CAL LAB
THE INTERNATIONAL JOURNAL OF METROLOGY

2020
JANUARY
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MARCH

Choosing the Proper Measurement Tool

Converting a mV/V Load Cell Signal into Engineering Units

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VOLUME 27, NUMBER 1

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FEATURES

DEPARTMENTS

ON THE COVER: Technician Jim Hicks at his power supply workstation at the Transcat calibration facility in Denver, Colorado.

CALENDAR

UPCOMING CONFERENCES & MEETINGS

At time of printing, some of the following events were still tentative. Visit the event URL provided for the latest information.

Jun 22-24, 2020 MetroAeroSpace. An electronic virtual conference to be organized in lieu of a physical meeting in Pisa, Italy. The IEEE International Workshop on Metrology for AeroSpace represents an international meeting place in the world of research in the field of metrology for aerospace involving national and international institutions and academia in a discussion on the state-of-the-art concerning issues that require a joint approach by experts of measurement instrumentation and industrial testing, typically professional engineers, and experts in innovation metrology, typically academics. http://www.metroaerospace.org/

Jun 22-25, 2020 Sensor and Measurement Science International (SMSI). Nuremberg, Germany. The SMSI brings scientists and researchers from all concerned scientific fields together to secure the success of these ideas in the future. For the first time the new technical conference SMSI 2020 – Sensor and Measurement Science International will be held parallel to the SENSOR+TEST trade fair. https://www.smsi-conference.com/

Jun 23-25, 2020 SENSOR+TEST. Nuremberg, Germany. The SENSOR+TEST trade fair in Nürnberg is the world's leading forum for sensors, measuring and testing technology. https://www.sensor-test.de/

Jun 26, 2020 95th ARFTG Microwave Measurement Conference. Los Angeles, CA. Measurement techniques, approaches and considerations for frequencies from RF through THz. Measurement-based modeling, uncertainties and related topics are also covered. https://www.arftg.org/

Aug 22-27, 2020 CPEM and NCSL International. Denver, CO. The Conference on Precision Electromagnetic Measurements (CPEM) and NCSLI Annual Conference offer you an exceptional opportunity to attend, present, sponsor and exhibit at this outstanding conference venue. https://www.ncsli.org/aws/

Oct 27-29, 2020 38th North Sea Flow Measurement Workshop. Aberdeen, UK. TÜV SÜD. It is important now, more than ever, to stay ahead of developments in technology, regulation and practice. The North Sea Flow Measurement Workshop continues to meet these challenges head on. https://www.tuvsud.com/en-gb/events/north-sea-flow-measurement-workshop

Oct 28-30, 2020 Simposio de Metrologia. Queretaro, Mexico. The Secretary of Economy and the National Metrology Center (CENAM). The Metrology Symposium is a forum that promotes the exchange of experiences on the most recent advances and applications of metrology at the service of industry and society. https://www.cenam.mx/simposio2020/en/

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EDITOR'S DESK

Remote Learning

This issue's Calendar section posed a dilemma, probably for the very first time in the 27 years CAL LAB has been printing! Due to the *fluid* nature of world events at this moment in time, Webinars and Online & Independent Study listings will take the place of the usual in-person seminar listings. The Online & Independent Study section grows every year, so be sure to check it out! And, this will be the first time we've included webinars in the print edition. Folks often don't have the time or money to attend hands-on training, so it's important for the measurement community to know these resources are out there. This list is by means exhaustive, so please let me know if there is a program out there that we missed: office@callabmag.com.

Despite the advantages, remote learning can never replace the in-person experience, surrounded by others in a working or practice lab environment. In our last issue, Oct-Dec 2019 (Vol. 26:4), we ran an article called "Cost and Accessibility of Metrology, Calibration, Testing, and NDT Training," by Mr. Destefan and Mr. Hinton. In it, the authors cite the increasing importance for appropriately trained calibration and testing laboratory technicians, and the cost and effectiveness of different delivery methods when it comes to training these much needed personnel. They weighed pros and cons, graphed out costs, and came to the evergreen conclusion: we need to be introducing young minds to metrology in primary/secondary school and leveraging non-degree college programs at the local level.

In that vein for this issue, Mr. Fuehne, of Purdue Polytechnic Institute, shares with us the details of a dimensional measurement training program developed between his employer and local industry located in Columbus, Indiana in "Choosing the Proper Measurement Tool." I hope that readers will not just find this article of value, but they will take the idea of educational institutions partnering with industry, as an efficient means of training the next generation of measurement professionals, and help facilitate a similar partnership.

Last, but not least, Mr. Zumbrun of Morehouse contributed a very practical article on "Converting a mV/V Load Cell Signal into Engineering Units," for those calibrating instrumentation using a span calibration.

Happy Measuring,

Sita

CERTIFICATIONS

AC/DC Metrology. A2LA WPT. This self-directed online course is an overview of AC/DC metrology, with a specific focus on preparing the learner for the CCT (Certified Calibration Technician) exam. https://www.a2lawpt.org/e-learning

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

Certified Calibration Technician Exam Prep. A2LA WPT. This self-directed online course was designed to prepare the learner for the CCT (Certified Calibration Technician) exam, and covers the primary topics represented in the exam. https://www.a2lawpt.org/e-learning

Certified Calibration Technician Prep – Online. QC Training. Students prepare to take the ASQ's Certified Calibration Technician (CCT) exam. This course follows the ASQ body of knowledge with audio/visual presentations of the various topics to prepare the student for the CCT exam. https://qctraininginc.com/course/certified-calibration-technician-prep-online/

Certified Calibration Technician Question Bank - Web-Based. ASQ. Build confidence as you prepare for the ASQ CCT exam with hundreds of practice questions from ASQ. Simulate a timed exam from the convenience of your home or office, or review specific topic areas and identify your strengths and weaknesses. https://asq.org/training/catalog

DIMENSIONAL

Basic Dimensional Measurement Tools – Self Directed Learning. QC Training. This DVD course forms the basis for mastering more advanced measuring tasks to ensure that you'll get the accurate measurements needed for all data-based improvement efforts. https://qctraininginc.com/course/basic-dimensional-measurement-tools-self-directed-learning/

Coordinate Measuring Machine (CMM). A2LA WPT. This self-directed online course examines the basic concepts and principles of Coordinate Measuring Machines (CMMs), as defined by different manufacturers as well as the standard documents accepted by industry. https://www.a2lawpt.org/e-learning

Coordinate Measuring Machine Basics – Online. QC Training. This entry level course describes the CMM for the individual with limited to no knowledge of CMMs. Course content includes history of the CMM, basic terminology, specifications, standards, accuracy, and measurement uncertainty. https://qctraininginc.com/course/coordinate-measuring-machine-cmm-basics-online/

Dimensional Measurement User – E-learning. National Physical Laboratory. In this training course, learners will be introduced to dimensional metrology and the importance of good measurement practice. https://training.npl.co.uk/course/dimensional-measurement-user/

Geometric Dimensioning and Tolerancing (GD&T). A2LA WPT. This self-directed online course is an overview of Geometric Dimensioning and Tolerancing (GD&T) and is designed to give calibration technicians a general understanding of the history, applications, limitations, and use of GD&T. https://www.a2lawpt.org/e-learning

Level II Dimensional Measurement: Hardness. A2LA WPT. Participants in this self-directed online course will gain an advanced understanding of precision dimensional measurement relating to hardness. https://www.a2lawpt.org/e-learning

Level II Dimensional Measurement: Roundness. A2LA WPT. Participants in this self-directed online course will gain an advanced understanding of precision dimensional measurement relating to roundness. https://www.a2lawpt.org/e-learning

Level II Dimensional Measurement: Surface Texture. A2LA WPT. Participants in this self-directed online course will gain an advanced understanding of precision dimensional measurement relating to surface texture. https://www.a2lawpt.org/e-learning

Precision Dimensional Measurement. A2LA WPT. This Level I course covers the following precision dimensional measurement equipment as well as its usage and associated measurement principles: Gages/Gage Blocks, Interferometers, Optical Instruments. https://www.a2lawpt.org/e-learning

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

ELECTRICAL

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

ONLINE & INDEPENDENT STUDY

Electrical Instrumentation for Applied Measurements – OnDemand Internet Course. Technology Training, Inc. (TTI). This course provides a basic understanding of electrical measurement systems, as well as the engineering concepts for the whole measurement system. https://ttiedu.com/

Precision Electrical Measurement. A2LA WPT. This Level I course covers the following precision electrical measurement equipment as well as its usage and associated measurement principles: Analog Meters, Digital Multi-Meters, Faraday Shields. https://www.a2lawpt.org/e-learning

Precision Electrical Measurement – Self-Paced Online Training. Fluke Calibration. Making precision measurements is a skill that takes practice and experience to master. This course will increase your knowledge of terminology, concepts and procedures to help you become more proficient. https://us.flukecal.com/training

FLOW

Introduction to Pipettes. A2LA WPT. This Level I course covers the following types of pipettes as well as their usage, applications, and associated measurement principles: Positive Air Displacement, Single Volume, Adjustable, and Multichannel Pipettes. https://www.a2lawpt.org/e-learning

Precision Flow Measurement. A2LA WPT. This Level I course covers precision flow measurement equipment as well as its usage and associated measurement principles. https://www.a2lawpt.org/e-learning

FORCE & TORQUE

Precision Force & Torque Measurement. A2LA WPT. This Level I course covers the following precision force and torque measurement equipment as well as its usage and associated measurement principles: Transducers, Load Cells, Proving Rings, Torque Testers. https://www.a2lawpt.org/e-learning

GENERAL

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

Calibration Laboratory Operations – OnDemand Internet Course. Technology Training, Inc. (TTI). This course is for individuals who are involved in standards and calibration laboratories and for others who want a clear understanding of the special requirements that must be met by managers and other personnel in standards and calibration work. https://ttiedu.com/

Career Long Learning. Sine Calibration School. Our full curriculum starts with the Basic Calibration Course. From there, you can continue to learn with yearly courses in various calibration subjects to further your calibration understanding and knowledge. https://www.sinecalibrationschool.com/

Fundamentals of Calibration. Sine Calibration School. Our full curriculum starts with the Basic Calibration Course. From there, you can continue to learn with yearly courses in various calibration subjects to further your calibration understanding and knowledge. https://www.sinecalibrationschool.com/

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

Interval Analysis. A2LA WPT. This self-directed online course focuses on concepts associated with calibration intervals and interval analysis, specifically to determine the correct calibration interval necessary to maintain measurement quality over a time interval. https://www.a2lawpt.org/e-learning

Introduction to Analytical Measurement. A2LA WPT. This course introduces analytical measurement concepts that lay the foundation for a variety of analytical industry segments, including chemical, biotechnology, environments, and forensics. It covers relevant mathematics, common error sources, the operation of principle measurement, devices, and further key concepts. https://www.a2lawpt.org/e-learning

Introduction to Measurement and Calibration. A2LA WPT. This self-directed online course is an overview of measurement and calibration principles, starting with the purpose of metrology and the concepts associated with accuracy, error, bias and measurement uncertainty. https://www.a2lawpt.org/e-learning

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

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

Introduction to Metrology - e-Learning. National Physical Laboratory. This half-day, certified e-learning course has been designed to introduce metrology and explore its value for industry, the economy, science and society. https://training.npl.co.uk/course/introduction-to-metrology/

Measurement and Calibration Overview – Online Training. QC Training. This course is an introduction to the topics of measurement and calibration designed to give the student a general overview of the subject. It may also be considered a metrology 101 course for the new calibration technician or support personnel desiring to learn more about measurements. https://qctraininginc.com/course/introduction-to-measurement-calibration-online/

Measurement Fundamentals Explained – e-Learning. National Physical Laboratory. This is the first online open unit from NPL's 'Measurement Explained' series. This unit introduces metrology, along with some basic metrology concepts. This free course is the ideal precursor to our more extensive, certified, Introduction to Metrology e-Learning course. https://training.npl.co.uk/course/measurement-fundamentals-explained/

Measurements Overview (QIMT1200) – Online Metrology Courses. Quametec. A parallel series of courses, which provide an introduction to, and description of, typical measurements performed in the dimensional, physical and electrical disciplines in science and industry. https://www.qimtonline.com

Metrology Applications for Engineers and Scientists. A2LA WPT. This self-directed online course is designed to familiarize engineers and scientists with metrology, the science of measurement, as it applies to their respective disciplines. https://www.a2lawpt.org/e-learning

Metrology Applications for Engineers and Scientists – Web-based. ASQ. This course focuses on the science of measurement. When completed, you'll have a proper understanding of metrology concepts, basic statistics, reliability statistics and measurement uncertainty. https://asq.org/training/metrology-applications-for-engineers-and-scientists-metappwpt

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

Proficiency Testing. A2LA WPT. This self-directed online course covers information that laboratory management personnel need to conduct a better measurement assurance program and improve the outcome of proficiency testing. https://www.a2lawpt.org/

Safety in the Calibration Lab. A2LA WPT. This self-directed online course provides an understanding of potential hazards present in the calibration lab and how to mitigate risk by applying proper safety measures. https://www.a2lawpt.org/e-learning

Test Instruments Operation and Calibration. A2LA WPT. This is a general overview of the principles and best practices associated with operating and calibrating test instruments. https://www.a2lawpt.org/e-learning

INDUSTRY STANDARDS

Assessment to the Requirements of ISO/IEC 17025. A2LA WPT. This self-directed online course provides a comprehensive look at ISO/IEC 17025:2017 and its requirements from an auditing perspective. https://www.a2lawpt.org/e-learning

Assessment to the Requirements of ISO/IEC 17025 – Web-based. ASQ. This course is targeted toward management and what they need to be conformant to the standard. Learn about the requirements of the standard, how to prepare for the audit, how to conduct and audit of calibration suppliers. https://asq.org/training/catalog

Changes to ISO/IEC 17025:2017. IAS. The course will present the major new changes to ISO/IEC Standard 17025. https://www.iasonline.org/training/ias-online-training-now-available/

How to Calculate Calibration Uncertainty in Accordance with ILAC P14. ISOBudgets. This course is going to teach you how to calculate and report measurement uncertainty in your calibration reports. The process you will learn is based on the requirements of ISO/IEC 17025:2017 and ILAC P14:01/2013. https://www.isobudgets.com/courses/

Introduction to ISO/IEC 17025 for Technicians. A2LA WPT. This self-directed online course focuses on the requirements of ISO/IEC 17025, how it is applied to calibration and test laboratories, and identified key information that pertains to technicians who work in an accredited lab. https://www.a2lawpt.org/e-learning

ISO/IEC 17025 Compliance – Web-based. ASQ. Understand the terminology, concepts, and procedures relating to ISO compliance and uncertainty management. This self-paced online course is ideal for Calibration Coordinators, Calibration Technicians and Engineers, and Quality Coordinators and seeking to understand of the ISO 17025. https://asq.org/training/catalog

ISO/IEC 17025 for Laboratories. IAS. This 2-day Training Course examines structural components of the standard. Quality system and technical requirements are grouped in a manner that makes them clear and understandable. https://www.iasonline.org/training/ias-online-training-now-available/

ISO/IEC Conformance: Uncertainty Management. A2LA WPT. This self-directed online course provides a detailed perspective on the concept of uncertainty management as it pertains to ISO/IEC 17025. https://www.a2lawpt.org/e-learning

MASS

Basic Mass Computer-Based Training. NIST OWM. Free download available in English and Spanish. https://www.nist.gov/pml/weights-and-measures/laboratory-metrology/lab-metrology-training

Precision Mass Measurement. A2LA WPT. This Level I course covers precision mass measurement equipment as well as its usage and associated measurement principles. https://www.a2lawpt.org/e-learning

ONLINE & INDEPENDENT STUDY

MEASUREMENT UNCERTAINTIES

How to Calculate Measurement Uncertainty for ISO/IEC 17025. ISOBudgets. In this course, you will learn much more than just theory! Learn the tactics to calculate uncertainty, so you can confidently estimate uncertainty and impress your auditors. https://www.isobudgets.com/courses/

How to Calculate Measurement Uncertainty in Chemistry per EURACHEM/CITAC CG4 Guide. ISOBudgets. Learn how to estimate uncertainty in chemistry for ISO/IEC 17025:2017 accredited testing labs. This course is best suited for chemical testing labs that use HPLCs, GCs, and MS. https://www.isobudgets.com/courses/

Introduction to Measurement Uncertainty – e-Learning. National Physical Laboratory. This half day, certified e-learning course explores measurement uncertainty and related concepts. The course consists of a series of multimedia presentations, exercises and an extensive selection of additional content, all delivered through a self-paced learning experience. https://training.npl.co.uk/course/introduction-to-measurement-uncertainty/

Measurement Uncertainty. A2LA WPT. This self-directed online course is designed to instruct and evaluate the user on concepts of measurement uncertainty. https://www.a2lawpt.org/e-learning

Measurement Uncertainty – OnDemand Internet Course. Technology Training, Inc. (TTI). Course 132 begins with an introduction to measurement uncertainty and to the terms associated with it. Then the accuracy and limitations of statistics are discussed, with examples of the various types of distributions encountered in statistical tests. A discussion of sources of errors and their classification into random and systematic follow, before presenting the details of using traditional versus expanded uncertainty equations. https://ttiedu.com/

Measurement Uncertainty – Self-Paced Online Training. Fluke Calibration. Learn the fundamental concepts and how to successfully determine measurement uncertainty and quality improvement techniques. https://us.flukecal.com/training

Measurement Uncertainty – Web-based. ASQ. The focus of making quality measurements is to reduce uncertainty where possible, and to increase confidence in the measurements. It doesn't matter where the measurements are made: knowing about measurement uncertainty is important in expressing measurement results in design, manufacturing, or quality in the aerospace, medical device, automotive industry or a calibration laboratory. https://asq.org/training/catalog

Measurement Uncertainty Analysis – Online Training. QC Training. This course is an introductory presentation about Measurement Uncertainty concepts and calculations required of most calibration and testing laboratories accredited to ISO standards. https://qctraininginc.com/course/measurement-uncertainty-analysis-online/

Measurement Uncertainty Analysis (QIMT1410) – Online Metrology Course. Quametec. This course takes the student through the basics of the ISO GUM (Guide to the expression of Uncertainty in Measurement) to advanced concepts and methods designed to enable the student to perform measurement uncertainty analyses, from the simple to the complex, with confidence. https://www.qimtonline.com

Measurement Uncertainty Explained – e-Learning. National Physical Laboratory. It will introduce the basics of measurement uncertainty. It will provide an introduction to the concept and importance of measurement uncertainty and demonstrate the basics of uncertainty evaluation in eight steps. This free course is the ideal precursor to our more extensive, certified, Introduction to Uncertainty e-Learning Course. https://training.npl.co.uk/course/measurement-uncertainty-explained/

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

Understanding Uncertainty Budgets – e-Learning. National Physical Laboratory. This course teaches measurement uncertainty through practical examples of uncertainty budgets. https://training.npl.co.uk/course/understanding-uncertainty-budgets/

PRESSURE & VACUUM

Precision & Vacuum Measurement. A2LA WPT. This Level I course covers the following precision pressure and vacuum measurement equipment as well as its usage and associated measurement principles: Transducers, Pressure Measurement Devices. https://www.a2lawpt.org/e-learning

RF & MICROWAVE

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

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

Keysight RF & Microwave Fundamentals eLearning Program. Keysight Technologies. Build a strong foundation in RF & microwave fundamentals. This includes learning about the most important measurements, critical success factors for ensuring accuracy, and how to get the most productivity and value from your Keysight instrument. https://www.keysight.com/find/rffundamentals

Microwave Principles. A2LA WPT. This self-directed online course provides an overview of microwave and radiofrequency microelectronics systems of all sizes and types, their applications, and the measurement and calibration principles associated with them. https://www.a2lawpt.org/e-learning

RF Measurement, Calibration and Connector Care. A2LA WPT. This self-directed online lesson describes principles and background information for the measurement of radio frequency electromagnetic fields. https://www.a2lawpt.org/e-learning

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- Single supply option
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ONLINE & INDEPENDENT STUDY

TEMPERATURE

Precision Humidity Measurement. A2LA WPT. This Level I course covers the following precision humidity measurement equipment as well as its usage and associated measurement principles: Hygrometers, Chilled Mirror Hygrometers, Wet and Dry Bulb Psychrometers. https://www.a2lawpt.org/e-learning

Precision Temperature Measurement. A2LA WPT. This Level I course covers the following precision temperature measurement equipment as well as its usage and associated measurement principles: Thermocouples, Resistance Temperature Detectors, Thermistors, Infrared Sensors. https://www.a2lawpt.org/e-learning

TIME & FREQUENCY

Time and Frequency Measurement. A2LA WPT. This self-directed online course is an overview of the basic concepts of time and frequency measurement, as they apply to a wide range of disciplines. https://www.a2lawpt.org/e-learning

VIBRATION

Acoustics and Vibration Measurement. A2LA WPT. This self-directed online course will enable calibration technicians to precisely and reliably measure acoustics and vibration in accordance with relevant ISO standards. https://www.a2lawpt.org/e-learning

Fixture Design for Vibration and Shock Testing – OnDemand Internet Course. Technology Training, Inc. (TTI). Technology Training, Inc. Course 157 starts with a basic introduction to shakers and vibration testing. General considerations in fixture design are discussed next, along with an introduction to instrumentation and sinusoidal vibration testing, as they apply to the fixture design and evaluation process. https://ttiedu.com/

Have a training event or online study program you want us to know about?
Email **office@callabmag.com**

WEBINARS

INDUSTRY STANDARDS

Aug 27, 2020 Document Control and Record Keeping. NIST OWM. This 2 hour webinar will introduce the fundamentals of Laboratory Management System Document Control and Record Keeping that are necessary to successfully implement ISO/IEC 17025:2017. https://www.nist.gov/news-events/events/2020/08/5613-document-control-and-record-keeping

Oct 29, 2020 Internal Auditing Best Practices. NIST OWM. This 2 hour webinar will consider internal auditing techniques and best practices that are used by a metrology laboratory to comply with ISO/IEC 17025:2017 criteria. https://www.nist.gov/news-events/events/2020/10/5616-internal-auditing-best-practices

LEGAL

Aug 12, 2020 Measurement Systems for Legal Metrology. NIST OWM. This 2-hour webinar will introduce measurement system basics, including the use of unit symbols, prefixes, and transitioning within and between measurement systems units. https://www.nist.gov/news-events/events/2020/08/5603-measurement-systems-legal-metrology

SOFTWARE

Jul 20-24, 2020 MET/TEAM® Basic Web-Based Training. Fluke Calibration. You will learn a systematic approach to recording the information you need to manage your lab assets routinely, consistently and completely. This course is typically held from 10:00 am to 12:00 pm (Noon) Pacific Standard Time. https://us.flukecal.com/training

Aug 31-Sep 4, 2020 MET/TEAM® Basic Web-Based Training. Fluke Calibration. You will learn a systematic approach to recording the information you need to manage your lab assets routinely, consistently and completely. This course is typically held from 10:00 am to 12:00 pm (Noon) Pacific Standard Time. https://us.flukecal.com/training

Sep 28-Oct 2, 2020 MET/CAL® Procedure Development Web-Based Training. Fluke Calibration. The course is designed for those who are directly involved in the operation of MET/CAL calibration software and are required to write or modify procedures. The workshop is presented as a five-part, ten-hour course with each two-hour session scheduled on consecutive days. https://us.flukecal.com/training

New Standard Aims to Improve Temperature Measurement Accuracy

W. CONSHOHOCKEN, Pa., Dec. 3, 2019 – A new ASTM International standard will help improve the accuracy of temperature measurement essential in many industries. ASTM's temperature measurement committee (E20) developed the new standard.

"Temperature is one of the most measured physical quantities in industry," says ASTM International member Frank Liebmann, a metrology engineer at Fluke Calibration. "It affects most industrial processes, so ensuring a more accurate determination of temperature is very important."

The new standard (soon to be published as E3186) will help lab technicians who regulate temperature sensors using calibrators known as dry block calibrators or dry wells, Liebmann says. The new standard includes guidance on possible errors and on determining calibration uncertainty when using dry block calibrators. Calibration laboratories will be the primary users of the standard, according to committee members. However, these devices are often deployed to the field for onsite verification.

ASTM International welcomes participation in the development of its standards. Become a member at www.astm.org/JOIN. The next meeting of ASTM International's temperature measurement committee is May 11-12, 2020, in Boston, Massachusetts, USA.

To purchase standards, contact ASTM International customer relations (tel +1.877.909.ASTM; sales@astm.org).

About ASTM International

Committed to serving global societal needs, ASTM International positively impacts public health and safety, consumer confidence, and overall quality of life. We integrate consensus standards – developed with our international membership of volunteer technical experts – and innovative services to improve lives… Helping our world work better.

Universe in the Balance

February 12, 2020, NIST News - Researchers at the National Institute of Standards and Technology (NIST) have found a way to link measurements made by a device integral to microchip fabrication and other industries directly to the recently redefined International System of Units (SI, the modern metric system). That traceability can greatly increase users' confidence in their measurements because the SI is now based entirely on fundamental constants of nature.

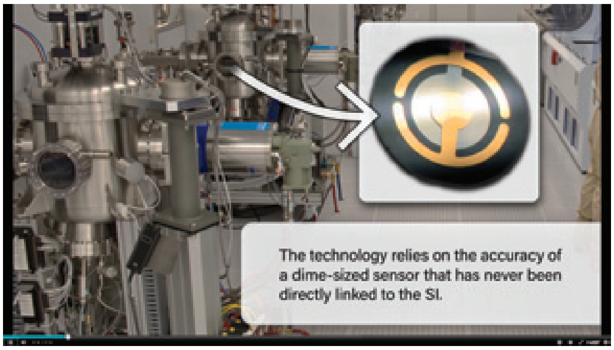
The device, a dime-size disk called a quartz crystal microbalance (QCM), is critically important to businesses that rely on precision control of the formation of thin films. Very thin: They range from micrometers (millionths of a meter) to a few tens of nanometers (billionths of a meter, or about 10,000 times thinner than a human hair) and are typically produced in a vacuum chamber by exposing a target surface to a meticulously regulated amount of chemical vapor that sticks to the surface and forms the film. The greater the exposure, the thicker the film.

Thin films are essential components in electronic semiconductor devices, optical coatings for lenses, LEDs, solar cells, magnetic recording media for computing, and many other technologies. They are also employed in technologies that measure the concentration of microbial contaminants in air, pathogens in the water supply, and the number of microorganisms that attach themselves to biological surfaces in the course of infection.

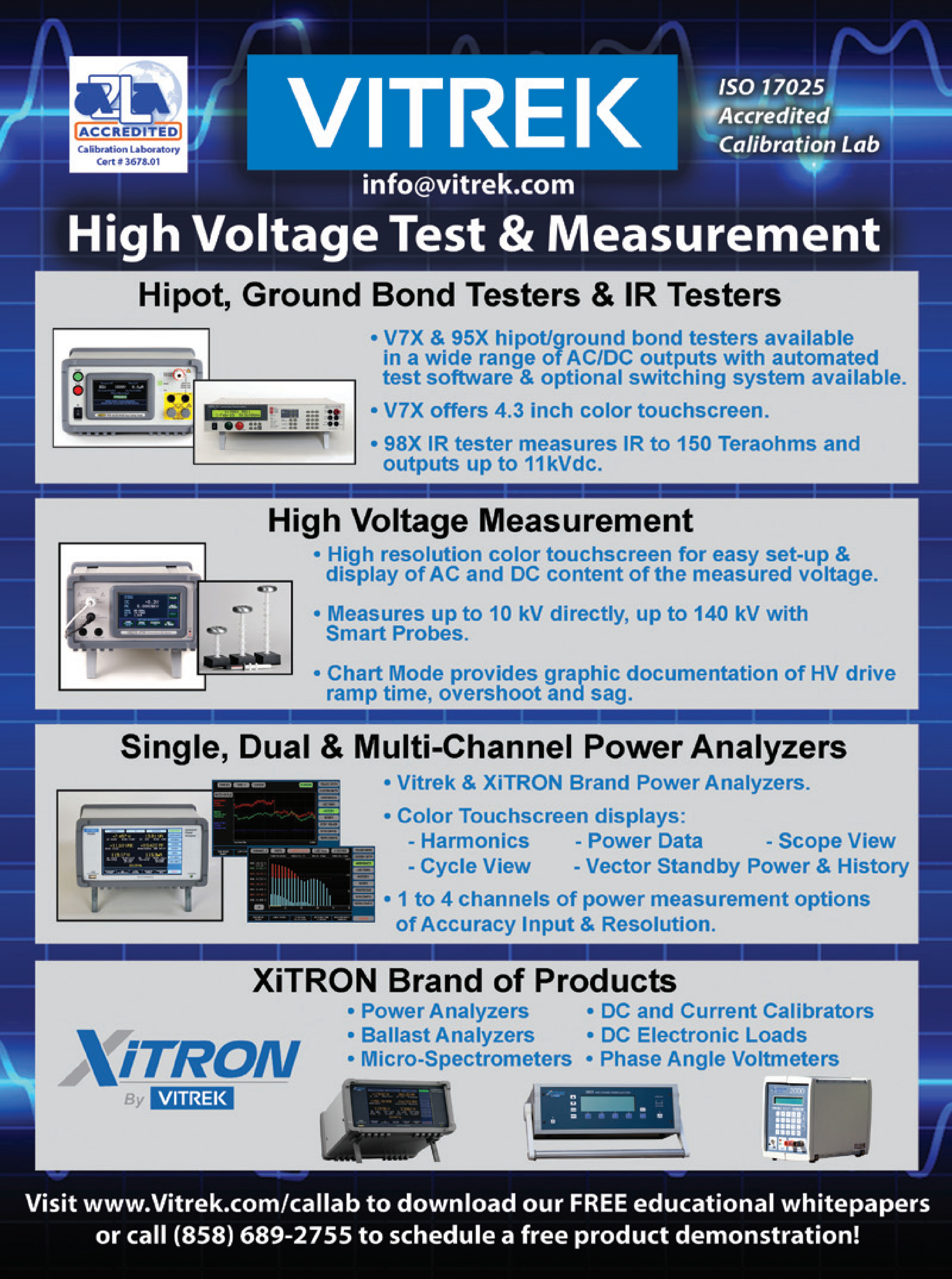
All those uses demand extremely accurate measurements of the film's thickness. Because that is difficult to measure directly, manufacturers frequently use QCMs, which have a valuable property: When an alternating current is applied to them, they vibrate at a resonant frequency unique to each disk and its mass.

To determine exactly how much film material is being deposited, they place the a QCM disk in the vacuum chamber and measure its resonant frequency. Then the disk is exposed to a chemical vapor. The more vapor that adheres to the QCM, the greater its mass — and the slower it vibrates. That change in frequency is a sensitive measure of the added mass.

"But despite ubiquitous implementation of QCMs throughout industry and academia," said NIST physicist and lead researcher Corey Stambaugh, "a direct link to the SI unit of mass has not existed." The relationship between the SI unit of mass (the kilogram) and resonance frequency is assumed to be well characterized after decades of QCM measurements. But over the years, industry has made inquiries to NIST regarding the absolute mass accuracy of these frequency measurements. The new results presented by Stambaugh and colleagues are in large measure a response to those queries.



This animation demonstrates a new method for linking mass measurements made using quartz crystal microbalances directly to the SI. Ensuring the accuracy of these tiny sensors could provide a common reference for the microelectronic fabrication industry, among other applications. Credit: Sean Kelley/NIST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"We expect that our findings will enable a new, higher level of assurance in QCM measurements by providing traceability to the new SI," said NIST physicist Joshua Pomeroy, who with Stambaugh and others report their findings today in the journal *Metrologia*. The redefinition of the SI units in May 2019 eliminated the previous metal prototype kilogram as a standard and instead defined the kilogram in terms of a quantum constant.

In the new SI, mass at the kilogram level will be realized in the United States using that constant in NIST's Kibble balance.

In the new SI, NIST They have also developed a standard instrument, called the electrostatic force balance (EFB), that provides extremely accurate measurement of masses in the milligram range and lower), which are directly linked to the SI by way of a quantum constant. The EFB provided the team with reference milligram sized-masses with a precision on the order of a fraction of a microgram (1/1,000,000th of 1 gram, or about one millionth the mass of an average paper clip).

Stambaugh and colleagues carefully weighed an uncoated quartz disk, then suspended it in a vacuum chamber and measured its resonant frequency. About 0.5 meters (20 inches) below the disk was a furnace that heated a quantity of gold to 1480 C (2700 F). Gold vapor from the furnace rose and attached itself to the lower surface of the QCM, increasing its mass and thus slowing its resonant frequency. The scientists repeated the procedure at different time intervals and thus different amounts of mass accretion. was repeated at different time intervals. The researchers deposited gold vapor was over different time intervals and recorded the subsequent changes in resonant frequency. They weighed the disk again using the same EFB reference masses. This provided an accurate measurement of the change in mass, and thus provided an exact measure of the amount of gold deposited.

In the course of the work, the team also performed a complete assessment of the uncertainties in the QCM measurements. They identified the most accurate mathematical method of correlating the addition of mass to the change in the QCM's resonant frequency.

"This work provides a key step in a technique for traceably tracking — and thus correcting for — mass changes over time," said NIST physicist Zeina Kubarych.

In that regard, the new findings could help improve the way mass is disseminated following the new SI definition. The new kilogram is "realized" — converted from an abstract definition to a physical reality — through highly controlled laboratory measurements in a vacuum chamber. But the working standards of the kilogram will be disseminated — physically delivered to measurement-science laboratories — in the form of metal masses in the open air. That means that water vapor and whatever else is in the air can adsorb onto the surface of a kilogram working standard, causing inaccurate measurement of its mass.

Because humidity and air contaminants differ substantially around the world, measurements of a carefully calibrated mass standard can differ appreciably from place to place at the levels of accuracy needed for industrial and scientific metrology. If, however, a calibrated QCM were to accompany each standard, it could provide an accurate measure of the amount of material adsorbed in transit and at the destination, helping the labs to receive more accurate definitions of the new kilogram while taking environmental conditions into account.

Paper: C. Stambaugh, H. Shakeel, M. Litorja and J. M. Pomeroy. Linking mass measured by the quartz crystal microbalance to the SI. *Metrologia*. Published February 12, 2020. DOI: 10.1088/1681-7575/ab54a5

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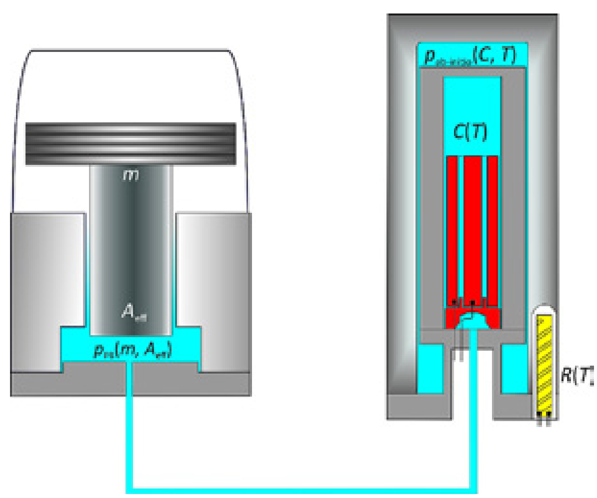
A Different Way of Measuring Pressure

February 25, 2020, PTB News - Within the scope of the work on the redefinition of the base unit kelvin, PTB developed a new method for pressure measurement based on the capacitance measurement of helium gas. From the first attempt, it was almost as good as the world's best method for pressure measurement with a piston manometer.

Pressure is the result of a force acting vertically onto a surface. Today, the most accurate pressure measurements are still working according to this principle, where the gas pressure under a piston of a certain area is adjusted via the mass stack i.e. via the weight force. At the same time, it has long been endeavored to develop further high-



Left: Conventional pressure measurement with a pressure balance according to $p_{PB} = F_g/A_{eff}$ (PB: pressure balance; g: gravitational force; A_{eff}: effective surface of a piston/cylinder system). Right: The new electrical approach: the relative change in capacitance $C(T)$ caused by the measuring gas at a known temperature T, which is determined by means of a calibrated resistance thermometer $R(T)$, can be directly linked to the gas pressure. The dielectric constant and the interaction of the gas particles enter into the required ab initio calculations: $p_{ab\text{-}initio}(C, T, Gas_{ab\text{-}initio})$

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pipettes.com 800.242.6022 info@pipettes.com precision methods. As early as 1998, Mike Moldover of the US American metrology institute NIST had voiced his idea of measuring pressure via an electrical (capacitance) measurement using theoretical calculations of the gas properties of helium. In the following years, however, implementing this groundbreaking thought would prove to be a real challenge. Both the precision capacitance measurement and the highly stable capacitors needed for this purpose, as well as the theoretical calculations using solely natural constants (ab initio calculations) were not yet possible with the required accuracy. Moreover, there was no accurate possibility to compare them with conventional pressure balances.

Each of the experimental obstacles has been removed at PTB over the last decade. Due to activities carried out within the scope of the new definition of the base unit Kelvin, conventional pressure measurements both with pressure balances and via capacitance measurements were raised to an unprecedented level worldwide. Thanks to the latest theoretical calculations achieved by diverse research groups across the globe, it has now become possible to measure a pressure of 7 million pascals (i.e. 70 times normal pressure) with a relative uncertainty of less than $5 \cdot 10^{-6}$. This uncertainty has been confirmed by comparison with a conventional pressure balance. It was the first comparison on an equal footing between mechanical and electrical pressure measurements.

Thus, a second method is now available to calibrate pressure with high accuracy. The method itself and the direct comparison with the conventional pressure standard offer, for one thing, the possibility to verify theoretical calculations of helium – an important model system in atomic physics. For another, they also allow other gases to be measured and thus, both theory and gas metrology to be further developed.

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Scientific publication: C. Gaiser, B. Fellmuth, W. Sabuga: Primary gas-pressure standard from electrical measurements and thermophysical ab initio calculations. *Nature Physics* 16, 177–180 (2019)

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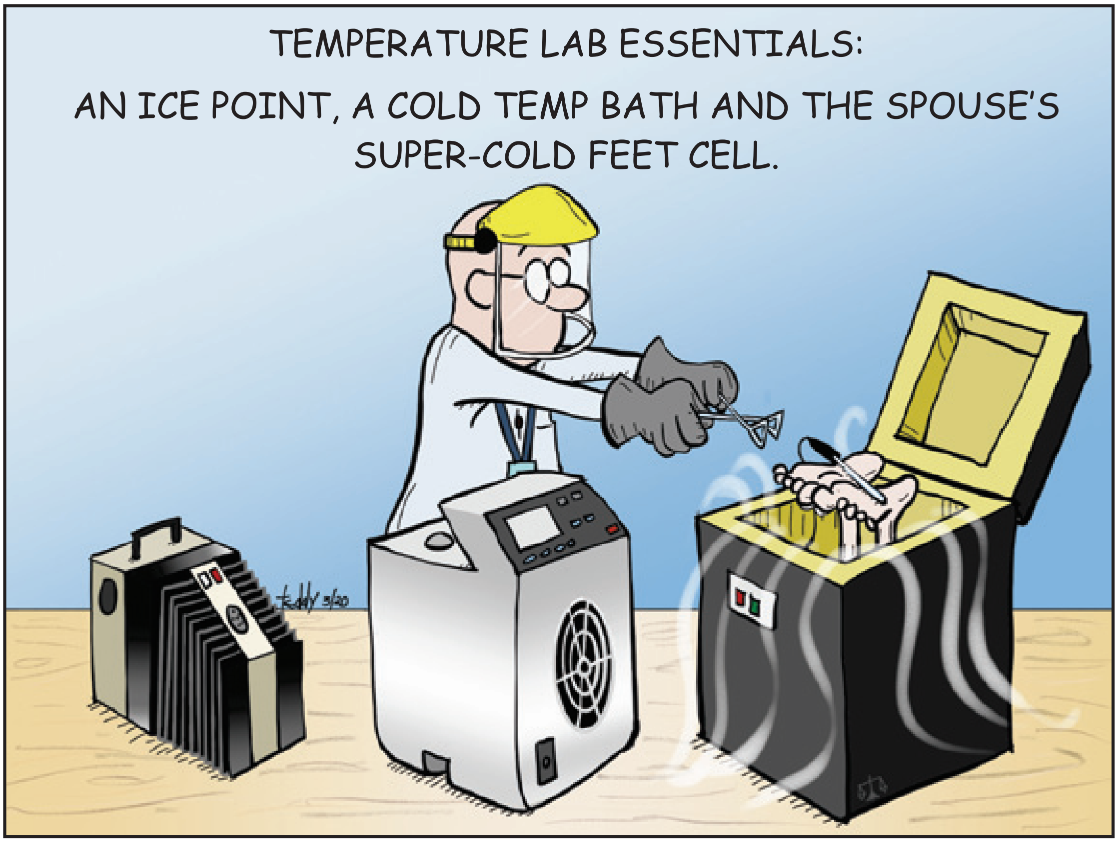
CAL-TOONS by Ted Green teddytoons@icloud.com



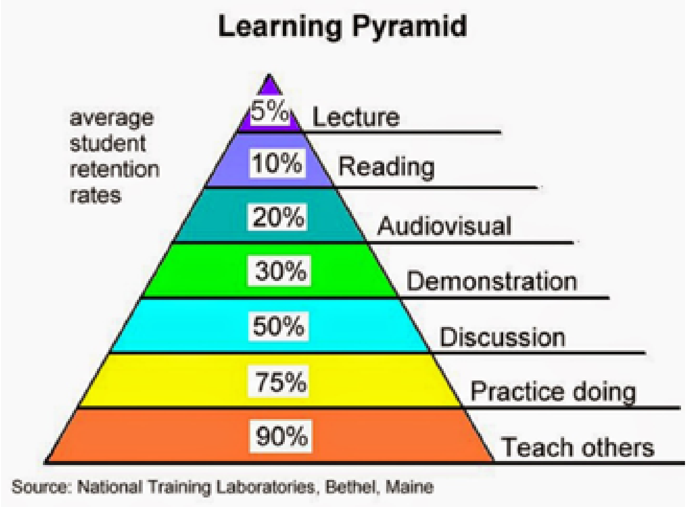
Choosing the Proper Measurement Tool

Joseph P. Fuehne, Ph.D., P.E.
Purdue Polytechnic Institute

The Purdue Polytechnic Institute in Columbus utilizes metrology tools with targeted measurement artifacts, which may be 3-D printed or machined, to facilitate learning and provide opportunities to demonstrate competency in basic measurement tools. Analog and digital calipers, analog and digital micrometers, Pi tapes, bore micrometers, and dial indicators are all demonstrated and employed during these training sessions. Trainees are required to complete measurement forms that are developed using a spreadsheet program and submit those completed forms for assessment. An element of the training involves using different tools to measure identical features on a part, highlighting the different scales, resolutions, potential errors and uncertainties, as well as the obvious ease or challenge to utilize each tool. A digital dimensional measurement tool has obvious advantages due to the ease of reading the value, but it may not always be the best tool for the specific measurement. Those who have little experience in measurement may tend to believe the value on the tool without considering appropriate procedures, units, and mechanics of actually using the tool – pressure applied to the measurement surface, proper zero-setting of the tool etc. In the case of measuring diameters, is there consideration and evaluation of using a two-point instrument versus a three-point instrument? These issues are highlighted only if different tools are used to measure the same feature and the values are recorded.

1. Introduction

Purdue Polytechnic Columbus (PPC), a statewide extension of the Purdue Polytechnic Institute on the main campus in West Lafayette, Indiana, has utilized and managed an environmentally-controlled measurement center at its campus in Columbus, Indiana for the past 8 years. During that time, much learning has occurred among PPC faculty and staff and that has led to a university-industry collaboration to deliver training programs to interested industries. Specifically, the industrial partner is Cummins, Inc., with headquarters located in Columbus, IN and engineering and manufacturing operations located around the world. The collaboration has identified measurement and quality training opportunities for several different groups within the corporation. This might include quality engineers, manufacturing engineers, design engineers, machine tool operators, managers, and newly-hired production workers. Rather than try to define and develop opportunities for all those groups, the decision was made to focus first on the newly-hired production workers who have a large influence on product quality but are not likely to understand how their behavior may impact that quality.



2. Portable, Short-Session Training Program

The proposed training would be 8 separate 2-hour sessions that would focus on various dimensional measurement tools with a few short modules included that cover important aspects of metrology such as calibration, calibration stickers, gage repeatability and reproducibility, sources of errors and uncertainty. The materials are portable so that the training can occur onsite rather than have employees travel to the training. Short, two-hour sessions are employed to minimize impact on manufacturing operations and maximize training time by not having long, tedious sessions where trainees just sit and listen. A pilot session will occur in March of 2020 with Cummins and will provide much-needed feedback on improving the program.

3. Dimensional Tools and Competency Badges

Instruction during the training for newly-hired production staff focuses on dimensional tools like micrometers, calipers, bore micrometers, pi tapes, rulers, dial indicators and functional gauges (go/no go) in both English and metric versions. There are short, modular lectures associated with each tool and then plenty of practice time to learn the operation of each tool. The Learning Pyramid (shown on previous page) demonstrates the average student retention rates for various learning activities. Clearly, actually practicing the skills results in superior retention over lecture, reading, and watching videos. Demonstrating how to read measurement tools or watching internet videos on how to do this do not provide much retention of the skill. Practice doing the skill does provide the best retention and is utilized extensively in the training. This may not be popular among the trainees who probably expected to be able to sit comfortably in a chair or desk while watching a boring lecture. However, understanding of the tool stems from this practice and this understanding is what provides the employee with the knowledge and confidence to choose the proper tool for the task.

Competency badges are also earned for each tool. Participants complete measurements independently on each tool without assistance from colleagues or instructors. Measurements are recorded on supplied sheets that identify the particular measurement required and the associated resolution for each tool. A minimum score of 80% is required to earn the competency badge for each tool.

4. Calipers

Calipers are popular dimensional measurement tools whether they are Vernier (shown in Figure 1), dial or digital. For obvious reasons, digital calipers are popular because little operator skill is required to properly read the instrument. Dial calipers require more skill to read while Vernier calipers certainly demand more training, skill and patience to read correctly.

All three caliper types are used in the training which includes a measurement effort that highlights the advantages and disadvantages of each one and ultimately compares the capability of calipers to micrometers (depth, outside, and bore) and to dial indicators. The objective is to not only assist participants in learning how to use the various measurement tools but also provide some understanding of which tool is preferred for the assortment of measurements required for a successful manufacturing activity. This understanding hopefully leads to recommendations and good decisions by the new employee on how to properly measure a feature or part.

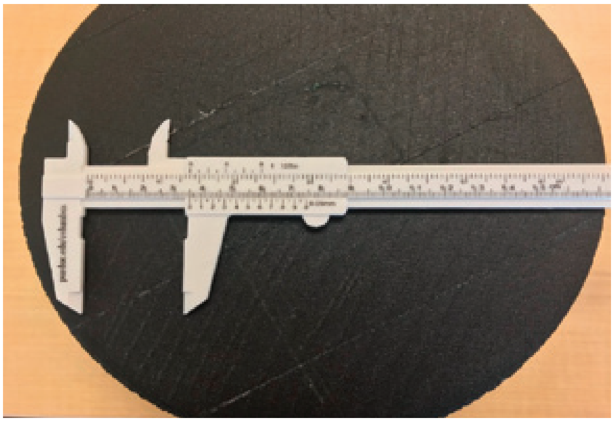


Figure 1. Vernier Calipers utilized in the measurement activities.

5. Three-Point Bore Micrometers

The differences in diameter measurements between two-point caliper measurements and three-point micrometer measurements are significant. The Vernier caliper utilized is shown in Figure 1 while Figure 2 shows the bore micrometers. The three-point micrometer allows for consistent contact between the instrument and the workpiece while the two-point caliper instruments suffer from a plethora of maladies including inconsistent contact even with a single operator, alignment with the hole axis, inability to account for out-of-roundness, and others. A short exercise which exposes the flaws with two-point measurements as compared to three-point measurements is also included.

Figure 2. Three-point micrometers with inch units.

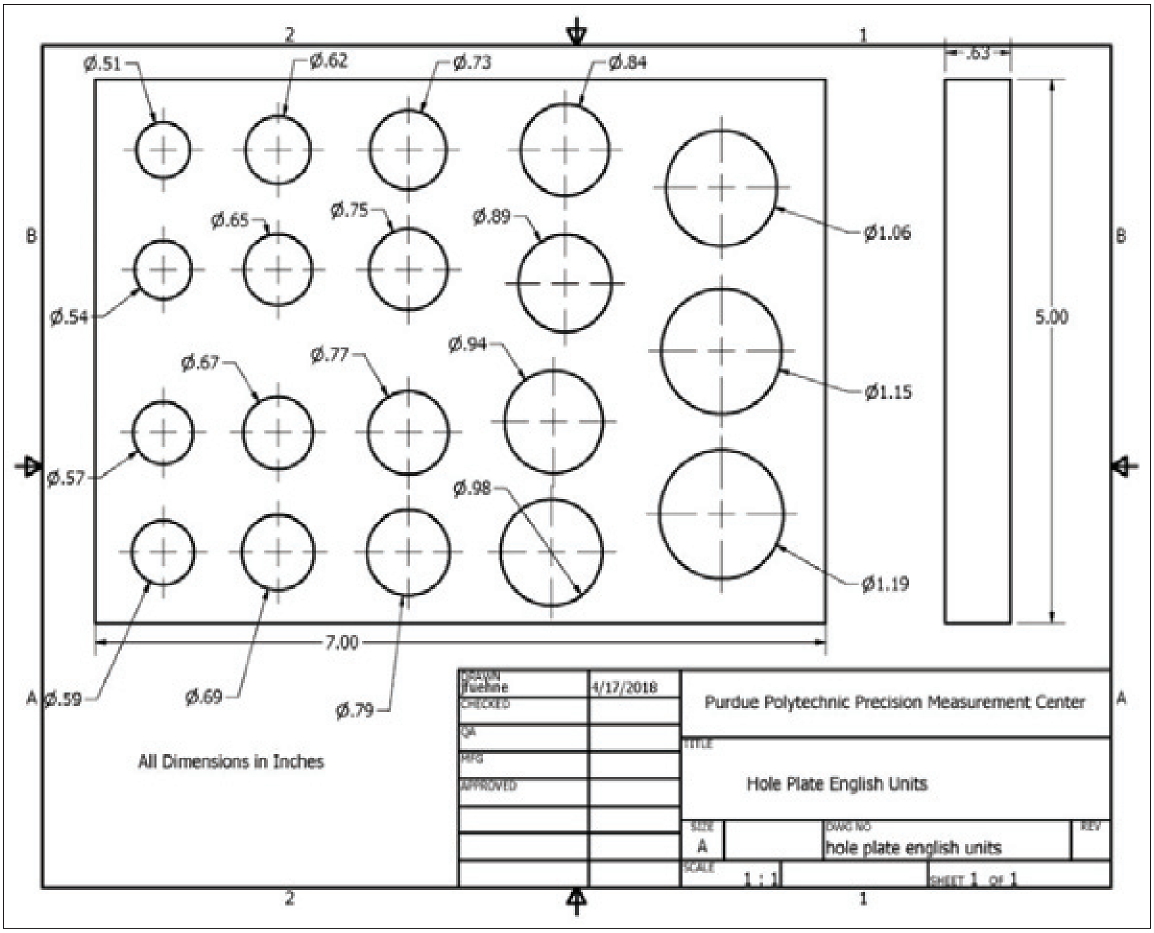


Figure 3. A drawing of one of the measureable artifacts used to practice three-point bore micrometers.

Figure 3 is a drawing of a 3-D printed part employed in this part of the training class. The holes represent a range of diameters to allow the participant an opportunity to use all five of the bore micrometers illustrated in Figure 2. The side-by-side comparison of measurement results from these tools provides the participant an opportunity to consider measurement science in a different way – it's not just about making measurements with any tool available but promotes the idea that there might be a better or more appropriate tool for the task. This type of consideration represents critical thinking and gives the employee an opportunity to improve the process and hopefully leads to the company manufacturing higher quality parts.

Table 1 and Figure 4 display results of the inside diameter measurements made with varying tools. Figure 4, in particular, highlights the difference between the 2-point calipers and the three-point bore micrometers, which provided values much closer to those determined using a coordinate measuring machine (Zeiss Duramax). The CMM is able to scan the around the entire hole, collecting many points that are used to determine the diameter. The objective is to provide the employee with a base of measurement knowledge and practice that affords the ability to make constructive decisions about how to measure. A digital caliper that can measure from 0 to 8 inches provides a convenient alternative for most measurements but that doesn't necessarily make it the best tool for the task.

6. Outside Micrometers

Outside micrometers are very similar to operate as the bore micrometers previously discussed. Typically, outside micrometers are also limited to certain ranges of measurements. In Figure 2, it might be apparent that the bore micrometers are valid only within certain ranges; for example, the five bore micrometers cover a diameter range of 0.5 inches to 1.2 inches.

Two sets of outside micrometers are exercised during the training depending on the length of the artifact being

Nominal Hole Diameter (inches)	Three-Point Micrometer			Vernier Caliper			CMM (inches)	Digital Caliper (inches)
0.62	Minimum Mic Value =	0.6000	inch				0.61248	0.604
	Sleeve/Barrel Reading =	0.0000	inch	Zero-Line Reading =	0.56250	inch		
	Thimble Scale Reading =	0.0142	inch	Vernier Scale Reading =	0.03125	inch		
	Total Measurement =	0.6142	inch	Total Measurement =	0.59375	inch		
0.65	Minimum Mic Value =	0.6000	inch				0.64399	0.635
	Sleeve/Barrel Reading =	0.0250	inch	Zero-Line Reading =	0.5625	inch		
	Thimble Scale Reading =	0.0172	inch	Vernier Scale Reading =	0.0625	inch		
	Total Measurement =	0.6422	inch	Total Measurement =	0.6250	inch		
0.67	Minimum Mic Value =	0.6000	inch				0.65327	0.64
	Sleeve/Barrel Reading =	0.0500	inch	Zero-Line Reading =	0.625000	inch		
	Thimble Scale Reading =	0.0090	inch	Vernier Scale Reading =	0.015625	inch		
	Total Measurement =	0.6590	inch	Total Measurement =	0.640625	inch		
0.69	Minimum Mic Value =	0.6000	inch				0.69196	0.6815
	Sleeve/Barrel Reading =	0.0750	inch	Zero-Line Reading =	0.6250000	inch		
	Thimble Scale Reading =	0.0044	inch	Vernier Scale Reading =	0.0390625	inch		
	Total Measurement =	0.6794	inch	Total Measurement =	0.6640625	inch		
0.73	Minimum Mic Value =	0.7000	inch				0.72104	0.716
	Sleeve/Barrel Reading =	0.0000	inch	Zero-Line Reading =	0.68750	inch		
	Thimble Scale Reading =	0.0172	inch	Vernier Scale Reading =	0.00000	inch		
	Total Measurement =	0.7172	inch	Total Measurement =	0.68750	inch		
0.75	Minimum Mic Value =	0.7000	inch				0.74015	0.725
	Sleeve/Barrel Reading =	0.0250	inch	Zero-Line Reading =	0.6875000	inch		
	Thimble Scale Reading =	0.0164	inch	Vernier Scale Reading =	0.0234375	inch		
	Total Measurement =	0.7414	inch	Total Measurement =	0.7109375	inch		
0.77	Minimum Mic Value =	0.7000	inch				0.76624	0.7475
	Sleeve/Barrel Reading =	0.0500	inch	Zero-Line Reading =	0.6875000	inch		
	Thimble Scale Reading =	0.0094	inch	Vernier Scale Reading =	0.0546875	inch		
	Total Measurement =	0.7594	inch	Total Measurement =	0.7421875	inch		
0.79	Minimum Mic Value =	0.7000	inch				0.79074	0.77
	Sleeve/Barrel Reading =	0.0750	inch	Zero-Line Reading =	0.7500000	inch		
	Thimble Scale Reading =	0.0164	inch	Vernier Scale Reading =	0.0000000	inch		
	Total Measurement =	0.7914	inch	Total Measurement =	0.7500000	inch		

Table 1. Table of results comparing a three-point micrometer to a Vernier caliper for measuring hole diameters.

measured. Both English and metric units are considered as well given the current bi-unit standard configuration of manufacturing in the US. Digital micrometers are also utilized to provide experience and practice with these tools, which may find more use in today's manufacturing environment. Figure 5 provides an example of the worksheet employed to assist participants in learning to read outside micrometers.

An important aspect of any measuring instrument is the contact pressure between the instrument and the artifact. An advantage of most micrometers – outside, inside, bore, and depth – is a ratchet mechanism that allows for consistent and repeatable contact pressure between the instrument and artifact. Calipers typically don't have this feature, requiring the user to establish their own feel for that pressure, resulting in inconsistency. The training also emphasizes this aspect of using the instruments.

A spreadsheet, shown in Table 2, is used to make the same measurement – length of small wooden cylinders shown in Figure 5 – with a dial indicator, analog micrometer and a digital micrometer. Like the previous worksheets, the individual measurements are broken down to emphasize the various parts of each measurement. For example, participants record the minimum value on the micrometer, the value of the sleeve, the value of the thimble and, finally, the value of the Vernier scale if one exists. Recognizing and recording the individual components of the measurement to achieve the final measurement encourages understanding of the instrument and lessens the anxiety involved in reading a complex instrument.

With dial indicators, an indirect measurement approach is used to illustrate how dial indicators are most often employed. Typically, gauge blocks are used to set the "zero" of the dial indicator to the nominal value of the dimension and then the indicator will provide the difference between the measurement and the nominal dimension. For example, if a block is placed under the instrument and the indicator is on "zero" then the dimension is equivalent to the nominal value. Any value other than zero on the indicator is simply added or subtracted from the nominal dimension. Dial indicators are very useful in situations when they are practically treated as go/no-go gauges. A range is established on the indicator with red arrows and the user is instructed that any indicator reading between those arrows specifies a "good" part and any reading outside of the arrows designates a "bad" part. This technique is not quite as simple as a go/no-go gauge but is very functional under certain conditions.

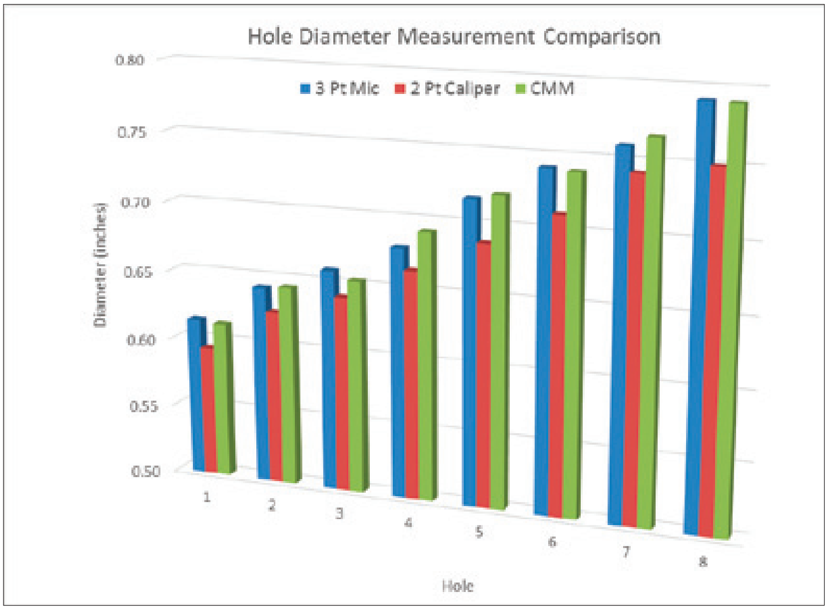


Figure 4. A bar graph showing inadequacy of 2-point calipers for diameter measurements.

The spreadsheet shown in Table 2 breaks down the dial indicator and analog micrometer readings into their various parts, again assisting the user in the task. Participants will be asked to measure 10 different cylinders and record the numbers on the cylinders in addition to the measurements.

Measuring the same feature with different tools begins the development of basic measurement understanding. Different tools have varying resolution, different precision, and require the user to have a fundamental understanding of measurement and of the tools to make a proper decision.

	Dial Indicator Measurements English Units			Micrometer Measurements - English Units					Digital Micrometer Measurements
Item Number	Gauge Block Setting	Length Variance (inches)	Total Length (inches)	Minimum Mic Value	Sleeve/Barrel Reading	Thimble Scale Reading	Vernier Reading	Total Length (inches)	Digital Reading Total Length (inches)
1	0.950	-0.004	0.946	0.0000	0.9250	0.0210	0.0005	0.9465	0.94590
4	0.950	0.028	0.978	0.0000	0.975	0.001	0.0008	0.9768	0.97600
6	0.950	-0.018	0.932	0.0000	0.925	0.009	0.0007	0.9347	0.94150
2	0.950	0.023	0.973	0.0000	0.95	0.022	0.0008	0.9728	0.96875
3	0.950	-0.017	0.933	0.0000	0.925	0.007	0.0005	0.9325	0.93860
8	0.950	0.045	0.995	0.0000	0.975	0.018	0.0004	0.9934	0.99640
10	0.950	-0.015	0.935	0.0000	0.925	0.015	0.0003	0.9403	0.93525
5	0.950	-0.022	0.928	0.0000	0.9	0.024	0.0005	0.9245	0.92555
7	0.950	0.020	0.970	0.0000	0.95	0.015	0	0.9650	0.96950
9	0.950	-0.013	0.937	0.0000	0.925	0.014	0.0001	0.9391	0.93735

Table 2. Worksheet displaying exercises for measuring with dial indicators, analog micrometers and digital micrometers.

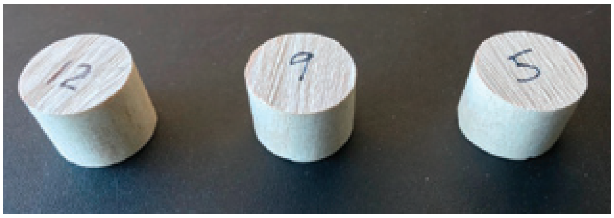


Figure 5. Small, numbered cylinders used to make and compare measurements with dial indicators and analog and digital micrometers.

7. Outside and Inside Diameter Measurement

Another underutilized tool for outside diameter measurements is the Pi tape. The training includes measuring the various outside diameters visible in the artifact shown in Figure 6.

Measuring outside diameters is a challenge. Calipers and micrometers are generally two-point measuring tools. Multiple two-point measurements could be taken with those tools and the results could be averaged but the Pi tape offers a much better solution. In practice, a coordinate measuring machine might be the best option to measure diameter and also provide roundness or circularity if needed but that's an expensive tool and a time-consuming operation that are typically not practical for manufacturing. The Pi tape has a Vernier scale and wraps entirely around the cylindrical object which effectively represents many points compared to the two points for calipers and micrometers and does account for variances in roundness. Table 3 presents results for diameter measurements of the illustrated artifact using a Vernier caliper, Vernier Pi tape, and the CMM.

The objective in introducing the Pi tape is not really that it is more accurate but that it is yet another measuring instrument that can be utilized. Some of the diameters on the object shown in Figure 6 could not be measured with calipers or micrometers (excepting specialty or custom-made tools) and would have required a tool like a Pi tape or a CMM to successfully measure. This is a critical part of the overall training program – to familiarize participants with as many measuring instruments as possible to improve overall understanding of measurement, to recognize advantages and limitations of each instrument, and to make sound, fundamental decisions regarding the choice of the best tool for the task.

Callout	Nominal (inches)	Vernier Caliper (inches)	Pi Tape (inches)	Digital Caliper (inches)	CMM (inches)
Diameter 1	4	4.028	4.021	4.0415	4.01304
Diameter 2	4.7	4.738	4.724	4.7425	4.71507
Diameter 3	5.55	5.592	5.587	5.559	5.56598
Diameter 4	6.75	6.800	6.773	N/A	6.76930

Table 3. Results of diameter measurements comparing Vernier caliper, Pi tape, digital caliper and CMM measurements.

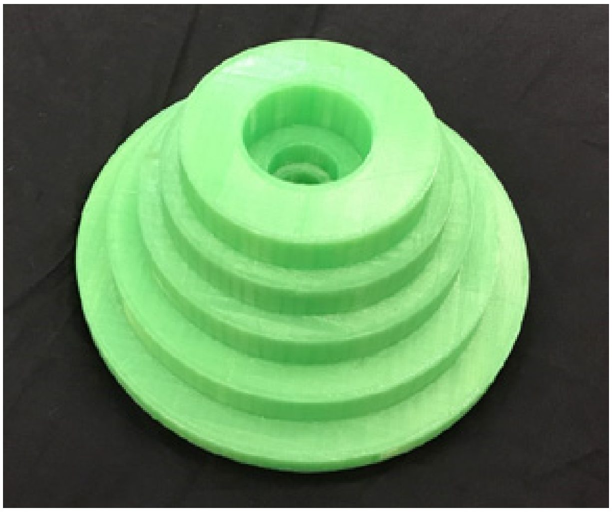


Figure 6. 3D printed artifact used for measuring outside diameters.

8. Testing With Various Materials

Figure 7 shows the artifact used for participant evaluation. The part is adopted from a similar part used for demonstration purposes on the Zeiss CMM. It has been manufactured from several different materials – ABS plastic used with 3D printing and aluminum and steel that has been machined. All three are shown in the photo. Figure 8 is a dimensioned drawing of the artifact with all dimensions in millimeters.

Participants are required to complete the dimensions in Table 4 with the indicated tool. The letters in the table refer to the dimensions indicated in Figure 9. A mix of English

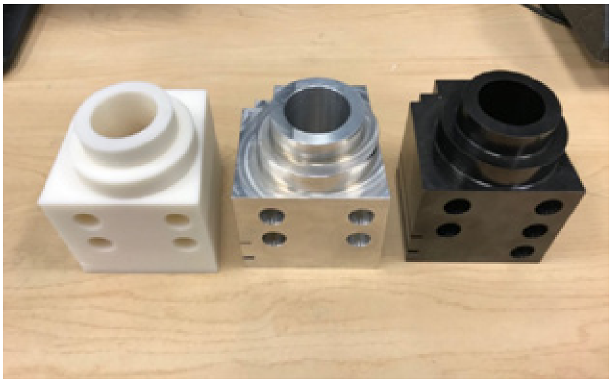


Figure 7. CMM artifact manufactured with 3 different materials employed for the dimensional measurement competency testing.

and metric units is also employed in the table. The differing materials of the blocks allow participants to experience the different "feel" between the blocks and the measuring instrument. It's difficult to properly describe the differences between materials so the best way is to simply provide artifacts for the participants to recognize this themselves. Again, this is a hands-on activity for our participants to demonstrate competency in using basic measurement tools.

9. Conclusions

The objective of this work is to provide very specific details about a measurement training program developed jointly between Purdue Polytechnic Columbus and Cummins, Inc. in Columbus, Indiana. Various measurement tools are employed for dimensional measurements and 3-D printed parts are often utilized as measurement artifacts. Not only does the training program focus on teaching the skills to properly use the tools but also emphasizes the idea that one tool may be more appropriate for a certain type of measurement than the others. This is the beginning of understanding more about measurement and how it affects the quality of manufactured products. This effort emphasizes that this understanding is best attained through using and practicing with measurement tools. Simply listening to lectures or watching videos and demonstrations is not sufficient. The only true way to understand strengths and limitations of various tools is to use them often and strive toward proficiency with them.

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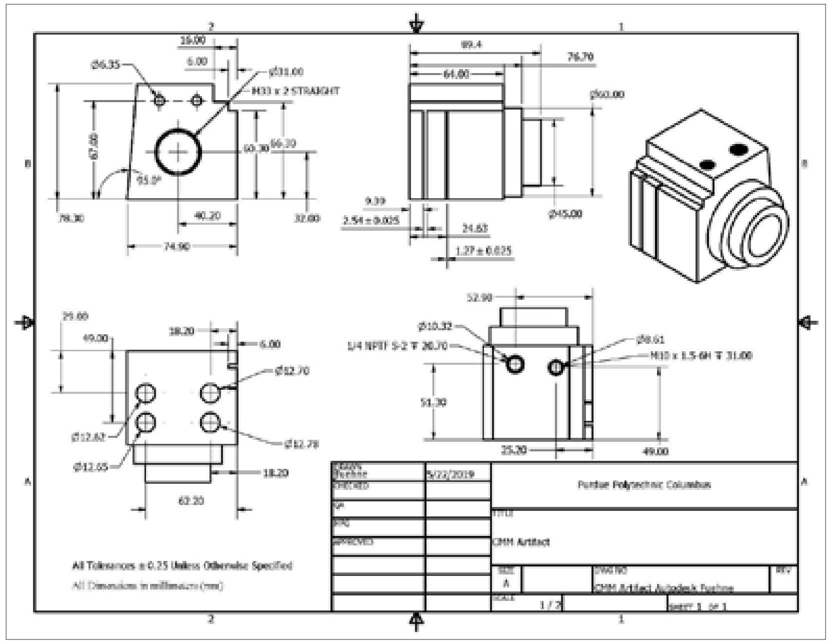

Figure 8. A fully dimensioned drawing of the CMM artifact used for the dimensional measurement competency testing.

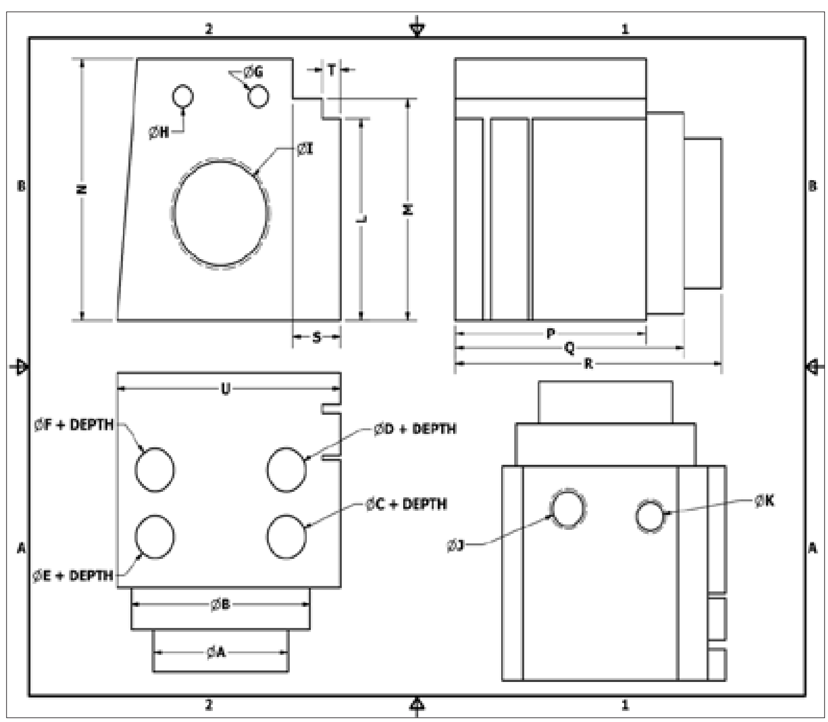

Figure 9. A similar drawing of the CMM artifact with letters to designate the dimensions to be measured by the participants.

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Stepped Block Dimensions				
Dimension	Instrument	Aluminum	ABS Plastic	Steel
A	Pi Tape (inches)			
B	Pi Tape (inches)			
C	Digital Caliper (mm)			
C Depth	Digital Caliper (mm)			
D	Dial Caliper (inches)			
D Depth	Dial Caliper (inches)			
E	Vernier Caliper (inches)			
E Depth	Vernier Caliper (inches)			
F	Digital Caliper (mm)			
F Depth	Digital Caliper (mm)			
G	Vernier Caliper (inches)			
H	Vernier Caliper (inches)			
I	Bore Micrometer (mm)			
J	Bore Micrometer (mm)			
K	Digital Caliper (mm)			
L	Micrometer (mm)			
M	Micrometer (inches)			
N	Digital Micrometer (mm)			
P	Digital Micrometer (mm)			
Q	Dial Caliper (inches)			
R	Vernier Caliper (inches)			
S	Digital Caliper (mm)			
T	Digital Caliper (mm)			

Table 4. Table of dimensions to be completed by participants.

Converting a mV/V Load Cell Signal into Engineering Units

Henry Zumbrun
Morehouse Instrument Company

One might read the headline and think why is mV/V or a calibration curve relevant to me or my instrumentation? If you use load cells or other instrumentation that are calibrated using a span calibration, the chances are that someone is setting them up using a 2-point, 5-point, 6-point, or some number of point span calibrations. Typically, this type of setup often has high errors, and the article aims to discuss a more accurate way to eliminate most of these errors. Though the article is written with a load cell application in mind, the same concept can be applied to several disciplines. With load cells in mind, we prefer meters that can read in mV/V and can be connected to a computer via USB, or with a serial port.

Understanding What mV/V Is and How It Relates to Load Cells

Most bridge-based sensors typically specify a rated output Sensitivity (R.O.) shown in Figure 1. This Rated Output is generally found under Electrical specifications. It is usually in mV/V, where mV/V is the ratio of the output voltage to the excitation voltage required for the sensor to work. Most load cells are strain gauge-based sensors that provide a voltage output that is proportional to the excitation voltage. Many feature four strain gauges in a Wheatstone bridge configuration. When force is applied, the relative change in resistance is what is measured by the indicator. The load cell signal is converted to a visual or numeric value by a "digital indicator." When there is no load on the cell, the two signal lines are at equal voltage. As a load is applied to the cell, the voltage on one signal line increases very slightly, and the voltage on the other signal line decreases very slightly. The difference in voltage between the two signals is read by the indicator. Recording these readings in mV/V is often the most accurate method for measurement. The reason it is the most accurate method is many meters on the market can handle ratiometric measurements. They can measure the input in mV and divide that measurement by the actual voltage being supplied. For instance, we could have a mV measurement of 40.1235 mV and an excitation measurement of 9.9998 V. When displaying in mV/V; one would have 4.01243 mV/V. Many meters that do not handle ratiometric measurements have some internal counts that get programmed at the time of calibration. These meters still read the change in resistance; they require programing or points to be entered that correspond to force values. When programmed, these meters will typically use an approach using span points.

Specifications	Model - Capacity (lbf / kN)					
	300-2K / 1-10	5K-10K / 20-50	25K-50K /100-250	60K / 300	100K / 500	200K / 900
Accuracy						
Static Error Band, % R.O.	± 0.04	± 0.05	± 0.05	± 0.05	± 0.05	± 0.07
Non-Linearity, % R.O.	± 0.04	± 0.05	± 0.05	± 0.05	± 0.05	± 0.07
Hysteresis, % R.O.	± 0.03	± 0.05	± 0.05	± 0.05	± 0.05	± 0.07
Non-Repeatability, % R.O.	± 0.01	± 0.01	± 0.01	± 0.01	± 0.01	± 0.01
Creep, % Rdg / 20 Min.	± 0.03	± 0.03	± 0.03	± 0.03	± 0.03	± 0.03
Off-Center Load Sensitivity, %/in	± 0.25	± 0.25	± 0.25	± 0.25	± 0.25	± 0.25
Side Load Sensitivity, %	± 0.25	± 0.25	± 0.25	± 0.25	± 0.25	± 0.25
Zero Balance, % R.O.	± 1.0	± 1.0	± 1.0	± 1.0	± 1.0	± 1.0
Temperature						
Range, Compensated, °F	+15 to +115	+15 to +115	+15 to +115	+15 to +115	+15 to +115	+15 to +115
Range, Operating, °F	-65 to +200	-65 to +200	-65 to +200	-65 to +200	-65 to +200	-65 to +200
Sensitivity Effect, % Rdg / 100°F	0.08	0.08	0.08	0.08	0.08	0.08
Zero Effect, % R.O. / 100°F	0.08	0.08	0.08	0.08	0.08	0.15
Electrical						
Recommended Excitation, VDC	10	10	10	10	10	10
Input Resistance, Ω	350 +40/-3.5	350 +40/-3.5	350 +40/-3.5	350 +40/-3.5	350 +40/-3.5	350 +40/-3.5
Output Resistance, Ω	350 ± 3.5	350 ± 3.5	350 ± 3.5	350 ± 3.5	350 ± 3.5	350 ± 3.5
Sensitivity (R.O.), mV/V, Nominal	2	4	4	4	4	4
Insulation Bridge/Case, MegΩ	5000 @ 50 VDC	5000 @ 50 VDC	5000 @ 50 VDC	5000 @ 50 VDC	5000 @ 50 VDC	5000 @ 50 VDC
Mechanical						
Safe Overload, % R.O.	150	150	150	150	150	150
Weight, lbs	1.0	2.9	9.1	11.2	23.5	59
Weight w/Base, lbs	2.5	6.5	21.5	26	52.5	139
Flexure Material	Aluminum	Steel	Steel	Steel	Steel	Steel

Figure 1. Morehouse Calibration Shear Web Load Cell Specification Sheet

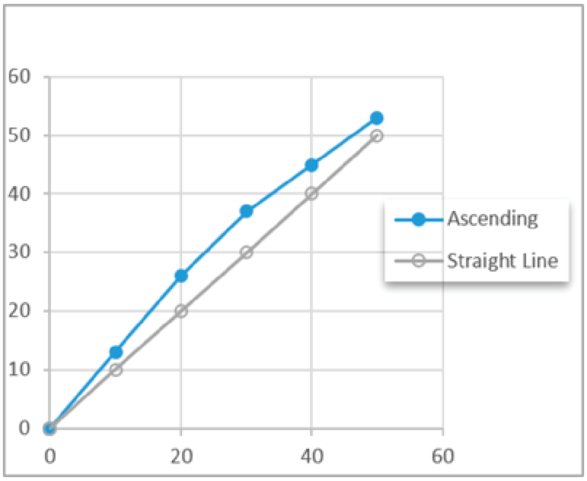

Figure 2. Load Cell Curve Versus a Straight Line

Programming a Load Cell System via Span Points

I guess that almost everyone is familiar enough to remember algebra and drawing a straight line between two points. One would typically find the slope of the line, which could predict other points along the line. The common formula of y = mx + b, where m designates the slope of the line, and where b is the y-intercept, b is the second coordinate of a point where the line crosses the y-axis. The main issue with this approach when programming a load cell is that the meter and load cell are going to have some deviations from the straight line. This deviation is often referred to as non-linearity and can usually be found on the specification sheet. Figure 1 for the load cell shows the non-linearity specification under accuracy. Non-Linearity is defined as the algebraic difference between the OUTPUT at a specific load, usually the largest applied force, and the corresponding point on the straight line drawn between minimum load and maximum load. There are other factors such as stability, thermal effects, creep recovery and return, and the loading conditions when the points are captured that will influence the bias of each point. The programming of these meters is most likely going to follow a linear approach. Some will have a 2-pt span, some 5-pts, and some even more. They may try to draw a straight line through all the points, or they may try and segment several lines. In all cases, there will be additional bias created from this method as the force measuring system will always have some non-linear behavior.

Figure 3 is an example of a Morehouse Calibration Shear Web Load Cell with a Non-Linearity specification of better than 0.05 % of full scale. In this example, the actual Non-Linearity is about 0.031 % using mV/V values and 0.032 % when using calculated values, which is well below the specification. However, one should never claim the device is accurate to 0.032 %, as this is a short-term accuracy that was achieved under the ideal conditions. Often, an end-user will see the results below and make a claim that the system is accurate to a number such as 0.05 % and believe they are going to maintain it. However, the end-user must account for additional error sources such as stability/drift, reference standard uncertainty that was used to perform the calibration, resolution of the force measuring device, repeatability and reproducibility of the system, the difference in loading conditions between the reference lab and how the system is being used, environmental conditions, and the difference in adapters—all of which can drastically increase the overall accuracy specification. As a rule, accuracy is influenced by how the system is used, the frequency of calibration, the non-linearity of both the load cell and meter, as well as thermal characteristics. In addition, what the reference lab achieves is short term and does not include the stability of the system or adapters, which are often the most significant error sources. If interested, there is a previous *CAL LAB* article on adapters that can be referenced [1].

Note: Several manufacturers claim specifications that use higher-order math equations for non-linearity to achieve unrealistic specifications. These unrealistic specifications often present themselves at the time of calibration, which often results in having to raise the system accuracy beyond what was expected.

Figure 3 below is an example of a 2-pt span calibration. Values are programmed at 1,000 and 10,000 lbf. These values can often be entered into the meter or captured during setup with the force measuring system under load. In the above example, one can see the instrument bias or error. Instrument Bias is defined in section 4.2 of JCGM 200:2012 as the average of replicate indications minus a reference quantity value [2]. When

		Indicator with 2-pt adjustments		
Applied Force lbf	Actual Readings (mV/V)	Programmed Points	Calculated Values 2 pt span	Error
200	0.08279		199.6	0.4
1000	0.41415	0.41415	998.6	1.4
2000	0.82851		1997.6	2.4
3000	1.24302		2997.0	3.0
4000	1.65767		3996.8	3.2
5000	2.07242		4996.8	3.2
6000	2.48726		5997.0	3.0
7000	2.90216		6997.4	2.6
8000	3.31709		7997.8	2.2
9000	3.73203		8998.3	1.7
10000	4.14696	4.14696	9998.7	1.3

Figure 3. Programming an Indicator with a 2-pt Span Calibration

we talk about bias, we are talking about the difference between the calculated values minus the applied force values. In the above example, the worst error is 3.2 lbf, which is around 0.08 % of applied force when 4000 lbf is applied. Sometimes programming different points at 0 % and maybe 80 % may reduce the bias, though it will depend on the specification and how linear the system is. However, there is a much better method to fit the data points that will still use simple algebra. That method is commonly referred to as the least-squares method.

		Using Coefficient Conversion	
Applied Force lbf	Actual Readings (mV/V)	Calculated Values polynomial	Error
200	0.08279	199.9	0.1
1000	0.41415	999.9	0.1
2000	0.82851	1999.9	0.1
3000	1.24302	2999.9	0.1
4000	1.65767	3999.9	0.1
5000	2.07242	4999.9	0.1
6000	2.48726	5999.9	0.1
7000	2.90216	6999.9	0.1
8000	3.31709	7999.9	0.1
9000	3.73203	8999.9	0.1
10000	4.14696	9999.9	0.1

Figure 5. Bias or Measurement Error When Using Coefficients

Using Least Squares Method

Many indicators do not allow the end-user to enter anything other than span points. They do not allow the use of the "best-fit" or least-squares method. However, many indicators do have USB, IEEE, RS232, or other interfaces that will enable computers to read and communicate with the indicator. When software can communicate with an indicator, a method of regression analysis can be used, which often better characterizes the force measuring system. This method of regression analysis begins with a set of data points to be plotted on a x- and y-axis graph. The term "least squares" is used because it is the smallest sum of squares of errors. This method will contain a formula that is a bit more complex than a straight line. The formula often uses higher-order equations to minimize the error and best replicate the line. Figure 4 below shows a plot from the actual readings in mV/V and fit to a 3rd order equation. Instead of using the equation for a straight line (y=mx+b), we have a formula that uses x values that are raised to higher powers, such as Response (lb) = A0 + A1F + A2F² Force (lbf) = where: F = Force (lbf) where: R = A0 = 0.0614 A1 = 2415 A2 = -1.4436 A3 = 0.17379. These are often called coefficients. They are often labeled as A0, A1, A2, A3. A0 would determine the point at which the equation crosses the Y-intercept, while the other coefficients determine the curve. Many force standards allow curve fitting of a 3rd degree and limit the maximum degree fit to a 5th degree. The most recognized legal metrology standards for using Coefficients are ASTM E74 and ISO 376. ASTM E74 *Standard Practices for Calibration and Verification for Force-Measuring Instruments* is primarily used in North America, while ISO 376 *Metallic materials — Calibration of force-proving instruments used for the verification of uniaxial testing machines* is used throughout much of Europe and the rest of the world.

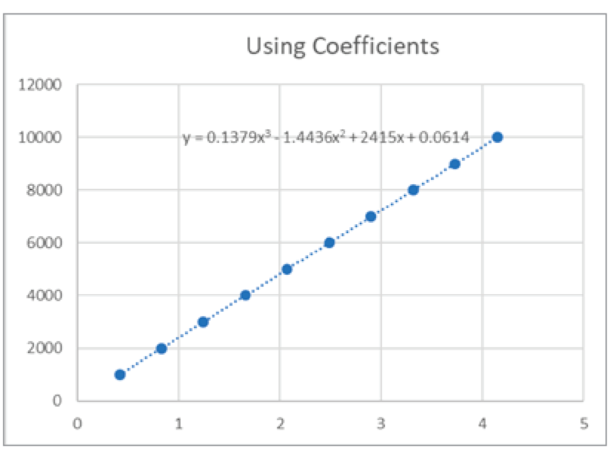

Figure 4. Graph of a 3rd Order Least Squares Fit

When the equation in Figure 4 is used on the actual readings, the values calculated using the coefficients are very close to the applied force values. The bias or measurement error is around 0.1 lbf (Figure 5). I believe 0.1 lbf is less than the 3.2 lbf error, as shown using a 2-pt span calibration.

The overall difference in the errors between these two methods is quite high. Figure 6 best summarizes these errors. One process produces an almost exact match, which is 0.001 % of full scale, while the other is 0.032 % of full scale. The worst point at 4,000 lbf has a difference of 3.06 lbf or 2413 %. The question is, what method do you think meets your needs? The process of using coefficients will often require additional software and a computer. The 2-pt adjustment will not. There are other differences and considerations relating to calibration.

Calibration Differences

One of the more significant differences is with calibration. Any force measuring system is going to drift over time. The typical expectation of our customers is tweaking the units sent in for calibration, which is an attempt to minimize the bias. However, from the man who dropped his marbles, tweaking may not be good practice. Edward Deming has said, "If you can't describe what you are doing as a process, you don't know what you're doing." If one is always adjusting the values or processes, it tends to become more out of control. It becomes more challenging to spot trends, which is an ISO/IEC 17025 requirement. Section 7.7.1 states [3], "The laboratory shall have a procedure for monitoring the validity of results. The resulting data shall be recorded in such a way that trends are detectable and, where practicable, statistical techniques shall be applied to review the results." With a span calibration that requires adjustments at every calibration interval, are trends truly detectable? When coefficients are used, the reference laboratory is merely reading the Actual Reading mV/V values at the time of each calibration. It is much easier to establish the baseline or monitoring the results based on units that are rarely adjusted.

Note: Adjustments could happen if an indicator failed or a simulator is used to standardize the meter. Though that is another error source relating to the electrical side. If the indicator and load cell are paired and stay together as a system, this point is moot. It is highly recommended that one keeps their load cells and meter paired from one calibration to the next. When the reference laboratory reads and reports in mV/V using the least-squares method, one's "As Received" calibration becomes the same as the "As Returned." The end-user is given a new set of coefficients to use. The mV/V values are recorded and can be monitored. The new coefficients will likely account for any drift that has happened and bring the force-measuring system back to having much lower bias than the span calibration.

The good news is software is available that complies with ISO 376, ASTM E74, and E2428 requirements and eliminates the need to use load tables, excel reports, and other interpolation methods to ensure compliance with these standards. NCSLI RP-12 states in section 12.3 [4], "The uncertainty in the value or bias, always increases with time since calibration." When the drift occurs, the indicator needs to be reprogrammed. As most quality systems require an "As Received" calibration, the indicator needs to be reprogrammed, and an "As Returned" calibration is performed. The actual level of work results in calibration costs that are much higher than they need to be. Morehouse developed our HADI and 4215 systems with software to avoid the excess costs as the coefficients used in the software are based on mV/V values and the "As Received" and "As Returned" calibrations are the same with the end user only needing to update the coefficients in the software. The software allows for conversion from mV/V to lbf, kgf, kN, N and reduces the overall cost for the customer while meeting the quality requirements in ISO/IEC 17025:2017.

		Indicator with 2-pt adjustments			Using Coefficient Conversion			
Applied Force lbf	Actual Readings (mV/V)	Programmed Points	Calculated Values 2 pt span	Error	Calculated Values polynomial	Error	Diff in Errors	% difference
200	0.08279		199.6	0.4	199.9	0.1	0.25	189%
1000	0.41415	0.41415	1000.0	0.0	999.9	0.1	-0.11	116%
2000	0.82851		1997.6	2.4	1999.9	0.1	2.26	1846%
3000	1.24302		2997.0	3.0	2999.9	0.1	2.82	2109%
4000	1.65767		3996.8	3.2	3999.9	0.1	3.06	2413%
5000	2.07242		4996.8	3.2	4999.9	0.1	3.05	2180%
6000	2.48726		5997.0	3.0	5999.9	0.1	2.83	2060%
7000	2.90216		6997.4	2.6	6999.9	0.1	2.47	1856%
8000	3.31709		7997.8	2.2	7999.9	0.1	2.02	1446%
9000	3.73203		8998.3	1.7	8999.9	0.1	1.56	1055%
10000	4.14696	4.14696	9998.7	1.3	9999.9	0.1	1.12	776%

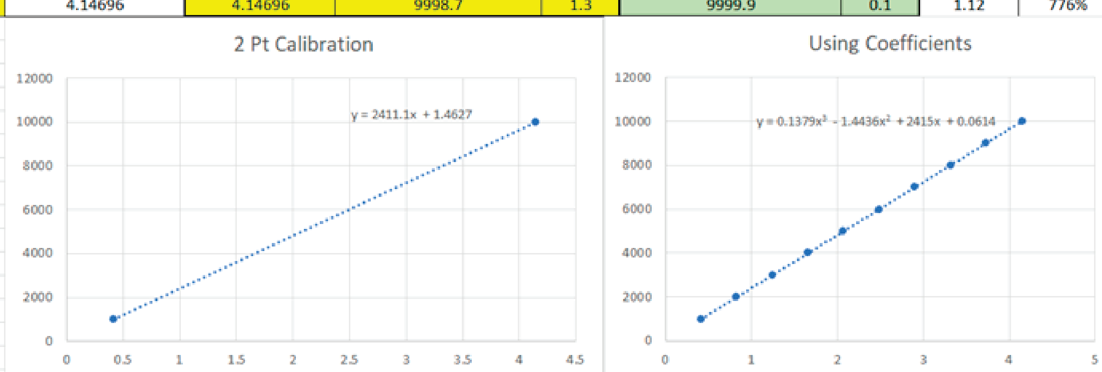

Figure 6. Difference Between 2-pt Span and Coefficients on the Same Load Cell

Conclusion

If the end goal is the best accuracy available, the recommendation is going to be an indicator that reads in mV/V where software can read the meter, ASTM E74 calibration, and software to convert mV/V values to Engineering units. With these systems, we specify the accuracy from anywhere of 0.005 % to 0.025 % of full scale. These do not include the effects of drift, which is usually better than 0.02 % on these systems. For other systems that have a 5 or 10 pt. calibration, a meter is used to span the readings. We typically do not get better than 0.1 % of full scale if the calibration frequency is one year and have had several systems that can maintain 0.05 % of full scale on a six month or less calibration interval. The actual results will vary on how much the system is used and on the individual components of the system.

References

[1] H. Zumbrun, "The Importance of Adapters in Force Measurements," *CAL LAB: The International Journal of Metrology*, Vol. 26:2, pp 28-32.

[2] JCGM 200:2012 *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*.

[3] ISO/IEC 17025:2017 *General requirements for the competence of testing and calibration laboratories*.

[4] NCSLI RP-12 *Determining and Reporting Measurement Uncertainties* (2013).

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Additional note from the author: I want to wish everyone the absolute best in these troubling times. I think many have realized how vital calibration is to provide life-sustaining businesses with the measurement traceability chain required to ensure more accurate testing methods, better temperature checks, and improve the overall health and safety for our population. I would like to thank our team and the many other organizations out there that are making sacrifices to keep equipment calibrated. May you all stay healthy and know you are appreciated. Stay safe and keep on making those measurements that will help make a difference.

Rohde & Schwarz Test Solutions for 5G Base Stations

Munich, March 23, 2020 — As a leading manufacturer of wireless test solutions, Rohde & Schwarz has extended its portfolio for generation and analysis of 5G signal waveforms. For 5G base stations, RF test solutions for the 5G frequency ranges FR1 (450 MHz to 7.125 GHz) and FR2 up to 44 GHz will be demonstrated.

For over-the-air (OTA) tests on 5G base stations in the FR2 range, Rohde & Schwarz is launching a unique solution based on the R&S FE44 frontend modules, which support signal generation and analysis in the lower-frequency IF band. This enables low-loss transmission of 5G signals and the use of cost-effective T&M instruments by avoiding the need for equipment designed for the millimeterwave range. The R&S SMW200A vector signal generator generates the 5G signals, and the R&S FSVA3000 provides the right analysis functions. Both are ideal for 5G tests thanks to their excellent RF characteristics. The frontend modules can be mounted near the antennas of the DUT on the OTA test chamber.

In the transmit direction, the 5G signals generated in the IF band by the R&S SMW200A are upconverted to the FR2 range up to 44 GHz. This ensures that the high output power is generated exactly where it is needed. On the receive side, the R&S FE44A converts the FR2 signal at the antenna inputs down to the IF band and sends it with low attenuation losses to the R&S FSVA3000 for analysis. This solution is suitable for test systems in production.

For speed-optimized production tests of 5G base stations, Rohde & Schwarz has developed a scalable, high-performance server based testing analysis platform. The R&S SMBV100B vector signal generator and the R&S FSVA3000 spectrum analyzer are used as RF test solutions. The powerful R&S QuickStep test executive software is used to automatically control the test setup and verify test results. The solution is using a 10 Gigabit Ethernet network, where the combination of the server based approach and parallel processing enables extremely high measurement speeds. The infrastructure consists of commercially available components. The combination of the R&S SMBV100B and the R&S FSVA3000 is also ideal for flexible testing of WLAN, cellular and IoT components and devices in R&D, verification and production.

Rohde & Schwarz also offers a new test solution for base stations and small cells that enables cross-channel measurements up to 4x4 MIMO on 5G transmissions in the FR1 range. The solution consists of the R&S SMW200A signal generator, two R&S SGT100A vector RF sources, the R&S RTP164 high-performance oscilloscope used as a measuring receiver, and the 5G analysis options of the R&S VSE vector signal explorer software running on a laptop.

The R&S SMW200A generates the 3GPP-compliant 5G test signals, which can be transmitted on up to four channels using the two additional vector RF sources. The oscilloscope provides phase coherent acquisition of all four signals, a basic prerequisite for cross-channel measurements. The integrated hardware-accelerated digital downconverter of the R&S RTP164 mixes the signals down to the baseband in real time. The R&S VSE software performs measurements in line with 3GPP specifications. Users can also perform MIMO-specific measurements and flexibly compile the test results. The solution is suitable for tests during the development and verification of 5G base stations.

Short demo videos about these and other industry-leading wireless test solutions from Rohde & Schwarz are available at www.rohde-schwarz.com/mwc.

Ralston Instruments ControlPak Pressure Controller

The ControlPak is a compressed gas volume controller that can really take a beating. It provides precise control over compressed gas sources for smooth and quick calibration testing. Encased in durable, tactical plastic designed to withstand mud, intense sun, and extreme cold, it's the ideal platform for pressure calibration and pressure testing in the field. With fine control of pressure from 0-3000 psi (0-20 Mpa), you can perform both ultra-precise low-pressure differential or high-pressure static pressure calibrations with a single setup. It includes multiple outlet ports so you can connect a calibrator and your DUT directly without a tee, and its soft-seated valves allow the user to pressurize and depressurize incrementally, so there's no need for a regulated pressure supply. It also has a built in storage compartment for holding extra hose and adapters. And to top it all off - all outlet connections, hoses and adapters are Ralston Quick-test ™ fittings, which create secure, leak-proof connections without the need for tools or thread tape. The ControlPak provides solid, stable pressure with excellent control over test pressure.

For more information, contact Ralston Instruments at ralstoninst.com/cmcp or call +1 440-564-1430 for more information.

Fairview Microwave Class AB High Power Amplifiers

IRVINE, Calif. (February 27, 2020) - Fairview Microwave Inc., an Infinite Electronics brand and a leading provider of on-demand RF, microwave and millimeter wave components, has released a new series of Class AB broadband high power amplifier modules that incorporate GaN, LDMOS or VDMOS semiconductor technology.

Fairview's comprehensive new line of class AB broadband high power amplifiers consists of 18 new models spanning frequency bands from 20 MHz to 18 GHz. These designs are unconditionally stable and operate in a 50 Ohm environment. They offer power gain up to 53 dB and saturated output power levels from 10 Watts to 200 Watts. This line includes 2 new heatsink modules with DC controlled cooling fans specifically designed for the 18 new models to ensure optimum baseplate temperature for highly reliable performance.

"This new series provides our customers with more options for applications that need a high power, small-form-factor RF amplifier that uses cutting-edge semiconductor technology with wide dynamic range over a broad array of frequencies, high linearity and exceptional efficiency," explained Tim Galla, Product Line Manager at Pasternack.

These compact coaxial packages utilize N-Type or SMA connectors and have integrated D-Sub control connectors for DC bias, enabled with TTL logic control and temperature and current sense functions. The rugged assemblies can withstand relative humidity exposure up to 95% maximum and operate over a wide temperature range from -20°C to +60°C.

Fairview's new class AB, high power amplifiers and heatsinks are in-stock and available for immediate shipping with no minimum order quantity required.

For inquiries, Fairview Microwave can be contacted at +1-972-649-6678.

About Fairview Microwave

A leading supplier of on-demand RF and microwave products since 1992, Fairview Microwave offers immediate delivery of RF components including attenuators, adapters, coaxial cable assemblies, connectors, terminations and much more. Products are shipped same-day from the company's ISO 9001:2015 certified production facilities in Lewisville, Texas.

Starrett Rotary Table Springs Force Tester

ATHOL, MA U.S.A. (March 24, 2020) - The L.S. Starrett Company, a leading global manufacturer of precision hand tools/ gages, a broad range of force testing, metrology equipment, and more, has introduced a newly designed Rotary Table Springs Force Tester. The system is setup to test multiple springs in a single setup without the need for additional operator input as required when springs are tested one by one. The batch testing volume production approach saves time, and significantly increases test throughput, while freeing up the operator to attend to other jobs.

Multiple springs can be loaded and tested in the Rotary Table Force Tester System, and the system will provide a pass/ fail report on each spring. Detailed information on each spring is also available including free length, spring rate, and critical load and distance points. Different rotary table options are available to accommodate a customized number of springs in a single setup.

The Rotary Table Springs Tester solution features the Starrett FMS-1000-L3, a single-column force measurement system optimized for high-volume production and quality control testing. The FMS-1000-L3 frame has a 1000N (225lbf) testing capacity, ideal for tensile or compressive testing. The system includes the test frame, controller & software. The controller features a Windows operating system with a high resolution color, multi-touch display, Wi-Fi, Bluetooth and USB 2.0 port(s). The Rotary Table Springs Force Tester has L2 Plus software featuring analysis tools to measure and display results on a single graph. Once this is complete, the results are automatically measured and placed on all of the test runs within a batch. Displays include full graphs, split graphs with data tables, or as a data table complete with statistical calculations or tolerance results.

For more information on the Rotary Table Force Tester System and Starrett Force Measurement Solutions visit (starrett.com/rotarytable), telephone: (978) 249-3551, or email: general@starrett.com.

About The L.S. Starrett Company

Founded in 1880 and headquartered in Athol, MA U.S.A., The L.S. Starrett Company (www.starrett.com) is a leading global manufacturer of precision measuring tools and gages, optical comparators and vision systems and force and hardness testing solutions. Starrett has over 1,600 employees worldwide and annual sales exceeding $200 million. The L.S. Starrett Company is publicly traded on the NYSE, symbol SCX.

Vitrek Launches Best-In-Class Programmable DC Load Product

The Vitrek DL Series offers industry-leading performance in 125W-500W applications; supports best-in-class transient loading capability (from 0.1µW resolution to 14.5kW pulses); features high-speed pulse loading up to 100 kHz; boasts up to ten times better measurement accuracy.

Poway, CA, December 12, 2019 — Vitrek, the leader in high-voltage test and measurement equipment, introduces the DL Series of digital, programmable DC loads, designed to support the testing requirements for the latest generation of off-line power supplies, dc-dc converters and LED drivers. The DL Series is also equipped to handle a wide range of battery testing requirements. The devices are offered in three power ratings (125W, 250W and 500W), each with input voltages of 0-150V or 0-500VDC. Unlike comparable programmable DC loads, the DL Series is capable of supporting loading sequences utilizing constant voltage (CV), constant resistance (CR), constant current (CC) and constant power (CW) in any combination in single or arbitrary sequences of up to 100 steps.

The DL Series provides high-current transient loading capability twenty times higher than other units in this class while also being capable of generating µA loads. Measurement accuracy is typically in order of magnitude better at lower loading levels and double that of competing devices at higher loads. The instruments allow for a current or power sweep of up to 500 steps in each direction to and from set values and a voltage dependent current loading mode for complex variable output supplies. Standard OCP/OPP/OTP/OVP features and battery test modes are among other loading modes also included.

The instruments feature a comprehensive self-test function, providing assurance that all loading and measurement circuitry is properly functioning. Multiple interfaces are included as standard to allow for fully automated use. Additional unique features of the DL Series include historical data logging capability, both graphical and numerical, and graphical X/Y plotting of V vs A or W using swept loading. The DL Series offers leading transient performance in timing - with pulsed loading up to 100kHz - and wave shape, with the unique ability to view the current and voltage waveforms directly on-screen using the built-in internal scope.

"The DL Series of programmable DC loads was designed to enable users to conduct real-world testing," said Chad Clark, Vitrek's VP Sales & Marketing. "These instruments feature a high-resolution, touchscreen display. The intuitive touchscreen operation - with built-in data history and scope mode - are popular features of the entire family of Vitrek instruments."

Visit https://vitrek.com/dl-series-electronic-dc-load/ to learn more about Vitrek's DL Series or to request a free product demonstration.

About Vitrek

Since 1990, Vitrek has provided innovative global solutions for high voltage test and measurement including electrical safety compliance testers, multi-point high-voltage switching systems and graphical power analyzers. Vitrek also supplies precision high voltage measurement standards to national laboratories and calibration labs around the world. This unique combination of capabilities positions Vitrek as a leading provider of test solutions serving the photovoltaic, medical equipment, power conversion, electrical component and appliance industries.

Mensor Introduces the New CPT6030 Analog Pressure Transducer

The CPT6030 Analog Pressure Transducer is the newest offering in Mensor's lineup of precision pressure transducers. The CPT6030 is a one-of-its-kind precision measurement device with true 2-wire 4 – 20 mA pressure output with accuracy as high as 0.025% FS.

The CPT6030 is a self-contained smart transducer that carries all its compensation and calibration data on board. The precision transmitter is characterized over a temperature range of -20 to 75 C to ensure high performance over a wide temperature range. Together with a calibration adapter, it is easy to adjust multiple points in the range of the transducer.

The transducer can be used to verify and calibrate industrial and process pressure measuring transmitters as a compact calibration solution. The rugged stainless steel body gives it an IP-67 rating and allows use in field or harsh environments.

The CPT6030 is available in pressure ranges as low as 10" of H2O to up to 15,000 psi, and with a recalibration interval of 365 days to cover applications in aerospace, oceanography, calibration labs and process instrumentation.

Contact a local sales representative for more information.

Metrology Automation Lunch & Learn

Michael Schwartz
Cal Lab Solutions, Inc.

Wow, how the world can change in just a few months. And each of us have had to adjust to the changing times. We at Cal Lab Solutions decided to start a Metrology Automation Lunch & Learn and so far, we have completed three of them in the past six weeks.

This was an idea I had last year at NCSLI in Columbus, Ohio. Talking to other automation engineers and managers, we all thought it would be a good idea to virtually meet up once or twice a month and discuss how to write better metrology software. So thanks to COVID-19, we had free time in our schedules. I hope this will continue well into the future.

The first Lunch & Learn we did covered how Cal Lab Solutions writes flexible drivers in Fluke's MET/CAL® platform. We have been using this driver model for more than 18 years. I firmly believe it is the best way to support flexible standards in MET/CAL—especially when you have a good revision control tool.

The interesting thing in that Lunch & Learn was how this 18 year old driver model is very similar to much of the work we are doing with the NCSLI 141 Metrology Information Infrastructure and Automation Committee. The concept of writing drivers around metrology functions, instead of equipment types, has lasted the test of time.

The next Lunch & Learn focused on drivers in an OOP (Object Oriented Programming) language. Unlike write drivers in an antiquated scripting language, in an OOP language like VB.NET, child class functionality can be inherited. This allows the programmer to write code once and share it with several specialized parent classes.

For example, in Metrology.NET® drivers, all the I/O calls are contained in the instrument base class. If you want to send a command to an instrument you simply write Me.Write("*RST"). All the I/O pointers, VISA Resource strings, and multi-threading tools are all contained in the base class.

We also covered how ISO/IEC 17025 uncertainties can be managed without having to update the automation scripts, all done in the base class. This allows the automation engineer to focus on writing better automation and the metrologist to manage uncertainties.

The third Lunch & Lean focused on Control Charts. As this is something I am currently adding to Metrology.NET, I thought it a good idea to share with the community and get some valuable feedback.

We reviewed a control chart for a Fluke 742-1 resistor that had been calibrated six times. Using an Excel file as a reference, we converted all the mathematical functions to a VB.NET class called "ControlChart." This allowed us to load the ControlChart class with all the calibration data in the Excel file and validate the math in the class.

When evaluating the VB.NET class compared to the Excel file, it became apparent the VB.NET class was easier to support and maintain than the Excel File. The problem with the Excel file is every time a new calibration data is added, some of the fields have math statements that need to be updated to include the new calibration data. Whereas the VB.NET code has a List(of CalData) object that holds x number of points. In the VB.NET code all you have to do is add more data and all the calculations adjust automatically.

We plan to do more Lunch & Learns and hope that other engineers in the community would like to show all of us some tips and tricks. If you have knowledge you would like to share, please feel free to email me MSchwartz@CalLabSolutions.com.

For those of you who missed the first three Lunch & Learns, they are available on our website: https://www.CalLabSolutions.com.

Note, the ControlChart Class will also be made available to the metrology community. It's about all of us creating better software. ❧

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