CAL LAB

THE INTERNATIONAL JOURNAL OF METROLOGY

Calibrating Long Scale Digital Multimeters with Fluke MET/CAL® and the Fluke 57xxA Through 90-Day Characterization

Using Metrology.NET® to Calculate ISO/IEC 17025 Uncertainties for Fluke MET/CAL®

The New ISO/IEC 17025:2017

Metrology - Why We Do What We Do

2017
JULY
AUGUST
SEPTEMBER

Electric Current Measurement

DS Series Current Transducers

DANISENSE

±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

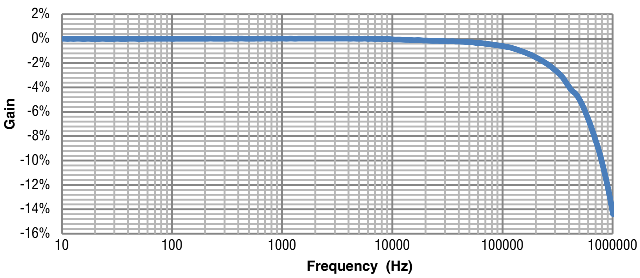
	DS200	DS600	DS2000	DS5000
Primary Current, rms	200A	600A	2000A	5000A
Primary Current, Peak	±300A	±900A	±3000A	±7000A
Turns Ratio	500:1	1500:1	1500:1	2500:1
Output Signal (rms/Peak)	0.4A/±0.6A†	0.4A/±0.6A†	1.33A/±2A†	2A/±3.2A†
Overall Accuracy	0.01%	0.01%	0.01%	
Offset	<20ppm	<10ppm	<10ppm	<5ppm
Linearity	<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˚

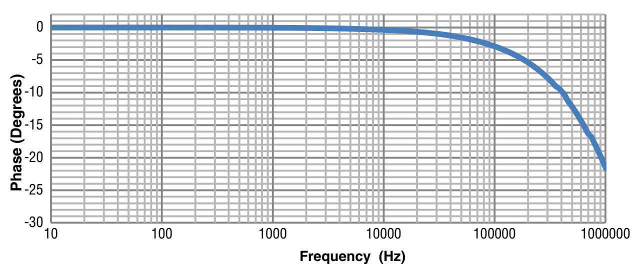
† Voltage Output options available in ±1V and ±10V

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 24, Number 3

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FEATURES

DEPARTMENTS

ON THE COVER: Technicians performing a calibration at CEESI's water lab in Nunn, Colorado, US.

UPCOMING CONFERENCES & MEETINGS

Sep 9-15, 2017 AUTOTESTCON. Schaumburg, IL. AUTOTESTCON is the world's premier conference that brings together the military/aerospace automatic test industry and government/military acquirers and users to share new technologies, discuss innovative applications, and exhibit products and services. It is sponsored annually by the Institute of Electrical and Electronic Engineers (IEEE). http://www.autotestcon.com

Sep 19-21, 2017 International Congress of Metrology (CIM). Paris, France. The event allows: to improve measurement, analysis and testing processes, and control risks; to follow the evolution of techniques, advances in R&D and discover industrial applications; to explore the exhibition showcasing innovations and solutions. http://cim2017.com

Sep 27-29, 2017 IEEE International Workshop on Measurements & Networking. Naples, Italy. The IEEE International Workshop M&N represents a forum for researchers and practitioners from industry, academia, and government involved in the area of modeling, measurement and quantitative evaluation of communication networks, sensor networks and distributed infrastructures. http://www.ieee.org

Oct 9-11, 2017 3DMC. Aachen, Germany. Following the highly successful inaugural 3D Metrology Conference and exhibition last year, the organizing committee is pleased to announce 3DMC 2017, which will be held in the Tivoli sports stadium at Aachen, Germany. 3DMC is a conference and exhibition dedicated to the application and development of 3D measurement technology for industrial, scientific and cultural purposes. http://www.3dmc.events/

Oct 29-Nov 3, 2017 32nd ASPE Annual Meeting. Charlotte, NC. The American Society for Precision Engineering (ASPE) promotes the future of manufacturing in America by advancing precision engineering through supporting education and encouraging the development and application of precision principles. http://aspe.net/technical-meetings/32nd-annual-meeting/

Dec 4-6, 2017 The Second Gulf Metrology Forum. Doha, Qatar. The Gulf Organization for Industrial Consulting (GOIC), through its close scrutiny of the industries, foresees a bigger role can be played by metrology in the GCC energy sector focusing on the new technologies in the various energy fields. http://www.gmf.goic.org.qa

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Printed in the USA.

ISSN No. 1095-4791

EDITOR'S DESK

A Little of This & That

Occasionally, we visit a lab to take photos for the cover of the magazine. Last week, the folks at Colorado Engineering Experiment Station (CEESI) invited us out for a tour of their facility out in Nunn, Colorado. Not only are they a flow meter calibration lab for the energy industry, but they also sponsor and host conferences and training programs each year in Colorado, throughout the US, and internationally. Of all the photos I took, it was those impromptu moments when we turned a corner and there was the perfect shot! It's one of those shots that is on this issue's cover.

I am excited about this issue, as it's packed with everything from the practical to the novel. Michael Johnston gave a presentation last spring at the Measurement Science Conference Training Symposium in Anaheim, California, on regular characterization of a Fluke 57xxA calibrator in order to handle verifications for high accuracy multimeters. Upon request, Michael kindly wrote up this short but sweet paper for us. It's a classic Metrology 101 paper I hope every cal lab using a 3458A will find useful.

Next up, Michael Schwartz (our publisher) explains how to use REST based service calls to calculate measurement uncertainties. In an environment where automation software must meet the increasing needs of the calibration lab, Michael is developing ways that different software applications can share resources. He explains this and provides a working example using "systems-of-systems architecture" Metrology.NET and Fluke MET/CAL.

Dr. George Anastasopoulos of International Accreditation Service (IAS) wraps up his series of reports on the new ISO/IEC 17025 standard with this complete article on the changes. He has been attending each of the ISO/CASCO meetings, so we are very appreciative he could share his knowledge and experience with us.

And finally, Paul Hanssen of Workplace Training shares with us a fun piece about the frustrating experience of trying to explain to family and friends what we do in the world of metrology, and why… because it's kind of necessary, right?! Everything from our cell phone service to the manufacturing of solar eclipse lens film depends on metrology, whether we're aware of it or not.

Happy Measuring,

Sita Schwartz
Editor

SEMINARS: Dimensional

Sep 26-27, 2017 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.

Oct 3-6, 2017 Dimensional Measurement Training: Level 2 – Measurement Applier. Bristol, UK – INSPHERE Ltd. 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. http://www.npl.co.uk/training.

Oct 5-6, 2017 Hands-On Gage Calibration and Repair. Los Angeles, CA. IICT. This 2-day hands-on workshop offers specialized training in calibration and repair for the individual who has some knowledge of basic Metrology. Course includes hands on calibration and repairs and adjustments of micrometers, calipers, indicators height gages, etc. http://www.iictenterprisesllc.com.

Oct 10-11, 2017 Hands-On Gage Calibration and Repair. Phoenix, AZ. IICT. This 2-day 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 10-12, 2017 Hands-on Gage Calibration. Aurora (Chicago), IL. Mitutoyo Institute of Metrology. This course is an 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/.

Oct 17-19, 2017 Dimensional Measurement Training: Level 1 – Measurement User. London, 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 19-20, 2017 Hands-On Gage Calibration and Repair. Chippewa Falls, WI. 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.

Additel

Automatic Handheld Pressure Calibrator Introduction

World's First Handheld Automatic Pressure Calibrator

Taking portable pressure calibration to a whole new level!

- ***Fully automatic calibrator with built-in pump and controller***
- ***Switchable internal pressure modules for expandable ranges***
- ***Accuracy (1 year) of 0.02%FS***
- ***External pressure modules available (measure only)***
- ***Less than 4 lbs (1.8 kg) for handheld operation***
- ***Source pressure, measure pressure and electrical***
- ***Optional HART communications***
- ***Optional data logging and task documenting***
- ***USB, Wi-Fi, and Bluetooth communications***
- ***4 Channels***

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Oct 30-31, 2017 Hands-On Gage Calibration and Repair. Atlanta, GA. 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 2-3, 2017 Hands-On Gage Calibration and Repair. Clearwater, Beach, FL. 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 7-9, 2017 Hands-on Gage Calibration. Aurora (Chicago), IL. Mitutoyo Institute of Metrology. This 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 13-16, 2017 Dimensional Measurement Training: Level 2 – Measurement Applier. Coventry University, UK. This course provides the underpinning knowledge and expertise for anyone who uses measurement tools or requires an appreciation of the importance of measurement, the principle knowledge and practical training for people who are required to use co-ordinate measurement techniques to complete their daily tasks. http://www.npl.co.uk/training.

Nov 15-16, 2017 Hands-On Gage Calibration and Repair. Schaumburg, 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.

Dec 5-6, 2017 Hands-On Gage Calibration and Repair. Oshkosh, WI. 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.

Dec 5-7, 2017 Hands-on Gage Calibration. Aurora (Chicago), IL. Mitutoyo Institute of Metrology. The Hands-On Gage Calibration course is a unique, active, educational experience designed specifically for those who plan and perform calibrations of dimensional measuring tools, gages, and instruments. http://www.mitutoyo.com/support/mitutoyo-institute-of-metrology/.

CALENDAR

Dec 11-13, 2017 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.

Dec 12-14, 2017 Dimensional Metrology. Aurora (Chicago), IL. Mitutoyo Institute of Metrology. Principles and practice are taught with a hands-on experiential learning approach to engage the students and promote retention of the concepts. http://www.mitutoyo.com/events/seminar-dimensional-metrology-7/.

Dec 13-14, 2017 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.

SEMINARS: Electrical

Oct 2-5, 2017 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. We will also teach various techniques used to make good measurements using calibration equipment. http://us.flukecal.com/training.

Oct 9-12, 2017 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. The student will learn how to make various types of measurements using different measurement methods. We will also teach techniques for making good high precision measurements using reference standards. http://us.flukecal.com/training.

SEMINARS: Flow / Pressure

Sep 20-22, 2017 Flow Measurement and Calibration. Munich, Germany. TrigasFI GmbH. This Training Seminar is intended for individuals with responsibility to select, calibrate and use liquid and gas flowmeters. It is designed to be an objective, independent review and evaluation of the current state of flow metering and calibration theory and technology for flowmeter users and metrologists. http://trigas.de/.

Oct 10-11, 2017 Basic Pressure Measurement. Delft, Netherlands. VSL Dutch Metrology Institute. http://vsl.nl/en/services/training.

CALENDAR

Oct 17-19, 2017 Fundamentals of Flow Measurement. Loveland, CO. Colorado Engineering Experiment Station (CEESI). This class will cover flow measurement topics applicable to a broad range of industries. http://ceesi.com/events.

Oct 23-26, 2017 Comprehensive Flow Measurement. Loveland, CO. Colorado Engineering Experiment Station (CEESI). This class will cover flow measurement topics applicable to a broad range of industries. http://ceesi.com/events.

SEMINARS: General & Management

Sep 28, 2017 Root Cause Analysis and Corrective Action. A2LA Headquarters – Frederick, MD. 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/.

Oct 6, 2017 Root Cause Analysis and Corrective Action. A2LA Headquarters – Frederick, MD. 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/.

Oct 16-19, 2017 Effective Cal Lab Management. Everett, WA. Fluke Calibration. This course 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.

Oct 25, 2017 Root Cause Analysis and Corrective Action. San Francisco, CA. A2LA. The RCA/CA course consists of presentations, discussions and exercises that provide participants with an in-depth understanding of how to analyze a system in order to identify the root causes of problems and to prevent them from recurring. http://www.a2la.org/.

Nov 3, 2017 Root Cause Analysis and Corrective Action. A2LA Headquarters – Frederick, MD. The RCA/CA course consists of presentations, discussions and exercises that provide participants with an in-depth understanding of how to analyze a system in order to identify the root causes of problems and to prevent them from recurring. http://www.a2la.org/.

Dec 4-8, 2017 Fundamentals of Metrology. Gaithersburg, MD. NIST. The Fundamentals of Metrology seminar will introduce the participant to the concepts of measurement systems, units, measurement uncertainty, measurement assurance, traceability, basic statistics and how they fit into the laboratory Quality Management System. https://www.nist.gov/news-events/events/2017/12/5505-fundamentals-metrology.

SEMINARS: Industry Standards

Sep 18-19, 2017 ISO/IEC 17025 and Laboratory Accreditation. A2LA Headquarters – Frederick, MD. This course is an introductory look at ISO/IEC 17025 and its requirements for demonstrating the technical competence of testing and calibration laboratories. In this course, you will be introduced to the A2LA accreditation process and will gain insight into the interpretation of the requirements of this international laboratory standard. http://www.a2la.org/.

Sep 25-26, 2017 ISO/IEC 17025 and Laboratory Accreditation. Boulder, CO. A2LA. This course is an introductory look at ISO/IEC 17025 and its requirements for demonstrating the technical competence of testing and calibration laboratories. In this course, you will be introduced to the A2LA accreditation process and will gain insight into the interpretation of the requirements of this international laboratory standard. http://www.a2la.org/.

Sep 28, 2017 ISO/IEC 17025 Advanced: Beyond the Basics. Boulder, CO. A2LA. This is an advanced course in the application of ISO/IEC 17025 requirements. The course will provide a brief overview of the requirements of this laboratory standard, as well as provide an understanding of how to apply specific sections of the Standard in your laboratory. http://www.a2la.org/.

October 2-6, 2017, ISO/IEC 17025 Lead Assessor Training. San Antonio, TX. ANAB. This 4.5-day course will enable attendees to develop a solid understanding of the ISO/IEC 17025 standard and be able to plan and lead an ISO/IEC 17025 assessment. http://anab.org/training/

Oct 16-17, 2017 ISO/IEC 17025 and Laboratory Accreditation. A2LA Headquarters – Frederick, MD. This course is an introductory look at ISO/IEC 17025 and its requirements for demonstrating the technical competence of testing and calibration laboratories. In this course, you will be introduced to the A2LA accreditation process and will gain insight into the interpretation of the requirements of this international laboratory standard. http://www.a2la.org/.

Nov 1-2, 2017 ISO/IEC 17025 and Laboratory Accreditation. A2LA Headquarters – Frederick, MD. This course is an introductory look at ISO/IEC 17025 and its requirements for demonstrating the technical competence of testing and calibration laboratories. In this course, you will be introduced to the A2LA accreditation process and will gain insight into the interpretation of the requirements of this international laboratory standard. http://www.a2la.org/.

Nov 7-8, 2017 ISO/IEC 17025 and Laboratory Accreditation. Charleston, SC. A2LA. This course is an introductory look at ISO/IEC 17025 and its requirements for demonstrating the technical competence of testing and calibration laboratories. In this course, you will be introduced to the A2LA accreditation process and will gain insight into the interpretation of the requirements of this international laboratory standard. http://www.a2la.org/.

Nov 13-15, 2017 Internal Auditing to ISO/IEC 17025. San Francisco, CA. ANAB. This 2.5-day training course prepares the internal auditor to clearly understand technical issues relating to an audit. Attendees of this course will learn how to coordinate a quality management system audit to ISO/IEC 17025:2005 and collect audit evidence and document observations, including techniques for effective questioning and listening. http://anab.org/training/isoiec-17025-training/internal-auditing-to-isoiec-17025/.

Dec 4-5, 2017 ISO/IEC 17025 and Laboratory Accreditation. A2LA Headquarters – Frederick, MD. This course is an introductory look at ISO/IEC 17025 and its requirements for demonstrating the technical competence of testing and calibration laboratories. In this course, you will be introduced to the A2LA accreditation process and will gain insight into the interpretation of the requirements of this international laboratory standard. http://www.a2la.org/.

SEMINARS: Mass & Weight

Oct 23-Nov 3, 2017 Mass Metrology Seminar. Gaithersburg, MD. NIST Office of Weights and Measures. This 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. https://www.nist.gov/news-events/events/2017/10/5456-mass-metrology-seminar.

SEMINARS: Measurement Uncertainty

Oct 11, 2017 Introduction to Estimating Measurement Uncertainty. Edwardstown, SA. NMI (Australian Gov. - Dept. of Industry, Innovation and Science). This course will give you a clear step-by-step approach to uncertainty estimation with practical examples. http://www.measurement.gov.au/Services/Training/Pages/default.aspx.

Nov 6, 2017 Introduction to Measurement Uncertainty. Charleston, SC. A2LA. Participants who have never developed uncertainty budgets usually develop the required skill well before the end of the class. Others who seek explanations of GUM complexities obtain clarifications expressed in simple terms. http://www.a2la.org/.

CALENDAR

Nov 7-8, 2017 Applied Measurement Uncertainty for Calibration Labs. A2LA Headquarters – Frederick, MD. https://www.a2la.org/training/index.cfm.

Nov 15, 2017 Introduction to Estimating Measurement Uncertainty. Malaga, WA, Australia. NMI (Australian Gov. - Dept. of Industry, Innovation and Science). This one-day course (9 am to 5 pm) will give you a clear step-by-step approach to uncertainty estimation with practical examples; you will learn techniques covering the whole process from identifying the sources of uncertainty in your measurements right through to completing the uncertainty budget. http://www.measurement.gov.au/Services/Training/Pages/default.aspx.

Nov 16-17, 2017, Fundamentals of Measurement Uncertainty. San Francisco, CA. ANAB. Attendees of this 2-day course will learn a practical approach to measurement uncertainty applications, based on fundamental practices. Measurement uncertainty for both testing and calibration laboratories will be discussed. Attendees will gain an understanding of the steps required, accepted practices, and types of uncertainties that need to be considered by accredited laboratories. http://anab.org/training.

Nov 21-23, 2017 Uncertainty Calculation. Delft, Netherlands. VSL Dutch Metrology Institute. http://vsl.nl/en/services/training.

SEMINARS: RF & Microwave

Oct 17-19, 2017 VNA Tools Metrology and Uncertainty Workshop. Ontario, CA. Federal Institute of Metrology METAS. VNA Tools is free and supports most of the Vector Network Analyzers in today's market. The software is ideal for flexible and modular external VNA calibration, error correction algorithms, device control, graphical capabilities, and a project-based data analysis. The software is available for download at www.metas.ch/vnatools. The three day course provides a practical and hands-on lesson with this superior and versatile software. https://www.metas.ch/metas/en/home/dl/kurse---seminare.html.

Nov 7-9, 2017 VNA Tools Metrology and Uncertainty Workshop. Bern-Wabern, Switzerland. Federal Institute of Metrology METAS. VNA Tools is free and supports most of the Vector Network Analyzers in today's market. The software is ideal for flexible and modular external VNA calibration, error correction algorithms, device control, graphical capabilities, and a project-based data analysis. The software is available for download at www.metas.ch/vnatools. The three day course provides a practical and hands-on lesson with this superior and versatile software. https://www.metas.ch/metas/en/home/dl/kurse---seminare.html.

SEMINARS: Radiometry

Oct 25-26, 2017 Radiometry Measurement. Lindfield, NSW. Australian Government NMI. This two-day course (9 am to 5 pm) covers the broad range of equipment and techniques used to measure colour and light output, the basic operating principles involved in radiometry, working techniques, potential problems and their solutions. http://www.measurement.gov.au/Services/Training/Pages/default.aspx#.

SEMINARS: Software

Oct 23-27, 2017 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/training.

Nov 6-10, 2017 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 18-20, 2017 Advanced Topics in Temperature Metrology. American Fork, UT. Fluke Calibration. A three-day course for those who need to get into the details of temperature metrology. This course is for experienced calibration technicians, metrologists, engineers, and technical experts working in primary and secondary-level temperature calibration laboratories who would like to validate, refresh, or expand their understanding of advanced topics in temperature metrology. http://us.flukecal.com/training.

Sep 21-22, 2017 Infrared Calibration Training. American Fork, UT. Fluke Calibration. A three-day course with plenty of hands on experience in infrared temperature metrology. This course is for calibration technicians, engineers, metrologists, and technical experts who are beginning or sustaining an infrared temperature calibration program. http://us.flukecal.com/training.

Sep 29, 2017 Testing Temperature Controlled Enclosures. Lindfield, NSW. Australian Government NMI. This one day course (9 am to 5 pm) is for people involved in routine performance testing of temperature controlled enclosures (oven, furnace, refrigerator and fluid bath). It incorporates an extensive overview of AS 2853 requirements and common industry practice and it also includes hands-on practical demonstrations. http://www.measurement.gov.au/Services/Training/Pages/default.aspx#

Oct 5, 2017 Introduction to Temperature and Temperature Measurement. Delft, Netherlands. VSL Dutch Metrology Institute. http://vsl.nl/en/services/training.

Nov 7-9, 2017 Practical Temperature Calibration Training. American Fork, UT. Fluke Calibration. Three day course loaded with valuable principles and hands-on training designed to help calibration technicians and engineers get a solid base of temperature calibration fundamentals. http://us.flukecal.com/training.

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

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/programs.shtml.

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

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/programs.shtml.

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 (CCT) Prep – Online Learning. QC Training. Using the same materials used in our 3-day classroom training, students prepare for ASQ"s examination for Certified Calibration Technician. https://qctraininginc.com/delivery/online-and-sdl/.

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. https://qctraininginc.com/delivery/online-and-sdl/.

Electronics for Non-Electronic Engineers – OnDemand Complete Internet Course. Technology Training, Inc. (TTI). To help participants to understand the concepts and terminology of electronics. https://pubs1.ttiedu.com/store.

Introduction to Measurement and Calibration – Online Learning. 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. https://qctraininginc.com/delivery/online-and-sdl/.

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 Uncertainty – e-Learning Course. NPL. You will learn how risks are estimated enabling good decision-making in practical contexts, such as in manufacturing and regulation. http://www.npl.co.uk/training.

Introduction to Metrology - e-Learning Course. 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. https://pubs1.ttiedu.com/store.

ISO/IEC 17025 Compliance. WorkPlace Training, tel (612) 308-2202, info@wptraining.com, http://www.wptraining.com/.

Measurement Uncertainty – OnDemand Complete Internet Course. Technology Training, Inc. With this option, individuals who cannot attend a live course can view the course materials and view pre-precorded lectures, complete with student/instructor discussions. https://pubs1.ttiedu.com/store.

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 Learning. The QC Group. Targeted for calibration technicians, quality managers, engineers, quality technicians, and other users of uncertainty budgets. https://qctraininginc.com/delivery/online-and-sdl/.

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. https://pubs1.ttiedu.com/store.

Precision Measurement Series Level 1 & 2. WorkPlace Training, http://www.wptraining.com/.

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 Learning. QC Training. Advance your career with a low-cost, online course in precision dimensional measurement, tools and techniques. https://qctraininginc.com/delivery/online-and-sdl/.

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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/.

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

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PTB scientist Christof Gaiser with the core of the dielectric-constant gas thermometer. The different silver-colored pressure vessels have special capacitors which are filled with helium to carry out the measurement that takes place inside them.
Credit: PTB

Boltzmann Constant Determined

PTB has succeeded in measuring the Boltzmann constant k independently. A fundamental condition laid down by the Consultative Committee for Thermometry (CCT) has thereby been met, so that all obstacles to the redefinition of the kelvin have been removed by fixing the value of the Boltzmann constant. The final measurements of k with a dielectric-constant gas thermometer were conducted with a relative uncertainty of 1.9 ppm (parts per million). Compared to the uncertainty of 15 ppm obtained at the beginning of the project back in 2007, this represents a reduction by a factor of 8.

For a unit to be based on a fundamental constant, the latter should, as a matter of principle, be measured by means of two methods which are independent of each other and have a comparable uncertainty. As early as 30 years ago, the Boltzmann constant k had already been determined with a relative uncertainty of 1.8 ppm by means of the acoustic gas thermometer. Over the past decade, this method was further refined by various metrology institutes, with the most accurate result exhibiting an uncertainty reduced by a factor of 2. These results allow the first condition of the CCT for the new definition to be met, namely obtaining an averaged value for the Boltzmann constant with an uncertainty of less than 1 ppm.

An independent method of doing this is dielectric-constant gas thermometry, which PTB has been using for many years. This method consists in determining the pressure of the measuring gas, helium, in a gas-filled capacitor. This approach is based on the fact that helium, as a dielectric, changes the capacitance of the capacitor. At pressures up to 7 MPa, the uncertainty of the pressure measurement had to be reduced by a factor of 4. This has now been achieved with a worldwide unequalled relative uncertainty of 1 ppm. In order to measure the capacity changes, relative uncertainties of a few parts per billion may not be exceeded. Moreover, the material parameters for the capacitors – at these high pressures – had to be determined at the metrological limit, and a gas purity of better than 99.99999 % had to be ensured. This could only be achieved thanks to various cooperation projects within PTB (with the two working groups "Pressure" and "Geometrical Standards") and thanks to large-scale international cooperation.

Now that the Boltzmann constant has been determined with sufficient precision by means of both methods, CODATA will compute the final value of k in September 2017. This will pave the way for the redefinition of the kelvin based on a fundamental constant. Presumably in the fall of 2018, the whole International System of Units (SI) will rest upon a new basis.

Contact

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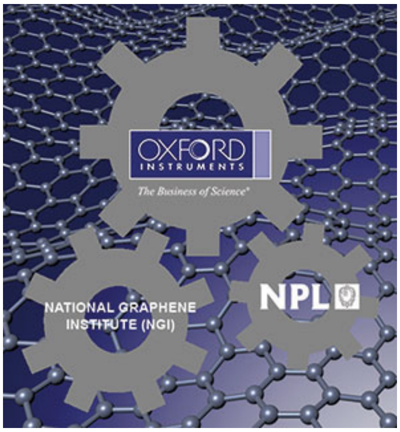
Scientific publication

C. Gaiser, B. Fellmuth, N. Haft, A. Kuhn, B. Thiele-Krivoi, T. Zandt, J. Fischer, O. Jusko, W. Sabuga: Final determination of the Boltzmann constant by dielectricconstant gas thermometry. Metrologia 54, 280–289 (2017)

Source: PTB-News 2.2017, http://www.ptb.de/cms/presseaktuelles/zeitschriften-magazine/ptb-news.html.

Turnkey Quantum Hall System for Graphene Characterisation & Primary Resistance Metrology



31 July 2017 - Oxford Instrument announces the successful completion of the collaborative project with National Physical Laboratory (NPL) and the National Graphene Institute (NGI) at University of Manchester. The project has been partially funded by the Innovate UK for development of commercial measurement system for nanotechnology applications, reducing operational costs, time and complexity. The collaboration was led by Oxford Instruments and the turnkey system has been developed, verified and tested at company's Tubney Wood site in UK. The quantum measurement system operates at cryogen

free low magnetic fields and will enable primary resistance calibrations with unprecedented accuracies to be used by the national (metrology) laboratories and industrial companies.

"This is an exciting achievement by the consortium in demonstrating the industrial feasibility of using graphene and 2D materials to commercialize quantum measurement systems and enable new innovative and turnkey solutions in standard measurements and 2D materials characterization", said Ziad Melhem, the Alliances Manager from Oxford Instruments NanoScience.

Graphene is a revolutionary, two-dimensional (2D), atomic scale carbon material with unmatched properties and is expected to revolutionize industry and consumer products over the coming years. Graphene's discoverers from Manchester University in the UK were awarded the Nobel Prize in 2010. Graphene is the first truly 2D material and is classed as a "super-material" offering extremely high electrical and thermal conductivity, hydrophobicity, strength, and impermeability to all gases. Graphene is widely seen as a new platform material for advanced manufacturing, with applications including electronics, fashion and sports wearable technology, mining, water conservation and purification, automotive structures and energy storage.

Demand for accurate measurements at the nanoscale will continue to increase and the graphene-enabled quantum resistance system will provide the high-end electronics instrumentation industry with a primary resistance standard for the first time. The system can be used directly on the factory floor dramatically reducing the calibration traceability chain and improving the precision of electronics instrumentation. The quantum Hall effect (QHE) is one of the most fundamental phenomena in solid-state physics and its observation in graphene was the acid test that proved that this material is a true two-dimensional crystal of the highest quality. The QHE is also the cornerstone of electrical metrology as it is the primary realisation of the unit for resistance, the ohm.

The UK has been a global leader in research on graphene since it was discovered at the University of Manchester and supported since then by over £80 million funding from the UK government. Innovate UK and the Engineering and Physical Sciences Research Council (EPSRC) are investing an additional £2.5 million in technical feasibility studies to target the applications of graphene with the greatest commercial potential. Oxford Instruments NanoScience, the

National Physical Laboratory (NPL) and National Graphene Institute (NGI) at Manchester University were awarded a grant from Innovate UK, to test the operation of a turnkey quantum Hall system in industrial environment.

Professor Vladimir Falko, Director of the NGI at Manchester University commented, "It happens very rarely that blue-sky fundamental research delivers applicable results at the timescale of just one decade. In this case, we are lucky to be able to beat the clock."

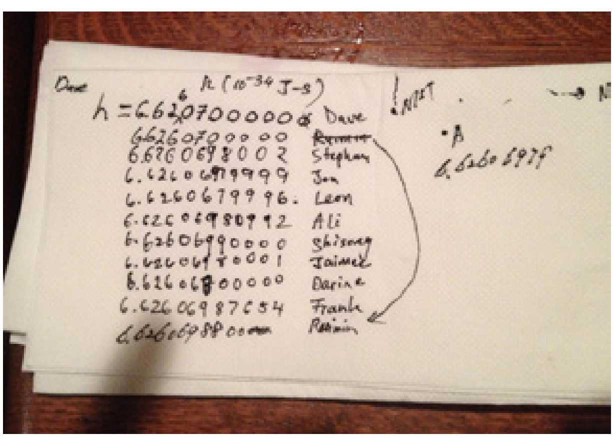
Dr JT Janssen, NPL Research Director said, "This is an exciting development because calibration laboratories have long wanted to have primary resistance traceability on the shop floor. This novel technology will make this a reality for the first time and open the door to many more innovative applications."

Source: https://www.oxford-instruments.com/news/2017/july/announcing-the-successful-industrial-feasibility-t.

New Measurement Will Help Redefine International Unit of Mass

NIST News, June 30, 2017 - Using a state-of-the-art device for measuring mass, researchers at the National Institute of Standards and Technology (NIST) have made their most precise determination yet of Planck's constant, an important value in science that will help to redefine the kilogram, the official unit of mass in the SI, or international system of units. Accepted for publication (http://iopscience.iop.org/article/10.1088/1681-7575/aa7bf2/pdf) in the journal Metrologia, these new results come ahead of a July 1 international deadline for measurements that aim to redefine the entire SI in terms of fundamental constants of nature.

The new NIST measurement of Planck's constant is 6.626069934 x 10−34 kg·m2/s, with an uncertainty of only 13 parts per billion. NIST's previous measurement (https://www.nist.gov/news-events/news/2016/06/nists-newest-watt-balance-brings-world-one-step-closer-new-kilogram), published in 2016, had an uncertainty of 34 parts per billion.



In December 2013, before NIST began its experiments on its newest Kibble balance, group members wrote their predictions on the value of Planck's constant they would measure. Shisong Li, a guest researcher from Tsinghua University in China, came closest. His prediction differed by only about 5 parts per billion from the measured result. Credit: NIST

The kilogram is currently defined in terms of the mass of a platinum-iridium artifact stored in France. Scientists want to replace this physical artifact with a more reproducible definition for the kilogram that is based on fundamental constants of nature.

Planck's constant enables researchers to relate mass to electromagnetic energy. To measure Planck's constant, NIST uses an instrument known as the Kibble balance, originally called the watt balance. Physicists widely adopted the new name last year to honor the late British physicist Bryan Kibble, who invented the technique more than 40 years ago.

NIST's Kibble balance (https://www.nist.gov/pml/redefining-kilogram-watt-balance) uses electromagnetic forces to balance a kilogram mass. The electromagnetic forces are provided by a coil of wire sandwiched between two permanent magnets. The Kibble balance has two modes of operation. In one mode, an electrical current goes through the coil, generating a magnetic field that interacts with the permanent magnetic field and creates an upward force to balance the kilogram mass. In the other mode, the coil is lifted at a constant velocity. This upward motion induces a voltage in the coil that is proportional to the strength of the magnetic field. By measuring the current, the voltage and the coil's velocity, researchers can calculate the Planck constant, which is proportional to the amount of electromagnetic energy needed to balance a mass.

There are three major reasons for the improvement in the new measurements, said physicist Stephan Schlamminger, leader of the NIST effort.

First, the researchers have much more data. The new result uses 16 months' worth of measurements, from December 2015 to April 2017. The increase in experimental statistics greatly reduced the uncertainty in their Planck value.

Second, the researchers tested for variations in the magnetic field during both modes of operation and discovered they had been overestimating the impact the coil's magnetic field was having on the permanent magnetic field. Their subsequent adjustment in their new measurements both increased their value of Planck's constant and reduced the uncertainty in their measurement.

Finally, the researchers studied in great detail how the velocity of the moving coil affected the voltage. "We varied the speed that we moved the coil through the magnetic field, from 0.5 to 2 millimeters per second," explained Darine Haddad, lead author of the NIST results.

In a magnetic field, the coil acts like an electric circuit consisting of a capacitor (a circuit element that stores electric charge), a resistor (an element that dissipates electrical energy) and an inductor (an element that stores electrical energy). In a moving coil, these circuit-like elements generate an electrical voltage that changes over time, said Schlamminger. The researchers measured this time-dependent voltage change to account for this effect and reduced the uncertainty in their value.

This new NIST measurement joins a group of other new Planck's constant measurements from around the world. Another Kibble balance measurement (http://iopscience.iop.org/article/10.1088/1681-7575/aa70bf), from the National Research Council of Canada, has an uncertainty of just 9.1 parts per billion. Two other new measurements use the alternative Avogadro technique (https://www.nist.gov/physical-measurement-laboratory/silicon-spheres-and-international-avogadro-project), which involves counting the number of atoms in a pure silicon sphere.

The new measurements have such low uncertainty that they exceed the international requirements for redefining the kilogram in terms of Planck's constant.

"There needed to be three experiments with uncertainties below 50 parts per billion, and one below 20 parts per billion," Schlamminger said. "But we have three below 20 parts per billion."

All of these new values of the Planck's constant do not overlap, "but overall they're in amazingly good agreement," Schlamminger said, "especially considering that researchers are measuring it with two completely different methods." These values will be submitted to a group known as CODATA ahead of a July 1 deadline. CODATA will consider all of these measurements in setting a new value for Planck's constant. The kilogram is slated for redefinition in November 2018, along with other units in the SI.

Before they started these experiments, Schlamminger and his group went to lunch in December 2013. On a lunch napkin, each group member wrote his or her prediction of the value of Planck's constant that the group would determine through their measurements. They tucked away this napkin under their Kibble balance nearly four years ago, and they have now compared the predictions. Shisong Li, a guest researcher from Tsinghua University in China, came closest. His prediction differed by only about 5 parts per billion from the measured result. There is no word yet on how the team plans to celebrate the winner's guess.

Source: NIST News, June 30, 2017 (https://www.nist.gov/news-events/news/2017/06/new-measurement-will-help-redefine-international-unit-mass).

CAL-TOONS by Ted Green teddytoons@icloud.com

Calibrating Long Scale Digital Multimeters with Fluke MET/CAL® and the Fluke 57xxA Through 90-day Characterization

Michael Johnston
Northrop Grumman Aerospace Systems

Due to the high accuracy of the long scale (8½-digit) meters, the standards and methods required to perform a verification of the device often make automation of the process difficult. Alternatively, guardbanding is sometimes used to allow for the use of less accurate standards. However, due to the excellent stability of the Fluke 57xxA, it is possible to use a periodically characterized value of the output in place of other standards and methods for a direct measurement.

By performing an artifact calibration and subsequently characterizing the value of the 57xxA every 90 days, a user can maintain a data file for use with a simplified MET/CAL procedure for rapid verification of long scale multimeters.

Introduction

By way of example, this paper will focus on the process for verifying the Keysight 3458A, since it is the one this process was designed around. Many procedures for the 3458A verification require the user to perform a characterization at the time of the calibration. However, when a lab handles a reasonable volume of the 3458A, this additional calibration time can add up as an unnecessary time sink. The Fluke 57xxA offers stability that is typically in excess of its specifications. By monitoring this stability over a long-term study, it is possible to use a characterization performed every 90 days as the basis for 3458A verification, thereby reducing the calibration time of each unit. This paper will outline the process used by Northrop Grumman Aerospace Systems (NGAS) for this verification.

Artifact Calibrations

> Artifact Calibration is the process of transferring the assigned value(s) of an artifact to a large array of multidimensional parameters. Typically the term Artifact Calibration is used to describe the process when it is implemented internally in an instrument. [1]

For the Fluke 57xxA, the artifact calibration process consists of using a 732A or 732B voltage reference and 741-1 and 741-10k standards resistors to adjust the internal references of the calibrator. NGAS performs an artifact calibration every 90 days for each of our 57xxA standards. This allows us to use a 2-year calibration interval while using the calibrator at its 90-day specifications. In addition to the benefit of extending the time between full calibrations, the artifact calibration report provides us with data on the long-term behavior of the instruments. Figure 1 is a section of the artifact calibration report for a 5720A.

The "Shift" column quantifies the drift from the last artifact calibration. We can use this data to analyze the long-term behavior of the unit. Rather than using the specification of the 57xxA calibrator, we replace it with the calculated uncertainty at 95.4% confidence level assigned to the characterized calibrator. One of the contributors in that calculation is the worst 90-day drift value from the historical data.

Figure 2 is a sample of data collected on one of our calibrators over the course of more than 4 years. It is quickly apparent from the data collected over the life of the calibrator that the actual performance exceeds the specifications.

DC VOLTAGE OUTPUT SHIFTS

RANGE	Point	Zero Shift	Full Scale Shift		Spec (+/-)	Shift (% spec)
220 mV	+FS	0.00010 mV	-0.00042 mV	-1.89 ppm	9.27 ppm	-20.41
	-FS	0.00010 mV	0.00061 mV	2.76 ppm	9.27 ppm	29.79
2.2V	+FS	0.0000000 V	-0.0000020 V	-0.90 ppm	4.36 ppm	-20.64
	-FS	0.0000000 V	0.0000020 V	0.90 ppm	4.36 ppm	20.65
11V	+FS	0.000000 V	-0.000005 V	-0.46 ppm	3.27 ppm	-14.19
	-FS	0.000000 V	0.000005 V	0.46 ppm	3.27 ppm	14.19

Figure 1. Artifact Calibration Report

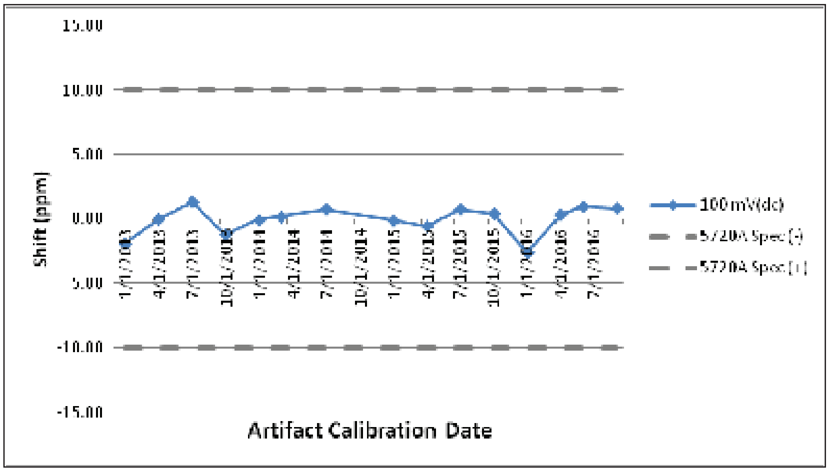


Figure 2. 100 mV(dc) Drift History

Characterization Method

Following this artifact calibration for the 57xxA that we use to calibrate the 3458A, we perform a characterization of certain cardinal points.

The resulting values from this characterization describe the setting of the 57xxA required to generate a nominal output, with the exception of the frequency characterization, which is a direct reading of the output. This section will describe the process of this characterization.

Data File Creation

A recent change to the process that was made to assist with integration into Fluke MET/CAL was the creation of a procedure with the singular purpose of providing data retention of the characterizations. Previously, the data was collected and stored by hand in a digital format. The new MET/CAL procedure continues with the manual steps to retrieve the actual values, but then allows the user to enter the data in the MET/CAL interface to generate a characterization report similar to the previous one, as well as update a data file for use with other procedures, including the 3458A verification procedure. The characterization itself is performed manually, with the MET/CAL procedure only instructing the user which point to test and allowing them to enter the actual value for retention and creation of the data file.

Additionally, the procedure displays the change from the last recorded characterization (in ppm) to allow the user to verify continued stability over time.

DC Voltage Characterization

The output of the 57xxA is compared to a Fluke 732A (maintained with a voltage value weekly based on our bank of four 732B references), with a 752A divider to utilize the lower uncertainty of the 10 V(dc) output, with a Keithley 155 Null Detector to nominalize the output. The technician changes the output setting on the 57xxA until the null detector reads zero, then records the setting, correcting for the actual value of the 732A.

AC Voltage Characterization

The output of the 57xxA is connected to a Fluke 792A and the output of the 792A is connected to a calibrated 3458A Option 002 in DC Voltage Mode. The technician changes the output setting on the 57xxA until the multimeter indicates a nominal DC output based on the calibration data for the 792A. For higher voltage ranges, a 792A-7002 is included in the setup.

Resistance Characterization

Calibrated values of the Fluke 742A resistors and an IET Labs SR1050 (referenced to the 742A-1M) are used for the resistance verification of the 3458A, but for the sake of simplicity, these values are entered in the MET/CAL procedure at the time of characterization for use in verification. The user is given the option to update the values in the verification procedure for the 3458A.

DC Current Characterization

The 57xxA current output is placed across the 742A resistors and the resulting voltage drop is measured with a calibrated 3458A Option 002 in DC Voltage mode. The technician changes the output setting on the 57xxA until the multimeter reads a voltage drop corresponding to a nominal current output and records the associated output setting.

AC Current Characterization

The 57xxA current output is placed across a Fluke A40-10MA current shunt and the output of the shunt is connected to the input of the 792A, with the output of the 792A connected to a calibrated 3458A Option 002 in DC Voltage Mode. The technician changes the output setting on the 57xxA until the multimeter indicates a nominal DC output based on the calibration data for the 792A.

Frequency Characterization

The Wideband Output of the 5720A is measured with a Keysight 53131A Frequency Counter referenced to a Symmetricom-Xli GPS receiver and the result is recorded.

Nominal V(dc)	Range V(dc)	Worst-Case 90-Day Drift Value	Combined Uncertainty (k=2)	3458A Opt 002 90-day Specification	Calculated TUR
100 m	100 m	2.6 ppm	0.29 µV	0.85 µV	2.9
1	1	1.3 ppm	1.7 µV	5.4 µV	3.2
1	10	1.3 ppm	1.7 µV	5.1 µV	3.0
-1	10	1.3 ppm	1.7 µV	5.1 µV	3.0
-10	10	0.5 ppm	12 µV	47 µV	3.9
10	10	0.5 ppm	12 µV	47 µV	3.9
100	100	1.5 ppm	190 µV	680 µV	3.6
1000	1000	1.9 ppm	2.3 mV	18.6 mV	8.1

Table 1. Comparison of Drift, 3458A Specification, and Combined Uncertainty

Verification Method

With the characterization described above completed, the verification of the 3458A becomes a simple direct reading test. Where necessary, MET/CAL uses TUR guardbanding to reduce the acceptance limits to meet a 4:1 TUR. During development of the procedure, the expanded uncertainty is defined in the source code based on our specific standards to reflect the analysis presented in this paper. These uncertainties were calculated by considering the worst-case shift of one characterization period. The historic data is tracked separately to monitor for increases in this contributor to allow for updating of the uncertainties.

Table 1 is an extended comparison of the behavior of the 57xxA (via worst case drift and the calculated combined uncertainty) and the specifications of the 3458A. DC Voltage mode is the most difficult to achieve 4:1 TURs during testing, but with the method described in this paper, we are able to exceed 2.9 TUR on all test points prior to guardbanding implementation.

The 57xxA output is set to the recorded characterization value, making our expected output the nominal value for each test, and the measurement is taken with the 3458A in NPLC 100 and 5 readings being averaged (10 readings for AC Voltage). A 10-second stabilization period is included after each change of set point.

Conclusion

By demonstrating that the actual behavior of the 57xxA is much better than its specifications and maintaining a characterized value to use, we are able to perform a full verification of a 3458A via automation in a much faster manner.

References

[1] Fluke Calibration. (n.d.). “Artifact Calibration: Theory and Application.” Retrieved April 11, 2017, from http://us.flukecal.com/node/2065.

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Using Metrology.NET® to Calculate ISO/IEC 17025 Uncertainties for Fluke MET/CAL®

Michael L. Schwartz
Cal Lab Solutions, Inc.

Writing automated calibrations and controlling test equipment is easy. But once you have the automation working, now it's time to calculate the uncertanties. Often calculating uncertanties and documenting the results takes longer than writing the actual procedure. Then there are the changes to the calculations, changes in customer requirements, as well as and industry regulations and standards. All of this takes time away from creating automation.

This paper will show you how to offload the task of calculating measurement uncertanties to a Metrology.NET service call, and how this division of tasks in software allows the programmer to focus on writing automation and the quality/metrology engineer to focus on uncertanties. By using a REST based service call, the quality engineer doesn't have to learn programming, nor is the programmer required to learn all the details about the uncertainty calculation. Best of all, this REST call technique can be added to any software language, such as MET/CAL®, SureCal®, LabView® or any Metrology.NET® system.

Introduction

First we have to start with "What is a REST call, and why it is important?"

> Representational state transfer (REST) or RESTful web services is a way of providing interoperability between computer systems on the Internet. REST-compliant Web services allow requesting systems to access and manipulate textual representations of web resources using a uniform and predefined set of stateless operations… In a RESTful Web service, requests made to a resource's URL will elicit a response that may be in XML, HTML, JSON or some other defined format. The response may confirm that some alteration has been made to the stored resource, and it may provide hypertext links to other related resources or collections of resources. Using HTTP, as is most common, the kind of operations available include those predefined by the HTTP verbs GET, POST, PUT, DELETE and so on. [1]

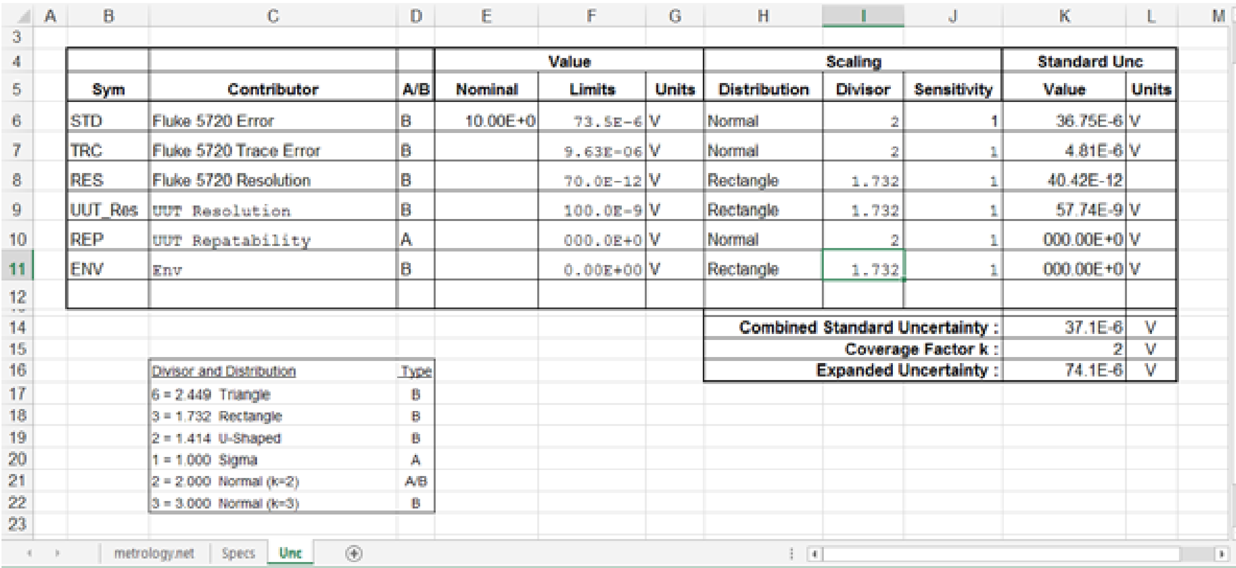
So what does all this mean to a metrologist, in layman's terms? Most people view the internet through a web browser and think of all the content on the worldwide web as documents and web pages. But to a computer all of that data is just 1 and 0s. With Web services and RESTful services, we can greatly increase precision and accuracy of things like uncertainty calculations, while at the same time decrease the manpower required. By adding just one simple RESTful service call for calculation uncertainties, we can centralize all of our uncertainty calculations in one single place. Then all of the lab's metrology software can call the same uncertainty calculator. This centralized REST based approach makes it extremely simple to verify all reported uncertainties comply with the lab's Scope of Accreditation.

This brings us to the core system-of-systems design of Metrology.NET and how it embraces a distributed computing model of shareable resources. By sharing a resource, other systems and other software packages are able to consume the shared resource. This allows an organization to consolidate all of their uncertainty calculations in a single location, no matter the programming language.

Creating a Standard

The most important part of a system-of-systems design is its modularity and ability to keep up with changing technologies! The architecture has been prebuilt, allowing labs to replace our uncertainty calculator with any future uncertainty tool that complies with the REST based communication standard. Think about that for a moment: Who designs a system that from day one the team is thinking about how to replace it with something better, something that hasn't even been invented; that is a true system-of-systems design.

The creation of a metrology based communications standard has been the goal of the key members of the National Conference of Standards Laboratories International (NCSLI) Measurement Information Infrastructure (MII) group for a number of years. We are the first company to define a Metrology.NET communication standard that



			Value			Scaling			Standard Unc	
Sym	Contributor	A/B	Nominal	Limits	Units	Distribution	Divisor	Sensitivity	Value	Units
STD	Fluke 5720 Error	B	10.00E+0	73.5E-6	V	Normal	2	1	36.75E-6	V
TRC	Fluke 5720 Trace Error	B		9.63E-06	V	Normal	2	1	4.81E-6	V
RES	Fluke 5720 Resolution	B		70.0E-12	V	Rectangle	1.732	1	40.42E-12	
UUT_Res	UUT Resolution	B		100.0E-9	V	Rectangle	1.732	1	57.74E-9	V
REP	UUT Repatability	A		000.0E+0	V	Normal	2	1	000.00E+0	V
ENV	Env	B		0.00E+00	V	Rectangle	1.732	1	000.00E+0	V

Combined Standard Uncertainty :	37.1E-6	V
Coverage Factor k :	2	V
Expanded Uncertainty :	74.1E-6	V

Divisor and Distribution	Type
6 = 2.449 Triangle	B
3 = 1.732 Rectangle	B
2 = 1.414 U-Shaped	B
1 = 1.000 Sigma	A
2 = 2.000 Normal (k=2)	A/B
3 = 3.000 Normal (k=3)	B

Figure 1.

performs RESTful service calls to an uncertainty server. When we started this project, we wanted something very simple and easy to implement for any software platform. We wanted to simply tell the server the calculator to use and pass it a set of name value pairs. If the server is able to successfully calculate the uncertainties, it will return the uncertainty and the revision number of the calculator that it uses.

The first objection I always get is "Each uncertainty calculator is different! You can't standardize it, because it is different!" Correct, each uncertainty calculation is different and will require a different set of name value pair inputs, but that doesn't mean we can't standardize the interface! The key to this design is the simple name, value pairing to the interface for all uncertainty calculations. This interface is simple and easy, as well as infinitely expandable for all measurement disciplines. The consumer of the REST service can pass as few or as many name value pairs as they want. The server will either complete the calculation or fail by returning "39e39" as the result. SIMPLE!

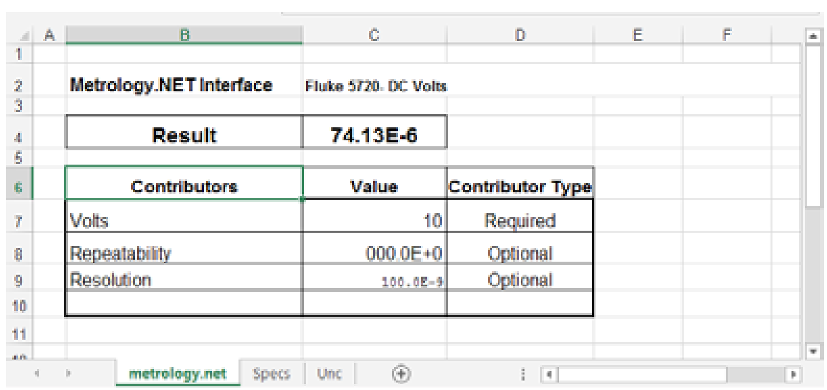
Handling Uncertainty Calculations

One of the goals we had, when were designing the system, was to address the disconnect between a lab's scope of accreditation uncertainties and the uncertainties calculated by the automation software. Many labs have learned the hard way when an auditor writes them up because their automated calibration software produces uncertainties less than their accredited values. Having all your uncertainties calculations in one system or systems could alleviate this problem!

In this example, I want to keep things pretty simple. I know there are several uncertainty gurus out there who know uncertainties forward and backwards. But, the goal of this paper is to provide an example of how to call external uncertainty calculations from a MET/CAL procedure. It is important to note, this example will work with any version of MET/CAL all the way back to version 6.0 and above. And, it does not require a copy of Microsoft Office or Excel to be installed on the local workstation.

First, we have to create our uncertainty calculation (Figure 1). We will use a very basic one we created around a Fluke 5720A DC Voltage Accuracy.

Once we have a spreadsheet with all the lab's numbers, we have to add the Metrology.NET. To do this, we need to add a Metrology.NET interface tab to the spreadsheet.



Metrology.NET Interface	Fluke 5720. DC Volts
Result	74.13E-6

Contributors	Value	Contributor Type
Volts	10	Required
Repeatability	000.0E+0	Optional
Resolution	100.0E-9	Optional

Figure 2.

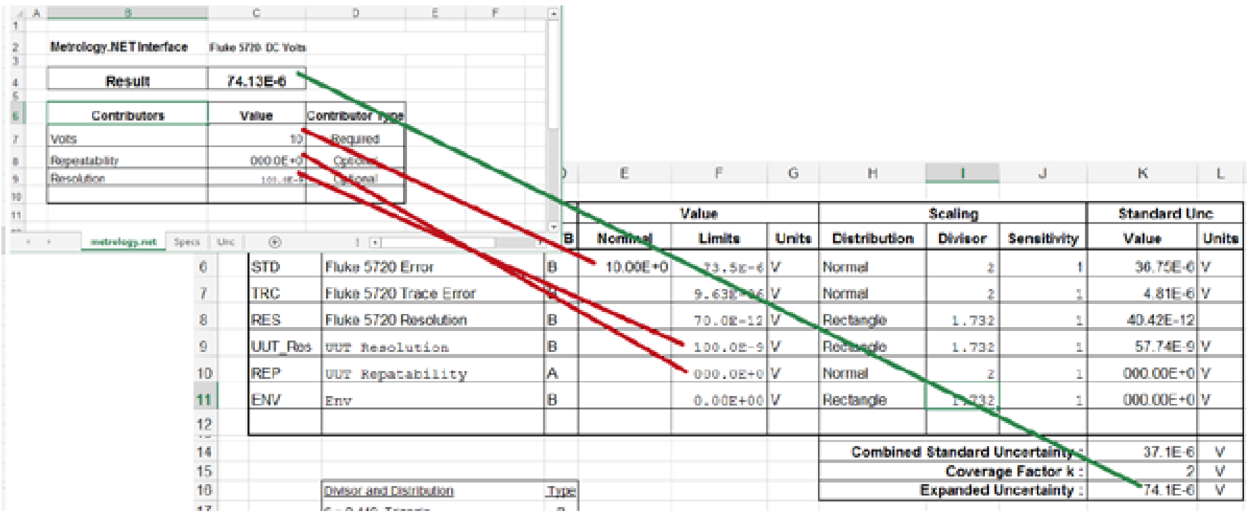


Figure 3.

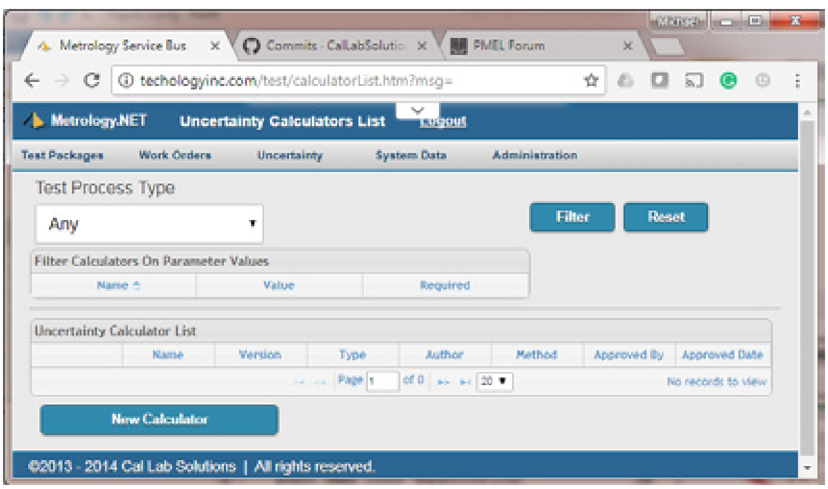


Figure 4.

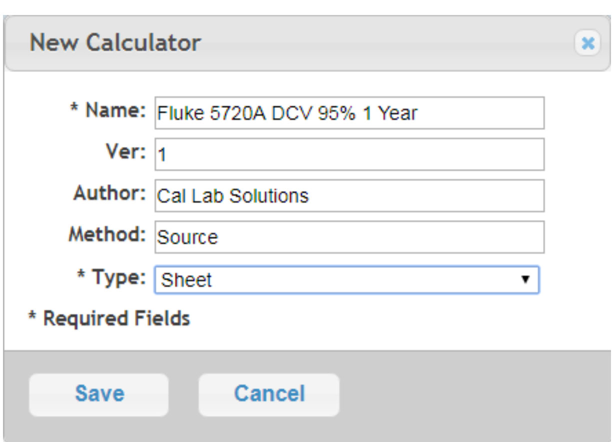


Figure 5.

When the spreadsheet is uploaded to the server, it will use this tab as the calculator's inputs, run the calculation, and return the results.

The inputs in the Metrology.NET tab (see Figure 2) are specific to the measurement process. They can be required or optional. Values can be text or numeric. If an input is required, then the consuming software must provide the value in the name value pairs passed to the calculator. If a required parameter is not provided, the server will return "39e39." If an input is listed as optional, a default value in the spreadsheet will be used. In this example, we are listing optional repeatability and resolution.

Next, we must wire the inputs in the Metrology.NET tab to the other cells in the spreadsheet. The server will enter the values in the input cells, and the values will propagate throughout the spreadsheet, until it eventually updates the calculation results field.

In the Fluke 5720A Example Spreadsheet (Figure 3), you can see the Volts Value in call "Metrology.NET:C7" is linked to the "Unc:E6" cell. By changing the Volts Value, it updates and changes the E6 and F6 cells and recalculates the total uncertanties. The same thing is true for the Repeatability C8 and Resolution C9 cells. When the values in cells C7-C9 are updated, the calculations are propagated through the spreadsheet and the Expanded Uncertainty is updated in cell "Unc:K16," then copied to the resulting value to the linked cell "Metrology.NET:C4."

The Metrology.NET tab's purpose is to define a standard way of interfacing with any spreadsheet-based uncertainty calculator. There is a little more work involved in this methodology, but the advantage is the system can now use any spreadsheet with any number of Input Contributor Values, all standardized.

Creating a Calculator

Next, we need to upload the spreadsheet to the server so we can use it in multiple applications. To do this, we need to navigate to the Uncertainty Calculators List Page (Figure 4) then press the "New Calculator" button. Fill in the information for the New Calculator, being sure to select Sheet as the type (Figure 5).

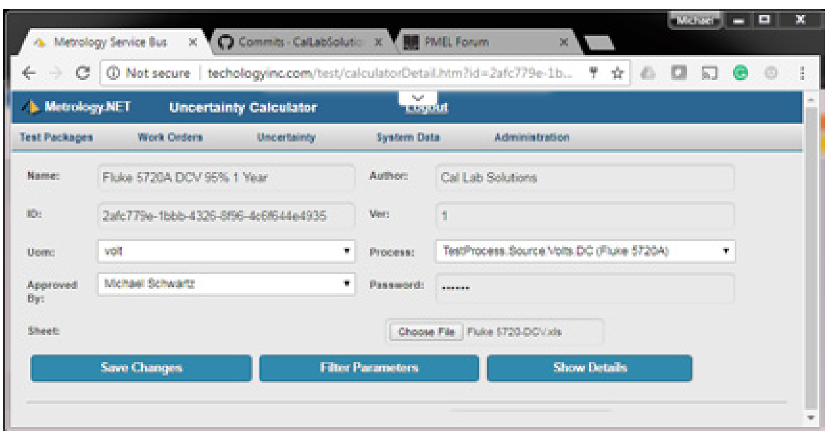


Figure 6.

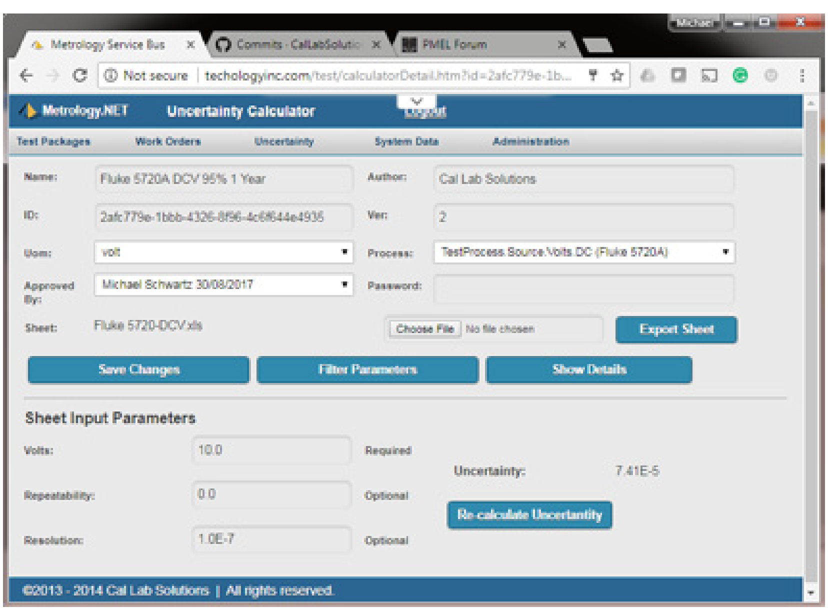


Figure 7.

Information about the spreadsheet will need to be uploaded to the server (Figure 6). The server needs to know the Units of Measure (UOM) for the spreadsheet and if it is attached to a specific metrology process—in this case "TestProcess.Source.Volts.DC (Fluke 5720A). Once you "Choose File" and select the spreadsheet to be uploaded, you can press "Save Changes."

The online uncertainty calculator is now ready for use. Notice the "Sheet Input Parameters" have been read from the spreadsheet (Figure 7). By changing the inputs and pressing "Re-Calculate Uncertainty," the server is able to use the spreadsheet to calculate any measurement uncertainty needed for the Fluke 5720A DC Voltage.

Now to save the Metrology.NET Calculator, we must make note of the calculator's ID. In this case the ID is "2afc779e-1bbb-4326-8f96-4c6f644e4935." We will need this ID later in our MET/CAL procedure. Note: These IDs are randomly created; they are a little ugly, but will guarantee you will always get the exact calculator when called. Also, make a mental note of the revision number of the calculator. All the changes made to this calculator are not under revision control. This is handy if you want to compare the results of two different versions of a calculator.

Performing Calculations

This example requires the McNetComm.exe and DosDoseDat.dll to communicate between MET/CAL and the Metrology.NET server. McNetComm.exe is a free software tool from Cal Lab Solutions, you can download it and many other MET/CAL tools from FTP://ftp.CalLabSolutions.com/FTP. These files must be placed in the work station's User Programs Directory.

The first thing we need to do is setup a login and password for the MET/CAL station. This will allow the workstation to securely communicate with the server. In this example, an account is set up for the MET/CAL Station, using:

Login: MC_Station1
Password: METCAL

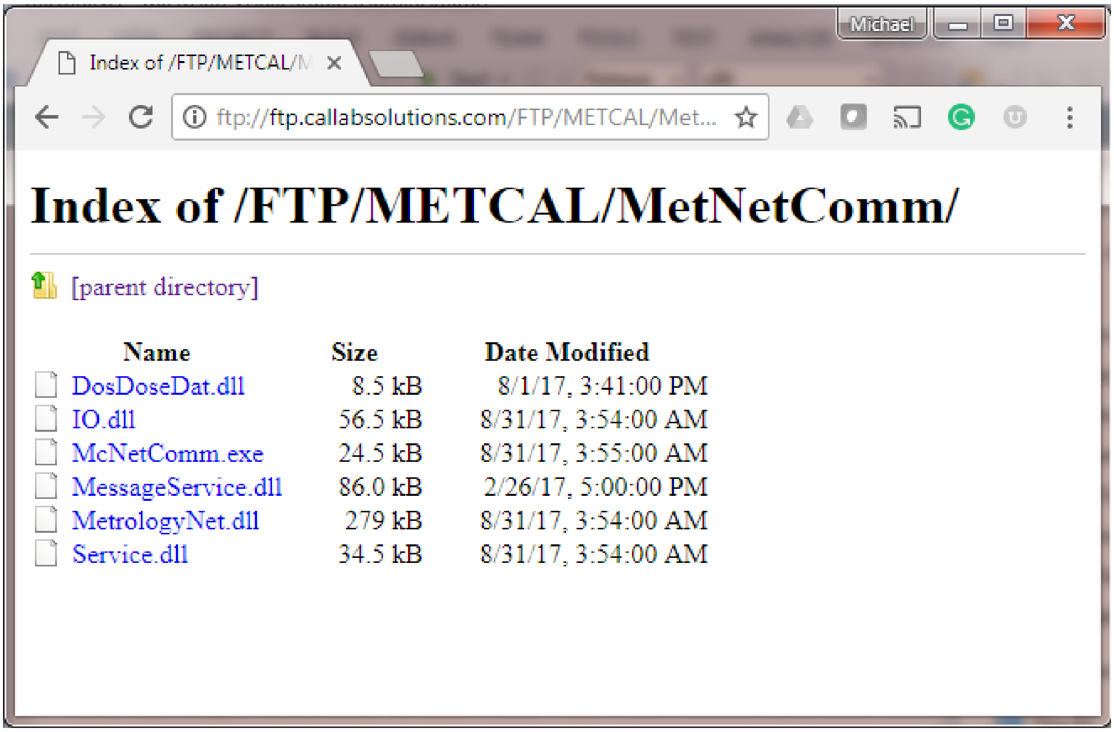


Figure 8.

The following lines of code will allow the MET/CAL workstation to log-in:

```
#================================================
#      Login in to the Metrology.NET Server
#================================================
 1.001  MATH        MEM2=     "URI='http://xxx.Metrology.NET/Server/'"
 1.002  MATH        MEM2=MEM2&", Login=' MC_Station1'"
 1.003  MATH        MEM2=MEM2&", Password='METCAL"
 1.004  DOS         McNetComm.exe Login

 1.005  IF          Find(MEM2,"Error",1)
 1.006  DISP          Error! Could not Connect the the Server
 1.007  END
 1.008  ENDIF
```

If the connection to the server is successful, MEM2 will contain the word "Connected" and the station can make any uncertainty calculations.

Now, all we have to do is load MEM2 with the Name Value pairs required by the uncertainty calculator. Simply separate Name Value pairs with commas: "Volts= 10, Resolution= 1e-5," etc. Note: You can pass more Name Value pairs than is required by the uncertainty calculator.

We also need to know the calculator's ID so we can select a specific calculator. In this example, we store that value in @UncCalcID. If we wanted a specific version of the calculator, we would add it to the end with a space like this @UncCalcID ="2afc779e-1bbb-4326-8f96-4c6f644e4935 2" We recommend leaving the specific version number off because it allows you to update uncertainty calculations without having to modify your code.

To call the calculator, we need the following lines of code:

```
#================================================
#      Calculate the Uncertainties for 10 V
#================================================
 1.009  MATH        @UncCalcID ="2afc779e-1bbb-4326-8f96-4c6f644e4935"
 1.010  MATH        MEM2="Volts= 10"
 1.011  MATH        MEM2=MEM2&", Resolution= 1e-5"
 1.012  MATH        MEM2=MEM2&", Repeatability= 2.4e-4"
 1.013  DOS         McNetComm.exe CalcUnc [V @UncCalcID]
 1.014  MATH        MEM = MEM2
 1.015  TSET        EXP_UNC = [MEM]
```

The resulting call to Metrology.NET will return the following string "0.0002515." We need to use that value in our MET/CAL code. I find the easiest way is with the TSET or TOL FSC. I prefer the TSET EXP_UNC, because it will override any and all MET/CAL uncertainty contributors, as well as allow you to use the TOL for UUT test limits.

Next, we can mix it with a Fluke 5720 call using the IEEE FSC. This example brings in all together:

```
#=================================================
#      Setup the Fluke 5720 & Calculate Uncertainties
#=================================================

 1.016  MATH        @Volts = 10

 1.017  IEEE       [@5720]OUT [V @Volts]V, 0Hz
 1.018  IEEE       [@5720]OPER
 1.019  IF        L[1]>23
 1.020  IEEE       [@5720]*CLS
 1.021  IEEE       [@5720]OPER
 1.022  ENDIF
 1.023  IEEE       [@5720]*OPC?[i!]

 1.024  MATH        @UncCalcID ="2afc779e-1bbb-4326-8f96-
4c6f644e4935"
 1.025  MATH        MEM2="Volts= " & @Volts
 1.026  MATH        MEM2=MEM2&", Resolution= 1e-5"
 1.027  MATH        MEM2=MEM2&", Repeatability= 2.4e-4"
 1.028  DOS        McNetComm.exe CalcUnc [V @UncCalcID]
 1.029  MATH        MEM = MEM2
 1.030  TSET       EXP_UNC = [MEM]
```

I know many MET/CAL programmers out there like to use the 5720 & M5720 FSC, but we like to use IEEE FSCs. Mostly because it allows us to use any DC Voltage calibrator without having to modify the UUT Code. If you like using the Fluke 5720 FSC, you can use it in place of the IEEE calls—it will still all work.

Conclusion

Yes, I know MET/CAL is fully capable of calculating expanded uncertainties. And, yes, I know the LIB FSC can interface with Microsoft Excel. So why go through the trouble of setting up a Metrology.NET server? The bigger issue is how to keep your entire lab's uncertainty calculations up-to-date and in sync with the lab's Scope of Accreditation. The process we've explained in this article allows you to use the same spreadsheet you are showing your accreditation body. Plus, if you are using more than just MET/CAL, you can call the same uncertainty calculator from other applications. The below example is a VB.NET application making the same call.

```
If Agent.LogIn("MC_Station1", "METCAL") = True Then

    'Create Parameters List
    Dim Params As New List(Of Parameter)
    Params.Add(Parameter.NewParameter("Volts", "10"))
    Params.Add(Parameter.NewParameter("Resolution", "1e-5"))
   Params.Add(Parameter.NewParameter("Repeatability", "2.4e-
4"))

    ' Create Link to Specific Calculator
    Dim UncCal As New Uncertainty("2afc779e-1bbb-4326-8f96-
4c6f644e4935", "", Params)
    UncCal.Calculate()

    ' See the Unc Calculation
    MsgBox("    Unc= " & UncCal.Uncertainty & vbCrLf & _
           "   Using= " & UncCal.UncertaintyID & vbCrLf & _
           "Version= " & UncCal.Version, vbOK)
Else
      Throw New Exception("Error Logging on to the Server!" &
vbCrLf & _
                     "Unknown User Name and/or Password!")
         End If
```

The even bigger picture of Metrology.NET is the creation of a system-of-systems solution for metrology. This example was system-of-systems approach to calculating uncertainties, using Fluke MET/CAL and Excel, which can be expanded to use VB.NET, C#, LabView, etc. So, long after Windows and long after Excel or MET/CAL are viable products, we will be performing REST based uncertainty calculations.

References

[1] Wikipedia, "Representational state transfer," https://en.wikipedia.org/wiki/Representational_state_transfer (accessed 08/31/2017).

Michael L. Schwartz (mschwartz@callabsolutions.com), CEO, Cal Lab Solutions, Inc., Aurora, Colorado, USA.

The New ISO/IEC 17025:2017

Dr. George Anastasopoulos
International Accreditation Service (IAS)

Photo of ISO/CASCO/WG44 at one of the meetings at Geneva ISO offices in Switzerland, September 19-23, 2016.

Introduction - Background information

This article has been written during the final draft (FDIS) stage of ISO/IEC 17025. As usual, only editorial changes are expected between FDIS and the final version of the standard. 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.

The 6th ISO/CASCO WG 44 meeting was held on July 10-12, 2017 in ISO Central Secretariat, Geneva. The deliverable of this meeting was the FDIS version of the new ISO/IEC 17025 version. The document is expected to proceed to publication, planned for end November/December 2017.

Please note that throughout this article the term "the standard" refers to the new ISO/IEC 17025:2017.

About the New Standard

The format of the new standard has been 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.

The new standard 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

General Information

According to International Accreditation Forum (IAF) and the International Laboratory Accreditation Cooperation (ILAC), accreditation is defined as "the independent evaluation of conformity assessment bodies against recognized standards to ensure their impartiality and competence."

This standard was developed with the objective of promoting confidence in the operation of laboratories and contains requirements for laboratories to enable them to demonstrate that they operate in a competent and impartial way and that they are able to provide valid results.

During its development phase, it has been tried to align the standard with the principles of ISO 9001, although this was not always practically possible. Still, it is a fair statement to make that the laboratories complying with the standard will also, in general, comply with the principles of ISO 9001.

The standard can be used for accreditation purposes, for self-assessment of the laboratories and for second party assessments by laboratory customers, regulatory authorities, organizations and schemes using peer-assessment.

Its requirements are applicable to any organization that performs the activities of testing and/or calibration and/or sampling associated with subsequent testing or calibration. Therefore, accreditation to the new standard can be also achieved by organizations offering sampling associated with subsequent testing or calibration. When the standard uses the term "laboratory," it is referring to any of the 3 options mentioned above (testing, calibration, and sampling).

The potential of performing only sampling activities is a new element in the standard. If, for example, a laboratory is performing tests and takes samples by its own capacity, it should meet all requirements related to both: sampling and testing. On the other hand, if any organization performs only sampling and then the samples are forwarded to a laboratory for testing, then this organization should comply with new standard requirements regarding sampling and its management system should ensure that the sampling activity doesn't affect negatively on test results. Requirements for sampling organizations are similar to testing and calibration laboratories: personnel shall be competent, equipment has to be maintained and calibrated, sampling procedure has to be validated, quality of sampling has to be assured, etc. Confirmation of competence of organization to provide sampling can be provided through accreditation against the new ISO/IEC 17025.

Guide 99 ISO/IEC, International vocabulary of metrology — basic and general concepts and associated terms (VIM), is referenced in the standard as a normative reference. The definitions also given in ISO/IEC 17000 are applicable. In addition, the standard provides the detailed definitions of the terms: impartiality, complaint, interlaboratory comparison, intralaboratory comparison, proficiency testing, laboratory, and decision rule.

Main Requirements

The Standard introduces its main requirements throughout the clauses 4 to 8.

Clause 4 - General Requirements

Impartiality and Confidentiality requirements are discussed in Clause 4. The risk-based thinking is evident throughout the standard. It should be noted that the new standard expects from the laboratory to plan and implement actions to address risks and opportunities. Although addressing risks and opportunities is the laboratory's responsibility, the standard sets specific requirements. The first requirement of such risks and opportunities that is needed to be addressed is mentioned in Clause 4, where the laboratory is required to identify and eliminate or minimize risks related to impartiality on an on-going basis.

The confidentiality requirements include, among others, the responsibility of the laboratory to inform its customer, in advance, of the information it intends to place in the public domain. It also discusses how to handle the release of confidential information required by law or authorized by contractual arrangements. The confidentially requirement is also extended to laboratory personnel, including any committee members, contractors, personnel of external bodies, or individuals acting on the laboratory's behalf, even in the case that information is obtained from sources other than the customer (e.g. complainant, regulators).

Clause 5 - Structural Requirements

In Clause 5, main requirements are defined, including: Legal status of the laboratory, organization and management structure, identification of management, range of laboratory activities, documenting its procedures, and availability of personnel responsible for the implementation and maintaining the integrity of the management system.

It should be noted that the new standard clearly requires (see clause 5.3) that the laboratory shall only claim conformity with this document for this range of laboratory activities, which excludes externally provided laboratory activities on an ongoing basis. This means that the laboratory is expected to be accredited, and include in the scope of accreditation only testing/calibration/sampling activities that is providing by utilizing its own resources.

In its 2005 version, the standard allowed to subcontract tests and calibrations in the case that the laboratory was not in a position to perform them. According to the new standard, the laboratory can be accredited only for those laboratory activities for which it is competent. Subcontracting is allowed only for outstanding situations, like overload of work, sickness of personnel, maintenance of equipment or other similar cases.

Clause 6 - Resource Requirements

Resource requirements are considered to include personnel, facilities, equipment, systems and support services necessary to manage and perform the laboratory activities. It is expected that all internal or external personnel of the laboratory shall be competent and act impartially. The standard doesn't refer to this clause for ALL personnel, only to personnel who could influence the results of laboratory activities. This is not only personnel directly involved in testing/calibration/sampling activities, but also personnel indirectly involved, like technical personnel; for example, personnel that perform maintenance of the equipment, or management system personnel, who evaluate suppliers and/or maintain the management system including internal auditing activities.

The competence requirements, which are expected to be documented, include education, qualification, training, technical knowledge, skills (like capacity to evaluate the significance of laboratory activities deviations), and experience. In addition, procedure and records are expected for selection, training, supervision, authorization, and monitoring of competence of personnel. The standard also defines the cases where it is expected for the laboratory to authorize personnel to perform specific laboratory activities.

The requirements for facilities and environmental conditions suitable for the laboratory activities are expected to be documented, including the conditions related to monitoring, controlling, and recording of environmental conditions. The standard sets requirements for those environmental conditions which can affect the results of laboratory activities. Depending on the nature of laboratory activities, the same parameter may or may not be important for the testing results. For example, the value of the relative humidity that can be critical and shall be controlled during some textile testing, is usually not critical during routine mechanical tests of plastics. Measures to control facilities may include access and use of areas affecting laboratory activities, prevention of contamination, and effective area separation, including sites or facilities outside of laboratory's permanent control.

A procedure for handling, transport, storage, use, and planned maintenance of equipment is required. Equipment requirements are applicable to hardware, software, measurement standards, reference materials, reference data, reagents, consumables, or auxiliary apparatus – whatever is required for achieving correct results during laboratory activities. It is also expected that the equipment used for measurement should achieve the required measurement accuracy or measurement uncertainty. The calibration requirements are described in details in clauses 6.4.6-6.4.13 including the requirements for relevant records.

The standard is giving great attention to metrological traceability issues. In addition to the main requirements which are described in details in Clause 6.5, an informative annex (Annex A) is available providing additional information, including guidance on how to establish and demonstrate metrological traceability.

Requirements related to the control of and communication with, external organizations providing products and services affecting laboratory activities are described in clause 6.6. Procedure and records are required to define, review and approve the laboratory's requirements for externally provided products and services (purchasing requirements), setting the criteria for evaluation, selection, monitoring of performance and re-evaluation of the external providers, ensuring that they conform to requirements and taking appropriate actions in the case that they don't.

Clause 7 - Process Requirements

An example of a possible schematic representation of the operational processes of a laboratory as described in the Clause 7 is presented in informative Annex B (Figure 1).

Process requirements are deployed as follows:

7.1 Review of requests, tenders and contracts

A procedure is required to address issues such as the level of understanding of requirements; laboratory's capability and resources to meet the requirements; implementation of appropriate control over external providers used (if any); and selection of appropriate methods to meet the customers' requirements. It is expected that the laboratory shall inform the customer when the required testing/calibration/sampling method is considered to be inappropriate or out of date. When a statement of conformity to a specification or standard is required, the decision rule (which specifies pass/fail criteria) selected shall be communicated to, and agreed with, the customer.

Contract review procedure shall be applied also for any changes in the contract/tender/request. Relative review records are required.

7.2 Selection, verification and validation of methods

The term "method" in the standard is used to identify calibration method, testing/measurement procedure, or sampling procedure. The laboratory is expected to ensure that it uses the latest valid version of a method, unless it is not appropriate or possible to do so. Methods used can include methods published in international, regional, or national standards; by reputable technical organizations; in relevant scientific texts or journals; as specified by the manufacturer of the equipment; or laboratory-developed/laboratory-modified methods. The laboratory shall verify that it can properly perform selected methods. Deviations from methods shall occur only if the deviation has been documented, technically justified, authorized, and accepted by the customer. Non-standard methods, laboratory-developed methods, and modified standard methods are expected to be validated, and relevant records are expected to be kept.

7.3 Sampling

The requirements of this clause are applicable to the laboratories which perform just sampling activities, as well as for testing and calibration laboratories which are responsible also for sampling. A sampling plan and a sampling method are expected to be available and implemented when the laboratory carries out sampling of substances, materials or products for subsequent testing or calibration. Records of sampling data should be retained per standard requirements.

7.4 Handling of test or calibration items

A procedure for the transportation, receipt, handling, protection, storage, retention, and disposal or return of test or calibration items should be drafted, including a system for the identification of test or calibration items. Deviations from specified conditions are expected to be recorded and the customer to be consulted for next steps. In the case that some items have to be stored or conditioned under specified environmental conditions, these conditions shall be maintained, monitored, and recorded.

7.5 Technical records

Requirements to retain technical records are in place to ensure the traceability of laboratory activities and to provide information for potential decision making. The technical records are expected to contain sufficient information in order to identify factors affecting the

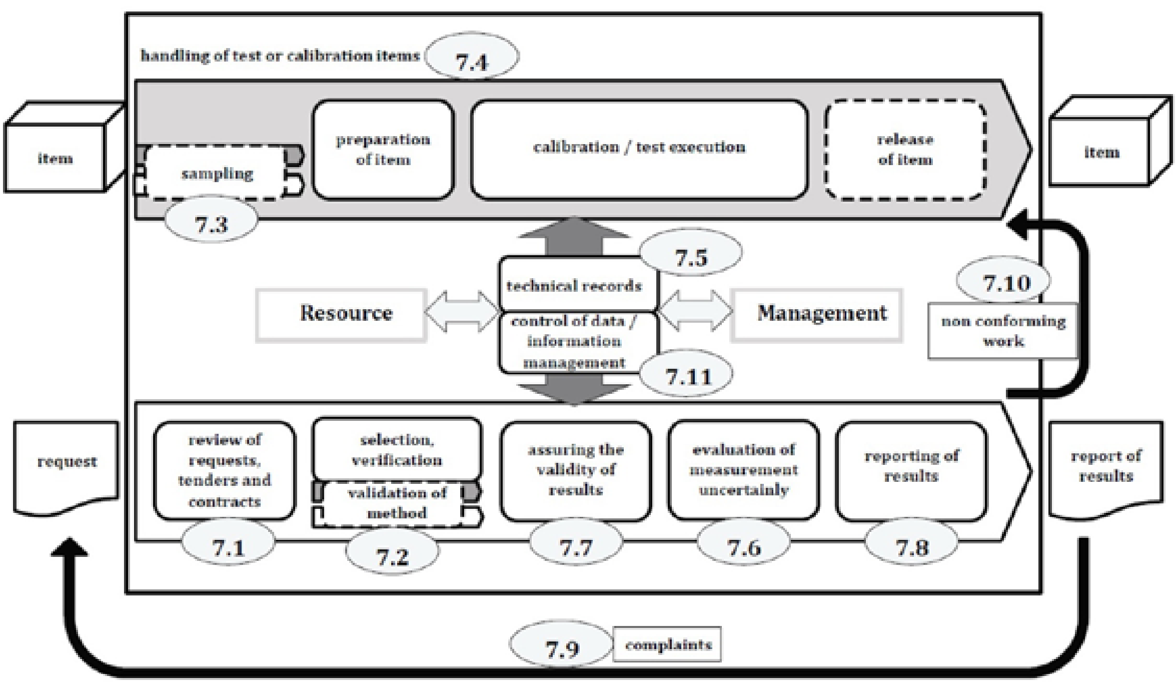


Figure 1. A Possible schematic representation of the operational processes of a laboratory.

measurement result and its associated measurement uncertainty and enable the repetition of the laboratory activity if required, providing traceability to previous versions or to original observations if amended.

7.6 Evaluation of measurement uncertainty

Testing laboratories are expected to evaluate measurement uncertainty considering all contributions which are of significance, including those arising from sampling. It is noted in the standard that for a particular method, where the measurement uncertainty of the results has been established and verified, there is no need to evaluate measurement uncertainty for each result, if the laboratory can demonstrate that the identified critical influencing factors are under control.

Calibration laboratories are expected to evaluate the measurement uncertainty for all calibrations considering all contributions which are of significance, including those arising from sampling.

7.7 Assuring the validity of results

A procedure of record keeping is required for monitoring the validity of results, which can include, among others, use of reference materials or QC materials, use of alternative traceable instrumentation, functional checks, use of standards with control charts, intermediate checks, replicate tests or calibrations, retesting or recalibration, correlation of results, review of reported results, intra-laboratory comparisons, and testing of blind samples. Participating in PT's (Proficiency Tests) and/or ILC's (interlaboratory comparisons) is expected where available and appropriate. Such activities, according to the standard, must be planned and reviewed.

7.8 Reporting of results

Laboratory activity results shall be reported. The standard sets requirements for results review and authorization as retained in the relative technical records. The common information required to be included in the test, calibration, or sampling reports is presented in details in clause 7.8.2. In addition, the specific information for test reports is presented in clause 7.8.3, for calibration certificates in clause 7.8.4, for reporting sampling in clause 7.8.5, for reporting statements of conformity in clause 7.8.6, for reporting opinions and interpretations in clause 7.8.7, and for amendments to reports in clause 7.8.8.

7.9. Complaints

A documented process is required for receiving, evaluating, and making decisions on complaints. This process is expected to be available to any interested party upon request. The outcomes to be communicated to the complainant shall be made by, or reviewed and approved by, individual(s) not involved in the original laboratory activities in question.

7.10 Nonconforming work

A Nonconforming work procedure is expected to be in place ensuring that the responsibilities and authorities for the management of nonconforming work are defined, subsequent actions are taken considering the risk levels; an evaluation is made of the significance of the nonconforming work; a decision is taken on the acceptability of the nonconforming work; the customer is notified, if possible; work is recalled, if needed; and the responsibility for authorizing the resumption of work is defined. Halting or repeating of work and withholding of reports, as necessary, can be considered among the required actions. Records of nonconforming work and relative actions are expected to be retained.

7.11 Control of data – Information management

This clause sets requirements for the laboratory information management system(s) used for the collection, processing, recording, reporting, storage, or retrieval of data.

Clause 8 – Management System Requirements

The laboratory can choose between implementing a management system in accordance with option A or option B. Option A lists the minimum requirements for implementation of a management system in a laboratory. Care has been taken to incorporate all those requirements of ISO 9001 that are relevant to the scope of laboratory activities that are covered by the management system. Option B allows laboratories to establish and maintain a management system in accordance with the requirements of ISO 9001. Laboratories that implement option B will therefore also operate in accordance with ISO 9001. Conformity of a laboratory to the requirements of ISO 9001 does NOT, by itself, demonstrate the competence of the laboratory to produce technically valid data and results. This is accomplished only through compliance to ISO/IEC 17025.

The requirements for documentation have been significantly reduced in Clause 8. The documentation requirements related to the operation of the management system per Clause 8 are:

- Management System policies and objectives (8.2.1)
- Analysis of Customer feedback (8.6.2)
- Corrective actions, non-conformities related records (8.7.3)
- Internal audit and results records (8.8.2)
- Management review input and output record (8.9.2)

It should be noted that there are no longer any requirements for documented procedures related to management system activities referred in Clause 8. There is also no requirement for Quality Manual.

By introducing the risk-based thinking in the standard, some reduction in prescriptive requirements and their replacement by performance-based requirements was possible. Clause 8.5 actions to address risks and opportunities are a new element added in the recent revision of the standard. This clause requires from the laboratory to consider the risks and opportunities associated with the laboratory activities. These activities are described throughout the standard and include risks related to impartiality (4.1.4), statements of conformity (7.8.6), nonconforming work (7.10.1), and corrective actions (8.7.1). It should be noted that the standard doesn't require a formal/specific method for risk management or a documented risk management process. Useful information can be found in ISO 31000, Risk management - Principles and guidelines, which is included as a reference in the bibliography.

Conclusion - Transition

Once the new standard's final version is published, expected by end of 2017, there will be a three year transition period. Accreditation bodies will need to have all laboratories assessed to the new standard by the end of 2020. Of course this doesn't mean that laboratories should wait for action until the end of the three years period. It is suggested to plan and initiate the transition process much earlier. The main transition steps to follow are:

- Decide on the overall timeline.
- Train the lab personnel who will be responsible for transition and implementation.
- Learn how to read, interpret and implement the new standard requirements.
- Conduct a gap analysis between the existing quality system and the requirements in the revised standard.
- Update management system's documentation. This includes updates to existing policies and procedures as required, plus the removal/modification/addition of policies and procedures. Hint: Grab the opportunity that the new standard is providing to reduce management system documentation.
- Create a training plan and a communication plan for the laboratory personnel.
- Implement the new and revised management system.

By careful preparation and timely action, all accredited laboratories can ensure a successful transition to the new ISO/IEC 17025:2017.

About the Author

Dr. George Anastasopoulos (ganas@iasonline.org) is the Director of Conformity Assessment Accreditation Services, of the International Accreditation Service (IAS). He has also served to the Bonn-Germany based, Accreditation Panel of the United Nations Kyoto Protocol system UNFCCC/CDM and the Hellenic Accreditation System (ESYD).

He is a Mechanical Engineer with an 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.

Dr. George Anastasopoulos is awarded with the EOQ Presidential Georges Borel Award for international achievements being at the edge of the development, use and diffusion of quality at international level through his professional activities and behaviors, personally contributing to the development of the European Quality movement through his accomplishments with a global impact in the field of quality.

Dr. Anastasopoulos presented many papers in technical and financial conferences, magazines and newspapers and is the author of many articles and books. He also presented many lectures as keynote speaker in topics such as Management Systems, Business Process Reengineering, Telecoms-FTTH-IT, Quality Assurance and Process Auditing. He participated in numerous consulting and research projects sponsored by government and industry in USA, European Union and many other countries worldwide.

Metrology - Why We Do What We Do

Paul Hanssen
Workplace Training, Inc.

It's a familiar story. We've all been there. Your kids, wife, friends (and maybe even your dog) ask:

"What is it you do again?"

"Metrology," you say.

"Oh right, *meteorology*. Is it going to rain tomorrow?"

"Actually, it's *metrology*. Metrology is not about weather. It's about measuring and calibrating things," you explain. Eyes begin to glaze as you continue.

"Metrology is the science of measurement!" you proclaim. Despite your enthusiasm, yawns break out, attention strays.

Of course YOU know that what you do is extremely important!

Metrology is Critical to Almost Everything

- Aviation - Airplanes would literally not fly without metrology. Metrology is critical to the operation of virtually all aircraft flight instruments that provide basic aerodynamic data such as airspeed, altitude, fuel, navigation and vertical speed, not only to the pilots but also to the aircraft's computers. Further, hundreds of sensors provide thousands of electrical, temperature, pressure, torque, mass and humidity measurements on every flight.
- Healthcare - 10,000 lives are lost each year due to improperly calibrated drug delivery instruments. Measurements (temperature, pressure, mass and volume) are critical for disease diagnosis, drug prescription and administration; therefore, metrology is a core part of primary health care.
- Technology - None of the everyday technology we take for granted like cell phones, the internet or credit card processing would work without metrology. High-speed electronics, wireless systems, antennas, network design and optimization, spectrum sharing, and public safety communications all require metrology in order to receive and remit within their intended range.
- Defense - The capability of DoD mechanical systems, radios and communication devices, radar systems, targeting devices and fire control systems, missiles, and aviation, satellite and space platforms to operate accurately and effectively depend on metrology.

- Energy - No matter if it is wind, solar, nuclear, fossil or hydro, the generation, transmission and distribution of electricity is measured each step of the way. So you pay for every amp and volt that reaches your house, and no more.

Things to Remember

Metrology Protects People

Dosing of drugs or measurement of radiation in radiotherapy, food safety and many others require measuring operations that are vitally important activities for public health. The reliability of measurement instruments in operating rooms or intensive care units is critical.

For years, ships, airlines and even amateur hikers have used emergency locator beacons originally developed by NASA in the 1970s. Now known as Search and Rescue Satellite Aided Tracking (SARSAT), this system has saved more than 40,000 lives over the years [1]. Search-and-rescue satellite systems are complex, comprising beacons, spacecraft and ground systems, all carefully calibrated to work together efficiently.

The application of labor law involves a system to monitor the hours worked, the noise and lighting levels in professional premises, measurements of ambient atmospheres (mercury vapors, fibers, decibels and particles), etc.

Road safety implies restrictions on speed, alcohol and vehicle braking efficiency as well as measurements to ensure that they are respected.

Protection of the environment implies statutory requirements on nuisances and the quality of air and water; this involves processes for making measurements, such as studies conducted by the National Center for Atmospheric Research.

Metrology Saves Money

All transactions made by individuals and companies involve measurements: nutrition labels on food, metering subscriber gas consumption, gasoline at the pump or on the pipeline, retail or bulk weighing, etc.

Measurement is an essential factor in the relations between businesses and customers. In the absence of reliable measurements, it is impossible to guarantee that the goods and services will match the customer's requirements.

Metrology is the Enabling Technology for Design, Manufacture and Quality

Competitiveness involves quality, which is the ability of a product to meet consumer and user requirements; and which involves all types of measurement in order to satisfy customer expectations of performance measurements for industrial products. Quality can be demonstrated to customers through certification, itself based on measurements.

Competitiveness assumes that industry measures and precisely controls the production volumes and the performance of the production tool, and that it minimizes the costs of rejects and rework operations.

"So, What Do You Do Again?"

In explaining *specifically* what you do, start with the industry you work in, the discipline, and finally, your specific role. Maybe this could be the Aviation Industry in the maintenance shop testing that the power supplies on the airplane instrument panels are working properly. Perhaps you work in the Biomedical Industry in a calibration lab, making sure the dose monitoring systems of a hospital/research facility/manufacturer are measuring within a specified range.

Some of you work cross-disciplines within metrology, such as writing automation software for electrical test and measurement equipment. Maybe you're the teacher, training the next generation of calibration technicians. Or maybe you've gone further into research, designing new and efficient methods of measuring temperature, microwave, mass, voltage, etc.

In Conclusion

I hope this article has been helpful in explaining what it is we all do and why you can feel very good about it! So, next time someone asks "What is it you do again?" you're ready to answer.

If you have an example of why metrology is important please send it to us. We will it add to our library.

References

[1] Hume, Ashley, "NASA Lab's Life Saving Work," https://www.nasa.gov/feature/goddard/2017/nasa-lab-s-life-saving-work.

Paul Hanssen (info@wptraining.com), Workplace Training, Inc., (612) 308-2202, 2022 Lake Rd, Wayzata, MN 55391. Workplace Training, Inc. is a group of metrology professionals providing training and consulting to the industry. More information on their services can be found at http://www.wptraining.com/.

Special thanks to Richard Fertell at Proteus Industries for his contribution to this article.

Mahr Digital Micrometer With Integrated Wireless

PROVIDENCE, RI – Mahr wireless data transmission capability is now integrated within its new digital micrometer Micromar 40 EWRi. The new 40 EWRi is the latest addition to Mahr's Integrated wireless family of products, including digital calipers, Indicators and depth gages, which allow users to measure faster, more easily and more reliably. Measurement data is transferred to an i-Stick on a computer without any interfering data cables, and MarCom software makes data acquisition simple: just take a measurement and transmit measuring data directly into MS Excel or via a keyboard code into any Windows program or existing SPC application.

Micromar 40 EWRi is the first digital micrometer with large 10 mm digits on a high contrast digital display, making for safe fatigue-free reading of the measured values. It offers an easy to understand tolerance display and additionally displays warning limits.

The reference system in the Micromar 40 EWRi makes handling the micrometer very simple since the zero position is set only once. This setting remains stored for all further measurements. Also, a new "Hold" function (digital lock) allows measured values to be "frozen" so they can be easily read.

Highly precise, the Micromar 40 EWRi micrometer is equipped with a state-of-the-art inductive measuring system that exceeds international standards. Class IP65 protection against dust, coolants and lubricants makes the Micromar 40 EWRi ideally suited for use in difficult environments in the manufacturing environment.

The MarConnect integrated wireless interface is active as soon as the i-stick is plugged in, and each micrometer/caliper/indicator is identified by signal coding in the MarCom software so there is no confusion as to signals. The micrometer confirms whether the transmitted data was transferred correctly, or whether the operator is in the receiving area of the i-Stick receiver. Since the wireless data transmitters are built into the micrometer/caliper/indicator, no interface boxes or additional batteries are required. Plus, integrating the transmitters into the gage electronics makes the units extremely energy efficient and can extend battery life up to 50% longer than competitive systems.

For more information visit http://www.mahrexactly.com/.

Yokogawa Meters & Instruments LS3300 AC Power Calibrator

Yokogawa Meters & Instruments Corporation announces that it has developed the LS3300, an AC power calibrator that can accurately and stably produce a wide range of AC power outputs for the calibration of power meters and other types of power measuring instruments. As it focuses exclusively on power meter calibration, the LS3300 will dramatically reduce the cost for our customers.

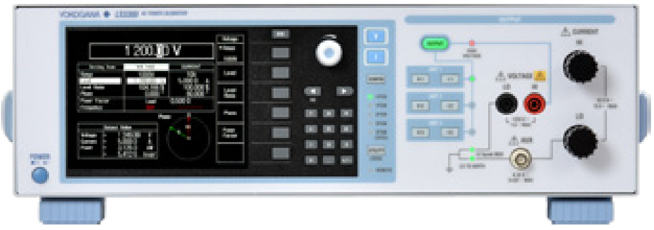
Instruments used to calibrate power meters and power analyzers are capable of simultaneous voltage and current output with adjustable phase and can also perform three-phase AC power calibration if multiple calibration units are used in synchronization. These multifunctional instruments have a high price-tag, are only capable of continuously outputting large currents for short periods, and are difficult to set up and operate for three-phase AC power calibration. As such, they do not meet the needs of customers who would like to calibrate smart meters and other power meters that require a large output current, calibrate single-phase AC power meters with a single unit, and easily and efficiently calibrate three-phase AC power.

In response to such needs, Yokogawa Meters & Instruments Corporation has developed the LS3300 AC power calibrator.

Features

1. Reduced cost - The LS3300 can calibrate AC voltage, current, and power as well as test both phase difference and power factor. While costing considerably less than other calibrators due to focusing exclusively on power calibration, the LS3300 delivers a high accuracy of ±0.045% and a superb stability of ±0.01% per hour.
2. Ideal for calibration of large-current measuring instruments and current sensors - Unlike many other calibrators on the market, the LS3300 includes as a standard feature, the ability to output currents of up to 62.5 A for extended periods of time. Further, three LS3300s can be synchronized to easily output currents of up to 180 A, thus enabling the calibration of instruments such as smart meters and shunt-resistor current sensors and other devices that require higher currents.
3. Ideal for calibration of three-phase AC power - One LS3300 unit can calibrate single-phase power meters. Multiple LS3300s can be used together to calibrate power meters used in single-phase three-wire AC power and three-phase AC power measurement. Using the multiunit control features of the LS3300, it is possible to automatically set the voltage, current, power factor, phase, and other values on slave devices by updating those settings on the master unit. This significantly reduces the amount of time needed for single-phase three-wire and three-phase AC power calibration.

For more information: http://tmi.yokogawa.com/products/generators-sources/standard/.



Ralston FieldLab

The Ralston Instruments FieldLab is a revolutionary pressure device for testing and calibration. With pressure ranges from 5 psi to 10,000 psi (350 mbar to 700 bar), certified for Class I Division 1 Hazardous locations, measurement uncertainty of 0.1% of reading, temperature compensated, lithium-ion rechargeable battery and a large color TFT display the FieldLab Pressure makes an indispensable addition to any pressure calibration or test kit.

The FieldLab is ideal for pressure data logging. Data logging templates or "Test Modes" can be created with different intervals and durations for different test situations. Data can be collected up to 2 million data points and logging continuously for up to 2 months. Create test templates or "Test Modes" on a PC using the included FieldLab Desktop software and easily load them onto one or more FieldLabs. On-screen prompts on the FieldLab allow the user to select from the loaded test modes and log data according to the template. Easily download datasets onto the PC and export data in CSV format or data and graph in PDF format.

Create a tests on a PC using the included FieldLab Desktop software and put it to one or more FieldLabs. On-screen prompts lead the user through a test and tell them right on the FieldLab whether the device under test is out of tolerance. Easily download datasets onto a PC for for creating calibration certificates. They can also produce a set of calibration data with the serial number or other important information on the device under test.

Ralston Instruments has taken the guesswork out of selecting the right equipment by creating kits that include the FieldLab to help users do their job faster and easier. Calibration kits consist of a pressure source, FieldLab, hoses and adapters you need to set up a calibration. Depending on the pressure and application we offer hand pumps, calibration manifolds, volume controllers or nitrogen gas sources along with a FieldLab pressure calibrator. That way users can show up in the field with all the items you need to do their job.

For more information please visit www.ralstoninst.com or email sales@ralstoninst.com.

Thunder Scientific 9500 Automated Humidity Generator

The Model 9500 Humidity Generator is a system capable of producing known humidity values using the fundamental, NIST proven, "two-pressure" principle. The 9500 is capable of continuously supplying an accurately known relative humidity, dew point, frost point, parts per million, or other calculated values for instrument calibration and evaluation as well as precision environmental testing. This system will automatically generate manually entered humidity and temperature set points as well as user created multipoint humidity and temperature profiles. All desired humidity's, temperatures, test pressures, flow rates, and time intervals may be programmed. Visual indications of system status are displayed in real time on the computer monitor.

Features

- 0.3% of Reading RH Uncertainty
- Traceable to SI
- High Flow Capability
- Based on NIST Proven Two-Pressure Principle
- Generate: RH, DP, FP, PPM, Multipoint Profiles

For further information call (800) 872-7728, e-mail sales@thunderscientific.com, or visit: http://www.thunderscientific.com/humidity_equipment/model_9500.html.

Morehouse Digital Force Gauges

York, PA – Morehouse Instrument Company (www.mhforce.com) has introduced new types of Digital Force Gauges. These new digital gauges offer improved performance and accuracy specifications. Compared to a typical analog ring force gauge with 0.5 % of full scale accuracy, these new gauges are two times more accurate at 0.25 %. Repeatability, resolution and reproducibility are also significantly improved. The new Morehouse digital force gauge displays direct force values and does not need an interpolation table. It offers several features including a max hold button; it records peak and valley forces, and is programmed using 11-12 data points taken from Morehouse accredited deadweight calibrations accurate to 0.002 % of applied force. Additionally, it features the new TIR function when the gauge displays the difference between maximum and minimum forces, while recording the maximum and minimum values in memory. This function can be of major assistance in varying force applications. Henry Zumbrun, Morehouse's president, said: "It has taken a bit of time to find the right solution to bring Morehouse force gauges into the forefront of measurement and we are happy to offer this new gauge and be able to retrofit all existing analog type gauges currently in use." The privately-owned firm is internationally known for ninety plus years of calibration integrity, designing, manufacturing, and selling test equipment and systems for force and torque calibration for a broad range of industries.

Find out more at www.mhforce.com or by calling 717-843-0081.

Thoughts on Database Design

Michael Schwartz
Cal Lab Solutions, Inc.

I am most known in the industry for my abilities related to writing automated calibration procedures. I have created projects in VB, Lab View, MET/CAL®, MUDCATS, C#, C++, and RMB, just to name a few. But I am also a pretty skilled database developer as well, having worked in MS Access, Dbase, PostgreSQL, My SQL, and SQL Server. I still have my Access 1.0 on 3.5" floppy disks from the 1990s because it was the first software I ever spent my hard earned money on, setting me back a whopping 99 bucks.

At the time, I was an E-4 in the US Army stationed at White Sands Missile Range, NM. I had been tasked with writing an inventory and calibration control database for the thousands of items we had on the EMI Testing Range. They gave me a copy of Dbase, but I hated it. So, I purchased a copy of Access instead.

What I learned way back then was how to create a relational database. Not all the items we had on-site were calibrated. In fact, I would speculate less than 5% required calibration. The problem was the contractors running the site would buy anything and everything in triplicate. We had thousands of items: test fixtures, computers, and equipment just lying around collecting dust. It was my job to inventory and organize all the equipment.

I started out with a pretty basic single table database I named "Assets." Since I am a lazy programmer, I quickly changed my design because my boss wanted supply information in the database. I got tired of typing in the National Stock Number (NSN) nomenclature and supply codes multiple times. This is where I first learned about "is a" and "has a" rules of object design. The idea is pretty simple: for a column or field name to belong in a table, it had to pass the "is a" test. For example, the asset is serial number 12345, so serial number should be a field in the Assets table. The "has a" test is a little more complex because its objective is to determine what fields should be in other tables and then related. In this case, the asset is a manufacturer does not make sense. So, manufacturer should be in another table.

Using the "is a" "has a" exercise in creating a database can be quite exhausting and often produces conditions that pass both tests, for example, the asset is a model number. By all rights, you could put the model number in the asset table, but the underlying value of the "is a" "has a" rules is for better database design.

Recently, I came across a database from a large, well respected company that seemed to break all the rules of good database design. When my customer told me they migrated their 12.5 GB database into a 60 GB database, I had to ask WTF? Most databases I have normalized actually shrunk in data, but never have I seen a database increase 4x in size. Something had to be wrong!

So we popped the hood and looked at the tables and structure of the database, and it was as I expected—very poor table relationship management! But it got worse… they were trying to do four different things in the core tables. As the application put data into a table it only used 1/4th of the fields. That left 3/4th of the table with DB NULLs. DB NULLs take up space; NULL data in integer, double, and fixed length string fields use the same storage space as real data. So, the 60 GB of data in the database was mostly empty space.

Now, I know not all the readers of Automation Corner want to be database experts, but I do have some simple advice when you are talking to someone about their database. Ask them what to you call the table and how many fields does it have? Then think about how many things you can logically associate with an "is a" relationship to the table. If their number is bigger than 2x your estimate, just say "Very interesting" and buy a different database.

I have done this often in the past. I asked one company "How many fields are in your Work Order table?" They said "Over 255. It is a pretty complex table." So, I thought, Asset ID, status, log-in dates, cal dates, technician, etc. and I could get to 25 or 30 fields (x2 for benefit of the doubt), but there is no way I can get to 255+ unless you are storing all the standards information used in the calibration in the work order table. If that is the case, then that means the maximum number of standards I can use in a calibration is limited to their database design. BIG PROBLEM!

That database is going to have the same problem as the first database I mentioned. It will get slow and clunky because it has to load records with "DB NULL" in memory. It will take more space on the hard drive and more space in memory because it was poorly designed.

Metrology databases over the next few decades will be moving into and participating with Big Data Systems. We have tons and tons of data that could add value to larger system. But to be usable, our databases will have to be fast and reliable! ❧

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Prior to the 2018 ISSFM, the Working Group of Fluid Flow (WGFF) will be having a meeting at the same location on March 19 - 20, 2018. More details on this meeting will be coming soon. For more information on the WGFF, refer to the Draft Terms of Reference.

For more information: www.isffm.org | isffm@ceesi.com

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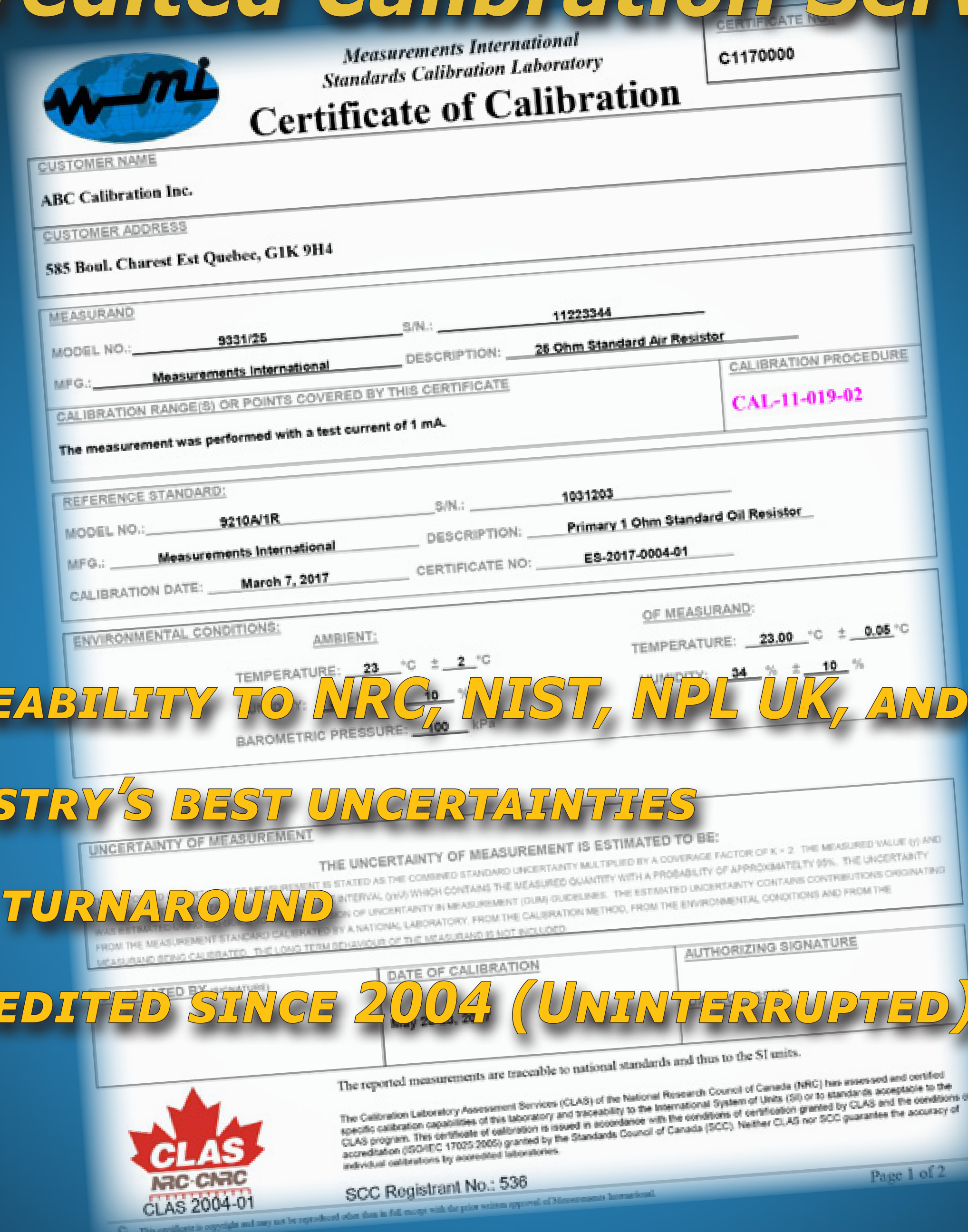
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CUSTOMER ADDRESS: 585 Boul. Charest Est Quebec, G1K 9H4
MEASURAND
MODEL NO.: 9331/25
S/N.: 11223344
MFG.: Measurements International
DESCRIPTION: 25 Ohm Standard Air Resistor
CALIBRATION RANGE(S) OR POINTS COVERED BY THIS CERTIFICATE
The measurement was performed with a test current of 1 mA.
CALIBRATION PROCEDURE: CAL-11-019-02
REFERENCE STANDARD:
MODEL NO.: 9210A/1R
S/N.: 1031203
MFG.: Measurements International
DESCRIPTION: Primary 1 Ohm Standard Oil Resistor
CALIBRATION DATE: March 7, 2017
CERTIFICATE NO: ES-2017-0004-01
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AMBIENT: TEMPERATURE: 23 °C ± 2 °C
BAROMETRIC PRESSURE: 100 kPa
OF MEASURAND: TEMPERATURE: 23.00 °C ± 0.05 °C
HUMIDITY: 34 % ± 10 %
UNCERTAINTY OF MEASUREMENT
THE UNCERTAINTY OF MEASUREMENT IS ESTIMATED TO BE:
DATE OF CALIBRATION
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