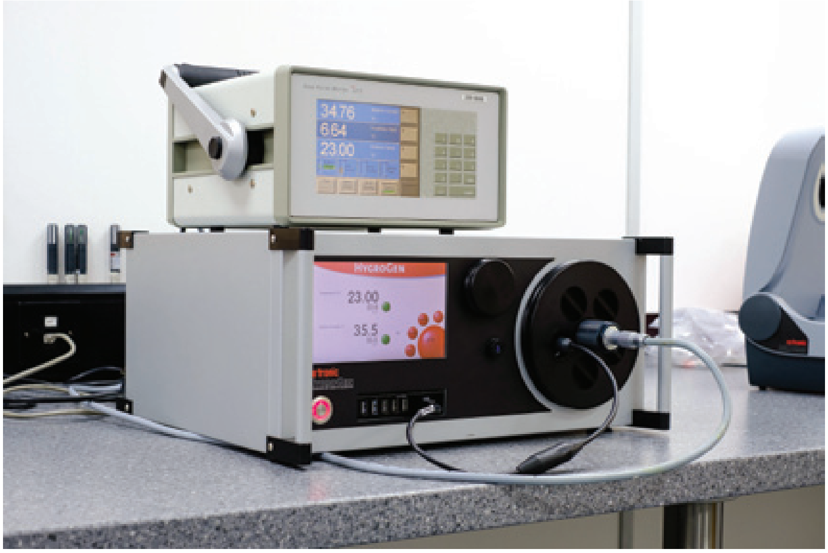

Figure 3. Chilled mirror placed inside of RH calibration chamber through an access port on the chamber door.

In cases where the unit under test is required to have lower uncertainties, the use of an external or secondary reference is common. Chilled mirrors can be attached to many portable RH generators providing an improvement of the reference uncertainties when compared to the control sensors. Depending on the configuration of chamber and chilled mirror, the chilled mirror may either be placed inside the test chamber of the portable RH generator or it may be external and have sample tube running to the test chamber. In either case, an external temperature probe is used to provide a lower uncertainty for the temperature value in the test chamber.

Figure 3 shows an example of a chilled mirror located within the test chamber of the portable RH generator. If the test chamber does not have sampling ports this may be the only option for using a chilled mirror as the humidity reference. The key drawback to this method is the reduction of capacity of the chamber since at least one position which could be used for a unit under test is taken. The chilled mirror module itself will also act as a heat source within the test chamber potentially affecting the temperature uniformity.

Figure 4. Chilled mirror connected to RH test chamber with sampling tubes.

Figure 4 demonstrates a setup using sampling tubes to connect the test chamber to an external chilled mirror. The system needs to remain a closed system in order for the humidity chamber to operate properly. This results in the need for a sampling tube as well as a return from the chilled mirror back into the test chamber. Depending on the level of relative humidity being generated, the sampling and return tubes may require heating to ensure that condensation does not form within the tubes thus creating incorrect readings.

A calibration system with an external chilled mirror using sampling tubes has the potential to be the lowest uncertainty setup for a portable RH generator. The lowest uncertainty is conditional on the type of chilled mirror used as well as the overall setup.

Measurement Uncertainty Samples

Figures 5 and 7 provide samples of uncertainty budgets for the Rotronic HygroGen HG2 portable RH generator to illustrate the uncertainty differences when using the control sensors for the reference as compared to using a RH Systems 973 Chilled Mirror. To simplify the comparison of calibration configurations the uncertainty contributors of the unit under test and some of the small uncertainty contributors have been left out of the uncertainty budgets.

Figure 5 shows that the major contributors to the overall calibration uncertainty is the reference probe when using the HygroGen HG2 as a standalone. The temperature measurements and gradients within the test chamber are significant but not nearly as dominant. Making the assumption that the unit under test devices to be calibrated are capacitive RH sensors, it is shown that this calibration configuration may be appropriate for field calibrations

Reference	Uncertainty Source	Value	Units	Distribution	Divisor	Standard Uncertainty	Sensitivity Coefficient	Standard Uncertainty (%RH)	% of Total Expanded Uncertainty
1	Reference Probe Uncertainty	0.90	%RH	Normal	2	0.450	1	0.450	28%
2	Reference Probe Drift	1.00	%RH	Rectangular	1.732	0.577	1	0.577	36%
3	Reference Probe Resolution	0.05	%RH	Rectangular	3.464	0.014	1	0.014	1%
4	Repeatability of Humidity	0.10	%RH	Normal	1	0.100	1	0.100	6%
5	Chamber temperature gradients	0.05	°C	Rectangular	1.732	0.029	4.96	0.143	9%
6	Temperature stabilization	0.01	°C	Rectangular	1.732	0.003	4.96	0.014	1%
7	Temperature repeatability	0.05	°C	Normal	1	0.050	4.96	0.248	16%
8	Humidity stabilization	0.05	%RH	Rectangular	1.732	0.029	1	0.029	2%
9	Humidity fluctuations	0.05	%RH	Rectangular	1.732	0.029	1	0.029	2%

Standard Uncertainty	0.794
Expanded Uncertainty (95% confidence level)	1.59

Figure 5. Sample Uncertainty Budget for 80 %RH at 23 °C test point using the control sensor of the Rotronic HygroGen HG2 as the reference.

provided higher uncertainties are acceptable. The RH measurement probes being calibrated may not meet the original manufacturer specifications but may still meet the process requirements.

It is important to note that the temperature gradients within the test chamber are relatively low due to the HygroGen HG2 actively controlling the temperature in the test chamber. A portable RH generator without active temperature control would have larger uncertainties related to temperature uniformity and stability which could cause the uncertainty contribution to be significantly higher.

Targeting the largest uncertainty contributors, the reference RH probe, creates a calibration configuration where a chilled mirror hygrometer and external temperature reference are used for the reference relative humidity values as shown in Figure 6.

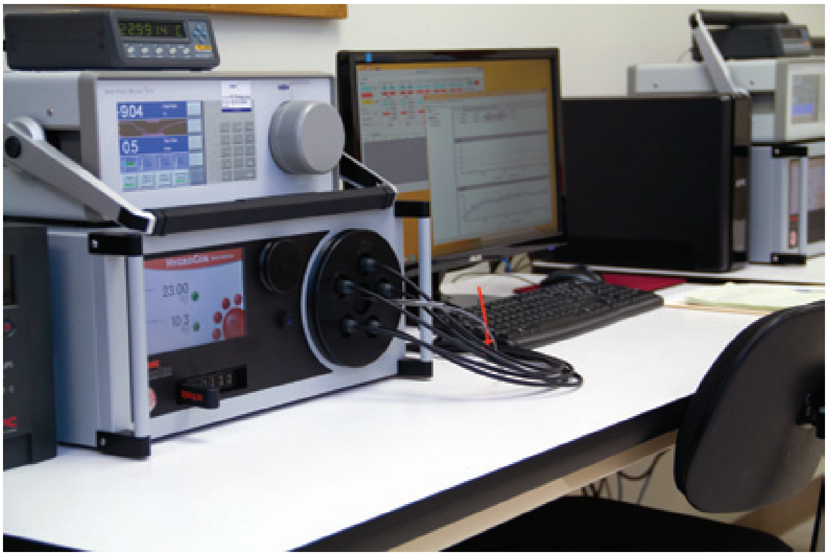

Figure 6. Portable RH Generator setup with External Chilled Mirror and Temperature Reference.

An RH System 973 chilled mirror and a Fluke 1504 readout measuring a Fluke 5610 thermistor probe are used to calculate the reference relative humidity for the uncertainty budget shown in Figure 7. The temperature uncertainties within the HygroGen HG2 chamber now are the largest contributors to the measurement uncertainty.

The uncertainty from this final calibration configuration now is sufficiently small that it is comparable to or less than the calibration uncertainty of the majority of the RH measurement devices which use capacitive RH sensors. This level of uncertainty now permits for calibrating these devices to meet manufacturer specifications.

In both calibration configurations, further improvements can be made to the temperature uncertainties. Limiting the test area within the test chamber would immediately allow for a reduction in the temperature gradient uncertainty once a validation study is completed.

Reference	Uncertainty Source	Value	Units	Distribution	Divisor	Standard Uncertainty	Sensitivity Coefficient	Standard Uncertainty (%RH)	% of Total Expanded Uncertainty
1	Chilled Mirror Uncertainty	0.05	°C	Normal	2	0.025	4.96	0.124	18%
2	Chilled Mirror Drift (1 year)	0.04	°C	Rectangular	1.732	0.023	4.96	0.115	16%
3	Temperature Uncertainty	0.007	°C	Normal	2	0.004	4.96	0.018	3%
4	Repeatability of humidity	0.10	%RH	Normal	1	0.100	1	0.100	14%
5	Chamber temperature gradients	0.01	°C	Rectangular	1.732	0.003	4.96	0.143	20%
6	Temperature stabilization	0.01	°C	Rectangular	1.732	0.003	4.96	0.014	2%
7	Temperature repeatability	0.05	°C	Normal	1	0.050	4.96	0.248	35%
8	Humidity stabilization	0.05	%RH	Rectangular	1.732	0.023	1	0.029	4%
9	Humidity fluctuations	0.05	%RH	Rectangular	1.732	0.029	1	0.029	4%

Standard Uncertainty	0.350
Expanded Uncertainty (95% confidence level)	0.70

Figure 7. Sample Uncertainty Budget for 80 %RH at 23 °C test point using RH Systems 973 as the Dew Point reference, a Fluke 1504 and 5610 as the Temperature Reference and the Rotronic HygroGen HG2 as the humidity source.

Conclusion

Significant improvements to portable RH generators have made improved performance and decreased uncertainties available for field calibrations. While the chambers available use similar methods for generating and maintaining relative humidity set points, differences in the design and construction of the chambers create a significant difference in performance. The most significant factors determining the overall performance of the chamber are the ability to control and minimize temperature effects as well as the method for measuring the reference readings. The potential exists for portable RH generators, when used with chilled mirror hygrometers, to rival the factory calibration uncertainties of RH measurement equipment using capacitive RH sensors.

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Michael Boetzkes is a metrology consultant specializing in relative humidity and temperature measurement. He has been involved with the manufacture and calibration of Temperature and Relative Humidity measurement equipment for 18 years. Michael is an industry expert in the implementation and evaluation of ISO17025 accredited laboratories for humidity and temperature. He brings practical and theoretical experience around calibration process, and uncertainty budget evaluation. Michael has presented relative humidity and calibration training sessions at NCSLI and MSC events.

The New ISO 17025 – What to Expect

Dr. George Anastasopoulos
Internation Accreditation Service (IAS)

Introduction - Background Information

ISO/IEC 17025 was first issued in 1999 by the International Organization for Standardization (ISO) and the International Electro-technical Commission (IEC). It is the single most important standard for calibration and testing laboratories around the world, with more than 50.000 laboratories accredited, globally.

At the International Laboratory Accreditation Cooperation (ILAC) General Assembly in October 2013 the Laboratory Committee (which is composed of stakeholder representatives of accredited testing and calibration) recommended that ILAC request that ISO/CASCO establish a new work item to comprehensively revise ISO/IEC 17025:2005. CASCO is the ISO committee that works on issues relating to conformity assessment. CASCO develops policy and publishes standards related to conformity assessment; it does not perform conformity assessment activities. CASCO's standards development activities are carried out by working groups made up of experts put forward by the ISO member bodies. The experts are individuals who possess specific knowledge relating to the activities to be undertaken by the working group.

A New Work Item Proposal (NWIP) was submitted by CASCO to ISO and approved in October 2014. An ISO/CASCO working group has since been established (WG44) and tasked with the revision of the standard titled: "Revision of ISO/IEC 17025 ISO/CASCO/WG 44."

The development process for ISO standards is divided into separate stages including:

Preparatory Stage

This stage covers the preparation of a working draft (WD) by the WG conforming to the ISO/IEC directives. The preparatory stage ends when a working draft is available as a first committee draft (CD).

Committee Stage

This stage is when comments on the draft from national member bodies are taken into consideration, with a view of reaching consensus. The committee stage ends when all issues have been resolved and a CD is accepted for circulation as an enquiry draft i.e. a Draft International Standard (DIS). Further CDs may be necessary where consensus is not reached prior to a DIS being available. The revision of ISO/IEC 17025 is now during this stage. CD2 is already published for comments.

Enquiry Stage

At the enquiry phase, the Draft International Standard (DIS) is circulated to all national member bodies for comment and vote.

Typically, the national bodies' mirror committees are responsible for monitoring and participating in the work of the relevant ISO committee. At this stage it is anticipated that the DIS will be released in the second half of 2016.

The DIS is approved if two-thirds of national member bodies are in favor and not more than one-quarter of the total number of votes cast are negative.

If the DIS is approved the project will go straight to publication. However, should the draft be significantly revised following comments at the DIS stage (even if the DIS has been approved) a decision may be made to prepare a Final Draft International Standard (FDIS) and circulate it to national member bodies for a further vote.

Publication Stage

At this stage the final draft is submitted for publication and only editorial corrections are made to the text. According to the WG44 work plan, it is expected that the revised version of the standard will be published in mid-end 2017.

About the New Standard - Changes

The format of the new standard will be significantly changed to be more in line with new ISO formatting guidelines. The basic format is similar to other new standards such as ISO/IEC 17020 and ISO/IEC 17065. It is expected that the new standards will be aligned to ISO 9001:2015 principles on resources and process. By following the new ISO 9001 philosophy it requires less documented procedures and policies and focuses more on the outcomes of a process. Example: no longer requires the laboratory to maintain a current job description (2005 – 5.2.4) but focuses on communicating to each person their duties, responsibilities and authorities (CD2 – 6.2.4)

Additional rigor is given in assuring the quality of results. Clarification/expansion of measurement decision risk is also expected to be included.

The new CD2 is now structured as follows:

1. Scope
2. Normative references
3. Terms and definitions
4. General requirements
5. Structural requirements
6. Resource requirements
7. Process requirements
8. Management requirements
    - ○ Annex A – Metrological Traceability (Informative)
    - ○ Annex B – Management System (Informative)
    - ○ Bibliography

Changes in the Requirements of New ISO 17025/CD2

The following are the main changes introduced through CD2:

- Usage of term "Laboratory Activities" instead of testing/calibration laboratories
- New ISO 17025 would be applicable to organizations that are also performing sampling without, necessarily, providing testing/calibration services.
- "Laboratory" is now defined as a body that performs one or more of the following activities:
    - ○ calibration
    - ○ testing
    - ○ sampling, associated with subsequent calibration and testing
- Liability insurance requirement (or reserves) is added
- Risk management requirements have been added as following:

  4.1.4 The laboratory shall identify risks to its impartiality

  7.1.7 a)…risk associated with the decision rule employed (such as false accept and false reject when a statement of conformity is requested)

  8.1.2 a) actions to address risks (related to MS)

  8.5 Actions to address risks and opportunities

  8.5.1 Risks and opportunities associated with the laboratory activities

  8.5.2 The laboratory shall plan actions to address these risks and opportunities;

  8.7.3 Risk of recurrence of the non-conformities encountered (Corrective Actions)

  8.9.4 The inputs to management review shall include; **m)** results of risk identification
- Updated requirements related to Internal QC/PT/ILC are defined at clause **7.8.1**: Regularly monitor the validity of activities undertaken and the quality of the laboratory output:

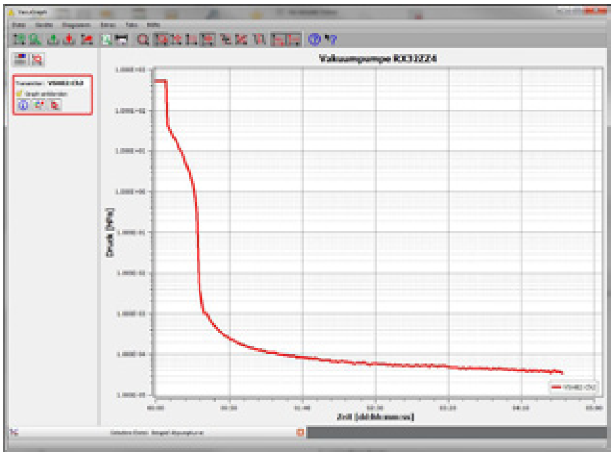
  a) regular use of reference materials or quality control materials;
  b) regular use of alternative metrologically traceable instrumentation;
  c) functional check of measuring and testing equipment;
  d) use of check or working standards with control charts, where applicable;
  e) periodic intermediate checks on measuring equipment;
  f) replicate tests or calibrations using the same or different methods;
  g) retesting or recalibration of retained items;
  h) correlation of results for different characteristics of an item;
  i) review of reported data by competent laboratory personnel;
  j) intralaboratory comparisons; and
  k) blind test.
- New Documentation Requirements have been introduced:
    - ○ Quality Manual is NOT required anymore
    - ○ Reduced procedural requirements in Management Systems section
    - ○ Reduced records requirements in Management Systems section

The Next Step

ISO/CASCO/WG 44 will meet again at Geneva, Switzerland, from September 20 to 23, 2016. The output of that meeting is expected to be the DIS version of the standard.

Dr. George Anastasopoulos (ganas@iasonline.org), is the Director of Conformity Assessment Accreditation Services, for International Accreditation Service (IAS). He is also the General Secretary of the International Personnel Certification Association IPC. He has also been member of the Bonn-Germany based, Accreditation Panel of the United Nations Kyoto Protocol system UNFCCC/CDM.

He is a Mechanical Engineer with a MSc and a PhD in Applied Mechanics from Northwestern University, Evanston, Illinois. He is also member of ISO/TC176 and ISO/CASCO technical committees which developed the new ISO 9001:2015 and new ISO 17025 (under development).



VacuGraph™ – The Ultimate Tool to Visualize, Analyze and Save Process Data

In combination with vacuum gauges of Thyracont Vacuum Instruments, the advanced VacuGraph™ software serves as the ultimate tool to visualize, analyze and save measurements on your PC in an efficient and easy way. As the world´s first standard pc software VacuGraph allows for an easy calculation of a leakage rates without the need for elaborate programming tasks.

The software was developed for particular use in service, commissioning and quality assurance of vacuum pumps and plants. Given the change of the program´s base to C++, VacuGraph 11 is lean, very stable and fast.

VacuGraph´s new, intuitively operated user interface offers a choice of different languages and a vast number of beneficial and handy improvements. With the help of the firmware upgrade assistant, all newly developed features for all Smartline™ active gauges of Thyracont Vacuum Instruments can thus always be automatically updated.

VacuGraph 11 is able to communicate simultaneously with any amount of active gauges, VD8 compact vacuum meters or display and control units. At the same time, the user can track measurement data online in real time and read out VD8 data loggers for quality assurance at a later point. In addition, there is the possibility to compare several measurement curves by overlapping them and single parts can be individually scaled. Measurement results can be printed, exported as CSV files and graphs saved as pixel or vector graphics.

The leakage calculation feature can easily determine the application´s tightness. Indicating the recipient volume, the software calculates the leakage rate by means of the rate-of-rise method. In doing so, VacuGraph™ often renders cost intense investments for the purchase of leak detectors unnecessary.

All parameters of Thyracont measurement gauges (e.g. units, data logging rates, gas correction factors, switch points, etc.) are easily configurable with the VacuGraph™ software. Programming skills, as required for the definition of parameters by software command via the instruments´ digital interface, are no longer necessary. In order to provide several devices with identical parameters or to generate backups for cases of emergency or need, individual profiles can be saved and, if required, restored without time-consuming re-configuration. Flexible parametrization permits easy integration of Thyracont Vacuum Instruments´ active sensors in any existing plant or substitution of present transducers.

VacuGraph™ is compatible with all Thyracont vacuum gauges with digital interface such as USB, Bluetooth® or RS485 and is now readily available for download in the Thyracont online shop via www.thyracont-vacuum.com.

The Bluetooth® word mark and logos are registered trademarks owned by Bluetooth SIG, Inc. and any use of such marks by Thyracont Vacuum Instruments is under license. Other trademarks and trade names are those of their respective owners.

Automated Thread Gage Calibration Machines Now Available in the USA

Micro Laboratories, Inc., (A2LA Cert Number 1312.01) Mentor Ohio is pleased to announce a new automatic way of calibrating thread gages. No thread wires, no math, very little skill required. You will be calibrating gages within 3 days of machine install.

IAC MasterScanners have been in use in several countries for many years and are only now becoming available through our representation in the United States.

The MasterScanner uses a mechanical probe to trace or scan the geometry of threads. The process is automated and can be done with minimal training. The probe is double sided and can scan Thread Plugs, Thread Rings, API, NPT, ACME, Buttress, ASME, Plain Rings and Plain Plugs. It also scans parts with built in CAD software.

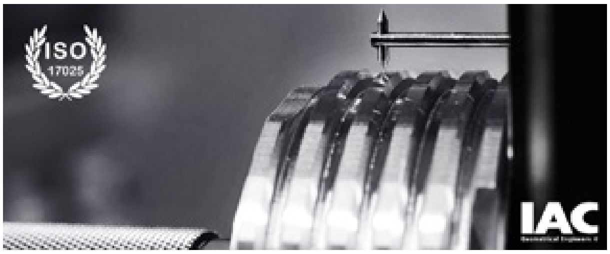
Change over from thread plugs to NPT plugs or rings takes only seconds. Most plug gages can be calibrated with the handles attached. Very little training is required and at our lab, thread gage calibration is now an entry level position. The operator just places the gage on the machine and following the on-screen directions and drop down menus selects the size of the gage. Within a few minutes the gage is calibrated and the certification is generated.

The calibration results include:

Pitch Diameter, Major Diameter, Minor Diameter, Lead Angle, Right and Left Angles of each thread, Flank Angle, and Taper for NPT type gages. The level of detail we can now see is significantly greater than using thread wires and an optical comparator or Lead Angle Checker. When used to check parts the MasterScanner can check hard to reach internal and external dimensions including diameters, radii, steps, and groves with 0.000001″ resolution.

The MasterScanner comes complete with software ready to generate certifications and can be modified using readily available off the shelf software. We also supply a very comprehensive uncertainty budget spreadsheet. Just revise as needed to include your temperatures, standards, etc. and it is ready to submit to your accreditation body. MasterScanners have been performing accredited calibrations around the world for many years.

For more information regarding the MasterScanner and its capabilities go to www.microlabs-inc.com or call 440-918-0001.



MasterScanner probe scanning a thread plug gage.

NEW PRODUCTS AND SERVICES

Morehouse Introduces a Quick Change Tension Member Calibration System

TM-100K-ASSEMBLY WITH TMA-120K-SET

York, PA – July 5, 2016 – Morehouse is pleased to introduce the new quick change tension member calibration system. This system allows laboratories to calibrate load cells so the force application is not distorted. The spherical used in the tension members minimize eccentric forces by improving vertical alignment. The result is improved repeatability which can allow lowers measurement uncertainty.

Morehouse Instrument Company is privately-owned and has been providing calibration measurement integrity since 1925. The company is a primary reference laboratory for force and torque measurements. Morehouse primary standards have uncertainties that are typically 10-50 times better than accredited calibration service suppliers that use secondary standards. Morehouse also designs, manufactures and sells test equipment and systems for force and torque calibration service applications in a broad range of industries. www.mhforce.com

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GEO Launches New Large Volume, Ruggedized Relative Humidity Calibrators

Ronkonkoma, NY (July 24th, 2016) — GEO Calibration Inc., the designer and manufacturer of GEO brand relative humidity and temperature calibrators, has launched two new units for high volume and rugged field calibration applications. The two new units, respectively called the Model 4000 and the Model 2000 SHR, represent the 9th and 10th units in GEO's single pressure (1P) humidity calibration chambers lineup.

The Model 4000 features a 38 Liter cylindrical chamber, three desiccant canisters with automatic switching and hot swapping, adaptive probe power supplies (3.3v, 5v, 12v, 24v), a touch screen display, and 10 USB ports to interface digital sensors under test with the embedded GEO software, thus allowing for 10 simultaneous, fully automatic calibrations. The chamber itself features 10 probe ports, ample space for chart recorders, and internal racks for bulk data logger calibrations. Internal testing shows stabilities of ± 0.1% Relative Humidity and 0.1° Celsius.

The Model 2000 SHR is the latest variant of the Model 2000 SP platform. The unit features a hardened plastic exterior shell, with clamshell style, clamp locking front and rear protective covers. Additional features include front mounted desiccant, and illuminated fill indicators. Two heavy duty handles on the side make this unit ideal for military home base and deployment applications, Transportable Field Calibration Unit (TFCU) teams, and in calibration van, or bare base operations.

The company's website at www.GeoCalibration.com contains more information.

Fluke Calibration 2271A Industrial Pressure Calibrator

EVERETT, Wash., July 12, 2016 /PRNewswire/ -- Fluke Calibration introduces the 2271A Industrial Pressure Calibrator, a comprehensive, automated solution for calibrating a wide variety of pressure gauges and sensors. The 2271A is ideal for calibration laboratories that are adding pressure calibration services because it features a broad range of pressure measurement capabilities in a single instrument.

The 2271A features a modular design so it can be configured to meet different needs and budgets, and can be expanded as needed to cover growing workloads. With its graphical user interface and intuitive menu structure, the calibrator is easy to set up and use so even less experienced technicians can operate it, and it can be fully automated to help calibration laboratories run more efficiently.

The calibrator operates from -100 kPa to 20 MPa (-15 to 3000 psi) for calibration of different types of pressure gauges and sensors with one device. Its removable pressure measurement modules make it easy to change or add measurement ranges. With its integrated electrical measurement module with HART capabilities, it provides a comprehensive solution for calibrating pressure transmitters.

The 2271A also features an optional Contamination Prevention System that helps keep contamination out of the calibration, providing an important safeguard.

To learn more about Fluke Calibration 2271A Industrial Pressure Calibrator, visit http://us.flukecal.com/2271A.

AUTOMATION CORNER

Calibration Lab Vectors of Vulnerability

Marcus Vickers
Operations Manager with WiSC Enterprises LLC

No, I am not talking about RF & Microwave calibration! In this context I am talking about the Vectors of Vulnerability through the calibration lab as it relates to Information Technology (IT) and cyber security. We all know that metrology touches everything. But what most of us don't know is Target® didn't get hacked; one of their service providers got hacked—specifically their HVAC vendor. And though that hack was an outside entity, it was able to gain access to many of Target's systems, including your credit card information.

Keep in mind, I spent much of my early career as a calibration technician, and now I work as a operations manager for a cyber security and vulnerability assessment company. It is my team's job to discover new ways to infiltrate and exploit systems, then engineer countermeasures to prevent it from happening in the first place.

Most cyber attacks follow a seven step "kill chain." But for the calibration lab, the first three are of particular interest because they fit the model of how Target was infiltrated. A threat actor would follow the same pattern of attack to exploit calibration equipment:

1. Reconnaissance
2. Weaponize
3. Deliver
4. Exploit
5. Install
6. Command & Control
7. Attack

For the most part, the systems and data inside the calibration lab are of little value to the average hacker beyond a few bitcoins from a ransomware attack. Hack a calibration lab and you can download a ton of calibration certificates or maybe learn the accuracy of a Fluke 5730A—not something that has any monetary value or anything that the hacker community would see as a real achievement.

But calibration labs make tempting pivot targets. Pivoting refers to a method used by hackers that uses the compromised system to attack other systems on the same network to avoid restrictions such as firewall configurations, which may prohibit direct access to all machines. Calibration labs make very tempting targets from a pivot attack perspective. A pivot attack of a calibration lab could allow the hackers to bridge air gapped networks, conduct reconnaissance, deliver malware, or collect proprietary or confidential data from the calibration lab customer sites.

Typically, IT combats hackers with updates, patches, and security assessments. Many of these updates are for security reasons. New computer and operating systems are key tools in the never ending fight to keep hackers out of our systems.

Turning our attention to the calibration lab, we find many systems that have not been updated in years. We have oscilloscopes running Windows 95, calibration systems written in DOS and Windows 3.1. All of these operating systems fell out of support years ago. In addition, if a patch existed, the process of patching an embedded OS is generally more complicated than what the corporate IT staff is used to supporting.

Many labs are running legacy software packages that are likely riddled with security issues. These vulnerabilities mixed with a little knowledge could be a recipe for disaster.

Often the threat actors with the capability to execute this type of attack will not be interested in advertising their findings. They will be more interested in keeping thier discovered zero day vulnerabilities to themselves in order to support a broader Advanced Persistent Threat (APT). An APT is an attack in which an unauthorized person gains access to a network and stays there undetected for a long period of time. The intention of an APT attack is to steal data rather than to cause damage to the network or organization. APT attacks target organizations in sectors with high-value information, such as national defense, manufacturing and the financial industry (http://searchsecurity.techtarget.com/definition/advanced-persistent-threat-APT).

At this point in time there is only circumstantial evidence that support/test equipment has been used or could be used as an attack vector. But all the warning signs are there, so metrology is going to have to add IT security to the growing list of job skills.


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Rs 100 Ω
Rt 100 Ω
Is -9.9976 mA
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Std. Dev. (ppm): 0.0017
Unc. (ppm): 0.0017
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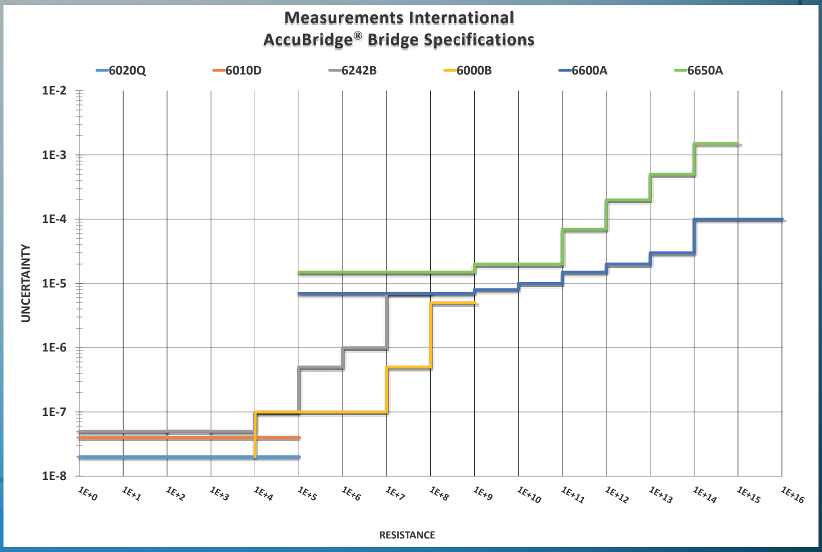
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