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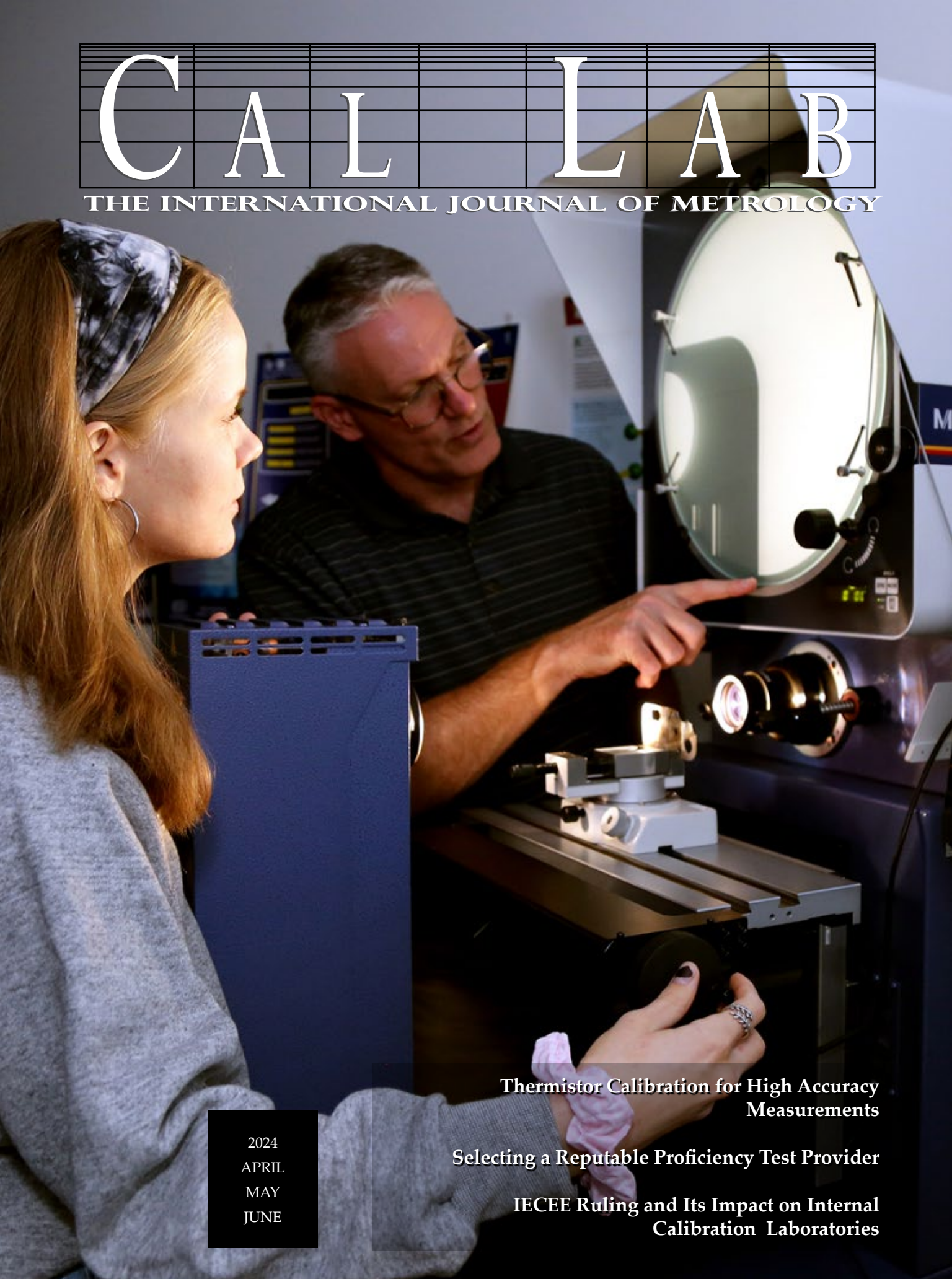
THE INTERNATIONAL JOURNAL OF METROLOGY



**Thermistor Calibration for High Accuracy Measurements**

**Selecting a Reputable Proficiency Test Provider**

**IECEE Ruling and Its Impact on Internal Calibration Laboratories**

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VOLUME 31, NUMBER 2

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# FEATURES



# DEPARTMENTS



**ON THE COVER:** Kevin Ruediger, right, a Butler County Community College professor and coordinator of the college's measurement science-metrology technology program, demonstrates the use of an optical comparator Wednesday, Oct. 25, 2023, to student Annabel Schaffner in BC3's metrology lab. The fall 2024 debut of a vocational scholarship administered by the BC3 Education Foundation increases to a maximum of $13,465 the amount in financial awards applicable to students in BC3's two-year career program.

# CALENDAR

**UPCOMING CONFERENCES & MEETINGS**

*The following event dates are subject to change. Visit the event URL provided for the latest information.*

**Aug 26-29, 2024 IEEE AUTOTESTCON.** National Harbor, MD. 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. https://www.autotestcon.com/

**Aug 26-29, 2024 IMEKO 2024 XXIV World Congress.** Hamburg, Germany. Organized by Physikalisch-Technische Bundesanstalt (PTB), the theme of the congress is "Think Metrology." https://www.imeko2024.org/

**Sep 7-11, 2024 XXXIV International Scientific Symposium Metrology and Metrology Assurance (MMA)**. Sozopol, Bulgaria. The MMA 2024 is a part of "Science Days of TU-Sofia" and it is organized by the Technical University of Sofia - Department of Electrical Measurements, Department of Precision Engineering and Measurement Instruments, and the Bulgarion Section of IEEE and with the attendance of Bulgarian Institute of Metrology, Union of the Metrologists in Bulgaria, Bulgarian Academicals Association of Metrology, and Kozloduy Nuclear Power Plant. https://metrology-bg.org/

**Sep 22-27, 2024 European Microwave Week (EuMW 2024).** Paris, France. The 27th edition of the European Microwave Week (EuMW 2024) will come to Paris to continue the annual series of highly successful microwave events that started back in 1998. EuMW 2024 comprises three co-located conferences: The European Microwave Conference (EuMC), The European Microwave Integrated Circuits Conference (EuMIC), The European Radar Conference (EuRAD). https://www.eumweek.com/conferences/general_info.html

**Jan 19-22, 2025 ARFTG Microwave Measurement Symposium**. San Juan, Puerto Rico. The 104th ARFTG Microwave Measurement Symposium will be co-located with Radio & Wireless Week (RWW-2025). https://arftg.org/104-conference/

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# EDITOR'S DESK

**Metrology Education**

Professional networking and education & training are familiar themes of my Editor's Desks. I apologize if one just seems to be an extension of the previous one. These themes are ever-prevalent and universal.

During a recent meeting at the NCSLI Workshop & Symposium and CPEM, in Aurora, Colorado, NCSLI's VP of Outreach initiated a conversation with international guests about how NCSLI and their organizations could better leverage their relationships—how to engage more productively. Participants of the conversation discussed succession planning at their organization when those with knowledge are rapidly retiring. They talked about how there is a generational divide in how people work; younger generations tend to career hop. That segued to how there was a dearth of metrology education and the challenge to deliver it into schools.

Admittedly, the conversation did not produce any action. However, it was clear that education was a central concern. And if they saw a way to engage with one another, it would have something to do with promoting education. It does seem like talking about metrology education is like throwing spaghetti on the wall… something has to stick eventually, right? In the meantime, this publication will continue to try to inspire and be a reference point for those seeking training in measurement science.

Each issue includes a Calendar section for all sorts of training events. If you visit www.callabmag.com you'll find a long list of educational institutions that offer metrology programs or classes. And if you look under News, you can learn about metrology research and activities outside your everyday experience.

Besides Fluke and Keysight, smaller manufacturers and engineering companies keep all sorts of useful information on their websites. We sourced this issue's Metrology 101 from CAS Data Loggers' collection of white pages. In a white paper by Terry Nagy, the Steinhart-Hart equation is explained as a way to get more precise readings from temperature sensor thermistors. We reprinted his paper, "Thermistor Calibration for High Accuracy Measurements," which includes a link to a spreadsheet calculator for finding the resistance of a thermistor.

Then Christopher Grachanen provides guidance when "Selecting a Reputable Proficiency Test Provider," with a focus on ISO/IEC 17043 compliance. And to round off this issue's feature articles, we asked WorkPlace Training to cover the topic of the IECEE ruling for internal calibration labs with their article, "IECEE Ruling and Its Impact on Internal Calibration Laboratories." The topic attracted enough concern on a LinkedIn post, I thought more coverage of the topic might be helpful for readers.

To circle back to the topic of metrology education, the folks at Butler County Community College sent us this issue's cover photo and a news story, complete with tour photos of their students. Photos of young men and women learning about measurement science is our equivalent of puppy photos—they just make me smile.

Happy Measuring,

Sita P Schwartz, Editor

# CALENDAR

**SEMINARS & WEBINARS: Dimensional**

**Aug 6, 2024 Introduction to Dimensional Metrology Hand Tools I – Fundamental Tools.** West Chester (Cincinnati), OH. Mitutoyo. EDU-101 is a one-day class for entry-level team members who need to learn the fundamentals of the steel rule, caliper, micrometer, pin gage, and gage block. https://www.mitutoyo.com/training-education/classroom/

**Aug 7, 2024 Introduction to Dimensional Metrology Hands Tools II – Surface Plate Tools.** West Chester (Cincinnati), OH. Mitutoyo. EDU-102 is a one-day class for entry-level team members who need to learn the fundamentals of the surface plate, height gage, indicator and stands, angle block, v-block, and sine bar. https://www.mitutoyo.com/training-education/classroom/

**Aug 8, 2024 Introduction to Dimensional Metrology Hand Tools III – Hole and Depth Tools**. West Chester (Cincinnati), OH. Mitutoyo. EDU-103 is a one-day class for entry-level team members who need to learn the fundamentals of depth gages, telescoping gages, holtest gages, bore gages, and thread gages. https://www.mitutoyo.com/training-education/classroom/

**Aug 20-22, 2024 Dimensional Gage Calibration and Repair.** Aurora, IL. Mitutoyo America's Gage Calibration course EDU-114 is a unique, active, educational experience designed specifically for those who plan and perform calibrations of dimensional measuring tools, gages, and instruments. https://www.mitutoyo.com/training-education/classroom/

**Aug 29-30, 2024 Introduction to Dimensional Metrology.** Pretoria, South Africa. NMISA. To obtain the basic understanding of Dimensional Metrology as use in measuring and inspection in industry. https://store.nmisa.org/collections/face-to-face-courses

**Sep 24, 2024 Introduction to Dimensional Metrology Hand Tools I – Fundamental Tools.** Aurora, IL. EDU-101 is a one-day class for entry-level team members who need to learn the fundamentals of the steel rule, caliper, micrometer, pin gage, and gage block. https://www.mitutoyo.com/training-education/classroom/

# CALENDAR

**Sep 25-26, 2024 Dimensional Gage Calibration.** Aurora, IL. Mitutoyo America's Gage Calibration course EDU-113 is a unique, active, educational experience designed specifically for those who plan and perform calibrations of dimensional measuring tools, gages, and instruments. https://www.mitutoyo.com/training-education/classroom/

**Sep 27, 2024 Small Tool Repair Course.** Aurora, IL. EDU-301 will focus on the care and repair of Mitutoyo small tools including calipers (digital and dial), micrometers (digital and mechanical), and indicators (digital, dial, and lever-style). This course does not cover laser or MDH high accuracy micrometers, LH-600 or QM height gages, or non-Mitutoyo tools. https://www.mitutoyo.com/training-education/classroom/

**Oct 21-25, 2024 Advanced Dimensional Metrology.** Pretoria, South Africa. NMISA. The course objective is to obtain an in-depth understanding of Dimensional Metrology. The course built on the Basic dimensional metrology course explaining the key principles and techniques used in dimensional metrology. https://store.nmisa.org/collections/face-to-face-courses

**SEMINARS & WEBINARS: Education**

**Aug 15, 2024 Metric System Education Resources.** Online. NIST. This 1.5-hour session will explore NIST Metric Program education publications and other resources teachers, parents, and students can download and freely reproduce. These resources are helpful to students as they become familiar with metric units, develop measurement quantity reference points, and learn more about SI basics. https://www.nist.gov/pml/owm/owm-training-and-events

**Feb 13, 2025 Metric System Education Resources.** Online. NIST. This 1.5-hour session will explore NIST Metric Program education publications and other resources teachers, parents, and students can download and freely reproduce. These resources are helpful to students as they become familiar with metric units, develop measurement quantity reference points, and learn more about SI basics. https://www.nist.gov/pml/owm/owm-training-and-events

# CALENDAR

### SEMINARS & WEBINARS: Electrical

**Sep 2-6, 2024 Basics of Electrical Metrology and Measurement.** Pretoria, South Africa. NMISA. Course objectives are to provide an enhanced understanding of the fundamentals and concepts that relate to metrology and calibration requirements, as well as the skills and techniques required for calibration, measurement theory, performing accurate electrical and electronic measurements, and interpreting the technical specifications and calibration reports. In addition, the calculation of measurement uncertainty is demonstrated with practical examples. https://store.nmisa.org/collections/face-to-face-courses

**Sep 23-26, 2024 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. https://us.flukecal.com/training

**Nov 4-7, 2024 Basic Hands-On Metrology.** Everett, WA. Fluke Calibration. This Metrology 101 basic metrology training course introduces the student to basic measurement concepts, basic electronics related to measurement instruments and math used in calibration. https://us.flukecal.com/training

### SEMINARS & WEBINARS: Flow

**Sep 16-20, 2024 Gas Flow Metrology.** Delft, Netherlands. VSL. The training Gas flow metrology provides information about the backgrounds of gas flow and energy measurements and the pitfalls that can be encountered in these measurements. Participants will be able to immediately identify potential measurement problems and take appropriate measures. https://www.vsl.nl/en/services/training/

**Sep 17-20, 2024 Gas Flow Calibration Using molbloc/molbox.** Phoenix, AZ. Fluke Calibration. Gas Flow Calibration Using molbloc/molbox is a four day training course in the operation and maintenance of a Fluke Calibration molbloc/molbox system. https://us.flukecal.com/training

**Sep 24-26, 2024 Seminar Flow Measurement and Calibration (Deutsch).** Neufahrn, Germany. TrigasFl. This seminar is designed for those interested in purchasing, calibration, engineering, and all users of flowmeters. The focus is on the physical fundamentals, the functionalities of modern flow measurement techniques, the theory and technology of calibration as well as metrological traceability. https://trigasfi.com/

**Sep 30-Oct 2, 2024 Seminar Flow Measurement and Calibration (English)**. Neufahrn, Germany. TrigasFl. This seminar is designed for those interested in purchasing, calibration, engineering, and all users of flowmeters. The focus is on the physical fundamentals, the functionalities of modern flow measurement techniques, the theory and technology of calibration as well as metrological traceability. https://trigasfi.com/

### SEMINARS & WEBINARS: Force & Torque

**Sep 9-13, 2024 Fundamentals of Torque Metrology: Practical Approach.** Pretoria, South Africa. NMISA. At the end of the course, attendees should have a good understanding of the fundamentals of torque metrology principles and torque measurements. https://store.nmisa.org/collections/face-to-face-courses

**Sep 16-20, 2024 Fundamentals of Force Metrology: Practical Approach.** Pretoria, South Africa. NMISA. At the end of the course, attendees should have a good understanding of the fundamentals of force metrology principles and force measurements. https://store.nmisa.org/collections/face-to-face-courses

### SEMINARS & WEBINARS: Industry Standards

**Aug 6-7, 2024 3004 Understanding ISO/IEC 17025 for Testing and Calibration Labs.** Online for the Americas. This Training Course applies to testing and calibration laboratories and regulatory agencies seeking to specify 17025 within their policies and regulations. https://www.iasonline.org/training/ias-training-schedule/

**Sep 17-18, 2024 Laboratories: Understanding the Requirements and Concepts of ISO/IEC 17025:2017.** Live Online. ANAB. Understand requirements of ISO/IEC 17025:2017, including general, structural, resource, process, and management system requirements. Learn practical concepts, such as impartiality, documents control, ensuring validity of results and risk management. Gain an understanding of an ISO/IEC 17025:2017 laboratory management system. https://anab.ansi.org/training

**Sep 17-19, 2024 Internal Training to ISO/IEC 17025:2017 (Non-Forensic).** Live Online. ANAB. This training is designed for laboratory managers, technical staff, and others who want or need to learn better audit practices. https://anab.ansi.org/training

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# CALENDAR

**Oct 8-9, 2024 3004 Understanding ISO/IEC 17025 for Testing and Calibration Labs**. Online for the Americas. This Training Course applies to testing and calibration laboratories and regulatory agencies seeking to specify 17025 within their policies and regulations. https://www.iasonline.org/training/ias-training-schedule/

**Nov 5-6, 2024 Laboratories: Understanding the Requirements and Concepts of ISO/IEC 17025:2017.** Live Online. ANAB. Understand requirements of ISO/IEC 17025:2017, including general, structural, resource, process, and management system requirements. Learn practical concepts, such as impartiality, documents control, ensuring validity of results and risk management. Gain an understanding of an ISO/IEC 17025:2017 laboratory management system. https://anab.ansi.org/training

**Nov 5-7, 2024 Internal Training to ISO/IEC 17025:2017 (Non-Forensic).** Live Online. ANAB. This training is designed for laboratory managers, technical staff, and others who want or need to learn better audit practices. https://anab.ansi.org/training

**Nov 12-13, 2024 3004 Understanding ISO/IEC 17025 for Testing and Calibration Labs.** Online for the Middle-East & South Asia time zone. IAS. This Training Course applies to testing and calibration laboratories and regulatory agencies seeking to specify 17025 within their policies and regulations. https://www.iasonline.org/training/ias-training-schedule/

**Dec 10-11, 2024 Laboratories: Understanding the Requirements and Concepts of ISO/IEC 17025:2017.** Live Online. ANAB. Understand requirements of ISO/IEC 17025:2017, including general, structural, resource, process, and management system requirements. Learn practical concepts, such as impartiality, documents control, ensuring validity of results and risk management. Gain an understanding of an ISO/IEC 17025:2017 laboratory management system. https://anab.ansi.org/training

**Dec 10-12, 2024 Internal Training to ISO/IEC 17025:2017 (Non-Forensic)**. Live Online. ANAB. This training is designed for laboratory managers, technical staff, and others who want or need to learn better audit practices. https://anab.ansi.org/training

# CALENDAR

### SEMINARS & WEBINARS: Mass

**Oct 7-11, 2024 Mass Metrology Course for High Accuracy: OIML class F to E.** Pretoria, South Africa. NMISA. The course provides fundamentals of mass measurements, looking at what affects reliability and accuracy of mass measurements, and how to ensure traceability in weighing. It also covers the evaluation of different weighing techniques used to calibrate mass pieces, the requirements for and calibration of weighing instruments and how to evaluate measurement uncertainty in weighing. https://store.nmisa.org/collections/face-to-face-courses/products/introduction-to-mass-metrology

**Oct 21-Nov 1, 2024 Mass Metrology Seminar.** Gaithersburg, MD. NIST. The Mass Metrology Seminar is a two-week, "hands-on" seminar. It incorporates approximately 30 percent lectures and 70 percent demonstrations and laboratory work in which the participant performs measurements by applying procedures and equations discussed in the classroom. https://www.nist.gov/pml/owm/owm-training-and-events

### SEMINARS & WEBINARS: Measurement Uncertainty

**Aug 5-7, 2024 Introduction to Measurement Uncertainty.** Everett, WA. Fluke Calibration. This course will teach you how to develop uncertainty budgets and how to understand the necessary calibration processes and techniques to obtain repeatable results. https://us.flukecal.com/training

**Sep 16-17, 2024 Measurement Confidence: Fundamentals.** Live Online. ANAB. This Measurement Confidence course introduces the foundational concepts of measurement traceability, measurement assurance, and measurement uncertainty and details ISO/IEC 17025 and ISO/IEC 17020 requirements. https://anab.ansi.org/training/measurement-confidence-fundamentals/

**Sep 18-19, 2024 Measurement Uncertainty: Practical Applications.** Live Online. ANAB. This class covers concepts and accreditation requirements associated with measurement traceability, measurement assurance, and measurement uncertainty. https://anab.ansi.org/training/

# CALENDAR

**Oct 2-3, 2024 3006 Uncertainty of Measurement for Labs.** Online for Middle-East & South Asia time zone. IAS. The training includes case studies and discussions, with application of statistical components in practical examples that are frequently encountered by testing laboratories. https://www.iasonline.org/training/ias-training-schedule/

**Oct 28-30, 2024 Uncertainty of Measurement for Testing Laboratories.** Pretoria, South Africa. NMISA. The objective of this course is to introduce analysts to the basic concepts of the estimation of uncertainty of measurement. During the evaluation of the measurement uncertainty, the focus will be on the identification and quantification of individual uncertainty sources according to the principles of the Guide to the Expression of Uncertainty of Measurement (GUM) (Type A and B evaluations). To combine these uncertainties into the final expanded measurement uncertainty, participants will be taught simplified approaches such as the use of relative uncertainties and method validation data. https://store.nmisa.org/collections/face-to-face-courses

**Oct 29-31, 2024 Measurement Uncertainty – Fundamentals and Application.** Aurora, IL. Mitutoyo. EDU-210 is firmly rooted in national and international standards in terminology and uncertainty. The course follows the concepts from ISO/IEC Guide 98-3 (GUM), which is the required standard for almost all uncertainty evaluations, including labs accredited to ISO/IEC 17025. This course also introduces the powerful concepts of test uncertainty (ISO 14253-5) for the evaluation of measurement uncertainty in the calibration of measuring instruments. https://www.mitutoyo.com/training-education/classroom/

**Dec 9-10, 2024 Measurement Confidence: Fundamentals.** Live Online. ANAB. This Measurement Confidence course introduces the foundational concepts of measurement traceability, measurement assurance, and measurement uncertainty and details ISO/IEC 17025 and ISO/IEC 17020 requirements. https://anab.ansi.org/training/measurement-confidence-fundamentals/

**Dec 11-12, 2024 Measurement Uncertainty: Practical Applications.** Live Online. ANAB. This class covers concepts and accreditation requirements associated with measurement traceability, measurement assurance, and measurement uncertainty. https://anab.ansi.org/training/

**SEMINARS & WEBINARS: Pressure**

**Oct 7-11, 2024 Principles of Pressure Calibration.** Phoenix, AZ. Fluke Calibration. A five-day training course on the principles and practices of pressure calibration using digital pressure calibrators and piston gauges (pressure balances). The class is designed to focus on the practical considerations of pressure calibrations. https://us.flukecal.com/training

**SEMINARS & WEBINARS: RF & Microwave**

**Sep 23-27, 2024 RF & Microwave Metrology Fundamentals.** Pretoria, South Africa. NMISA. This course is aimed at teaching theoretical and practical principles of measurements and calibrations in RF and Microwave Metrology. Overviews of various instrumentation used for the measurements and calibrations will also be discussed. https://store.nmisa.org/collections/face-to-face-courses

**SEMINARS & WEBINARS: Software**

**Sep 9-13, 2024 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. https://us.flukecal.com/training

**Oct 7-11, 2024 Advanced MET/CAL® Procedure Writing.** Everett, WA. Fluke Calibration. A five-day procedure writing course for advanced users of MET/CAL calibrations software. Prerequisites Note: This course covers advanced topics and requires an existing knowledge of MET/CAL calibration software. https://us.flukecal.com/training

**Oct 21-25, 2024 MET/TEAM® Asset Management.** Everett, WA. Fluke Calibration. This five-day course presents a comprehensive overview of how to use MET/TEAM Test Equipment and Asset Management Software in an Internet browser to develop your asset management system. You will learn a systematic approach to collect the information you need to manage your lab assets routinely, consistently and completely. https://us.flukecal.com/training

**Oct 29-31, 2024 VNA Tools Training Course.** Berne-Wabern, Switzerland. Federal Institute of Metrology METAS. VNA Tools is free software developed by METAS for measurements with the Vector Network Analyzer (VNA). The software facilitates the tasks of evaluating measurement uncertainty in compliance with the ISO-GUM and vindicating metrological traceability. 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 18-22, 2024 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. https://us.flukecal.com/training

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# CALENDAR

**SEMINARS & WEBINARS:**
**Temperature & Humidity**

**Aug 19-23, 2024 Non-Contact Thermometry Metrology.** Pretoria, South Africa. NMISA. The objective of this course is to teach the basic principle of infrared thermometers, the physics behind its operation, method of calibration and traceability. https://store.nmisa.org/collections/face-to-face-courses

**Aug 27-29, 2024 Temperature Measurement.** Sydney, Australia. National Measurement Institute. This three-day course (9 am to 5 pm) covers the measurement of temperature and the calibration of temperature measuring instruments. It incorporates extensive hands-on practical exercises. https://shop.measurement.gov.au/collections/physical-metrology-training

**Aug 30, 2024 Liquid-In-Glass Thermometry.** Sydney, Australia. National Measurement Institute, Australia. This one-day course will provide calibration and quality control technicians with the skills required to calibrate liquid-in-glass thermometers in accordance with NATA and 17025 requirements. https://shop.measurement.gov.au/collections/physical-metrology-training

**Sep 16-18, 2024 Practical Temperature Calibration.** American Fork, UT. Fluke Calibration. A 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. https://us.flukecal.com/training

**Oct 7-9, 2024 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. https://us.flukecal.com/training

# CALENDAR

**SEMINARS & WEBINARS: Validation & Verification**

**Aug 6, 2024 Validation and Verification of Analytical Methods.** Live Online. ANAB. This course provides an introduction to validation and verification of analytical methods and ISO/IEC 17025 & ISO/IEC 17020 requirements. https://anab.ansi.org/training-course-schedule/

**Oct 9, 2024 Validation and Verification of Analytical Methods.** Live Online. ANAB. This course provides an introduction to validation and verification of analytical methods and ISO/IEC 17025 & ISO/IEC 17020 requirements. https://anab.ansi.org/training-course-schedule/

**Oct 14-16, 2024 Method Validation.** Pretoria, South Africa. NMISA. The objective of this course is to introduce analysts to the basic concepts of method validation and quality control. https://store.nmisa.org/collections/face-to-face-courses

**Nov 19, 2024 Validation and Verification of Analytical Methods.** Live Online. ANAB. This course provides an introduction to validation and verification of analytical methods and ISO/IEC 17025 & ISO/IEC 17020 requirements. https://anab.ansi.org/training-course-schedule/

**SEMINARS & WEBINARS: Weight**

**Nov 4-7, 2024 5853 Balance and Scale Calibration and Uncertainties.** NIST. Gaithersburg, MD. This 4-day seminar will cover the calibration and use of analytical weighing instruments (balances and laboratory/bench-top scales), including sources of weighing errors in analytical environments, methodologies for quantifying the errors, and computation of balance calibration uncertainty and global (user) uncertainty. https://www.nist.gov/pml/owm/training

Visit **www.callabmag.com/calendar/** for upcoming metrology events & training!

## NIST Brings Mass Measurement to the Masses

*NIST has delivered a portable and highly accurate instrument for measuring mass to the U.S. Army, marking the first time in the U.S. that this technology is available outside of NIST.*

NIST News, June 12, 2024 — Bringing its cutting-edge invention to the larger world for the first time, the National Institute of Standards and Technology (NIST) has delivered a portable and superaccurate tabletop instrument for measuring mass to the U.S. Army, potentially revolutionizing critical measurements in a variety of applications, from weighing aircraft components to delivering exact doses of medicine.

NIST delivered the mass measurement instrument, known as a tabletop Kibble balance (https://www.nist.gov/news-events/news/2023/03/mass-revolution-kibble-balances-all), to the U.S. Army Redstone Arsenal near Huntsville, Alabama, in early April. This marks the first time in the U.S. that a tabletop Kibble balance has been put into use outside of NIST.

"This is the first Kibble balance that is out in the wild," said Stephan Schlamminger, NIST physicist. "The Army are good early adopters of this technology because they have a measurement lab and they have trained staff. This is the best type of place to test these devices in the field."

### Democratizing Precision Mass Measurements

In the U.S., NIST has been at the forefront of worldwide efforts to redefine the metric system, known as the International System of Units (SI). In May 2019, the scientific community changed how we define the kilogram, which is the basic unit of mass. In the past, the kilogram was defined by a physical object — a metal cylinder kept in France. The current definition is based on fundamental properties of nature that are always the same, such as the speed of light or the charge of the electron. Unlike traditional balances that rely on physical weights, the Kibble balance (https://www.nist.gov/si-redefinition/kilogram-kibble-balance) uses electrical currents and voltages to precisely measure mass, making it more accurate and stable over time.

The Kibble balance, originally a massive and expensive research project, has been a game changer in mass measurement. However, its size and cost have made it

inaccessible to many. Recognizing this limitation, NIST set out to make this technology more widely available by creating a much smaller and more portable version.

"We want to get this technology out of the measurement lab and into the hands of industry so that they can realize mass for themselves without having to rely on the primary Kibble balance at NIST. We want to put ourselves out of business," said NIST mechanical engineer Leon Chao.

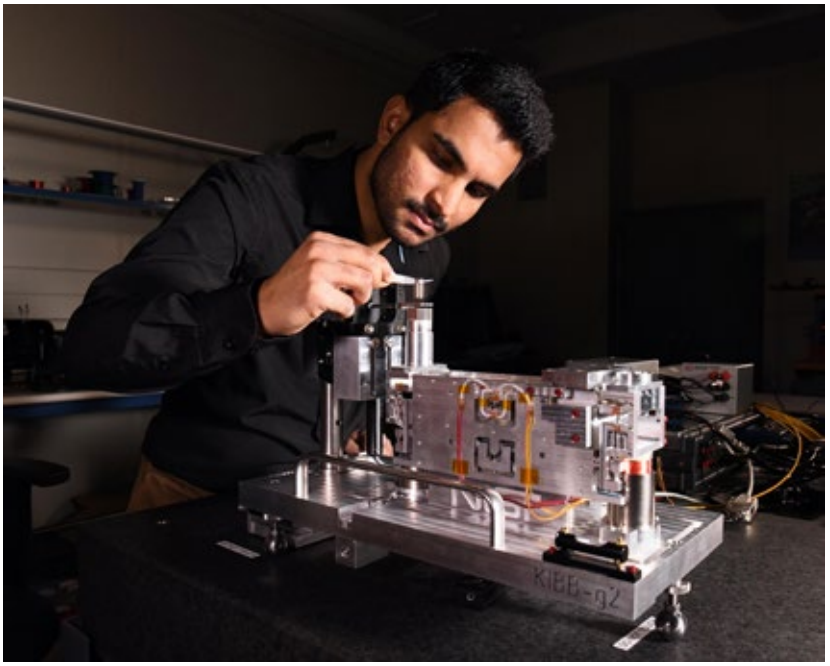
**Three-Year Collaboration Yields Success**

This vision caught the attention of the U.S. Army, which saw an opportunity to streamline its complex process for calibrating its mass measurements and tracing them back to the SI, which provides the fundamental scientific definition for the kilogram. Currently, the Army sends its mass standards to NIST, which then uses its Kibble balance to perform calibrations directly traceable to the SI. The Army then disseminates the calibrated mass standards to its users. These efforts are both costly and time-consuming. So NIST and the Army embarked on a three-year collaboration to develop the next generation of tabletop Kibble balances with a goal of eventually eliminating a portion of the current calibration chain.

The Army needs to make accurate mass measurements for a variety of purposes. Army medical facilities must precisely weigh small quantities of medication or samples for analysis. Army engineers need to know the precise weight of large equipment on airplanes to ensure they're light enough to take flight. While performing these tasks, the Army must ensure that its own equipment for measuring mass is properly calibrated to ensure that its measurements are accurate.

With the Kibble balance successfully delivered to Redstone, the Army plans to use it for its own mass calibrations and to study how easily the instrument can be transported and set up in different lab environments. This will inform future efforts to use tabletop Kibble balance technology in its measurement network.

"It's been an incredible journey to play a role in the development of this futuristic tabletop Kibble balance," said NIST chief mechanical engineer Kumar Arumugam. "Transforming this technology into a user-friendly and robust system has been a valuable learning experience that I'm honored to be a part of."



NIST engineer Kumar Arumugam examines the tabletop Kibble balance before its delivery to the U.S. Army. Credit: J. Lee/NIST

The collaboration between NIST and the U.S. Army represents a significant step forward in the quest for portable mass measurements that are more accurate and reliable, with far-reaching implications for the military, scientific and business communities.

"We've had a great experience working with the NIST team to get the tabletop Kibble from just a vision to a reality at Redstone," said Russell Kauffman, U.S. Army Primary Standards Laboratory general engineer. "If NIST wants to make something happen, it can happen."

**Empowering Local Calibrations**

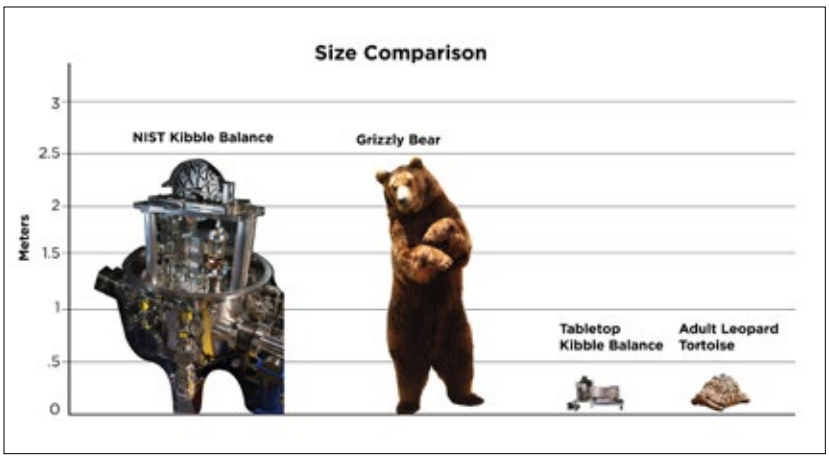
In a separate development, NIST has recently inked a collaborative agreement with tool developer Snap-on Inc. to expand the scope of the tabletop Kibble balance in the real world. The goal of this agreement is to create an accessible and user-friendly tabletop system (https://www.nist.gov/noac/technology/mass-force-and-acceleration/torque-realization) that can calibrate torque wrenches, which has been a long-standing, costly issue in the industry.

Torque wrenches are tools used to tighten nuts and bolts, ensuring that the proper tension is applied to avoid damage from over- or under-tightening. These tools are highly sensitive and require recalibration annually or after any accidental drops. However, the expense of sending them to specialized calibration labs has proved prohibitive for many mechanics, from local auto shops to airline maintenance facilities. As a result, some mechanics risk working with uncalibrated wrenches, potentially compromising critical torque applications, while others opt to replace their entire torque wrench inventory yearly — a wasteful and costly practice.

The partnership between NIST and Snap-on hopes to disrupt this inefficient system by bringing accessible, on-site calibration capabilities to local garages and airline hangars nationwide.

By democratizing access to precision mass measurements, NIST is empowering industries and organizations to perform their own calibrations with unprecedented accuracy and simplicity. Partnerships with the Army and industry allies are a significant step toward realizing NIST's vision of bringing cutting-edge measurement capabilities to the masses.

Source: https://www.nist.gov/news-events/news/2024/06/nist-brings-mass-measurement-masses




Measuring just a fraction of the size of the massive NIST-4 Kibble balance, which stands as tall as a grizzly bear, the tabletop Kibble balance is about the size of a tortoise. While not as accurate as its larger counterpart, the tabletop Kibble balance serves a crucial purpose — making this cutting-edge technology accessible to a wider audience. Credit: N. Hanacek/NIST

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Made to Last

Kevin Ruediger, left, a Butler County Community College professor and coordinator of the college's measurement science-metrology technology program, demonstrates the use of a pneumatic air gauge Thursday, Nov. 10, 2016, to Tim Ellenberger and Kirk Gibson in BC3's metrology lab. The fall 2024 debut of a vocational scholarship administered by the BC3 Education Foundation increases to a maximum of $13,465 the amount in financial awards applicable to students in BC3's two-year career program.

## Instrumental Scholarships

*Opportunities reach 11 for students in BC3's rare metrology associate degree program*

(Butler, PA) June 26, 2024 – A rare associate degree program in metrology provided by a western Pennsylvania community college has now a record 11 scholarship opportunities applicable to its students as they learn to make precise chemical, electrical and dimensional measurements and gain practical insight through visits to a U.S. Department of Commerce agency four hours distant.

The associate degree program at Butler County Community College has been reported to be one of only three in the United States.

The fall 2024 debut of a vocational scholarship administered by the BC3 Education Foundation increases to a maximum of $13,465 the amount in financial awards applicable to students in BC3's two-year measurement science-metrology technology career program, said Bobbi Jo Cornetti, the foundation's development coordinator.

The foundation is a 501(c)(3) charitable organization that acquires and manages private funds for the college's benefit.

The John Baker Elks Lodge Vocational Scholarship, established by a Butler County chapter of the fraternal organization, will fund two $500 awards for students in a BC3 career program such as measurement science-metrology technology, Cornetti said.

BC3's program emphasizes the traceability of measurements, instrument calibration, precise laboratory procedures and the theoretical aspects of experimentation.

Karen Newpol appreciates precise measurement because, she said, "it makes for a better end product."

**Donor Rep: Career Programs Advantageous**

Newpol is chaplain of the Cranberry Elks Lodge 2249 that founded the scholarship. BC3's career programs — in which students can develop the skills needed to enter the workforce immediately upon graduation — may enhance a graduate's earning potential, Newpol said.

"You are starting in the workforce two years earlier than going for a four-year degree," Newpol said. "It is better to establish yourself. We want to help make college more

affordable and to get students into the workforce quickly."

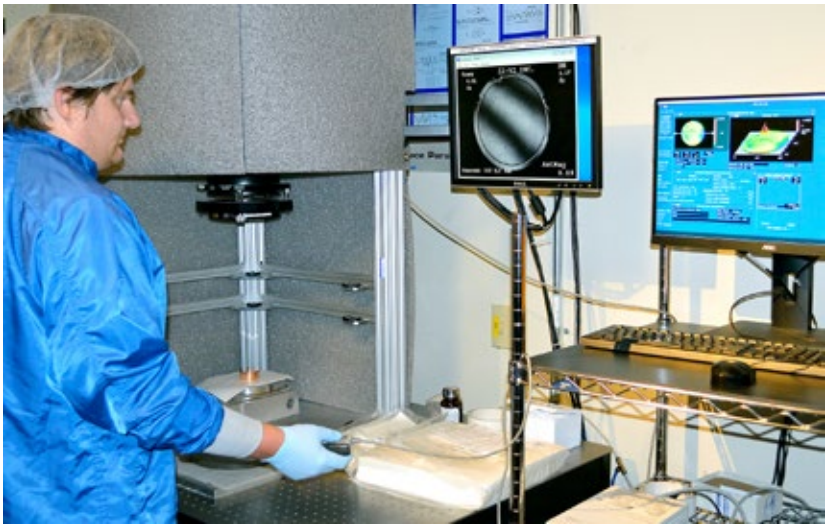
The college's 62-credit measurement science-metrology technology program prepares graduates for positions in which biomedical, chemical, dimensional, electrical, mechanical and optical measurements are performed.

Financial awards applicable to students in the program in 2024-2025 range from $420 to $2,500, Cornetti said.

"Scholarships and the training we provide give our students a head start into entering a technical field," said Kevin Ruediger, a BC3 professor and coordinator of the college's program.

BC3 graduates have later worked for private companies or for government organizations such as NASA and the National Institute of Standards and Technology, said Matt Kovac, dean of the college's science, technology, engineering and mathematics division.

"The fact that so many of these scholarships identify at least in part with metrology is a testament to the quality of the program," Kovac said, "and a recognition of the skill sets that students come away with. The only barrier some students have is resources. The scholarships put into the realm of possibility enough resources for students to be able to get through the program and reach their potential."



Photos shown clockwise, starting at top: Zachary Kress, a Butler County Community College student, is shown in April visiting the National Institute of Standards and Technology in Gaithersburg, MD; Zachary Kress, a Butler County Community College student, uses interferometry Friday, June 21, 2024, in the quality assurance department of a Butler County manufacturer where he was a summer intern; Jessica Silva, a Butler County Community College student, is shown in April visiting the National Institute of Standards and Technology in Gaithersburg, MD; Butler County Community College students, Annabel Schaffner, Ethan Gaspers, Jessica Silva, and Zachary Kress, are shown in April visiting the National Institute of Standards and Technology in Gaithersburg, MD.

**Scholarships "Took That Worry" Away**

Annabel Schaffner studied instruments such as a FARO Quantum S 2.5-meter, seven-axis articulating arm coordinate measuring machine, and an optical comparator, as she received $4,660 in financial awards over two years from the BC3 Education Foundation.

"I took advantage of the scholarships," Schaffner said. "I didn't even have to think about taking out loans. The scholarships just took that worry off my shoulders."

Schaffner applied what she learned from BC3's program as a recent intern with one of Butler County's 265 manufacturers, as did Zachary Kress.

Schaffner said she helped "to calibrate different hand tools, things like micrometers, calipers and gauge blocks in the lab" and Kress said he used interferometry – "light waves to measure radius and flatness of parts" – in the quality assurance department of a different company.

**Trip to NIST "Super-Beneficial"**

Schaffner and Kress also traveled in April with other BC3 students and college employees to the National Institute of Standards and Technology in Gaithersburg, Md., an approximately 240-mile drive from the college's main campus north of Pittsburgh.

"It's great that the program provides the opportunity to do this," Kress said. "The trip to NIST was super-beneficial to me. Everything metrology in the U.S. is traceable back to NIST. We were able to see all kinds of real-life examples of how they calibrate things and analyze their scales. It was interesting to see how they do it and all of the top-of-the-line equipment they use."

Kress intends to graduate from BC3 in May 2025 with associate degrees in measurement science-metrology technology and in engineering. Schaffner graduated debt-free from BC3 in May 2024 and with summa cum laude honors.

Schaffner said her associate degree in metrology from BC3 is "very unique" and that her research since graduation has shown "many different job opportunities out there, locally and out of state if you want to travel."

Graduates of the college's 41-year-old program have worked in positions such as instrumentation engineer, metrology and maintenance manager, quality engineering technician, research lab technician and research engineering technician.

"There are probably 10 open positions for every qualified person," said Bob Dodds, a 2006 graduate of BC3's program who worked three years for NASA's Glenn Research Center, Cleveland, and is now senior principal metrology engineer at Northrop Grumman, Baltimore.

"Metrology skills are very much needed, especially as we go forward with the future of engineering and pushing the boundaries of science," Dodds said. "There are fewer and fewer technical schools out there. The program at BC3 is instrumental in filling that educational gap.

"The degree in metrology from BC3 is something that you can be proud of. Scholarships may mean you do not have to work now as a student and can concentrate on finishing the program."

Central Georgia Technical College, Macon, Ga., and Monroe County Community College, Monroe, Mich., have been reported to offer associate degrees in the field, according to callabmag.com, the website for *CAL LAB: The International Journal of Metrology*.

The first scholarship benefiting students in BC3's program was established with the BC3 Education Foundation by the National Conference of Standards Laboratories International in 1993.

– Written by William Foley

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## The State of U.S. Science and Engineering 2024

The U.S. National Science Board (NSB) is congressionally mandated to release summary reports on science, technology, engineering, and mathematics (STEM), from nine Indicator reports, in even years. The 2024 edition of The STEM Labor Force: Scientists, Engineers, and Skilled Technical Workers (https://ncses.nsf.gov/pubs/nsb20243/preface) report was published on May 30th, 2024, by the NSB.

*The State of U.S. Science and Engineering 2024* provides "Key Takeaways," mined from comprehensive data gathered by The National Center for Science and Engineering Statistics (NCSES). Some of them include:

- International students "accounted for about a third of science and engineering (S&E) master's and doctoral degree recipients… in 2021." Also, foreign-born individuals made up 19% of all STEM workers and 43% of doctorate-level scientists and engineers."
- Women make up 35% of all STEM workers.
- The STEM workforce makes up nearly a quarter of the U.S. workforce with more than half of those being "Skilled Technical Workers" who do not possess a four-year degree.
- The U.S. "is the largest performer of research and development" with China not being comparatively far behind as second.
- Not surprisingly, the U.S. and China "are the largest contributors to a global network of artificial intelligence (AI) research publishing."

Overall, this summary report provides information on the U.S. STEM education and workforce, U.S. global performance and funding of research and development, and how major countries contribute to global science and engineering endeavors. This report and related S&E Indicators can be found online at the U.S. National Science Foundation's website: https://www.nsf.gov/nsb/.

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## Guide for the Calibration of Sensors for Seismic, Infrasound and Hydroacoustic Monitoring Published

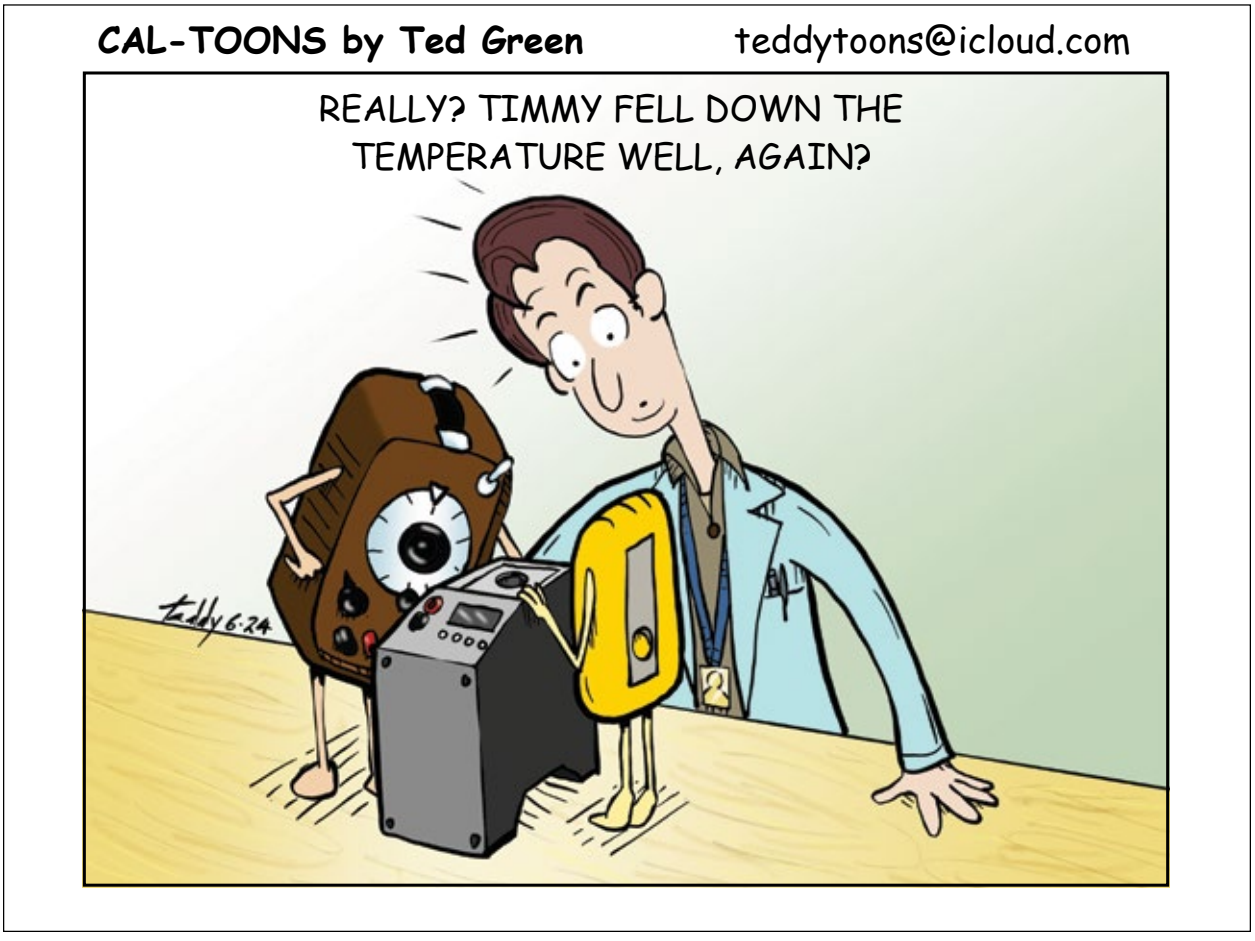
*An EMPIR project that demonstrated first traceability for extremely low-frequency sound and vibration measurements has published a good practice guide*

EURAMET News, July 23, 2024 — The careful monitoring of low frequency sound and infrasound can detect extreme events, such as earthquakes, tsunamis or volcanic eruptions. The International Monitoring System (IMS) also use monitoring stations to detect nuclear explosions and hence check compliance with the provisional Comprehensive Nuclear-Test-Ban Treaty (CTBT), outlawing further testing of nuclear weapons.

However, at the start of 2018 many detection systems lacked supporting calibration and traceability to the International System of Units, (the SI). This was addressed by the now completed EMPIR project Metrology for low-frequency sound and vibration (19ENV03, Infra-AUV) which represented the first consolidated attempt to address the needs identified across three technologies in this area – airborn acoustics, seismology and underwater acoustics.

The consortium has now published a good practice guide on traceability for seismo-acoustic and hydroacoustics sensor systems deployed in IMS networks.

A seismograph transmitting vibrations of an erupting volcano.



The guide, whilst aimed at the International Monitoring System and its observation stations, is also organized by technology, with stand-alone sections for Seismic, Infrasound and Hydroacoustic sensor systems. The full traceability and calibration chain is described for each – from primary realization methods to those that can be implemented in the field.

With input from all project partners each technology used is detailed with emphasis on the newly developed calibration facilities on primary and secondary laboratory calibration and their on-site counterparts.

Three case studies are described in the guide each illustrating the benefits that serve to inform deployment strategies. These include:

- Clarity in the resulting uncertainty in field parameters derived from the measurement data, through analysis of the propagation of measurement uncertainty.
- New capabilities to detect defects in sensor system components, and even correct for such occurrences in post-processing.
- A demonstration of the feasibility of an on-site calibration method developed for one technology being successfully applied in another.
- Optimization of the number of reference sensors that can adequately cover an entire sensor array.

For the first time in the world, thanks to the Infra-AUV project, traceability for extremely low-frequency sound and vibration measurements has been established.

Dr Bruns (PTB) who coordinated the project said about the guide:

"This document sums up more than three years of intensive research and development effort and we hope it will provide a significant gain for data quality for the whole field of geoscientific measurements."

*This EMPIR project was co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States.*

Source: https://www.euramet.org/publications-media-centre/news

# Thermistor Calibration for High Accuracy Measurements

Terry Nagy
CAS Data Loggers

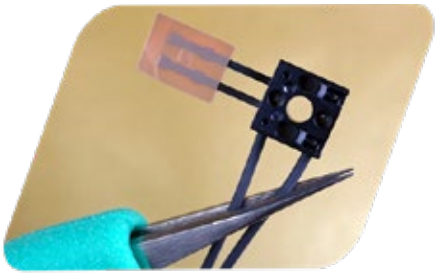


Figure 1. Technician prepares to install a thermistor into a measurement device.

## Calculating Steinhart-Hart Coefficients for High-Precision Readings

Technicians and engineers often use thermistors to measure temperature in applications which require high accuracy. Thermistors operate by changing resistance as their temperature changes in a very predictable but non-linear way. This characteristic allows them to provide higher accuracy than thermocouples or RTDs, albeit within a narrower temperature range. In order to ensure this high accuracy, thermistor calibration is an important consideration.

One challenge when using thermistors is calculating the temperature from the measured resistance value because of their non-linear behavior. To accomplish this, the Steinhart-Hart equation[1] is used to convert a thermistor sensor's resistance to temperature. When compared against other methods, Steinhart-Hart models will give you much more precise readings across the sensors' temperature ranges, often within a few hundredths of a degree. Although the Steinhart-Hart equation is not universally known, it is useful in data logging applications such as measuring lake water temperatures, solar hot water systems, and skin temperature measurement.

1 https://en.wikipedia.org/wiki/Steinhart-Hart_equation

Thermistor manufacturers don't always provide users with Steinhart-Hart coefficients for their sensors; they may simply provide resistance versus temperature tables. In the case of a manufacturer-provided table, it's not immediately obvious how to derive the necessary coefficients. Or, the user may want to perform self-validation of thermistors by measuring the resistance at several known temperature points and use this data to derive the Steinhart-Hart coefficients. To speed up the process, there are several Steinhart-Hart calculators online which allow you to enter the temperature and resistance values and then generate the coefficients. You'll find a link to our own online calculator, along with an example table, at the end of this article.

## Deriving Steinhart-Hart Coefficients for Thermistor Calibration

In cases where the Steinhart-Hart coefficients are not provided by your thermistor manufacturer or if you are doing thermistor calibration, you can derive them yourself. First, you'll need three accurate resistance values (either from a table or measured) at three known temperatures and then insert them into the formula to derive the A, B and C coefficients.

The Steinhart-Hart equation is commonly defined as

$$\frac{1}{T} = A + B\ln(R) + C(\ln(R))^3$$

where

- **T** is the temperature (given in kelvins);
- **R** is the resistance at T (given in ohms);
- **A**, **B**, and **C** are the Steinhart-Hart Coefficients which differ according to your thermistor model/type and its particular temperature range; and
- **Ln** is the natural logarithm.

The equation is sometimes presented as containing a $(\ln(R))^2$ term, but this does not significantly improve the conversion accuracy.

To find the Steinhart-Hart coefficients, you need to know at least three operating points. For this, we use three values of resistance data for three known temperatures.

$$\begin{cases} A+(\ln R_1)B+(\ln R_1)^3 C=\frac{1}{T_1} \\ A+(\ln R_2)B+(\ln R_2)^3 C=\frac{1}{T_2} \\ A+(\ln R_3)B+(\ln R_3)^3 C=\frac{1}{T_3} \end{cases}$$

After inputting the values for $R_1$, $R_2$, and $R_3$ giving resistance at the temperatures at $T_1$,$T_2$, and $T_3$ (in degrees Kelvin), you can determine the Steinhart-Hart coefficients A, B, and C:

$$L_1=\ln(R_1)\, L_2=\ln(R_2) \text{ and } L_3=\ln(R_3)$$

$$Y_1=\frac{1}{T_1},\ Y_2=\frac{1}{T_2} \text{ and } Y_3=\frac{1}{T_3}$$

$$\gamma_2=\frac{Y_2-Y_1}{L_2-L_1}\ \gamma_3=\frac{Y_3-Y_1}{L_3-L_1}$$

$$\Rightarrow C=\left(\frac{\gamma_3-\gamma_2}{L_3-L_2}\right)(L_1+L_2+L_3)^{-1}$$

$$\Rightarrow B=\gamma_2-C\left(L_1^2+L_1L_2+L_2^2\right)$$

$$\Rightarrow A=Y_1-\left(B+L_1^2C\right)L_1$$

If instead you want to find the resistance of a thermistor given its temperature, you must use the inverse of the Steinhart-Hart equation:

$$R=\exp\left(\sqrt[3]{x-y}-\sqrt[3]{x+y}\right)$$

where

$$y=\frac{A-\frac{1}{T}}{2C}, \text{ and}$$

$$x=\sqrt{\left(\frac{B}{3C}\right)^3+y^2}.$$

Our engineers developed a Steinhart-Hart thermistor coefficient calculator in the form of an Excel spreadsheet that does this automatically. Figure 2 shows an example of how to enter your actual temperature in Celsius and Kelvin (Col. B and C) and your sensor's resistance (Col. D) at 3 reference points (T1-T3) to derive the 3 Steinhart-Hart coefficients (A, B, C).

You can obtain a copy of this spreadsheet by visiting https://dataloggerinc.com/wp-content/uploads/2019/08/steinhart_hart_calculator_2019.xlsx.

---

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www.dataloggerinc.com

*This article was previously released as a white paper on the Data Logger website. To view this and other white papers, visit: https://dataloggerinc.com/resources/white-papers/.*

| | tactual in C | tactual in K | Resistance | Tcalc | | Y | R | L |
|---|---|---|---|---|---|---|---|---|
| T1 | 10 | 283 | 1991.4 | 283 | | 0.003534 | 1991.4 | 7.596593 |
| T2 | 60 | 333 | 248.7 | 333 | | 0.003003 | 248.7 | 5.516247 |
| T3 | 122 | 395 | 37 | 395 | | 0.002532 | 37 | 3.610918 |
| | | | | | | | | |
| | | | | | | G2 | 0.000255037 | |
| | | | | | | G3 | 0.000251381 | |
| | | | | | | | | |
| | | | Steinhart-hart | Coefficients | | C | 1.14745-E07 | |
| | | | | | | B | 0.000240116 | |
| | | | | | | A | 0.001659205 | |

Figure 2. Downloadable spreadsheet to help calculate Steinhart-Hart coefficient.

# Selecting a Reputable Proficiency Test Provider

Christopher L. Grachanen

## Forward

A proficiency test (PT) is a blind test to participants that is intended to prove or disprove participant's measurement or testing competence. Any action that breaks the integrity of that process ultimately destroys the value the PT is intended to provide. It starts with selecting a reputable provider: one who adheres to ISO/IEC 17043 and ISO/IEC 13528; one who has invested in the properly qualified staffing to manage the PT process; one who has built the necessary safeguards into their PT process to preserve integrity; one who will help ensure a laboratory receives constructive feedback throughout their PT participation providing a cornucopia of opportunities to verify and improve laboratory operations and avoid potential pitfalls.

## Provider Services

Like most consumer services, proficiency test providers differ in their scope, quality, and faithfulness (integrity) in providing required services. For providers, the following are fundamental services to be performed congruent with industry accepted practices:

- Development and dissemination of test plans and instructions
- Acquisition of participants' test data
- Analysis of participants' test data
- Analysis evaluation and results reporting

Industry accepted practices for providers are given in ISO/IEC 17043, Second edition 2023-05, *Conformity assessment – General requirements for the competence of proficiency testing providers*, used in conjunction with ISO/IEC 13528, *Statistical methods for use in proficiency testing by interlaboratory comparison*. ISO/IEC 17043 is characteristically used in assessing providers for accreditation. Providers are accredited by accreditation bodies such as the American Association for Laboratory Accreditation (A2LA) which denotes accreditations as:

> *Accreditation is synonymous with both the quality and competence of an organization, based on international standard(s). Accreditation refers to the recognition given to an organization by an authoritative body such as A2LA. It is a process by which an authoritative body gives formal recognition that a Conformity Assessment Body (CAB) fulfills specified requirements and is competent to carry out specific tasks. Accreditation is the most appropriate way to ensure an organization's competence in performing a specified task.*

ISO/IEC 17043 denotes PTs as:

> *Proficiency testing (PT) is widely recognized as an essential tool for demonstrating the competence of conformity assessment bodies. PT can provide evidence of competence and it can be an indicator of an underlying or emerging problem. This document is intended to promote confidence in the operations of PT providers. It contains requirements for PT providers to enable them to demonstrate that they operate competently and can generate valid evaluations of participant performance.*

PTs determine laboratory performance by means of comparing and evaluating calibrations or tests on the same or similar items or materials by two or more laboratories in accordance with predetermined conditions.

This paper will focus on ISO/IEC 17043 compliance as related to topics to consider when selecting a provider. Documented evidence is deemed essential for determining a provider's successful compliance. Provider advertisements, promotions and customer correspondence should always be delivered congruently within the context of successful compliance... this cannot be overly emphasized.

## Provider Considerations

Essentially the main reasons laboratories participate in PTs are:

- Accreditation Requirements – By far the biggest reason
- Evaluation and Improvement of current processes
- Gain confidence in the ability to provide valid results
- Simply because it is good laboratory practice

ISO/IEC 17043 lists servals reasons why laboratories engage in PT's. First and foremost is to evaluate the performance of laboratories in regard to specific measurements in order to identify differences in measurements results. These differences may or may not be satisfactory given each laboratory's uncertainties and the known value of the measured PT artifact. Other reasons given are Identification of measurement problems, validation of measurement uncertainty claims, assigning values to reference materials, education of participating laboratories based on comparison outcomes, and additional user confidence in their measurement and test results.

Regarding laboratory accreditation and PTs, the International Laboratory Accreditation Cooperative (ILAC), ILAC P-9 denotes several requirements associated with obtaining laboratory accreditation such as demonstrated competency i.e. satisfactory PT results, minimum PT activities required for accreditation, and PT testing policies, procedures, and plans as well as identifying alternatives to proficiency testing.

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*, specifies laboratories shall monitor performance by comparison with other laboratories where available and appropriate. This monitoring shall be planned, reviewed and include, but not be limited to, participation in PTs and/or participation in interlaboratory comparisons other than proficiency testing. ISO/IEC 17025 contains the following note:

> *NOTE – ISO/IEC 17043 contains additional information on proficiency tests and proficiency testing providers. Proficiency testing providers that meet the requirements of ISO/IEC 17043 are considered to be competent.*

PT providers do not request participants to make a statement of "Pass – Fail" relative to a certain specification. Rather, providers are looking to see if a participant is making a measurement that is in acceptable agreement via statistical means (Z-Score[1], En[2], etc.), with the other participants making like measurements.

Participation in PT services provides documented evidence of the participant's ability to perform testing within acceptable criteria as defined in ISO/IEC 17043 and is an accepted means to substantiate the participant's competence to perform a test. Providers essential services must ensure:

- Test plans and instructions are fit for purpose, provide sufficient guidance and are accurate.
- Acquisition of customer data is protected, standardized and error checked
  - Ensuring the confidentiality of client data is paramount. providers must implement robust data protection measures to safeguard sensitive information. Often, providers will use non-disclosure agreements (NDAs) to formalize their commitment to confidentiality.
- Analysis of customer data is appropriate, non-biased and provides meaningful insight
  - Providers should conduct tests and analyze data without bias. This impartiality is crucial for producing accurate and reliable results that customers can trust.
- Analysis evaluations (methodologies) are industry accepted, performed competently, and validated
  - Providers must be accountable for their methods and results. This means being open to audits, peer reviews, and providing customers with the necessary information to understand and verify the processes used.
  - Providers should only employ qualified and competent staff. This ensures that all aspects of the analysis evaluation are conducted by individuals with the necessary expertise and knowledge.
- Evaluation reporting is confidential, impartial and easily understood from a layman's perspective
  - Transparent reporting practices are essential. This includes providing detailed and understandable reports that clearly communicate the results and their implications.

When shopping around for a PT provider, what are some of the steps one should consider helping to ensure rendered services meet your laboratory's needs and provide reported results that are accurate and truthful? Some helpful steps are:

- Determining if a provider is accredited, this is an assurance that the provider has demonstrated compliance to ISO/IEC 17043. Using an accredited provider assures an assessor that a laboratory accreditation required PTs have been administered, evaluated, and reported per industry accepted practices.
- Determining if a provider provides tests which are applicable and beneficial to one's laboratory activities.
- Querying how long the provider has been providing services.
- Reviewing list of companies that have used their services.
- Reviewing any customer testimonials.
- Querying the provider if it has ongoing training and development for their staff to maintain and enhance their skills and knowledge.
- Determining a provider's non-profit status. Many reputable proficiency testing providers operate as nonprofit organizations. This structure helps ensure that their services are driven by the goal of maintaining high standards rather than generating profit, reducing potential conflicts of interest.
- Determining if a provider has a system in place to gather and act on feedback from customers to address any issues promptly.

These beneficial steps help to filter out potential PT provider candidates that do not meet your laboratory's needs as well as bringing to light any issues needing additional fact finding. The above steps provide a top-level screening of provider candidates which can then be evaluated for additional salient criteria such as confidentiality and impartiality. Confidentiality safeguards regarding customer data and evaluation reporting is clearly defined in ISO/IEC 17043 section 4.2 with sub-sections 4.2.1 and 4.25 especially noted:

*4.2.1 The PT provider shall be responsible, through legally enforceable agreements, for the management of all information obtained or created during the performance of PT activities. The PT provider shall inform the client in advance of the information it intends to place in the public domain. Except for information that the client makes publicly available, or when agreed between the PT provider and the client, all other information is considered proprietary information and shall be regarded as confidential.*

*NOTE The terms "proprietary" and "confidential" do not preclude publication for academic and new insights of information purposes, provided that neither clients nor participants can be identified, including by inference.*

*4.2.5 The identity of participants in a PT scheme shall be confidential and known only to persons involved in the operation of the PT scheme, unless the participant or the customer waives confidentiality.*

It can be easily ascertained that unauthorized disclosure of a participant's data may reveal insight as to a customer's testing methodology or capability which may be proprietary, confidential, or otherwise inappropriate to disclose. Unauthorized disclosure of evaluation results has the potential to be negatively used by a laboratory's competition to gain unfair advantage over a laboratory either publicly or via word of mouth. It is prudent to take the time to understand a provider's confidentiality policy prior to utilizing their services.

Provider impartiality directly impacts the integrity of rendered services. ISO/IEC 17043 addresses impartiality as follows:

*4.1 Impartiality*

*4.1.1 PT activities shall be undertaken impartially.*

*4.1.2 The PT provider shall be structured and managed so as to safeguard impartiality.*

*4.1.3 The PT provider shall be responsible for the impartiality of its PT activities and shall not allow commercial, financial or other pressures to compromise its impartiality.*

*4.1.4 The PT provider shall monitor its activities and its relationships to identify threats to its impartiality. This monitoring shall include the relationships of its personnel.*

*NOTE A relationship can be based on ownership, governance, management, personnel, shared resources, finances, contracts or marketing (including branding). Such relationships do not necessarily present a PT provider with a threat to impartiality.*

*4.1.5 If a threat to impartiality is identified, its effect shall be eliminated or minimized so that the impartiality is not compromised.*

Without impartiality, the integrity of provider services may be compromised. Lack of objectivity, e.g. compromised neutrality, due to financial and/or reputational interests can influence a provider's judgment and actions. The mere perception of a conflict of interest can damage the credibility of a PT as well as PT participants in terms of a perceived rigged, (i.e. predetermined), outcome.

A laboratory's failure to successfully pass a PT can be viewed as an embarrassment for laboratory personnel. More importantly, it could lead to negative consequences such as potential product recalls, re-testing costs, negatively impacting reputations, etc. and, in some cases, failure is to be avoided at all costs. These scenarios can result in pressure on the provider to manipulate test data to avoid negative consequences for the participant. Providers must never insinuate or promise to compromise PT data integrity to entice new customers or to satisfy and retain existing customers.

Lastly one other impartiality issue has to do with laboratory accreditation assessors advocating the use of a particular PT provider. Per industry accepted guidelines, assessors cannot suggest, recommend, provide incentives, or inflict retaliatory measures regarding the use or non-use of a particular PT provider.

Compromised PT provider integrity typically manifests as:

- Doubts about the validity and reliability of the tests, undermining the fundamental purpose of a PT
- Reputational damage if conflicts of interest are determined

## Summary

Because there is no guarantee that all PT providers conform to a high level of performance, consumers are advised to do their homework when selecting a PT provider. Take the time to ask tough questions. Take the time to look at the PT provider's ISO/IEC 17025 accreditation and their validation reports to ensure they are following ISO/IEC 17043 requirements and adhere to ISO/IEC 13528 standards for the statistical methods implemented in their calculations. Consumers are encouraged to report any noncompliance of industry accepted practices as well as any impartiality issues such as insinuations or offers to influence a PT outcome via appropriate channels such as the BBB, the provider's accreditation body, or other avenues. It is up to consumers to demand professionalism of the highest caliber and integrity beyond reproach. Think of it this way: The assessors are the scouts looking to ensure all of the controls are in place for professional services to be provided. The consumers are the watchdogs that have the power to verify those professional services have been delivered consistently and to report violations so that all consumers are protected.

## Endnotes

[1] Z-Score is a statistical measurement of a score's relationship to the mean in a group of scores. $|z| \leq 2$ = satisfactory performance, $2 |z| \geq 3$ = unsatisfactory performance

[2] En is a statistic that is derived by dividing the difference between test data and assigned data by the square root of the sum of the squares (RSS) of test data uncertainty and assigned data uncertainty. $|En| \leq 1$ = satisfactory performance, $|En| > 1$ = unsatisfactory performance

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# IECEE Ruling and Its Impact on Internal Calibration Laboratories

Tim Osborne
A2LA WorkPlace Training

"... is traceable to NIST." That phrase either comforts or convicts. If nothing else, it makes most calibration laboratories cringe and accreditation bodies... you can add the verb. From MIL STD 45662A to all things ISO today, people in the US and abroad have depended upon the US National Institute of Science and Technology (NIST) for their source of metrological traceability.

In 2003, four years after ISO/IEC 17025 became a standard, I attended a measurement science tradeshow in Berlin, Germany. Tasked to identify the latest trends and opportunities, I was the only US citizen in the crowd, an unfamiliar face in this community, and recognized by only one person from the UK in a sea of measurement experts from national metrology institutions (NMIs) and senior industry representatives.

One of the chief challenges at this forum focused on the lack of NIST traceable (standard) reference materials available to industry. I made a drastic mistake by saying that many other NMIs exist in the world and that, like the US, they should be listening to their respective communities and developing traceability solutions or, at a minimum, collaborating with other NMIs to create solutions. It was the shot heard around the world. The problem is, the bullet is still traveling, but use of the traceability phrase and dependence upon NIST alone are losing speed.

One area where corrections are being made in the measurement community is the IEC System for Conformity Assessment Schemes for Electrotechnical Equipment and Components (IECEE). It is enforcing an accurate understanding and implementation of metrological traceability in the certification industry.

In this article, we aim to identify why and in what ways the IECEE changed its ruling on internal calibrations, share some of the major pros and cons of performing internal calibrations, and when testing laboratories must comply with the IECEE changes.

In June of 2023, the IECEE issued a ruling targeting internal (captive or embedded) calibration laboratories within testing laboratories that evaluate product conformity to certification schemes. Simply stated, the rule requires internal calibration laboratories to become accredited or all calibrations be performed by accredited external suppliers. Why? To reduce risk to the consumer, especially when certifying a product achieves certain objectives, i.e., safety, quality, efficiency, or performance.

IECEE's ruling was based upon trending certification body testing laboratory (CBTL) nonconformities focused on a breakdown of the understanding behind IECEE Committee of Testing Laboratories (CTL)'s operational document OD 5011 titled, "Requirements for Traceability of Calibrations and Calibration Intervals [2]." The breakdown in understanding was realized through assessments and peer evaluations in three specific areas within the definition of metrological traceability (quotations added to emphasize the areas of weakness):

1. A "proper" estimation (evaluation) of the measurement uncertainty [7];
2. traceability of the SI through NMIs or "competent" laboratories or producers, use of certified reference materials [6] or consensus methods; and
3. "valid" measurement methods (procedures).

It might be postulated that IEC's relationship to IAF (International Accreditation Forum) and ILAC (International Laboratory Accreditation Cooperation) through the tripartite agreement and ancillary documents (ILAC P10 [3], and P14 [4]) led to the discovery of this trend and assisted to drive change.

Below are excerpts from the OD as a point of reference.

In clause 8.1.1 of OD 5011 it states that:

*Calibrations shall be regarded as being traceable if the calibrations are done by following the requirements of ISO/IEC 17025, "General requirements for the competence of testing and calibration laboratories" and by one of the following:*

*a) The instrument was calibrated by a National Metrology Institute.*

*b) The instrument was calibrated by an ISO/IEC 17025 accredited calibration laboratory.*

*c) The instrument was calibrated by an internal or external calibration laboratory assessed on an annual basis, by the CBTL, NCB or responsible department within the CBTL or NCB, and found to comply with the requirements of ISO/IEC 17025. The assessments shall be conducted by a qualified ISO/IEC 17025 assessor or metrologist.*

*For specialized instruments where no accredited calibration laboratory is available, the instrument may be calibrated by the instrument manufacturer provided that the calibration standards used are traceable to national or international units of measurement, the traceability chain is identified and an estimation of uncertainty of measurement is included on the calibration certificate.* [2]

In clause 8.1.2, OD 5011 defines metrological traceability similarly to that of the International Vocabulary of Metrology, VIM (JCGM 200 [8] or ISO/IEC Guide 99 clause 2.41), which the latter defines as: "The property of a measurement result whereby the result can be related to a reference through an unbroken chain of calibrations, each contributing to the measurement uncertainty [2]."

Figure 1 below specifically illustrates the traceability of the root terms and examples that lie within them, where appropriate. It should be used to

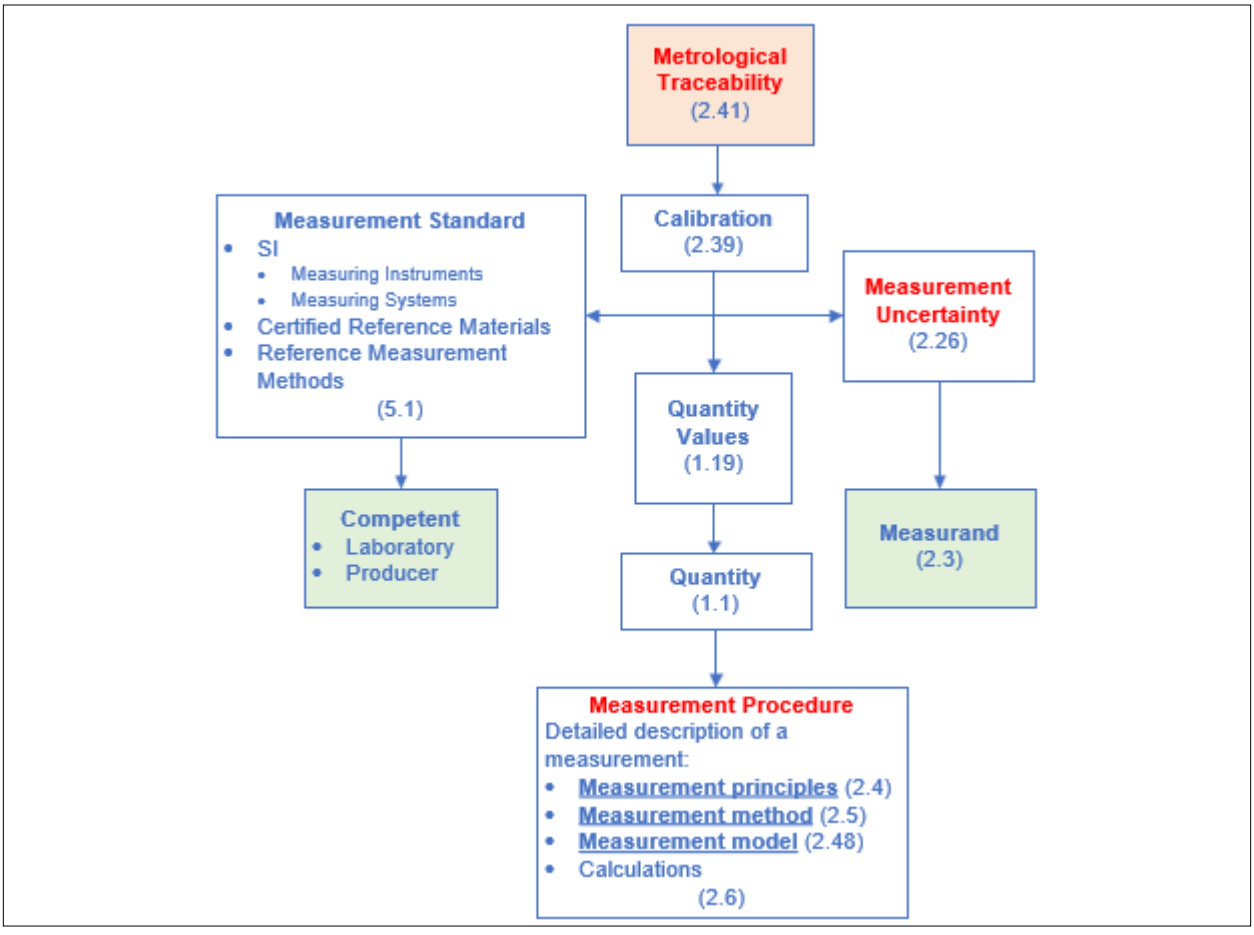


Figure 1. Metrological traceability base terminology [8]

gain an appreciation and understanding of and the potential impact on the consumer from the findings by the IECEE.

It is important to remember the role of the IECEE and its impact on society, specifically to benefit and protect the consumer of electrical or electronic products. Its schemes address the safety, quality, efficiency and overall performance of components, devices and equipment for homes, offices, workshops, health facilities among others. In all, IECEE covers 23 categories of electrical and electronic equipment and testing services. Consumers are reluctant to purchase cell phones that inadvertently cause an anomaly with a pacemaker or an EV's computer system. The sole purpose of measurement science is to mitigate risk, e.g., the risk of failure to meet the objectives of the product. This is the sole reason for its decision to launch this rule and implement an action plan to release the requirements to industry. Therefore, testing laboratories should carefully consider the risks associated with internalizing the internal calibration of their own test equipment. The bottom line is that the cost to implement must be less than the cost to outsource.

The primary motive for business is that it must serve the stakeholders well. Internalizing calibration service for its own test equipment has several benefits. First, consideration of leadership should be the cost of asset utilization or velocity. The downtime from outsourcing assets to the original equipment manufacturer or accredited 3rd party testing laboratory can be devastating to a testing laboratory. This was painfully realized during the COVID-19 pandemic where vendor turnaround times were not weeks but months. Supply chain interruptions can and does have a significant impact to manufacturers and, subsequently, consumers. By internalizing critical calibrations, the testing production turnaround is drastically reduced and certified product to the consumer more predictable because of uninterrupted testing.

Another benefit to internalizing calibrations is the provision of other avenues of promotional growth within the business, especially for those who are inclined to quality and measurement science. Investing in staff growth through sound training and consulting strengthens the company and loyalty becomes a key successor factor for business.

A third benefit is to reduce asset maintenance costs. Internalizing the calibrations and maintenance and performing them at points and times necessary to support testing is potentially more cost effective than outsourcing.

On the other hand, it is important for the business leader to understand both short-term and some of the long-term negative impacts of internalizing calibrations. The first is hiring or training the staff called upon to provide the calibrations who not only understand the measurement process to ensure the calibrations accurately test the test instruments, but also know when a measurement is not suitable and to troubleshoot. In a season where finding competent calibration engineers or technicians is difficult at best, so is finding an institution that can train on good measurement principles and effective quality control.

Second, acquiring higher echelon measurement standards comes at a higher acquisition and maintenance cost. For this article, higher echelon (precision and accuracy) standards are termed reference standards, and is the equipment used to calibrate the test equipment. Sometimes these reference standards are called calibration standards. Depending upon the measurand, the reference standard might require more precise environmental controls to maintain its own operational performance specifications which might lead to increased facility costs.

Many companies resort to developing the calibration methods internally. With AI at our fingertips and some procedures available on the web, internal resources already taxed with several other responsibilities, cobble together a procedure that seems reasonable without validating it to ensure it meets the needs of the testing laboratory or the certification body. Having personally tested ChatGPT 4.0, with writing procedures, calculating measurement uncertainty, and diagraming processes, it can and does yield errors and all output should be technically scrutinized. However, with the proper training and consulting, a testing laboratory can overcome many of these challenges. As was demonstrated by the IECEE ruling, sometimes change requires a mandate to change.

According to the Certification Management Committee (CMC), a governing group within the IECEE, it was decided that internal calibrations by

an internal laboratory will have to be accredited or the calibrations should by outsourced to accredited organizations (outsourced) for the following laboratory types:

- Certification Body Testing Laboratories (CBTL)
- Specialized Testing Laboratories (SPTL)
- Subcontractors, and
- Customer Testing Facilities (CTF; all levels)

The effective implementation dates are as follows:

- New applicants: 2024-01-01
- Existing IECEE recognized labs: 2026-12-31

Additional discussions will be held at the CTL level (Committee of Testing Laboratories), a subcommittee of the CMC, to revise OD-5011 [2] and probably add exceptions for equipment that could be subject to verification instead of calibration (with wording/definition to be provided for verification vs calibration).

A question that has been often asked is, "Do you think this new ruling will impact other industries or areas of conformity assessment?" The truth is that we don't know. However, we must remember that part of IECEE's mission is to improve the safety of the products it certifies through its schemes. We believe, but cannot confirm, that areas where risk (safety) to the consumer, to animals, or environment could be negatively impacted, this approach might cascade to the revision of international standards as well as accreditation policies and requirements. In some of the ISO standards we have seen, in draft form, climate change statements are making their way into the fabric of ISO culture and resulting documents. If you recall from the opening statements, there is an MOU [1] with IEC, IAF, and ILAC. Since there is a documented memorandum between these organizations, there is a definite probability that conversations that happened in the IECEE CMC (Certification Management Committee) in 2023 will likely happen in the ISO TAGs and ILAC. The outcomes are "to be determined."

## References

[1] IEC – ILAC – IAF Memorandum of Understanding
[2] IEC OD 5011 Ed 1.3 Committee of Testing Laboratories (CTLs) Requirements for Traceability of Calibrations and Calibration Intervals
[3] ILAC P10 ILAC Policy on Metrological Traceability of Measurement Results
[4] ILAC P14 ILAC Policy for Measurement Uncertainty in Calibration
[5] ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories
[6] ISO 17034, General requirements for the competence of reference material producers
[7] JCGM 100, Evaluation of measurement data – Guide to the expression of uncertainty in measurement (GUM)
[8] JCGM 200, International vocabulary of metrology – Basic and general concepts and associated terms (VIM)

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Tim Osborne is the Vice President of A2LA WorkPlace Training, a not-for-profit business that provides training and consulting services focusing on measurement science, quality management systems, and supporting processes. Tim, sponsored by NCSL International and Trescal, served as a member of ISO WG 44 which updated the latest revision of ISO/IEC 17025.

### CPEM Launch of 6820T

Prescott, Ontario, July 11th, 2024 – President Ryan Brown and Vice President Alessio Pollarolo proudly unveiled Measurements International's groundbreaking achievement, the 6820T Tabletop Quantum Hall Resistance system, at the prestigious CPEM/NCSLI Conference in Colorado, held from July 8th to July 11th, 2024. Standing alongside the innovative device, they showcased its unparalleled capabilities and cutting-edge technology poised to redefine metrology standards worldwide.

The 6820T QHR system represents a leap forward in precision measurement. Operating flawlessly at 4 Kelvin with a magnetic field capacity of up to 5 Tesla, this system integrates the latest QHR Graphene Devices from RISE in Sweden. This collaboration has enabled Measurements International to offer customers not only the QHR value but also additional QHARS values including 100 Ω, 1 kΩ, and 10 kΩ.

"We are thrilled to introduce the 6820T Quantum Hall Resistance System, a testament to our commitment to innovation and excellence in metrology," said President Ryan Brown. "This system not only meets but exceeds the rigorous demands of our customers, ensuring accuracy and reliability in every measurement."

Vice President of Metrology, Alessio Pollarolo added, "With the incorporation of advanced QHR Graphene Devices, developed by RISE, we are setting new benchmarks in precision and performance. The 6820T QHR system is poised to revolutionize how industries approach metrological standards."

Measurements International remains dedicated to advancing technology and pushing the boundaries of metrology with each new release. The 6820T QHR system underscores their ongoing pursuit of excellence and leadership in the field.

For more information about the 6820T QHR system and Measurements International's innovative solutions, please visit https://mintl.com/products/quantum-hall-system/.

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### New Digital Pressure Gauge with Cloud Data Logging Software and Mobile Application

SAN LUIS OBISPO, CA – AMETEK STC and Crystal Engineering are proud to announce the release of the groundbreaking XP3i digital pressure gauge, an evolution of the renowned XP2i, designed to empower users with enhanced precision and unmatched connectivity. The XP3i Intrinsically Safe pressure gauge contains the features and functions that have made the XP2i an industry standard but now offers them with twice the accuracy and a Bluetooth connection. At 0.05% of reading, the accuracy of the XP3i opens it up to new applications previously unavailable to its predecessor. In addition, the XP3i is also fully temperature compensated from -20°C to +50°C. This is not just a general specification but individually documented on each XP3i gauge in the supplied ISO 17025 accredited calibration certificate - performed across the complete temperature range.

For customers seeking to create and maintain a comprehensive digital record of their pressure test, the XP3i introduces the upgraded DataLoggerXP mode. With internal storage capable of collecting over 200 million data points, professionals can effortlessly download the stored data using Crystal's new cloud-based software or mobile application.

In addition to the new gauge, Crystal Engineering introduces the CrystalConnect mobile application, a powerful tool that utilizes Bluetooth technology to communicate with the XP3i seamlessly. This eliminates the need for cumbersome cable connections, offering technicians the flexibility to connect to an XP3i in potentially hazardous environments, hard-to-reach locations, or from the comfort of a control room or vehicle, even in inclement weather conditions.

For users requiring the XP3i's intrinsic safety, a Bluetooth connection allows the gauge to remain installed in the process, avoiding removing it from the hazardous location before connecting.

Crystal Engineering presents the CrystalControlWeb cloud-based software, the final piece of the XP3i data logging program. This software allows users to effortlessly upload their stored data from the XP3i. If a wireless connection is desired, CrystalControlWeb allows users to manually upload files wirelessly downloaded to the CrystalConnect mobile application.

Once information is uploaded, the user can access a full suite of features and functionality to analyze, share, and store log files. CrystalControlWeb is accessible from


any web browser worldwide, and users can connect via computers or mobile devices. Additionally, the ability to share data within organizations streamlines collaboration, making it easy to access data across the globe. Some CrystalControlWeb features include:

- Export data as .csv or .pdf
- Upload data from any PC
- Customizable graphing and data manipulation
- Logged data management
- Secure PDF exports with digital signatures
- Device configuration

CrystalControlWeb allows users to comprehensively understand their data, systems, and processes. Visit http://www.crystalcontrolweb.com for a demonstration of the subscription model and a free trial.

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### Thunder Scientific Corporation Model 1220 Humidity Generation System

Thunder Scientific's product line continues to deliver outstanding performance while delivering some of the tightest uncertainties available in today's market by utilizing the fundamental "two-pressure" principle. With the discontinuation of Thunder Scientific's Model 1200 humidity generation system, many users have been left without a suitable system that is both mobile and capable of delivering tight uncertainties required to support their metrology programs. To meet this continuing need, Thunder Scientific is pleased to announce the newest addition to its product line: the Model 1220 Humidity Generation System.

The Model 1220 takes many of the features found in our popular Model 2500ST and 2900 humidity generation systems and combined them into a smaller, more mobile system.

Key Advantages of the Model 1220:

- Includes Calibration Traceable to SI
- RH Uncertainty: 0.6% of Reading (Range: 10 to 95 %RH)[1]
- Temperature Uncertainty: 0.031°C (Range: 5 to 60 °C)[1]
- Frost Point/Dew Point Uncertainty: 0.05 °C FP (Range: -22 to 0 °C FP)/0.08 °C DP (Range: 0 to 50 °C DP)[1]
- No Refrigerants – Thermoelectric Cooling/Heating
- Test Chamber Dimensions: 8″ x 8″ x 8″
- Multi-point Touch Display
- Easy to Use and Can be Calibrated by the User
- ControLog Embedded Automation Software
  - Data automatically retrieved and stored in a spreadsheet style format
  - Multiple graphs for visual representation of data
  - Auto Profiling feature for automation
  - Customizable device connections for ASCII based serial devices
- Physical Dimensions: 16.1″ (H) x 27.9″ (W) x 19.2″ (D)
- Input Power of 100 to 240 VAC, 50/60 Hz, at 5 amps

All Specifications are preliminary and subject to change.

For more information about the Model 1220, visit www.thunderscientific.com, and to take advantage of discounted introductory pricing, request a quote by sending an email to: sales@thunderscientific.com.

1 Uncertainty values represent an expanded uncertainty using a coverage factor, k=2, at an approximate level of confidence of 95%.

# Metrology Digitalization Workshop

Michael L. Schwartz
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Last week, I had the privilege of presenting at NCSLI's first annual "Metrology Digitalization Workshop," a significant milestone in our field. I couldn't help but reflect on the journey we've taken since 2002, when my first abstract on "Creating an XML Schema for Calibration Data Exchange" was rejected. NCSLI's paper selection focused more on measurement uncertainties and quality; software wasn't a focus back then. Fast forward to this year's NCSLI, where we held two panel sessions, multiple papers on digital metrology, and a full-day workshop, all centered on digital metrology. The progress is truly inspiring!

The full-day workshop focused on building a standardized model for digitalizing metrology and measurement-related data. So let me first begin with a short definition of the two:

**Digitalize** - is the process of converting analog data into a digital format.

**Digitalization** - is the broader process of using digital technologies to transform business processes and create new business models.

In essence, digitalization is the application and expanded use of digitized information to achieve strategic goals.

As part of the workshop, attendees broke off into small groups and brainstormed how they foresee the needs, changes, challenges, and goals for the future. We used a process called CATWOE, with two 20 minute breakout sessions, one in the morning and one in the afternoon.

**CATWOE** is a framework used to analyze and define business stakeholder perspectives. It stands for Customers, Actors, Transformation, Worldview, Owners, and Environment. By examining these elements, organizations can comprehensively understand the different viewpoints involved in a project or process. This holistic approach helps identify potential challenges, conflicts, and opportunities, ultimately leading to more informed decision-making and successful outcomes.

I was skeptical. Twenty minutes for something this complex was not enough time. What I didn't account for was that the 40-ish people in the room were some of the world's smartest metrologists and software engineers. The ideas and conclusions from the groups were amazing.

Summary of Requirements:

**Data Structures**

1. Establish clear taxonomies and protocols for data exchange.
2. Create standardized digital calibration certificates with traceability.

**Digital Signatures and Identifiers**

1. Implement persistent digital signatures for long-term data validity.
2. Create a common digital identifier system for IQI.

**Metadata**

1. Include detailed measurement metadata and traceability information.

**Interoperability Framework**

1. Enable data sharing through APIs and standard formats.

Recommendations Moving Forward:

**Strategy and Communication**

1. Develop clear marketing to highlight business value and ensure long-term success.
2. Foster collaboration, articulate value, and understand customer needs.
3. Adapt NMI and AB roles to digital transformation.

**Digital Transformation and Standards**

1. Create a digital transformation group within ILAC.
2. Embrace agile development, focusing on value and efficiency.
3. Harmonize standards while maintaining flexibility.
4. Leverage existing resources for digitalization.
5. Develop adaptable code and adopt digital identifiers.
6. Align taxonomy for consistent classification.
7. Ensure compliance with normative standards.
8. Integrate instrument specifications and traceability.
9. Create user-friendly software with validation tools.

My personal takeaway was that "metrology digitalization will happen in the next few years." So far, it has been a slow start; but it's on an exponential growth curve. Most importantly, the metrology-taxonomy work from the NCSLI Measurement Information Infrastructure (MII) & Automation Committee will be pivotal to the international effort to digitalize metrology.

To quote R. Buckminster Fuller, "You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete."

**Our current approach to metrology-related business is obsolete.** It's time to rethink and recreate a new model. I plan to be a driving force in the coming changes.

**This article was written with the assistance of Google's Gemini.*

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