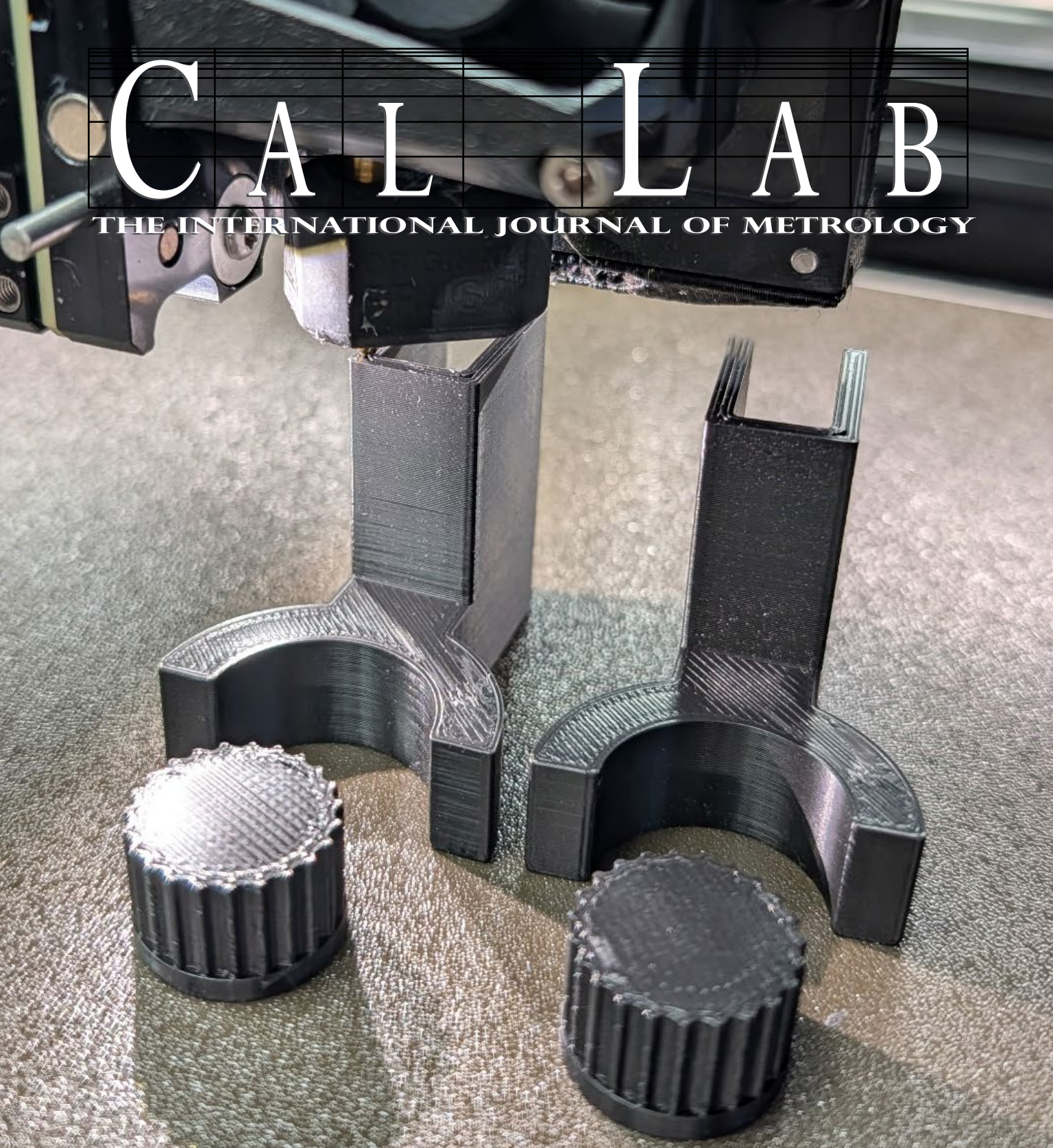
# CAL LAB

THE INTERNATIONAL JOURNAL OF METROLOGY



Beyond 4:1: What Calibration Ratios Were Meant to Do

Metrology for Newbs: Entering the Community, Not Just the Career

Resistance Decade Boxes – Where and How They are Used

2026
APRIL
MAY
JUNE

# PRECISION CURRENT INSTRUMENTATION AND CURRENT CALIBRATION

## DANISENSE HIGH PRECISION CURRENT TRANSDUCERS

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VOLUME 33, NUMBER 2

# FEATURES



# DEPARTMENTS



**ON THE COVER:** Custom Calibration Inc. — additive metrology in practice. The printed cradle holds tubular inside micrometers up to 40 inches parallel to a gauge-block stack during setting, killing the X/Y float and cosine error that creep in when the mic is held by hand. The printed knobs replace OEM gauge parts that aren't in stock or aren't made anymore. Two jobs from one printer: fixtures the market doesn't make at this size, and parts the supply chain can't deliver.

# CALENDAR

## UPCOMING CONFERENCES & MEETINGS

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

**Jun 7-12, 2026 IMS.** Boston, MA. The IEEE International Microwave Symposium (IMS) is the world's foremost conference covering the UHF, RF, wireless, microwave, millimeter-wave, terahertz, and optical frequencies. https://ims-ieee.org/

**Jun 8-11, 2026 European Test and Telemetry Conference.** Nürnberg, Germany. As a premier event in the test and telemetry field, ETTC brings together leading experts from the aeronautics, space, automotive, and defense industries. https://telemetry-europe.org/

**Jun 9-10, 2026 CEESI Ultrasonic Meter User's Conference.** San Antonio, TX. The CEESI USM Conference provides an opportunity for ultrasonic meter manufacturers and end users to discuss challenges in the hydrocarbon measurement industry. https://www.ceesi.com/Ultrasonic2026

**Jun 9-10, 2026 ITG/GMA Conference: Sensors and Measuring Systems.** Nürnberg, Germany. The "Sensors and Measurement Systems" conference, first held in 1982, is now the most important German-language scientific event in the field of sensor technology. The conference focuses on sensors and sensor systems for industrial use. https://sensoren2026.de/

**Jun 9-11, 2026 SENSOR+TEST.** Nürnberg, Germany. SENSOR+TEST is the world's leading forum for sensor, measurement and testing technology. https://www.sensor-test.de/

**Jun 23-25, 2026 NAPT Regional ILC Event.** Minneapolis, MN. NAPT Regional events give organizations the opportunity to participate in Inter-Laboratory Testing schemes that cannot be shipped from lab to lab, for the following instrumentation: Scales, Balances, Surface Plates, Optical Comparator, CMM, Vision System and Hardness Testers. https://proficiency.org/regional-ilcs/

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# EDITOR'S DESK

**Trust in Metrology**

We start this issue with a Metrology 101 by Tray Eason on fixed ratios, "Beyond 4:1: What Calibration Ratios Were Meant to Do," and why they do not control decision risk. He clearly defines and explains the origins of ratios and what modern calibration uses to control decision risk. These definitions and guidelines lay the groundwork for the calibration technician's understanding of their role in the lab and the wider metrology community.

Next, Joseph Rindone contributed a paper for "newbs" about the community of metrology, based on an understanding of trust. Coincidently (or maybe not--I didn't ask Joseph), the theme for World Metrology Day 2026 (worldmetrologyday.org) was "Metrology: Building Trust in Policy Making."

While the first article hints at the practical nature of trust through risk, competence, and traceability, the second defines trust in metrology outright. Like a civics course in primary and secondary school, the topic of ethics in metrology can be dropped out of a technician's schedule for the sake of efficiency. In fact, Joseph's article might be a first or one of the few contributions to *CAL LAB* on the subject. As a calibration instructor, the topic of ethics and trust stands out as fundamental to a technician's training, so we're very pleased to publish Joseph's contribution.

Finally, we have Jesse Morse's paper, "Resistance Decade Boxes – Where and How They are Used," introducing the reader to the humble decade box, its evolution and its uses in manufacturing and the electrical calibration lab. He shows how a modern decade box, using a binary based decade system, introduces less chance for error and enables automation. They can also be designed with specific applications in mind, making them indispensable for a wide range of industries.

I hope you'll find something invaluable in this issue and thank you for reading *CAL LAB*!

Happy Measuring,

Sita Schwartz

# CALENDAR

**Jul 7-8, 2026 Accreditation Matters.** Melbourne, Australia. Accreditation Matters 2026 is for Everyday Heroes, the people in Standards, Measurement, Testing, Accreditation and Conformity Assessment and those working in the fields of quality, trust and public safety. This conference will provide two days of practical learning, shared expertise, and strategic insight. https://www.accreditationmatters.com.au/

**Jul 20-24, 2026 CMSC.** Dallas, TX. The Coordinate Metrology Society Conference (CMSC) is the world's premier event for Measurement Technology Professionals sponsored by the Coordinate Metrology Society. https://www.cmsc.org/

**Jul 21-23, 2026 NAPT Regional ILC Event**. Greensboro, NC. NAPT Regional events give organization the opportunity to participate in Inter-Laboratory Testing schemes that cannot be shipped from lab to lab. NAPT is conducting on-site ILC Testing for the following instrumentation: Scales, Balances, Surface Plates, Optical Comparator, CMM, Vision System and Hardness Testers. https://proficiency.org/regional-ilcs/

**Jul 25-29, 2026 NCSLI Workshop & Symposium.** Kansas City, MO. Join measurement science professionals for two days of tutorials, three days of keynotes, and two days of technical sessions. This year, we celebrate "A Change in Time!" https://ncsli.org/

**Aug 31-Sep 3, 2026 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://conferences.ieee.org/conferences_events/conferences/conferencedetails/53493

**Sep 6-11, 2026 CPEM.** Madrid, Spain. The 35th edition of the Conference on Precision Electromagnetic Measurements is the most important scientific and technological conference in the domain of electromagnetic measurements at the highest accuracy levels. https://cpem2026.com/

# CALENDAR

**SEMINARS & WEBINARS: Dimensional**

**Jun 11-12, 2026 Gage Calibration & Repair Training.** Madison, WI. IICT Enterprises. Enhance your career knowledge in Metrology with this in-depth Gage use, Calibration, and Repair course. Recommended for people interested in pursuing the ASQ CCT Exam. https://calibrationtraining.com/calibration-metrology-training-events/

**Jun 15, 2026 EDU-101: Introduction to Dimensional Metrology Hand Tools I.** Aurora, IL. 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://mitutoyo.com/training-education/

**Jun 16, 2026 1-Day Virtual ISO Gage Calibration & Repair Training.** IICT Enterprises. Enhance your career knowledge in Metrology with this in-depth Gage use, Calibration, and Repair course. Recommended for people interested in pursuing the ASQ CCT Exam. https://calibrationtraining.com/calibration-metrology-training-events/

**Jun 16-17, 2026 EDU-113: Dimensional Gage Calibration.** Aurora, IL. Mitutoyo America's Gage Calibration course is a unique, active, educational experience designed specifically for those who plan and perform calibrations of dimensional measuring tools, gages, and instruments. https://mitutoyo.com/training-education/

**Jun 18, 2026 1-Day Virtual ISO Gage Calibration & Repair Training.** IICT Enterprises. Enhance your career knowledge in Metrology with this in-depth Gage use, Calibration, and Repair course. Recommended for people interested in pursuing the ASQ CCT Exam. https://calibrationtraining.com/calibration-metrology-training-events/

**Jun 18-19, 2026 EDU-302: Small Tool Repair Course.** Aurora, IL. Mitutoyo. This hands-on and interactive session is designed to support technicians who are responsible for the regular maintenance, repair, and calibration of common precision measuring gages. https://mitutoyo.com/training-education/

# CALENDAR

**Jun 23-25, 2026 EDU-105: Introduction to Dimensional Metrology Hand Tools V.** Lakeland, FL. Mitutoyo. EDU-105 is a three-day class for entry-level team members who need to learn the fundamentals of the steel rule, caliper, micrometer, pin gage, gage block, surface plate, height gage, indicator and stands, angle block, v-block, sine bar, depth gages, telescoping gages, holtest gages, bore gages, and thread gages. https://mitutoyo.com/training-education/

**Jun 24-25, 2026 Gage Calibration & Repair Training.** Atlanta, GA. IICT Enterprises. Enhance your career knowledge in Metrology with this in-depth Gage use, Calibration, and Repair course. Recommended for people interested in pursuing the ASQ CCT Exam. https://calibrationtraining.com/calibration-metrology-training-events/

**Jul 13-14, 2026 EDU-104: Intro to Dimensional Metrology Hand Tools IV.** Aurora, IL. Mitutoyo. EDU-104 is a two-day class for entry-level team members who need to learn the fundamentals of the steel rule, caliper, micrometer, pin gage, gage block, surface plate, height gage, indicator and stands, angle block, v-block, and sine bar. https://mitutoyo.com/training-education/

**Aug 4-6, 2026 EDU-114: Dimensional Gage Calibration and Repair.** Aurora, IL. Mitutoyo America's Gage Calibration course is a unique, active, educational experience designed specifically for those who plan and perform calibrations of dimensional measuring tools, gages, and instruments. https://mitutoyo.com/training-education/

**SEMINARS & WEBINARS: General**

**Jun 18, 2026 2062 Documenting Traceability and Calibration Intervals.** Online or Virtual Training. NIST. This 2-hour webinar covers the essential elements of metrological traceability and the documentary evidence required to support traceability and calibration intervals. https://www.nist.gov/pml/owm/owm-products-and-services/training-classes-and-events

**Jun 22-24, 2026 C-101 Calibration.** Mobile, AL. TriNova Technical Education. This instructor led calibration course is delivered by our experienced technical education specialists who deliver a high-quality course covering calibration fundamentals, detailed documentation procedures, temperature, and pressure basics, and basics of DP flow calibration. In-depth demonstrations and hands-on exercises will follow each lecture. https://trinova.arlo.co/w/

**Jul 27-31, 2026 2066 Fundamentals of Metrology.** Gaithersburg, MD. NIST. The 5-day Fundamentals of Metrology seminar is an intensive course that introduces participants to the concepts of measurement systems, units, good laboratory practices, data integrity, measurement uncertainty, measurement assurance, traceability, basic statistics and how they fit into a laboratory Quality Management System. https://www.nist.gov/news-events/events/2026/07/2066-fundamentals-metrology

**Aug 12-14, 2026 C-101 Calibration.** Clifton Park, NJ. TriNova Technical Education. This instructor led calibration course is delivered by our experienced technical education specialists who deliver a high-quality course covering calibration fundamentals, detailed documentation procedures, temperature, and pressure basics, and basics of DP flow calibration. In-depth demonstrations and hands-on exercises will follow each lecture. https://trinova.arlo.co/w/

**SEMINARS & WEBINARS: Industry Standards**

**Jun 9-11, 2026 Internal Auditing to ISO/IEC 17025:2017 (Non-Forensic).** Virtual or Online Training. ANAB. This training is designed for laboratory managers, technical staff, and others who want or need to learn better audit practices. Attendees of Auditing to ISO/IEC 17025 training course will learn how to coordinate a quality management system audit to ISO/IEC 17025:2017 and collect audit evidence and document observations, including techniques for effective questioning and listening. https://anab.ansi.org/training/

**Jun 9-12, 2026 Understanding ISO/IEC 17025:2017 for Testing & Calibration Labs.** Virtual or Online Training. This course is a comprehensive review of the philosophies and requirements of ISO/IEC 17025:2017. https://a2lawpt.org/

**Jun 23-26, 2026 Auditing Your Laboratory to ISO/IEC 17025:2017.** Online or Virtual Event. A2LA WorkPlace Training. This ISO/IEC 17025 auditor training course will introduce participants to ISO 19011, the guideline for auditing management systems as applied to ISO/IEC 17025:2017. The participant will learn about auditing principles and develop skills for performing higher-value internal audits. The course includes hands-on exercises for planning, establishing, implementing, and maintaining an audit program, and also focuses on developing auditing methods, questioning techniques, and record sampling. https://a2lawpt.org/

**SEMINARS & WEBINARS: Measurement Uncertainty**

**Jun 23-25, 2026 Applied Measurement Uncertainty for Testing Laboratories.** Online or Virtual Training. A2LA WorkPlace Training. During this workshop, the participant will be introduced to several tools and techniques that can be

# Choosing the Right Hipot Platform for Modern Manufacturing Electrical Safety Testing

## From Bench Testing to Fully Automated Production

Electrical safety testing has evolved from a standalone task into a critical part of modern manufacturing. As products grow more complex and production becomes more automated, choosing the right hipot platform is no longer just about voltage range—it's about speed, integration, and scalability.

## From Entry-Level Testing to Automated Production

Electrical safety testing often begins at the bench, where simplicity and reliability matter most. The V7X series delivers essential AC, DC, insulation resistance, and optional ground bond testing with fast setup and intuitive operation—ideal for low-volume environments.

As production demands grow, the 95X series adds higher output, picoamp-level leakage measurement, and advanced sequencing to support faster throughput and more complex applications like EV, power, and industrial systems.

In fully automated environments, testing must go further. The V10X platform is built for connected manufacturing—combining high-performance testing with network integration, advanced sequencing, and built-in reporting. It transforms electrical safety testing into a scalable, data-driven part of modern production.

## Matching the Platform to the Manufacturing Strategy

Choosing between the V7X, 95X, and V10X is about aligning test capability with production goals. The V7X supports efficient compliance testing, the 95X delivers speed and flexibility for high-throughput environments, and the V10X enables data-driven testing in fully automated systems.

All three platforms share Vitrek's accuracy and automation-ready design, with scalable support for multi-point testing via the 964i switching system. As testing impacts throughput, quality, and compliance, the right choice is one that meets today's needs while supporting future growth.

## How Vitrek Stacks Up Against Other Industry-Leading Testers

As electrical safety testing becomes more integrated into automated manufacturing, differences between hipot platforms go beyond voltage—factors like usability, speed, data, and integration now define performance.

- **Ease of Use:** Intuitive touchscreen control and barcode scanning reduce setup time and errors
- **Throughput:** Fast test cycles and sequencing support high-volume production
- **Data & Compliance:** Built-in reporting and centralized software enable traceability
- **Accuracy:** Low-noise, high-sensitivity measurements ensure reliable results
- **Automation: Standard** interfaces and system integration simplify scaling

VITREK HIPOT SELECTION GUIDE

| Decision Question | Outcome | Recommended Platform |
|---|---|---|
| Bench or low-volume testing? | Standalone / basic automation | V7X Series |
| Higher voltage or tighter leakage limits? | More power & precision needed | 95X or V10X Series |
| Multi-point automated testing? | Requires HV switching | V7x, 95X or V10X + 964i |
| Centralized data & audit traceability? | Enterprise test management | V10X + 964i + QT Insite |

## Conclusion

Vitrek hipot testers combine usability, speed, automation, and accuracy in one platform. Intuitive interfaces reduce errors, while fast testing and integrated switching support high-throughput production.

Built-in V10X reporting and QT Insite software simplify traceability and compliance. With a scalable ecosystem and consistent architecture, Vitrek delivers a practical, future-ready approach to electrical safety testing.

**See Vitrek's full line of hipot testers at Vitrek.com or request a free application review at https://vitrek.com/democallab/**

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applied in the testing laboratory environment to efficiently and effectively create measurement uncertainty budgets that comply with ISO/IEC 17025 requirements. https://a2lawpt.org/event/applied-measurement-uncertainty-for-testing-laboratories-5/

**Aug 5, 2026 Measurement, Uncertainty and Calibration Workshop.** Wellington, New Zealand. MSL. This course gives a broad high-level overview of measurement and calibration principles, and calculation of uncertainty. https://www.measurement.govt.nz/training

**Aug 19, 2026 Measurement, Uncertainty and Calibration Workshop.** Auckland, New Zealand. MSL. This course gives a broad high-level overview of measurement and calibration principles, and calculation of uncertainty. https://www.measurement.govt.nz/training

**SEMINARS & WEBINARS: Photometry & Radiometry**

**Aug 7, 2026 Spectrophotometer Calibration Workshop.** Wellington, New Zealand. MSL. This course covers the calibration of bench-top spectrophotometers, including wavelength accuracy, photometric accuracy, and stray light characterization. It is highly interactive and includes hands-on sessions to develop practical skills. https://www.measurement.govt.nz/training

**SEMINARS & WEBINARS: Pressure**

**Jun 17-18, 2026 Pressure Measurement.** Port Melbourne VIC, Australia. NMI. This two-day course (9 am to 5 pm each day) covers essential knowledge of the calibration and use of a wide range of pressure measuring instruments, their principles of operation and potential sources of error — it incorporates extensive hands-on practical exercises. https://shop.measurement.gov.au/

**Aug 4, 2026 Pressure Calibration Workshop.** Wellington, New Zealand. MSL. This workshop is a practical one-day session dealing with all aspects of pressure gauge and transducer calibration. https://www.measurement.govt.nz/training

# CALENDAR

**Aug 21, 2026 Pressure Calibration Workshop.** Auckland, New Zealand. MSL. This workshop is a practical one-day session dealing with all aspects of pressure gauge and transducer calibration. https://www.measurement.govt.nz/training

**SEMINARS & WEBINARS: Software**

**Jun 22-26, 2026 TWB 1031 MET/CAL® Procedure Development Web-Based Training.** Fluke Calibration. Learn to create procedures with the latest version of MET/CAL, without leaving your office. The workshop is presented as a five-part, ten-hour course with each two-hour session scheduled on consecutive days. https://www.fluke.com/en-us/product/fluke-software/fluke-calibration-software/training-twb-1031

**Jul 14-16, 2026 MC-203 Crystal Report Writing.** Everett, WA. Fluke Calibration. This course is designed for those who are involved with modifying or writing custom reports for use with MET/TEAM. https://www.fluke.com/en-us/product/fluke-software/fluke-calibration-software/training-mc-203

**Jul 27-31, 2026 MC-206 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://www.fluke.com/en-us/product/fluke-software/fluke-calibration-software/training-mc-206

**SEMINARS & WEBINARS: Temperature & Humidity**

**Aug 4, 2026 Humidity and Moisture Calibration Workshop.** Wellington, New Zealand. MSL. This practical one-day course will introduce you to humidity generation, calibration, and measurement, along with the conceptual framework for understanding the various limitations in humidity measurements. https://www.measurement.govt.nz/training

**Aug 6, 2026 Temperature Measurement and Calibration Workshop.** Wellington, New Zealand. MSL. This course covers the use, care, and calibration of liquid-in-glass, platinum resistance, thermocouple, and radiation thermometers. https://www.measurement.govt.nz/training

# CALENDAR

**Aug 7, 2026 Infrared Radiation Thermometry Workshop.** Wellington, New Zealand. MLS. This is a practical course covering problems with the use and calibration of infrared radiation thermometers, including reflections, absorption, emissivity, and instrumental effects. https://www.measurement.govt.nz/training

**Aug 18, 2026 Humidity and Moisture Calibration Workshop.** Auckland, New Zealand. MSL. This practical one-day course will introduce you to humidity generation, calibration, and measurement, along with the conceptual framework for understanding the various limitations in humidity measurements. https://www.measurement.govt.nz/training

**Aug 20, 2026 Temperature Measurement and Calibration Workshop.** Auckland, New Zealand. MSL. This course covers the use, care, and calibration of liquid-in-glass, platinum resistance, thermocouple, and radiation thermometers. https://www.measurement.govt.nz/training

**Aug 21, 2026 Infrared Radiation Thermometry Workshop.** Auckland, New Zealand. MSL. This is a practical course covering problems with the use and calibration of infrared radiation thermometers, including reflections, absorption, emissivity, and instrumental effects. https://www.measurement.govt.nz/training

**SEMINARS & WEBINARS: Time & Frequency**

**Jul 21-23, 2026 Time and Frequency Seminar.** NIST Campus. Boulder, CO. The 2026 NIST Time and Frequency Seminar brings together scientists, engineers, managers, laboratory technicians, students, and educators who want to learn about or work with time and frequency systems. This three-day course is the most comprehensive available. https://www.nist.gov/news-events/events/2026/07/2026-time-and-frequency-seminar

**Sep 9-10, 2026 Time and Frequency Measurement.** Lindfield NSW, Australia. NMI. This two-day course covers the broad range of equipment and techniques used to measure time and frequency and to calibrate time and frequency instruments. https://shop.measurement.gov.au/collections/physical-metrology-training

**SEMINARS & WEBINARS: Validation & Verification**

**Aug 13, 2026 Calibration Method Validation.** Webinar. NIST. This 2-hour webinar on Calibration Method Validation will examine the ISO/IEC 17025:2017 requirements for selection of calibration methods and for method validation and provide guidance on developing a process for validating a new or modified calibration process. https://www.nist.gov/pml/owm/owm-products-and-services/training-classes-and-events

**SEMINARS & WEBINARS: Vibration**

**Jun 23-25, 2026 Fundamentals of Random Vibration and Shock Testing Training.** Plano, TX. ERI. This three-day Training in Fundamentals of Random Vibration and Shock Testing covers all the information required to plan, perform, and interpret the results of all types of dynamic testing. Some of the additional areas covered are fixture design, field data measurement and interpretation, evolution of test standards and HALT/HASS processes. https://equipment-reliability.com/open-courses/

**Aug 18-20, 2026 Fundamentals of Random Vibration and Shock Testing Training.** Charlotte, NC. ERI. This three-day Training in Fundamentals of Random Vibration and Shock Testing covers all the information required to plan, perform, and interpret the results of all types of dynamic testing. Some of the additional areas covered are fixture design, field data measurement and interpretation, evolution of test standards and HALT/HASS processes. https://equipment-reliability.com/open-courses/

**SEMINARS & WEBINARS: Weight**

**Jun 25, 2026 Calibration of Weights and Balances.** Lindfield, NSW, Australia. NMI. This course covers the theory and practice of the calibration of weights and balances. It incorporates hands-on practical exercises to demonstrate adjustment features and the effects of static, magnetism, vibration and draughts on balance performance. https://shop.measurement.gov.au/collections/physical-metrology-training

**Aug 3, 2026 Balances and Weighing Workshop.** Wellington, New Zealand. MSL. This course provides training to assist laboratory personnel demonstrate quality assurance in their measurements. https://www.measurement.govt.nz/training

**Aug 18, 2026 Balances and Weighing Workshop.** Auckland, New Zealand. MSL. This course provides training to assist laboratory personnel demonstrate quality assurance in their measurements. https://www.measurement.govt.nz/training

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## Metrology and Quality Through Education

*A Micro-Course Model of Mini Courses for Measurement and Quality Professionals*

Carson, California, April 29, 2026 - The digital revolution driving how organizations function today is advancing at a pace where the foundational processes that prepare professionals, especially metrologists, with a challenge to remain current. Industry still needs the fundamentals: traceability, uncertainty, competence, calibration discipline, measurement assurance, and proper laboratory records.

Metrology is being reshaped by digital transformation. International work on digital calibration certificates and digital metrology infrastructures shows that the field is moving toward machine-readable, interoperable, and standards-based data exchange. This means professionals increasingly need both classical metrology competence and digital metrology awareness.

The primary and preferred source for obtaining these skills has resided in institutions of higher learning, even though substantial, metrology training is also provided through dispersed channels such as national metrology institutes, standards, and accreditation organizations, professional societies, industrial laboratories, equipment manufacturers, and specialized training programs.

Higher education models have not been altered for years. They are problematic in meeting the specific applications of metrology. Organizational processes have become more focused, and the general higher education body of knowledge does not apply to every organization. An element often overlooked in the college curriculum is the quality management system (QMS). The QMS is the foundation for a successful process performance in organization. Employees, who are subject matter experts in their respective functions, are not prepared to be effective participants or contributors to the QMS.

College graduates are hired with an education that most likely is outdated due to the pace of the digital transformation. They are not prepared to make a positive contribution to improve the organization's processes and procedures until a length of period of "onboarding" and "on-the-job" training is completed.

Credit: iStock/gilaxia

To remedy this, California State University, Dominguez Hills (CSUDH) developed an innovative, non-traditional college course program, introducing a series of continuing education "micro-courses." A micro-course is an instructor facilitated 4-to-6-hour class where specific topics are addressed in practical, not theoretical, detail.

The micro-course initiative offers an opportunity to bring concise, accessible, and technically sound education to the professionals who keep measurements reliable and meaningful quality. There are no course prerequisites or linear sequence of rigid course requirements. Employers can selectively identify the specific skills employees need to improve their company's processes. Individuals can selectively identify specific training, recorded through by e-badges in their personal learning portfolio, to enhance their resumes. Course scheduling is flexible.

**Typical basic topics include:**

1. Quality-focused titles with strong metrology linkage
2. Quality Begins with Measurement
3. ISO/IEC 17025 and ISO 9001: Where Metrology Meets Quality
4. Risk-Based Thinking in Measurement and Quality (Team approach)
5. Root Cause Analysis for Measurement and Quality Problems (Team approach)
6. CAPA for Laboratories and Technical Operations

**Metrology-focused titles:**

1. Fundamentals of Metrology for Modern Laboratories
2. Measurement Uncertainty: Practical Estimation and Use
3. Metrological Traceability: From Standards to Results
4. Calibration Principles for Technicians and Engineers
5. Decision Rules, Tolerance, and Measurement Risk
6. Applied Statistics for Metrology and Laboratory Quality
7. Elements of Mass Metrology
8. Competence in ISO/IEC 17025: What Technical Staff Must Know

These micro-courses are not simply about compliance. They are about competence. They are designed to help professionals understand why measurements can be trusted, how traceability is built, how uncertainty affects decisions, how calibration supports operations, and how quality systems become stronger when grounded in real metrology.

Metrology is the hidden infrastructure contained within the QMS of modern industry. When organizations invest in metrology and quality education, they improve technical credibility, reduce decision risk, strengthen compliance, and support better quality outcomes.

There is no established limit to the number of courses

meatest made to last

# Meatest Decade Boxes:

## Tools Worth Knowing - Solutions Worth Recommending

A versatile family for resistance, capacitance, simulation, verification, and calibration support





Every **Meatest decade box** is built with **real resistors and capacitors.** Yet instead of mechanical knobs, its internal standards are switched by relays, directed by a sophisticated control algorithm.

The result is clear: **Meatest decade boxes** deliver **no residual resistance,** wide ranges, and fine resolution. They are robust, remarkably easy to operate and adjust, and above all, **perfectly suited for automation.**

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completed. The company, the employee, or the individual professional can determine which areas would be of benefit to them. Course attendees receive a digital badge of completion that is included in their permanent educational portfolio, like the traditional college transcripts. Future micro-course program plans include recognizing college class credits thresholds when course completions are accomplished that align with current higher education guidelines for recognizing college credit for experiential learning outside of the traditional classroom.

An advantage of these micro classes is that they can be delivered on a schedule that is flexible. Micro-courses are very affordable compared with traditional college classes. These short-format professional courses are designed to bring focused, applied, and industry-relevant education to working professionals who need usable knowledge without committing to a long academic program. The central message is simple: metrology is not a support topic; it is a core operational discipline. It is the technical base that sustains calibration, testing, inspection, validation, traceability, uncertainty evaluation, process control, conformity assessment, and sound quality decisions.

Another advantage is that these micro-courses can be grouped to link two or three related topics, providing a broader and more coherent learning experience.

Also, timing of the courses can be adjusted to make the opportunity available when it is most appropriate and needed.

The digital transformation is reshaping how the processes with organizations function. If higher education is to continue to prepare future generations of professionals, especially in metrology, they must alter their model to provide continuing education in an agile format the aligns with industry needs.

There are no prerequisites for enrollment and no admission process.

For more information and to discover more about this certificate program, contact: Milton Krivokuca (mkrivokuca@csudh.edu), Quality Program Coordinator, and Emil Hazarian (ehazarian@csudh.edu), Professor of Metrology, CSUDH, Dominguez Hills, CA.

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### KBR Launches New Phoenix Lab to Advance Precision Measurement

03/17/2026 – KBR announced today the opening of its new Phoenix Metrology Engineering Center, an internationally accredited 4,500-square-foot facility providing advanced measurement, precision calibration and engineering services to commercial and national security customers. Metrology, the science of measurement, is essential to the Phoenix, Arizona, area's rapidly expanding aerospace, semiconductor, biomedical and defense industrial base.

The facility, located at 2145 S. 7th St. in Phoenix, delivers high accuracy measurement and performance verification services across electrical, dimensional, mechanical, torque and force disciplines. Its work helps ensure airplanes can fly safely, satellites operate reliably in orbit and manufacturing equipment produces parts that fit and perform exactly as designed. The lab is engineered to support both commercial manufacturing operations and mission-critical defense programs. It also features secure digital workflows, rugged mobile calibration kits and dedicated customer collaboration areas.

Credit: KBR

KBR's investment reflects the company's long-standing presence and economic impact in the Phoenix area. The company employs more than 150 local professionals, maintains more than 230,000 square feet of operational space in the region and plans to expand its high-tech workforce in technical services and fourth-party logistics.

"Accurate measurement is at the heart of performance and safety, powering everything from semiconductor tools to flight-critical aerospace components," said Doug Hill, president of KBR Readiness & Sustainment. "Phoenix is one of the fastest-growing high-tech hubs in the country, and our investment in Speed to Mission Impact℠ strengthens our ability to support the region's most critical programs."

KBR has more than 20 years of experience providing precision calibration, dimensional measurement and electrical and mechanical testing for commercial and national security customers. KBR's Mission Technology Solutions operates 21 metrology labs worldwide and performs over 10,000 measurements per day. Services are delivered in-house, at customer sites and through embedded technicians. The company also supports sensitive programs with secure workflows, including encrypted records and strict access controls.

Source: https://www.kbr.com/en/insights-news/press-release/kbrs-mission-technology-solutions-launches-new-phoenix-lab-advance-precision-measurement-high-tech-industries

## Calibration of Large Gears

PTB-News 1.2026 — PTB's Wind Energy Competence Center features a large coordinate measuring machine (CMM) that allows us to offer the world's only calibration services for the large gears used in wind energy systems. With a measuring volume of 5 m × 4 m × 2 m and equipped with both tactile and optical sensors, the system can calibrate not only gear quantities but also the diameter, shape, and straightness of 3D geometric elements.

The gearboxes of wind turbines are subjected to frequent load changes, which can lead to costly failures. To prevent such failure, precise measurements are essential for reliably verifying that manufactured gear components meet their geometric requirements. Having established a suitable traceability chain, PTB now offers calibration services for large components and specifically for the large gear components found in wind turbines.

These services rely on a gear ring standard with an outer diameter of two meters that was developed in collaboration with industry as part of a multisectoral project. This standard is an externally and internally toothed cylindrical gear with three identical tooth segments, each composed of three tooth spaces with different helix angles. Twelve temperature sensors can monitor the internal temperature of the standard, and additional contact sensors are mounted on its surface.

Traceability for this standard was achieved using the patented M3D3 method. The method employs four LaserTracers, whose interferometric measurements – supported by the frequency calibration of the laser and by calibrated environmental sensors (for temperature, pressure, humidity) – ensure direct traceability. This enables the traceable correction of positional data from the large coordinate measuring machine (large CMM).

Measurement of the gear measurement standard on PTB's large CMM. Credit: PTB

Building on this, the proven multiple orientation measurement procedure for gear calibration was also verified on the large CMM. For calibration, gear measurement standards are typically measured in eight different positions on the CMM: four in the normal position and four in the inverted position. In each of these positions, the standard is placed in four different orientations, with each orientation achieved by rotating the gear by 90° around the main axes. For this step, a new rotary table with a diameter of two meters is available, allowing the calibration to be carried out in a single run without manual intervention. This significantly reduces the measuring time.

The results of the gear parameter measurements are calculated from the averages of the multi-position measurements. The measurement uncertainties are in the range of less than 3 μm.

Scientific publication: A. Wedmann, A. Przyklenk, K. Kniel: Großverzahnungskalibrierungen im taktilen Scanningmodus und in Zweiflankenanlage. VDI-Berichte: 2440, 8. VDI-Fachtagung Verzahnungsmesstechnik 2024, 15 and 16 October 2024, Nuremberg, 195–210 (2024)

Source: https://www.ptb.de/cms/en/presseaktuelles/journals-magazines/ptb-news.html

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## Space: The Final Frontier for Standards

February 9, 2026, NIST News -- Wrapped snugly in a custom container, seven carefully chosen materials left Earth on Aug. 24, 2025, traveling at 17,500 mph. Nestled at the top of a Falcon 9 rocket, house dust, freeze-dried human liver and cholesterol joined four other scientific specimens to travel to the International Space Station (ISS). Called reference materials, these thoroughly studied samples serve important roles on Earth — and now beyond. These reference materials will play a critical role in understanding the effects of outer space on everyday objects as space becomes a place where people live, conduct research and even start new businesses. For example, drug development is already happening in low Earth orbit. As this kind of research grows, so will the need for reference materials.

Getting these reference materials into orbit was a collaborative effort among NIST, the National Oceanic and Atmospheric Administration (NOAA) Office of Space Commerce and the biotech company Rhodium Scientific. The goal is to advance U.S. leadership in the space sector by supporting the development of innovative commercial and scientific capabilities in outer space. This effort also supports the goals of two recent executive orders on U.S. activities in space.

**What Is a Reference Material?**

From spinach and cement to human fecal matter, over a thousand different reference materials sit in a Maryland warehouse until they are shipped to companies and scientists around the globe.

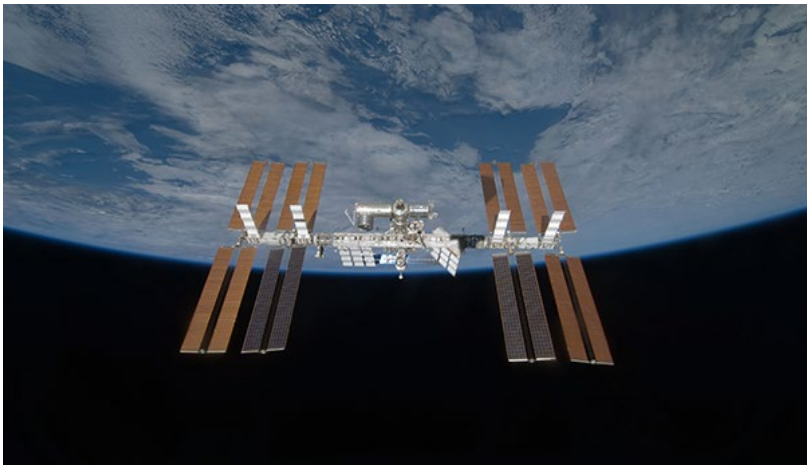
Many types of research and industry depend on the reference materials created and maintained by the National Institute of Standards and Technology (NIST). Labs can compare measurements of their specimens to these well-measured materials and calibrate their measurement devices to ensure that they are giving accurate readings. NIST's cholesterol reference material, for example, helps medical labs make sure their instruments for measuring cholesterol are working correctly. It's a vital quality control measure for monitoring people's health. Reference materials also help scientists communicate across time and space. If a researcher uses a reference material in a study, anyone can recreate that experiment by using that same reference, even if they're on a different continent decades later.

Six of the seven materials sent on this trip are not just reference materials, but standard reference materials (SRMs), meaning that they meet NIST's highest standard for measurement. They are cholesterol, tripalmitin, house dust, creatinine, urea and uric acid. The seventh sample, the human liver, is a reference material, which is NIST's next-highest standard. (See this page to learn the differences.)

**Why Did We Send Them to Space?**

Space affects people and things in unexpected ways. Its low-gravity environment causes astronauts to lose bone density and can weaken their cardiovascular systems. Above Earth's protective magnetic field, radiation from the Sun and other stars is more potent than on Earth.

It's not always obvious how outer space will affect things that have never been in orbit. In one stark example, a 2023 elementary school project showed that epinephrine, a drug used to treat life-threatening allergic reactions, chemically transforms into poisonous benzoic acid when exposed to cosmic radiation. It would be very bad if an astronaut or space tourist was accidentally injected with benzoic acid while trying to recover from anaphylaxis.



The International Space Station. Credit: NASA

The chemical changes caused by space are not all negative. For example, it's easier to grow protein crystals in microgravity. Taking advantage of this, scientists on the ISS studied the cancer drug Keytruda, which is made of protein crystals. The crystals of the drug formed much more evenly in microgravity than on Earth. This research led to a more convenient version of the drug that could be injected rather than slowly dripped through an IV bag.

"There are opportunities for whole categories of research and manufacturing in space, and standards will play an important role out there, just like on Earth," said NIST research chemist Dianne Poster, who is serving as senior adviser to NOAA's Office of Space Commerce.

Scientists still don't know much about how the space environment affects molecules important to human health. Space may make tiny but important changes to organic molecules in liver and other tissue.

"If people are going to be in space for any extended time, they're going to have to do medical testing, and we'll need to know how stable their cholesterol and urine molecules are in space and on Earth," explained NIST scientist Kate Rimmer. "These SRMs are an early step in getting that better understanding."

The seven chosen reference materials were the first to go into space because they are important for human health and relatively easy to launch into orbit. These SRMs come in a dry powder that can stay at room temperature, making them easier to package for space than, say, a blood plasma reference material, which needs to be at the very cold temperature of minus 80 degrees Celsius.

They are also some of NIST's best-measured materials. Five of them are "primary chemistry standards," extremely pure and stable chemicals that are easy to work with. "Primary standards are measured as completely as possible with current technology," said Rimmer, "and because of this, they are the starting point for many other chemical measurements."

The house dust SRM is not a primary standard, but it was chosen because it's one of NIST's best characterized SRMs and it contains lots of different chemicals that can affect human health. The dust was collected from vacuum cleaner bags across six different U.S. states. "Dust contains chemicals that people are exposed to every day, like outdoor pollutants from vehicle emissions and pesticides — all those things make their way into house dust," explained Poster, who helped develop the SRM in 2007. "It's a very good reservoir of these contaminants."

Studying house dust provides insight into indoor air quality, how chemicals move indoors, and potential health risks.

There is dust on spacecraft, just as there is in any place people live and work. As space becomes more populated and commercial space stations emerge, studying dust could be a useful tool for understanding and managing what's in the air within a closed environment.

"Standardizing how we measure biological and chemical changes in space is essential for creating a resilient, self-sustaining ecosystem where research and commerce can thrive," said Gabriel Swiney, director of NOAA's Office of Space Commerce's Policy, Advocacy and International Division. "This mission is a critical step toward a more dynamic and scalable space economy."

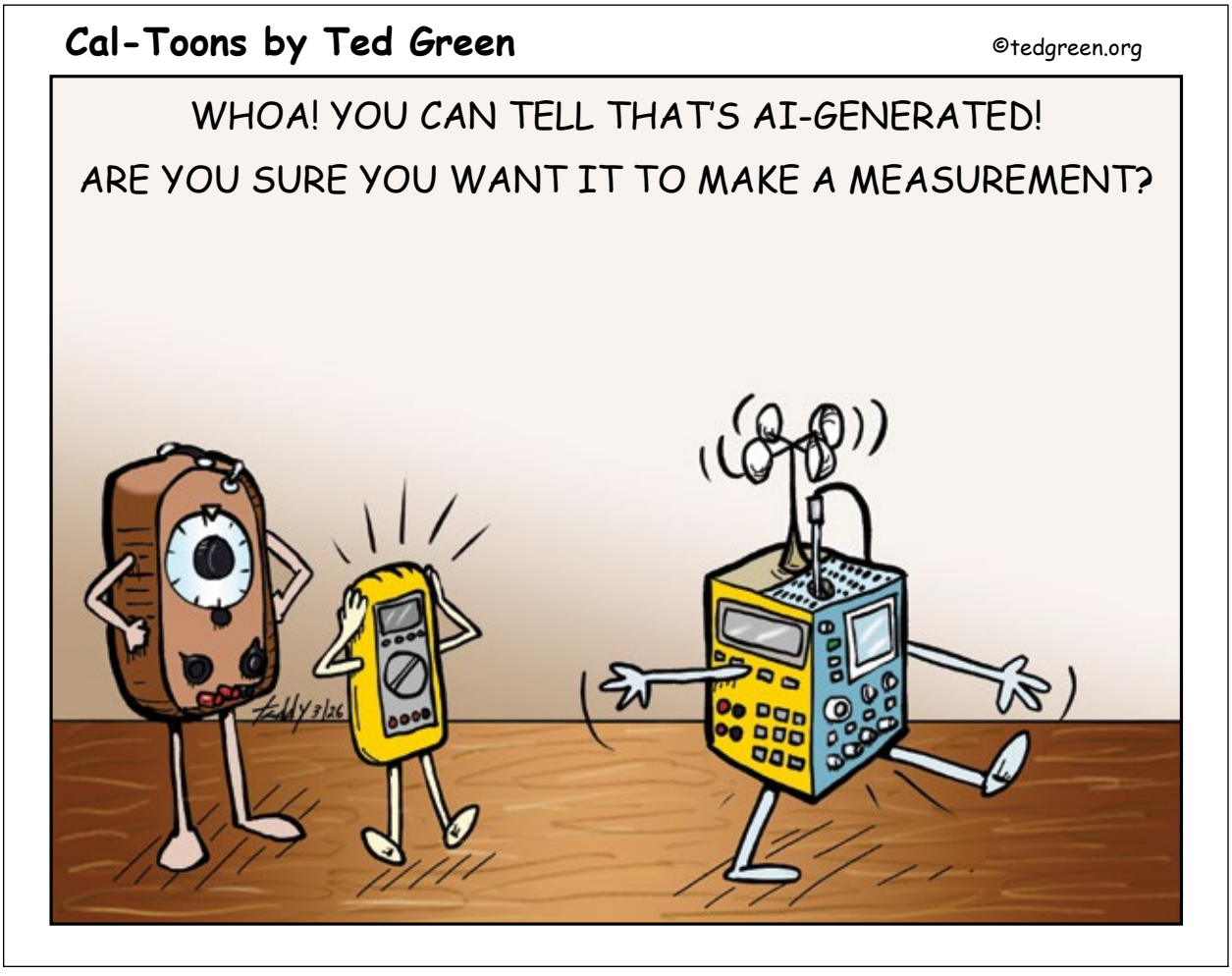
**What Will Happen at the End of the Project?**

NIST packaged the reference materials in special containers designed for space travel by Rhodium. While in space, the materials will stay in their packaging until it's time to come back home. After the mission is over, some of the samples will be sent to Rhodium's Space BioBank, where they will be held for future research. "Sending a sample to space for research can take years and cost millions of dollars," explained Rhodium CEO Olivia Holzhaus. "The key idea behind the BioBank is to have lots of different samples that have already been to space ready for testing and instantly available, making space research faster and more efficient. When they return, these space-traveled SRMs will be available to researchers and companies around the world."

Other samples will go back to NIST, where scientists will use advanced techniques such as nuclear magnetic resonance spectroscopy to measure whether the samples went through any chemical changes during their time on the ISS. The scientists aren't sure what changes they might see once the SRMs come back to them. Even if nothing changes, that will be valuable information for future space research.

"There aren't really any physical artifact reference materials for space right now," said Rimmer. "We're hoping to help develop the first."

Source: https://www.nist.gov/news-events/news/2026/02/space-final-frontier-standards



# Beyond 4:1: What Calibration Ratios Were Meant to Do

Tray Eason
SIMCO Electronics

## Introduction

The 4:1 calibration ratio is still widely referenced in industrial quality systems and procurement language. Many organizations treat it as a requirement for good calibration, and some treat it as an acceptance criterion. That use does not match the historical intent of ratio-based practices or the requirements of modern accredited calibration.

Modern calibration standards are built on quantified measurement uncertainty and documented decision rules. Fixed ratios such as 4:1 do not control decision risk for individual measurements. This article explains where 4:1 originated, how TAR and TUR differ, why ratios persist, and what ISO/IEC 17025 and ILAC guidance actually require for conformity assessment.

## Why Calibration Ratios Exist

Every calibration decision is made in the presence of measurement uncertainty. When a laboratory states that an item is within tolerance, there is always some probability that the true value lies outside the specification limits. That probability is measurement decision risk.

Two types of risk are central to conformity assessment:

- False acceptance (consumer risk), where a nonconforming item is accepted
- False rejection (producer risk), where a conforming item is rejected

In the mid-twentieth century, organizations needed scalable ways to limit incorrect decisions across large inspection and calibration systems. At the time, few laboratories had the statistical tools, computing capability, or structured uncertainty budgets required for rigorous uncertainty analysis. Accuracy ratios emerged as a practical surrogate. They were simple, auditable, and broadly effective in limiting gross measurement inadequacy.

However, they were never designed to eliminate decision risk or replace uncertainty analysis.

## What the 4:1 Ratio Was Intended to Do

The 4:1 ratio compares the tolerance of the unit under test to the capability of the calibration standard. In practical terms, if an instrument has a tolerance of ±1 unit, a 4:1 expectation implies a standard uncertainty of approximately ±0.25 unit or better.

Historically, this approach matured in inspection-driven manufacturing and defense programs. Early statistical work by Alan Eagle, Frank Grubbs, and Helen Coon established the relationship between measurement error and incorrect acceptance or rejection decisions. These principles were later codified in military calibration policy.

MIL-STD-45662A expressed the concept by requiring that the collective uncertainty of the calibration standards not exceed 25 percent of the tolerance being evaluated. That requirement is the origin of the widely cited 4:1 expectation expressed in uncertainty terms.

Importantly, even this military requirement referred to collective uncertainty, not simply to stated accuracy specifications. It recognized that multiple uncertainty contributors must be combined and that risk is driven by their combined effect.

As military standards transitioned into civilian quality systems, ratio-based practices migrated with them. Over time, the 4:1 ratio became embedded in procurement documents and quality manuals. In many cases, it evolved from a simplified risk control measure into a perceived requirement.

## TAR and TUR: A Necessary Distinction

### Test Accuracy Ratio (TAR)

Test Accuracy Ratio is typically defined as the tolerance of the unit under test divided by the stated accuracy of the reference standard.

The difficulty is technical. Accuracy specifications are commonly worst-case limits. They do not define statistical confidence and do not represent combined measurement uncertainty. They often exclude contributors such as environmental influences, repeatability, resolution, and method effects.

Because of this, TAR does not quantify measurement uncertainty and does not describe decision risk in probabilistic terms. It does not support conformity assessment under ISO/IEC 17025 or ILAC guidance. TAR persists primarily as legacy terminology or contractual language rather than as a technically rigorous metric.

### Test Uncertainty Ratio (TUR)

Test Uncertainty Ratio is defined as the tolerance divided by the expanded uncertainty of the measurement process.

Unlike TAR, TUR is based on:

- Combined standard uncertainty
- Documented uncertainty contributors
- A defined coverage factor, commonly k approximately equal to 2
- Traceability to national or international standards

TUR aligns with the Guide to the Expression of Uncertainty in Measurement, ISO/IEC 17025, ANSI/NCSL Z540.3, and ILAC policy documents.

However, TUR describes general measurement capability. It does not determine whether a specific measurement result is conforming. Two measurements with identical TUR values can carry very different probabilities of false acceptance depending on their proximity to specification limits.

## Global Risk Versus Specific Decision Risk

A fixed ratio such as 4:1 implicitly reflects an assumption about global or average risk across many measurements. It assumes that results are reasonably distributed within tolerance and that average risk is acceptable.

Calibration decisions, however, are made on individual measurement results. Risk is not constant across the tolerance band. It is very low near the center of tolerance and increases as results approach specification limits.

For example, consider a tolerance of ±10 units evaluated with a measurement process having expanded uncertainty of ±2.5 units, resulting in a 4:1 TUR. If results are broadly distributed, overall false acceptance risk may appear relatively low.

However, if a measurement result lies exactly at the specification limit, approximately half of the associated uncertainty distribution lies outside tolerance. The probability that the true value exceeds the limit becomes significant for that specific decision.

Both conditions can exist simultaneously. The overall system may appear conservative when viewed globally, while a particular acceptance decision may carry substantial risk.

This distinction explains why fixed ratios do not control decision risk.

## What Controls Decision Risk in Modern Calibration

Modern accredited calibration relies on quantified measurement uncertainty and documented decision rules.

### ISO/IEC 17025

ISO/IEC 17025 requires laboratories to evaluate measurement uncertainty and to apply documented decision rules when making statements of conformity. The standard does not mandate any specific calibration ratio.

The focus is on traceability, competence, and transparent risk management.

### ILAC Guidance

ILAC-G8 clarifies that decision rules must define how uncertainty is applied when determining conformity. This includes whether guardbands are used, which party assumes risk near specification limits, and what level of confidence is required for acceptance.

Fixed ratios are not a substitute for this analysis.

### ANSI/NCSL Z540.3

ANSI/NCSL Z540.3 formalized risk-based conformity assessment by requiring control of false acceptance risk. It provides mechanisms such as guardbanding and defined decision criteria. Ratios such as 4:1 are optional tools, not compliance requirements.

When properly implemented, uncertainty analysis combined with a documented decision rule provides explicit control of decision risk. A ratio alone does not.

## Where 4:1 Still Has a Role

The 4:1 ratio remains appropriate in certain circumstances:

- When a contract explicitly requires it
- When the application is low risk
- When uncertainty analysis is limited
- When it is used as a screening guideline rather than as the decision rule

Where 4:1 is contractually specified, it remains a valid requirement. Meeting that requirement may satisfy commercial expectations.

However, for accredited conformity assessment under ISO/IEC 17025, compliance requires uncertainty evaluation and documented decision rules regardless of the ratio achieved.

## Conclusion

The 4:1 calibration ratio was developed as a practical safeguard in an era when rigorous uncertainty analysis was not widely available. TAR reflects that legacy environment and is not aligned with modern uncertainty-based conformity assessment. TUR is technically sound but describes capability rather than decision risk.

In contemporary accredited calibration, risk is managed through quantified measurement uncertainty and clearly defined decision rules applied to each measurement result.

Ratios can inform measurement planning and contractual screening. They do not determine whether a specific acceptance decision is correct.

Understanding that distinction allows organizations to design calibration programs that are technically sound, standards-compliant, and aligned with actual risk rather than historical convention.

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# Metrology for Newbs: Entering the Community, Not Just the Career

Joseph Rindone

## Introduction: You Didn't Just Get a Job—You Entered a Discipline

Most people don't choose metrology, at least not at first. They arrive through necessity. A technician is handed an instrument and told to calibrate it. An engineer is tasked with verifying measurements. A scientist assumes the numbers coming off their equipment are inherently trustworthy. Somewhere along the way, they realize there is an entire discipline behind what they are doing, but by then, they are already in it. That is where the problem begins.

Because metrology is often introduced as a task instead of what it truly is: **a structured discipline built on trust, traceability, and defensible decision-making**. If you are new to this field, a "Newb," as I like to say, you are not just learning a job. You are stepping into a global community with standards, expectations, and consequences that extend far beyond your bench. And if you don't understand that early, you will spend years doing the work without ever truly understanding it.

## The Hidden Structure: A Community Built on Trust

Metrology is not isolated to your lab, your company, or even your country. It is a coordinated global system designed to ensure that a measurement made in one place can be trusted everywhere. At the center of that system are organizations like NIST, ILAC, and the ISO, whose frameworks, such as ISO/IEC 17025, define how laboratories demonstrate competence.

But the structure itself is only part of the story. What truly holds this system together is the expectation that every measurement is:

- **Traceable** to a recognized standard
- **Quantifiable** with known uncertainty
- **Defensible** under scrutiny

This is what separates metrology from general measurement. Anyone can take a reading. Very few can explain what that reading *means*, how reliable it is, and whether it can be trusted to make a decision. That is the standard you are stepping into.

Credit: iStock/Flashvector

## The Illusion of Competence

One of the most dangerous realities in this field is that it is entirely possible to appear competent without actually being competent. A technician can follow a procedure perfectly, record data correctly, and pass internal reviews—yet still have no real understanding of the measurement they just performed. An organization can pass an audit, maintain accreditation, and present a polished quality system while significant gaps remain hidden beneath the surface.

This happens because compliance is often mistaken for competence. Procedures are followed. Checklists are completed. Certificates are issued. But the deeper questions are never asked: What assumptions were made in this measurement? Where are the limitations of this method? What is the actual risk of being wrong?

Without those questions, the work becomes mechanical. And mechanical work, no matter how precise it looks, is vulnerable.

## Learning to Think, Not Just Perform

The turning point for every professional in metrology comes when they move beyond performing tasks and begin to understand the reasoning behind them. This is where real training begins.

In a strong environment, training does not stop at "how." It extends into "why" and "what if." A technician is not only shown how to execute a calibration but is taught how to recognize when something doesn't make sense, when data trends shift, when uncertainty grows beyond expectation, or when results appear deceptively clean.

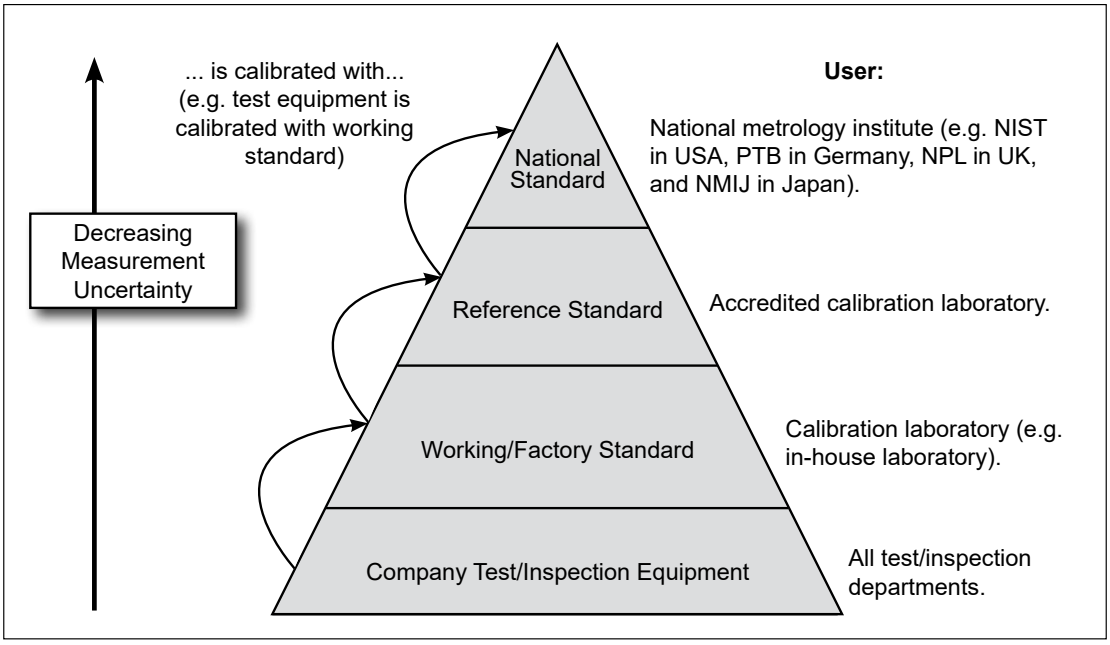
This kind of training is rare because it requires time, experience, and a willingness to challenge assumptions. It cannot be reduced to a checklist or completed through passive observation. But without it, growth is limited. And with it, everything changes.

## Evaluating Your Environment: The Unspoken Skill

Early in your career, one of the most important skills you can develop is the ability to evaluate the environment you are in.

Not all laboratories are equal. Not all training is effective. Not all leadership understands what metrology truly requires.

A strong laboratory environment is recognizable, not by the equipment it owns, but by the way it operates. Questions are welcome, not discouraged. Discussions about uncertainty and risk are normal, not avoided. Comparisons with external laboratories



through proficiency testing are embraced, not feared.

In contrast, weak environments often rely on routine, repetition, and the comfort of "how things have always been done." They may meet the minimum requirements of accreditation, but they do not foster growth or deeper understanding. Recognizing the difference early can shape the entire trajectory of your career.

## Beyond the Bench: Your Role in the System

If you take nothing else from this article, take this: You are not "just a technician."

Every measurement you perform feeds into a larger system of decisions, decisions about safety, performance, compliance, and risk. A single result can influence production outcomes, regulatory standing, or even human safety. That means your role is not limited to executing a task.

You are:

- Interpreting data
- Evaluating risk
- Supporting decisions

And whether you realize it or not, you are contributing to the credibility of the entire system.

## The Reality Check: Accreditation Is Not the Finish Line

There is a common belief, especially among those new to the field, that accreditation represents the highest level of competence. It does not.

Accreditation, such as compliance with ISO/IEC 17025, establishes a framework. It defines expectations. It provides a baseline for consistency and traceability. But it does not guarantee depth of understanding. It does not ensure strong training. And it does not eliminate gaps. Those are filled—or left unfilled—by the people inside the system. Understanding this distinction is critical. Because once you realize that accreditation is the starting point, not the destination, you begin to see where real improvement happens.

## Where We Go From Here

This article is your entry point, not into calibration, but into metrology as a discipline and a community. In the articles that follow, we will move beyond introduction and into application:

- How to evaluate a calibration provider beyond the certificate
- What accreditation really tells you, and what it doesn't
- How uncertainty affects real-world decisions
- Where laboratories fail, and why those failures matter

This will not be theoretical. It will be grounded in the realities of the field, where measurement, decision-making, and accountability intersect.

## Closing Thought

Metrology is one of the few professions where the smallest details carry the greatest weight.

A fraction of a unit. A misunderstood assumption. An overlooked uncertainty. These are not minor issues; they are the difference between confidence and error, between trust and doubt.

If you are new, you are entering a field that demands more than skill. It demands awareness. discipline, and integrity. And if you embrace that early, you will not just participate in metrology, y**ou will contribute to it.**

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Joseph Rindone (rindonejj@gmail.com) is a metrology consultant and educator. He has four decades of experience across NASA, the U.S. military, and commercial labs. He develops ISO/IEC 17025-aligned training programs and onboarding pathways that blend structured mentorship with modern learning tools.

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# Resistance Decade Boxes – Where and How They are Used

Jesse Morse
Morse Metrology

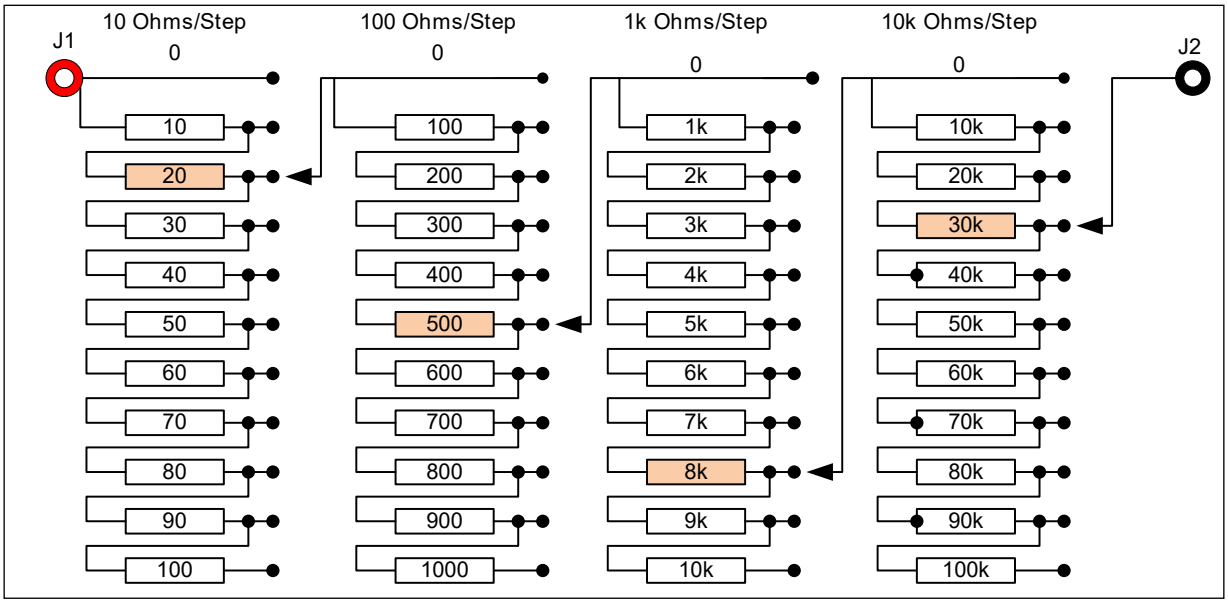
## Introduction

Once looked upon as a simple passive instrument of little importance mostly found in engineering and calibration departments. Today, however, they are perhaps an indispensable instrument, not only in those departments, but also in designing and managing manufacturing processes. Resistance decade boxes are useful in modern manufacturing for precision calibration, testing, and troubleshooting of electronic manufacturing systems, acting as adjustable loads to simulate specific resistance values. They are essential for verifying circuit board specifications, calibrating system sensors (e.g. RTDs), and optimizing product performance.

Studies show that these devices are commonly bought by manufacturing engineers, electronics design engineers, calibration departments, and by educational institutions to simulate, test, and calibrate electrical circuits. They are particularly useful for R&D, troubleshooting, and verifying equipment accuracy.

## What is a Decade Box

A decade box is an electronic test instrument that allows users to simulate values of resistance, capacitance, or inductance over a wide range. It functions as a variable electrical component emulator in circuits, making the selection of component values for a circuit or process controller very efficient—without having to physically insert individual resistors, capacitors, or inductors. Decade boxes streamline testing, calibration, and troubleshooting for manufacturing, engineering, servicing, and calibration departments.




Example 1. Manual Decade Box Example Depicting an Output of 38520 Ohms

The original design of decade boxes, some still available today, were organized as a network of individual components, such as resistors, capacitors, or inductors. The individual components are organized into multiple decades with ten settings per decade. In this type of decade box, manual switches are used to select the exact combination of components, connected in series, to provide the desired overall value at its output terminals. See schematic in Example 1.

The specific output value of this type of decade box is read directly from its dials or digital display.

Modern Decade Boxes are designed using a more efficient binary based decade system that uses many fewer components to create the desired output value and is a viable way to create an output by microprocessor control. See Example 2.

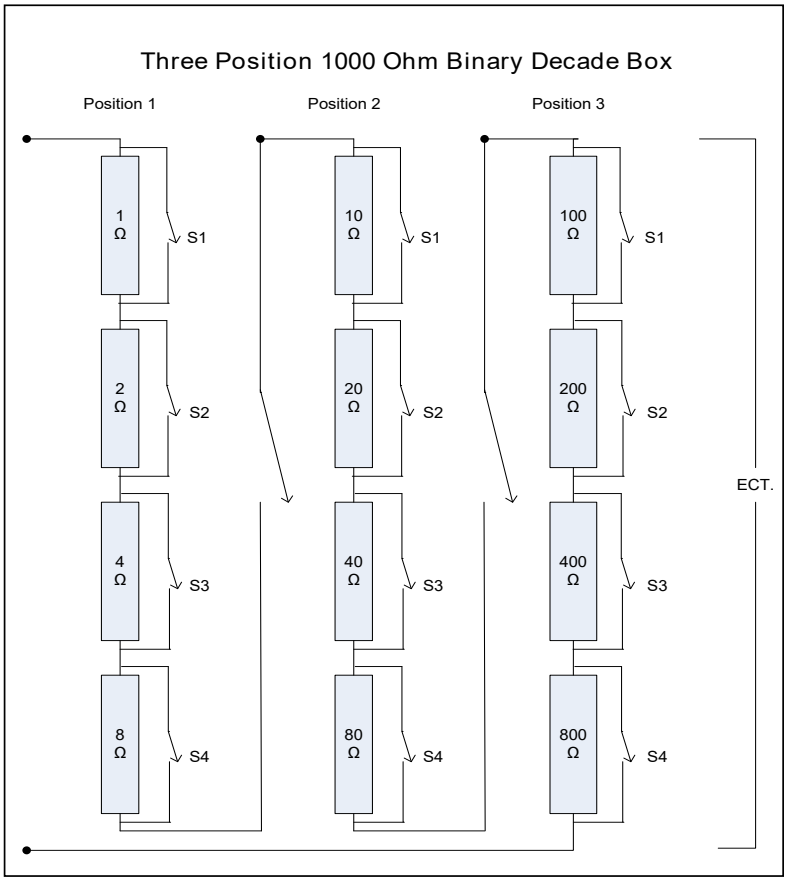
In this simple example, a three-decade device would require just twelve (12) resistors instead of thirty (30) that is needed in the traditional design.

Because of the simplicity of the internal networks in this design, a much more accurate and stable overall value is achieved. This is because less components are combined to provide the desired output value. This design also allows automation of the decade box. The output is set by either keying in the value on a front panel keypad, or by dialing the value using rotary switches. Note, however, that the rotary switches used in this design do not actually directly interconnect the internal resistance components, they simply "tell" the microprocessor what output is desired and it selects the proper components.

There are a variety of decade boxes designed for a spectrum of specific applications. Some are designed to provide basic values that are commonly needed, while others can withstand a varying amount of electrical loading. For example, there are high voltage boxes that are used in applications requiring voltages over several thousand volts. Other decade boxes are designed for precision with higher accuracy of the setting values. These, however, are limited in the amount of power that can be applied to the output value. Some are designed with values specific to certain applications, such as temperature sensor simulation.

## Where Decade Boxes are Used

As mentioned in the opening of this article, decade boxes are found in applications such as in circuit design, prototyping, and the calibration and testing of other measurement devices. Resistance Decade Boxes for example, are available to provide accurate resistance values from several giga-ohms down to micro-ohms depending on the range and resolution of the device. The Meatest model 632 is an example of modern resistance decade boxes designed for test and calibration applications where both a wide range of values (high precision) and high accuracy are required.




Example 2. Binary Based Decade System


Meatest Model 632 Decade Box

Decade boxes, such as these, can be used for calibration of insulation meters, megohmmeters and the resistance ranges of safety analyzers, sometimes referred to as HIPOT testers, or any other DC high resistance meter with test voltage up to 5 kV.

Other decade boxes can be found that can emulate lower resistances very accurately from 0.1 Ω to 20 MΩ, making them useful calibrating some Resistance Temperature Detectors (RTD) readout instruments.

Because of their versatility, they are indispensable in electronic manufacturing departments, product engineering departments, service organizations, and electrical calibration departments.

Examples on how decade boxes might be used in each of those departments follow:

### 1. Manufacturing/Production

In a production environment, a decade resistance box is used for quality control, circuit testing, and calibration by allowing technicians to precisely set and simulate various electrical resistance values. These instruments enable verification of process control systems and can be used to calibrate measurement instruments on the production line. They help to ensure product quality, consistency, and help prevent failures. They are particularly useful in discrete manufacturing, like in the production of circuit boards, for testing components before final assembly, and verifying that the circuit board meets required specifications.

For quality control, manufacturers use decade boxes to test process control systems by simulating various electrical sensors like process transmitters, temperature controllers, and pressure sensors, etc. Using decade boxes in this way, a manufacturer ensures that their products meet required specifications, and defective products are prevented from reaching the customer.

Decade boxes can be used for testing final products under various electrical conditions. By adjusting the values of components, manufacturers can ensure that the products work under a wide range of operating conditions.

### 2. Engineering

In engineering, an electronic engineer uses a decade box to quickly and accurately select precise resistance (or capacitance/inductance) values for circuit prototyping, troubleshooting electrical problems, and simulating changing circuit conditions on the fly, so the need for constantly swapping physical components to find the optimum value is eliminated. For example, during the prototype phase of a new product, engineers need to ensure the electrical characteristics are accurate. A decade box lets them test and fine-tune their designs with precise adjustable values.

### 3. Service

In servicing electrical instruments and devices, decade boxes are crucial for maintenance and troubleshooting. Technicians use decade boxes to emulate components in a circuit to identify and isolate faults. For example, if a component part is faulty or damaged, they can emulate that part using the decade box to see how the rest of the system reacts.

In cases where equipment needs a replacement part, decade boxes can be used to simulate the new component's behavior in the circuit before the actual replacement is made. This helps verify compatibility and functionality.

### 4. Calibration Operations

A calibration laboratory or department uses a precision decade box for calibration of measurement instruments, such as multimeters, capacitance meters, inductance meters, thermometers, and other test instruments.

When an unusual specific value of a parameter is needed, a decade box provides an easy way to generate precise values of resistance, capacitance, or inductance for calibration purposes. In a similar way, decade boxes can also be used as calibration transfer standards, which allows maintaining traceability without having to move laboratory standards outside the lab.

## Common Benefits Across All Areas

In general, decade boxes have benefits over other groups of products used for resistance simulation, such as electronic loads, because they use actual resistors that naturally respond to all kinds of signals - low, high, noisy, modulated, etc. Electronic loads have limitations and typically don't respond well to frequencies over 50/60 Hz.

Precision: Decade boxes provide highly accurate and repeatable values for calibration, testing, and research, ensuring that the systems under test are evaluated correctly.

Flexibility: They allow for rapid adjustments and easy switching between different values, saving time and reducing the need for multiple physical component parts.

Cost-Effective: Instead of needing many separate resistors, capacitors, or inductors, a single decade box can cover a wide range of values, reducing costs and inventory management complexity.

Portability: They are easy to move and set up, making them very portable and versatile tools across various departments.

## Considerations for Selecting a Decade Box

When selecting a decade box, look for specific features that yield high performance, especially in systems where sensors, tools, and cables are involved.

The key features to consider are driven by the intended application requirements:

- The ability to be controlled remotely via automation is especially key in high production factory processes.
- The range of component values.
- The application's requirement for accuracy and resolution.
- Clearly marked scales for each decade for manually operated instruments.
- Operating temperature range that fits the intended application.
- Durability, such as protective enclosures.
- Compatibility with the application's connector terminals—including banana plugs and BNC connectors.
- Portability: Lightweight options are ideal for on-site testing scenarios.

Whether it is working with electronics labs, capacitor modules, cables, or microcontroller-based setups, the right decade box can improve personnel productivity and accuracy.

## Conclusion

A decade box is more than just a passive testing device. They enable precision, innovation, and efficiency in electronics and electrical engineering throughout a company. Whether it's adjusting resistance in an experimental setup, simulating capacitive values for microcontroller inputs, or fine-tuning sensors and switches, this versatile tool simplifies the process with unmatched control and safety.

With decade boxes covering such a large array of applications, they are an essential asset for today's electronic engineers and technicians. Because component complexity is growing so fast, having a reliable and accurate decade box is no longer an option. It is a necessity.

For anyone considering using a decade box in their processes, it would be a good idea to tailor its use based on the specific needs of each department's application.

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## Renishaw to Showcase Robot Efficiency Solutions and Advanced Gauging Systems

WEST DUNDEE, IL – Renishaw, a global leader in precision engineering and manufacturing technologies, will highlight its latest solutions for maximizing robot performance and manufacturing efficiency at Automate 2026, taking place June 22–25 at McCormick Place in Chicago.

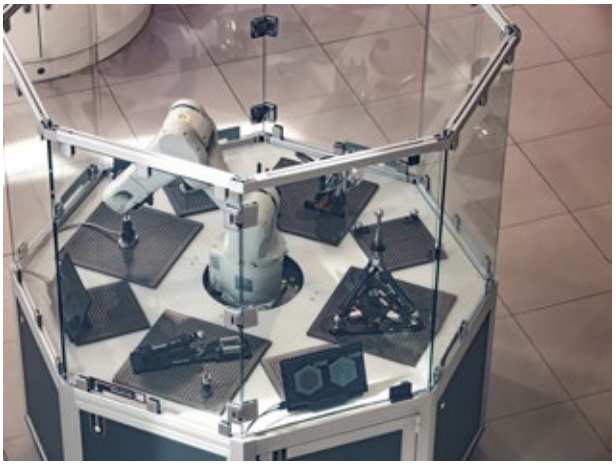
At booth #3853 (South Building), Renishaw will present a range of technologies designed to improve robot accuracy, reduce downtime, and enhance process control across automated manufacturing environments.

A key feature of the exhibit will be the U.S. debut of Renishaw's RCS (Robot Calibration System) demo cell, showcasing live demonstrations of cell recovery and in-field robot calibration. These solutions enable manufacturers to quickly recover from collisions or process interruptions, restore accuracy, and significantly reduce unplanned downtime.

In addition to robot calibration technologies, Renishaw will also exhibit its Equator-X™ dual-method gauging system, demonstrating fast, flexible measurement for high-throughput production environments. The system supports both absolute and comparative gauging, helping manufacturers maintain process control while adapting to changing production demands.

Renishaw will further highlight its portfolio of position and motion control encoders, which play a critical role in robotic performance. These encoders provide precise feedback for robotic joints, enabling accurate positioning, smooth motion control, and repeatable performance across a wide range of applications.

Renishaw encoders are specifically designed to address the unique requirements of robotic systems, including:



At Automate 26, Renishaw will highlight its portfolio of position and motion control encoders, which play a critical role in robotic performance, providing precise feedback for robotic joints, and enabling accurate positioning, smooth motion control, and repeatable performance across a wide range of applications.

- Large robotic joints (shoulders, elbows, hips, knees): AksIM-2™ and AksIM-4™ Dual Concentric encoders deliver true absolute positioning, improved repeatability, and reduced system complexity.
- Space-constrained or misalignment-prone joints: Orbis™ encoders provide high-speed operation with flexible installation options.
- Small, lightweight joints (grippers and dexterous hands): Compact solutions such as RM08 and AksIM-Mini™ offer ultra-small form factors, high accuracy, and true absolute position feedback.

These encoder technologies enable direct, high-precision feedback at every joint, supporting advanced robotic applications—from industrial automation to collaborative robots and dexterous robotic hands. Their compact, non-contact designs and high-speed capabilities make them well-suited for demanding environments where reliability and performance are critical.

"Automate is a key opportunity to demonstrate how Renishaw technologies help manufacturers get more from their robotic systems," said Dan Skulan, General Manager at Renishaw Inc. "From calibration and recovery to precision measurement and motion control, we're focused on delivering solutions that improve uptime, accuracy, and overall process confidence."

Renishaw's presence at Automate 2026 reinforces its commitment to advancing smart manufacturing through precision, connectivity, and automation-ready technologies.

For more information on Renishaw's industrial automation solutions, visit www.renishaw.com/industrial-automation.

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## Druck Launches UPS4E-IS, the World's Only Intrinsically Safe Pocket-Size Loop Calibrator

*New Calibration Technology Enhances Performance in Commercial and Hazardous Area Applications*

LEICESTER, U.K. – April 30, 2026 – Druck, a Crane Company business and a leader in pressure measurement and instrumentation, has launched the UPS4EIS, an intrinsically safe, pocketsize loop calibrator that sets a new benchmark for calibration in commercial and hazardous area applications. The UPS4EIS is the only intrinsically safe compact pocket-size loop calibrator available in the market today.

Designed for instrumentation technicians and maintenance engineers, the UPS4E-IS is an easytouse handheld device that sources and measures 4–20 mA signals in a single unit, with inbuilt datalogging to simplify testing, calibration and troubleshooting. By eliminating the need for multiple tools, it helps users save time, reduce complexity and improve accuracy in the field, measuring current and voltage with 0.01% accuracy.

ATEX and IECExcertified for Zone 0 environments, the UPS4EIS combines a rugged design with longlasting performance for safe, dependable operation in the harshest conditions. It delivers up to 100 hours in measure mode and 18 hours when powering a 12 mA loop—nearly double the typical battery life—setting a new benchmark for endurance in the field.

"Leveraging Druck's longstanding expertise in dependable loop calibration, the launch of the UPS4E-IS marks a significant leap forward in enhancing efficiency for handheld electric loop calibration for commercial and hazardous area applications," said Gordon Docherty, President of Druck. "Its introduction reinforces our commitment to providing innovative calibration solutions that empower technicians and engineers globally."

Building on the launch of the UPS4E in 2025 — the smallest electrical loop calibrator on the market — the UPS4EIS is the nextgeneration replacement for the popular UPS-II-IS and UPS-III-IS series.

The new technology has already been piloted by select customers who have praised its compact design, ease of use, accuracy, reliability, and time-saving features, all of which contribute to improvements in productivity.

## IndySoft Empowers the Technician with Launch of Scales

*IndySoft Scales is the only mobile calibration app purpose-built for scale field service*

CHARLESTON, S.C. (April 15, 2026) — IndySoft, the global leader in calibration and asset management software, today announced the launch of IndySoft Scales, a mobile calibration app that is touch-optimized, voice-enabled, and offline-first. The platform was designed for technicians who require more ease of use than a traditional laptop provides in the field.

IndySoft Scales tackles some of the industry's biggest pain points, such as delayed data from the field, inconsistent documentation quality, manual tolerance calculations, and paper-based workflows.

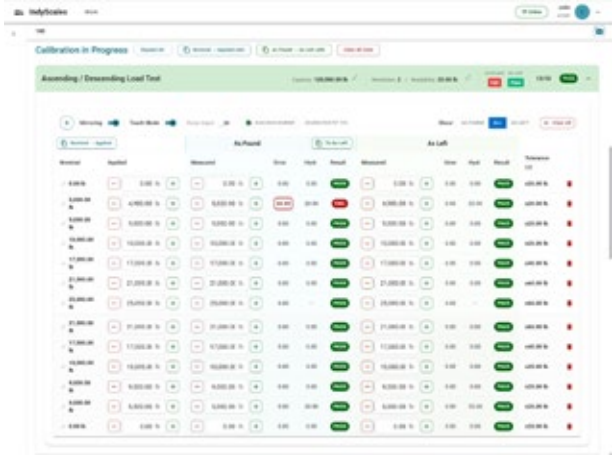
Designed for how scale calibration actually happens in the field, technicians can work efficiently, completing jobs 30% faster, and leave every customer site with a complete, professional record of the work they've done. For the technician, this means the day ends when the last job ends, eliminating the need for manual input, dual entry, or additional paperwork at the office or hotel. For the customer, this means instant professional certification.

Every feature traces back to the best experience for the technician doing the work: a touch interface with oversized controls so calibrations can be completed without an onscreen keyboard, voice input for hands-free operation, intelligent tests that reorder and recalculate as parameters change, and real-time pass/fail with red/green indicators so the technician knows instantly whether a scale passes.

"With IndySoft Scales, we're delivering innovation directly into the hands of the technician," said Rhett Price, CEO of IndySoft. "This extension of our IndySoft platform ensures that every field tech shows up prepared and leaves every site with a complete, compliant record of their work. We aren't just managing data; we're optimizing the entire calibration workflow from start to finish."

Scales ships with seven purpose-built test types, including ascending/descending, section, reverse section, eccentricity, repeatability, discrimination, and strain load. In addition, NIST Handbook 44 tolerances, pass/fail logic, and structured As Found/As Left data capture are built into every screen. Whether it's a roadside scale, gravel yard, or grain elevator, a technician can count on IndySoft Scales to provide faster, smarter calibrations on any device, anywhere. The app's offline-first architecture does not rely on a mobile or Wi-Fi signal.

IndySoft Scales is available now and compatible with any device a technician carries. Scale calibration has been waiting for software that works the way technicians do; IndySoft has delivered the solution. To see how it works in the field, register for our upcoming webinar, visit IndySoft.com, or contact sales@indysoft.com.



# Digitalizing the Bench: Why the Future of Metrology is Model-Driven

Michael L. Schwartz
Cal Lab Solutions, Inc.

As I prepare to speak at the DoD Digital Transformation in Metrology Workshop, I find myself reflecting on the massive evolution our industry has undergone. I remember when automation first arrived on the calibration bench; we treated it as a localized convenience. Technicians wrote long, linear scripts to control specific instruments, sending sequential commands to control equipment. At the time, this scripting era felt like magic, saving us from countless hours of manual dial-turning and handwritten record-keeping.

But that was then. Today, we stand on the edge of a far more profound transition: the leap from simple automation to true digitalization. This shift is not merely about writing faster scripts or turning paper certificates into PDFs. It is about fundamentally redefining how we structure, communicate, and utilize measurement data across the modern supply chain.

To understand where we must go, we have to be honest about the limitations of legacy approaches. Traditional automation is fundamentally rigid. It relies on hard-coded scripts where the reference standard and the Unit Under Test (UUT) are permanently welded together in the code. If a primary standard goes out of service, the workflow grinds to a halt. Swapping that standard means manually opening, editing, and re-testing the automated procedure. This creates an expensive, unsustainable cycle of maintenance I call "code rot." In a fast-moving economy, this rigid instrument lock-in is a luxury no modern laboratory can afford.

True digitalization breaks this bottleneck by separating the measurement requirement from the physical hardware. This is the core philosophy of Model-Driven Software Engineering. Instead of writing a line of code that configures a specific standard, we must define the metrological measurement requirement of the test itself—describing what parameter and tolerance must be verified on the UUT.

Under this model-based approach, the software platform acts as an intelligent coordinator. It knows the laboratory environment, identifies available standards that meet the metrological requirements, and automatically translates the request into the exact commands for the instrument being used. This means a single automated test definition can run on any bench, regardless of the specific manufacturers or models connected to it. We build a flexible, reusable metrological capability rather than a hardware-specific script.

The economic benefits are compelling. Historically, automation costs have been dominated by the engineering hours required to write, debug, and maintain complex scripts. Because a model-driven approach allows us to define the measurement rather than code the hardware interface, the amount of code we have to write drops precipitously. Writing less code means we can build new automation packages in less than a quarter of the time, dramatically lowering development costs and getting work out the door faster.

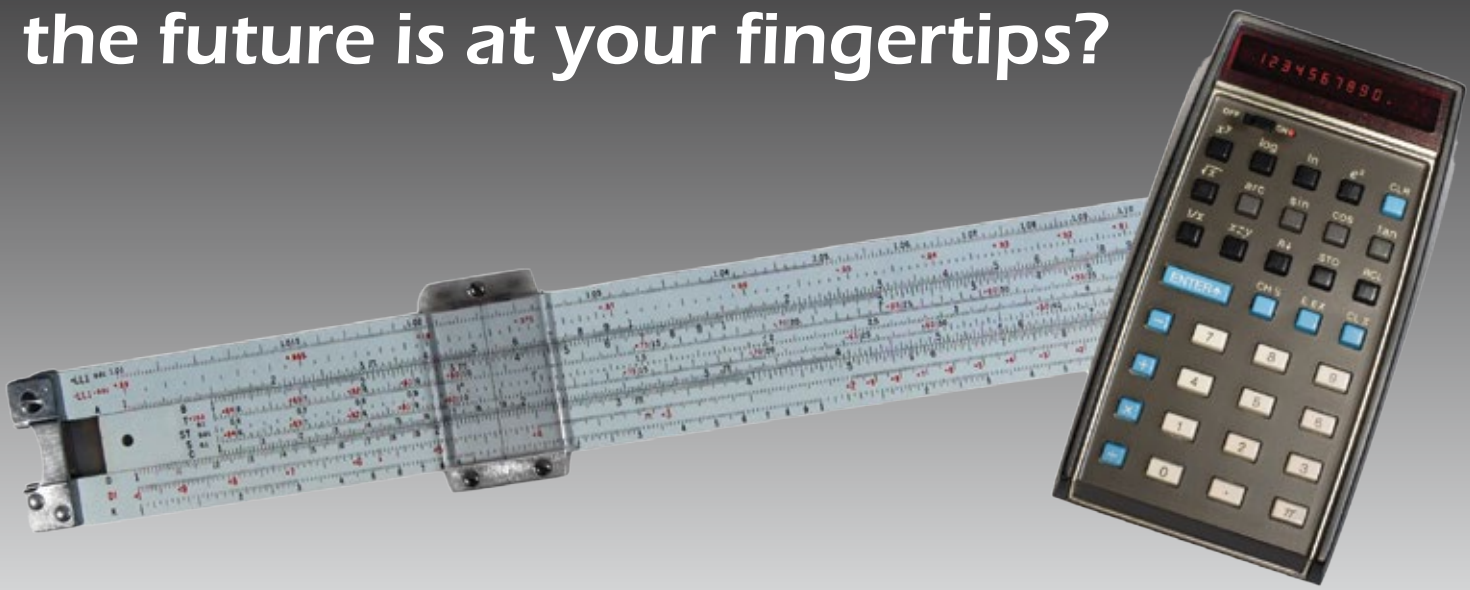
Furthermore, digitalization delivers the metrology trifecta: better, cheaper, and faster. It is *better* because we remove human error from hardware configuration, and ISO/IEC 17025 audit-ready uncertainty calculations are built directly into the data models. It is *cheaper* because it eliminates vendor lock-in, letting us maximize the multi-vendor assets we already own. It is *faster* because a "build once, use everywhere" philosophy instantly deploys capabilities across multiple benches.

This shift also redefines how calibration data integrates with enterprise systems. For years, automation existed in a silo, disconnected from the Laboratory Information Management System (LIMS). Modern digitalization demands an open, integration-first ecosystem. Our automation platforms must act as universal data-collection tools, piping structured, compliant measurement data directly into whichever LIMS the organization chooses. This is where modern architectures, such as **Metrology.NET**, are leading the industry—by acting as a flexible execution engine that plugs into an existing software stack, rather than forcing laboratories into closed-loop, cloud-only systems that compromise data sovereignty.

The era of hard-coded legacy scripts is drawing to a close. It is time for us to stop thinking like manual programmers and start thinking like digital architects.

METROLOGY.NET®

# Why struggle with the past when the future is at your fingertips?



# DISRUPTIVE INNOVATION

The **1972 introduction of the HP-35 scientific calculator** by Hewlett-Packard was a **classic example of disruptive innovation** that also triggered a **paradigm shift** in engineering and scientific calculations. The HP-35 effectively rendered the **slide rule**, the dominant tool for engineers and scientists for decades, **obsolete almost overnight**.

Similarly, **Metrology.NET** is positioned to revolutionize the calibration industry by replacing outdated legacy software with a modern, integrated, and automated solution.

| Aspect | Slide Rule (Legacy Software) | HP-35 Calculator (Metrology.NET) |
|---|---|---|
| **Ease of Use** | Complex, requires expertise and training | Simple, intuitive, minimal learning curve |
| **Speed & Efficiency** | Slow, manual calculations | Fast, automated processing |
| **Accuracy** | Prone to human error | Highly precise with minimal error |
| **Portability/Scalability** | Bulky, single-user | Compact, multi-user, and scalable |
| **Technological Advancement** | Mechanical, limited in functions | Digital, continuously evolving |
| **Market Disruption** | Decades of dominance ended overnight | Established software is now outdated |
| **Cost & ROI** | Initially cheaper, but labor-intensive | Higher upfront, but massive long-term savings |

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### Specifications

| | |
|---|---|
| Weight (lb) | **4** |
| Size (in) | **9.3 x 4.3 x 2.8** |
| Battery Life (hr) | **10** |
| Certification | **ISO 17025** |