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www.ncsli.org
Greetings! I hope you are enjoying the return of spring and warmer weather after a very long winter. For many of us, nothing represents the return of spring as much as the return of the great American pastime, baseball. I recently had the chance to attend a KC Royals spring training game in Surprise, AZ which was a great way to enjoy a day of sunshine, baseball, and spending time with family.

As you may know, NCSLI is now an official liaison with ISO Committee on Conformity Assessment. This group is the owner of ISO/IEC 17025. The world-wide members of ISO have voted to revise ISO/IEC 17025 and the first working group meeting was held in Geneva in February. With NCSLI's new liaison status, we were able to send two board members as NCSLI representatives to the meeting. I am very pleased that Jeff Gust NCSLI Standards and Practices VP and Tim Osborne NCSLI Operations VP were able to attend and represent our organization. In addition, another Board member, Georgette Macdonald (NRC Representative), attended as a representative of NRC. Look for more details about the first meeting in this issue of Metrologist.

As I mentioned in my previous article, the board is focusing on seven key objectives as outlined in our strategic plan, 2020 Vision. The first key objective is to “Provide Top Quality Products and Services.” This covers a wide range of initiatives, including the annual Workshop & Symposium, Technical Exchange, Metrologist Worldwide News, NCSLI Measure, region meetings, business office and website. I would like to briefly touch on each of these initiatives.

I would like to express my appreciation to Paul Packebush, NCSLI Conference VP, Tom Hutteman, NCSLI Meeting Planner and the Conference Committee for their diligent work in planning this year’s event. The 2015 NCSLI Workshop & Symposium will be held at the Gaylord Texan Resort and Convention Center in Grapevine, Texas from July 19-23, and the conference theme is “Measurement Science and the Quality of Life.” You will be seeing some exciting changes this year, so plan now to attend.

The 2015 Technical Exchange was held in Raleigh, North Carolina, on February 11-12, and was a great success. We had 162 tutorial registrations. Also on hand were 10 exhibitors, giving attendees a chance to meet with vendors and see firsthand their latest product offerings. New for this year was our partnership with AMRL, which is an organization that accredits construction material testing laboratories. AMRL representatives presented some of the tutorials, bringing an enhanced depth to the training content provided. I had a chance to participate in a couple of sessions with people whose background is in the testing community. It was an excellent opportunity to interact with members of the testing community and share ideas about how we can all benefit from increased interactions and sharing best practices. Many people were involved in planning and executing this event. I would like to recognize Mike Frisz, Technical Exchange Chair, all the tutorial presenters, the exhibitors, the NCSLI office staff, and of course all the attendees that made the 2015 Tech Exchange successful.

If you are like me, you enjoy reading each new issue of Metrologist Magazine. This publication is primarily the result of Linda Stone’s work and creative ability. Linda is the NCSLI Media Coordinator and is great person to work with. In order to keep Metrologist as a great publication, I encourage each of you to submit interesting news articles and reports from your local and regional meetings.

NCSLI Measure is the premier, peer reviewed NCSLI technical journal. Mike Lombardi is the editor, and is doing an excellent job. Mike utilizes a very capable team of associate editors, and a technical support team to assure that Measure continues to be a highly regarded technical journal. One of the biggest challenges for Mike and his team is to have a good number of technical papers in the pipeline for publication. As NCSLI members, I challenge each of you to consider writing and submitting timely and interesting technical papers. If you have any questions about the process, please contact Mike.

One of the great features of NCSLI is the local and regional meetings. These meetings are where people in our industry have a chance to network, attend technical presentations, tour laboratories and keep up with the latest technical advances. I encourage all local and regional coordinators to be getting your upcoming meetings planned and put on the calendar. As an NCSLI member, I encourage each of you to contact your local coordinator and volunteer to host a meeting or to make a technical presentation at a meeting.

Lastly, I would like to thank Tim Osborne, Craig Gulka and their team for their work to keep the website up and operational. Several improvements have been made and additional changes and improvements are being considered for this year.

As you can see, there are many great initiatives underway to keep NCSLI International a great organization and to provide top quality products and services!

ruburto@sandia.gov
A.com Electronic Measurement Technology
45 Rockefeller Plaza floor 20
New York, New York 10111
Contact: Moshe Appleboum, 212-899-5026, moshe.a@acom-test.com

Acom is a leading specialist in calibration and measurement of
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ownership, extend the lifetime of your equipment and make sure you
gain reliable, high performance operation at affordable prices.

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Lincoln, Nebraska 68501
Contact: James Hood, 402-479-4272
james.hood@duncanaviation.com

Duncan Aviation is the largest, family-owned aircraft service pro-
vider supporting the aviation needs of government and business
operators and other service providers. Services include major and
minor airframe inspections, engine maintenance, major retrofits for
cabin and cockpit systems, full paint and interior services and pre-
owned aircraft sales and acquisitions. Duncan Aviation’s in-house
calibrations lab has 11 team members in two locations meeting the
needs of customers from around the world with tool calibration and
repair. Their services include general electronics, radio frequency
electronics, pressure, torque, physical dimensional, and thermody-
namics. They calibrate and repair tools from many other industries,
such as medical and manufacturing. Duncan Aviation is owned and
operated by the Duncan family since its founding in 1956.

National Chung-Shan Institute of Science
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Longtan, Taoyuan 325, Taiwan (R.O.C.)
Taoyuan 32526
Contact: Chia-Teh Pan, +886-3-471-2201 ext. 350700
ics.taf0150@gmail.com, kcsend@yahoo.com.tw

Chung-Shan Institute of Science and Technology (CSIST) is a re-
search institute for national Defense. To respond to the needs of
global trend and local industries development, Lung-Yuan
Research Park is assigned as the window of "converting Defense
Technology into civil industries business value." Through executing
the Technology Development Program (TDP) from the Minis-
try of Economic Affairs (MOEA) and the dual-use technology de-
velopment plan, Lung-Yuan cooperates with industries, officials,
academics and institutes in Taiwan to play the role of national
economic promoter. It carries out the policy of promoting national
economic developments and local defense industries. Lung-Yuan
Research Park was established in coordination with the "Asia-Pa-
Have you considered what impact Measurement Science has had on the quality of your life? If you take time to consider it, you can appreciate what a large impact it has.
Gaylord Texan Resort & Convention Center  
1501 Gaylord Trail, Grapevine, Texas 76051  
Marriott Group Reservation | 877-491-5138  
NCSLI Room Rate $199  

Brimming with authentic Texas style and hospitality, the awe-inspiring Gaylord Texan Hotel and Convention Center invites you to experience the energy and excitement of the Lone Star State. Overlooking beautiful Lake Grapevine, Gaylord Texan is just six minutes from the Dallas-Fort Worth International Airport.

### Complete Conference Information

**AT NCSLI.ORG**

**Gaylord Texan Resort & Convention Center**  
1501 Gaylord Trail | Grapevine Texas 76051  
Marriott Group Reservation | 877-491-5138  
NCSLI Room Rate $199

### Registration and Hotel Information

**Gaylord Texan Resort & Convention Center**  
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Brimming with authentic Texas style and hospitality, the awe-inspiring Gaylord Texan Hotel and Convention Center invites you to experience the energy and excitement of the Lone Star State. Overlooking beautiful Lake Grapevine, Gaylord Texan is just six minutes from the Dallas-Fort Worth International Airport.

### Full Conference Registration Rates

<table>
<thead>
<tr>
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<th>Regular Rate</th>
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<tr>
<td>Member Rate</td>
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<tr>
<td>One Day Registration</td>
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<td>Extra Luncheon Ticket</td>
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### Tutorial Program Registration Rates

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<tr>
<td>1/2 Day Registration</td>
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<tr>
<td>1 Day Registration</td>
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<tr>
<td>2 Day Class Registration</td>
<td>$700 / $800</td>
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Lunch is included with Tutorial Registration.

### Complete Conference Information

**AT NCSLI.ORG**
Keynote Speakers
TUESDAY, JULY 21 & THURSDAY, JULY 23

Dr. Chris Greer is NIST Senior Executive for Cyber Physical Systems and National Coordinator for Smart Grid Interoperability. In these positions, he is responsible for strategic planning, program implementation and coordination with partners across the public and private sectors. Prior to joining NIST, Dr. Greer served as Assistant Director for Information Technology R&D in the White House Office of Science and Technology Policy and Cybersecurity Liaison to the National Security Staff. His responsibilities there included networking and information technology research and development, cybersecurity, and digital scientific data access. Dr. Greer has also served as Director of the National Coordination Office for the Federal Networking and Information Technology Research and Development (NITRD) Program. This program coordinates IT R&D investments across the Federal government.

Steve Russell is the DMS/DA Project Director for Duke Energy Carolinas and the Alstom DMS product within Grid Modernization. During his 29 year career with Duke Energy, Steve has worked in a wide variety of leadership roles including engineering, field operations and construction, finance, forecasting, scheduling, outage management and dispatching operations, metering, and corporate compliance and ethics. Steve also served as assistant to two of Duke Power’s presidents where he managed the office of the president and worked on a wide variety of special projects both internal and external to Duke Energy. In his current role as DMS/DA Project Director, Steve is responsible for the Distribution Automation deployments in the Duke Energy Carolinas jurisdiction as well as the Alstom DMS deployments, enhancements, and upgrades in the Duke Energy Carolinas and Midwest jurisdictions.

Screenwriter Amy Young is a filmmaker with strong experience in communicating science to a general audience. For six seasons, she was a technical script consultant on the CBS show NUMB3RS, which won a Public Service Award from the National Science Board. For her current documentary project, The State of the Unit: The Kilogram, Amy has filmed and interviewed people weighing everything from atoms to semi-trucks, gunpowder and fields of corn. Amy graduated from CalArts with an MFA in Film Directing. She currently works for two universities as a videographer and as program staff for a computational physics research group.
**Exhibit Hall**

**MONDAY, JULY 20 – THURSDAY, JULY 23**

**MONDAY, JULY 20, 2015**
Exhibitor Welcome Reception | 6:00 PM – 8:00 PM

**TUESDAY, JULY 21, 2015**
Continental Breakfast | 7:30 AM - 8:30 AM
Lunch Buffet in Exhibit Hall | 11:30 AM - 1:00 PM
Poster Presentations | 12:00 PM - 1:00 PM
Metrology Mixer | 4:30 PM - 6:00 PM
Join us for drinks, appetizers and networking!

**WEDNESDAY, JULY 22, 2015**
Continental Breakfast | 7:30 AM - 8:30 AM
Lunch Buffet in Exhibit Hall | 11:30 AM - 1:00 PM
Poster Presentations | 12:00 PM - 1:00 PM
Metrology Mixer | 4:30 PM - 6:00 PM
Join us for drinks, appetizers and networking!

**THURSDAY, JULY 23, 2015**
Open to the Public | 10:00 AM - 1:00 PM Exhibit Close

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**EXHIBITORS**

| A.com Electronic Measurement Technology | GEO Calibration |
| A.K.O. Inc. Torque Specialties Div. | Guildline Instruments |
| ABTech | IEEE |
| AccuMac Corporation | Interface, Inc. |
| ACR Technical Services Inc. | International Accreditation Service (IAS) |
| Additel Corporation | International Test and Evaluation Association |
| Alpha Electronics Corporation | Isotech North America |
| American Association for Laboratory Accreditation | JM Test |
| American Technical Services | Kaymont Consolidated |
| Ametek Test & Calibration Instruments | Keysight Technologies |
| Andeen-Hagerling, Inc. | King Nutronics Corporation |
| ANSI-ASQ National Accreditation Board/ACLASS | Liberty Calibration Corps |
| AOIP | Lockheed Martin Misson Systems and Training |
| ASQ-MQD | Lockheed Martin Technical Operations |
| AssetSmart | Mahr Federal, Inc. |
| Automotive Industry Action Group | Masy BioServices |
| Bionetics | Measurement Science Conference |
| Bruel & Kjaer North America Inc. | Measurements International |
| Cal Lab Solutions, Inc. | Mentor |
| Colorado Engineering Experiment Station Inc. | Mettler Toledo |
| Consumers Energy Lab Services | Mitutoyo America Corporation |
| Data Proof | Morehouse Instrument Company, Inc. |
| Esesco Calibration Laboratory | National Institute of Standards and Technology |
| Exelon Powerlabs | National Research Council Canada |
| Flexim Americas | National Voluntary Laboratory Accreditation Program |
| Fluke Calibration | NCiSL International |
| Fowler Precision Tools | NCiSLI — Dimensional PT Program |
| GE Measurement & Control Solutions | Northrop Grumman Corporation |
| GE Measurement & Control Solutions | Northrop Grumman Corporation |
| Norwegian Labs | On Time Support Inc. |
| Ohm-Labs, Inc. | Perry Johnson Laboratory Accreditation, Inc. |
| On Time Support Inc. | Pond Engineering Laboratories |
| Perry Johnson Laboratory Accreditation, Inc. | Pratt & Whitney Measurement Systems |
| Pond Engineering Laboratories | Precision Environments, Inc. |
| Pratt & Whitney Measurement Systems | Quality Magazine |
| Precision Environments, Inc. | Radian Research |
| Quality Magazine | Ralston Instruments |
| Radian Research | Rice Lake Weighing |
| Ralston Instruments | Sartorius Mechatronics Corporation |
| Rice Lake Weighing | SIKA USA Inc. |
| Sartorius Mechatronics Corporation | Tegam, Inc. |
| SIKA USA Inc. | The Modal Shop |
| Tegam, Inc. | Thunder Scientific Corporation |
| The Modal Shop | Tovey Engineering, Inc. |
| Thunder Scientific Corporation | Transcat, Inc. |
| Tovey Engineering, Inc. | Transmille Calibration |
| Transcat, Inc. | Trescal Inc. |
| Transmille Calibration | TRS-RenTelco |
| Trescal Inc. | Vaisala, Inc. |
| TRS-RenTelco | Vibration Research Corporation |
| Vaisala, Inc. | Western Environmental Corp. |
| Vibration Research Corporation | WorkPlace Training, Inc. |
| Western Environmental Corp. | Yokogawa Corporation of America |

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NCSL International | 2995 Wilderness Place, Suite 107 | Boulder, CO 80301 | (303) 440-3339 | info@ncsli.org
TUTORIAL PROGRAM

SATURDAY, JULY 18, 2015 | 8:00 AM – 5:00 PM
T1 - Train the Trainer — 2015 Trainer’s Summit
Jovie Masters, The Training Clinic
Discover things you can do in the first 10 minutes to establish an effective learning climate. Creatively identify session starters that will work for you. Learn how to end on a lasting point to help the transfer of learning to the job.

SUNDAY, JULY 19, 2015 & MONDAY, JULY 20, 2015 | 8:00 AM – 5:00 PM
T2 - An Introduction to Instrument Control and Calibration Automation in LabVIEW
Logan Kunitz, National Instruments Corporation
Automation of instrument calibration improves repeatability of service, reduces manpower requirements, and improves service margin. Many calibration laboratories understand the benefits of automation, but feel they lack the appropriate software to perform coding tasks. Modern programming environments and tools are extremely powerful, but can seem daunting to laboratory engineers. Alleviating these concerns, a number of software companies supply simplified tools and libraries to ease the interactions between calibration standards and automation software. Additionally, programming tools exist that are designed with the automation engineer in mind. During this two-day hands-on tutorial, session participants will explore the LabVIEW environment, learn to develop, instrument control, data-logging, and measurement analysis applications. At the end of the course, they will be able to create applications using basic design templates and architectures to automate processes, acquire, process, display, and store real-world data.

SUNDAY, JULY 19, 2015 | 8:00 AM – 5:00 PM
T3 - Fundamentals of Calibration in Dimensional Metrology
Amosh Kumar, Gordon Skattum, Mitutoyo Corporation
This tutorial provides an overview of calibration techniques and key issues in dimensional metrology. This tutorial will include a variety of hands-on practical calibration exercises. All the major types of dimensional calibrations will be discussed. We will start by studying the calibration, use, and traceability issues of the standards used in the field, such as gage blocks, ring gages, optical flats, thread wires, and length standards. We will then discuss the calibration of common small measuring tools such as micrometers, calipers, dial indicators, and height gages. Hands-on exercises in the calibration of small tools will include procedures, worksheets, and certificates. We will also discuss the field calibration of major instruments such as optical comparators and coordinate measuring machines. In addition to presenting specific calibration methods, a goal of the tutorial is on developing understanding of the principles behind the dimensional calibration methods thereby giving the attendee the necessary tools to extend the tutorial concepts to other types of calibrations.

SUNDAY, JULY 19, 2015 | 8:00 AM – 5:00 PM
T4 - Understanding ISO/IEC 17025 Requirements
Rob Knake, A2LA
This full-day tutorial covers highlights of ISO/IEC 17025 requirements. This course is applicable for organizations that are currently accredited, are in the process of obtaining their ISO/IEC 17025 accreditation or for those who are interested in applying the ISO/IEC 17025 requirements in their facility.

SUNDAY, JULY 19, 2015 | 8:00 AM – 5:00 PM
T5 - Pressure Metrology
Mike Bair, Fluke Calibration
This full day tutorial covers all the fundamental challenges of calibrating pressure instruments. The first half of the tutorial concentrates on the physics that have an effect on pressure measurement, including measurement modes, engineering units, the equation for a dead weight pressure gauge, the ideal gas law, surface tension and viscosity. The discussion includes practical considerations such as hardware selections, environmental concerns and data acquisition for all modes, fluids and ranges. The second half applies those concepts to hands on exercises with equipment supplied by the instructor. All participants will have the opportunity to take low pressure gas and high pressure oil calibrations. Error analysis and sources of uncertainties are discussed that are relevant to the hands on exercises.

SUNDAY, JULY 19, 2015 | 8:00 AM – 5:00 PM
T6 - Running the Effective Laboratory Better — Data Driven Improvements that Matter
Jesse Morse, Morse Metrology and Dr. Malcolm Smith, Wescan Labs
Today’s business and organizational climates have usurped traditional “seat-of-the-pants” calibration management by insisting on continuous improvement and the use of data based management decisions. Captured up in this new paradigm are independent calibration companies and calibration laboratories operating within and servicing their own organizations. This “How To” tutorial focuses on getting your calibration operation to maximum operational effectiveness, which will lead you directly to improvements in efficiencies. The tutorial covers five areas where performance measurement is critical in running an effective calibration operation. The five areas are: (1) customer satisfaction, (2) quality, (3) service levels, (4) productivity, and (5) finance. You will learn a range of necessary metrics and tools to help establish baselines and laboratory performance over time, which you can use to establish goals and monitor performance in each of the five mentioned areas.

SUNDAY, JULY 19, 2015 | 8:00 AM – 5:00 PM
T7 - Control Charts and Stability Analysis for Calibration Laboratory Reference
Jeff Gust, Fluke Calibration
This tutorial provides instruction on how to develop control charts for reference standards utilized in the calibration laboratory. The tutorial will primarily discuss electrical standards, but the application is valid for any metrological discipline. The primary focus will be an in-depth discussion of using linear regression to have a more complete understanding of all sources of uncertainty associated with reference standards. The tutorial also provides ideas about using control charts for daily use of check standards for calibrations that may perform a single measurement such as gage blocks. Real world examples of Laboratory Reference Standards will be used during the tutorial.

SUNDAY, JULY 19, 2015 | 8:00 AM – 5:00 PM
T8 - GD&T Workshop
E.A. “Tony” Bryce, Sandia National Laboratories
A basic introduction to the concepts of GD&T as defined in ASME Y14.5. Both the 1994 and 2009 standard will be covered. This course is suitable for those individuals needing a basic understanding of the concepts related to 2D drawings and CAD model definition.
TUTORIAL PROGRAM

SUNDAY, JULY 19, 2015 | 8:00 AM – 12:00 PM
T9 - Fundamentals of Gas Flow Measurement
Robert DeRemer - CSA Group
The main thrust of the Fundamentals of Gas Flow Measurement tutorial will be the comparison of volumetric flow meters and mass flow meters used in gas flow measurement applications. Specific topics that will be covered will include principles of operation of various types of flow meters, factors that influence when to choose a mass flow meter or a volumetric flow meter, how to interpret performance specifications, how the various types of meters are calibrated, and an example of measurement uncertainty.

SUNDAY, JULY 19, 2015 | 8:00 AM – 12:00 PM
T10 - Calibration Management Software — How to Select and Implement for Your Environment
Walter Nowocin, Medtronic Corporation
This half day two-part tutorial will engage you in understanding the key factors to consider in selecting and implementing a calibration management software solution for your laboratory, especially in a regulated environment. Based on practical lessons learned, it will guide you through the technical and business obstacles that everyone encounters. Each attendee will be given a CD and handouts of Business Software Requirements List, Vendor & Client Surveys, Test Script Template, GAMP 4 & 5 Information, and Vendor Comparison Excel Spreadsheet Template. Many of the topics can be applied to other software application decisions.

SUNDAY, JULY 19, 2015 | 8:00 AM – 12:00 PM
T11 - The Art of Resistance Metrology from Micro-Ohms to Tera-Ohms
Kai Wendler, National Research Council Canada (NRC) and Marlin Kraft, National Institute of Standards and Technology (NIST)
This half-day tutorial provides an overview of calibration techniques used at NRC and NIST. The tutorial will cover calibrations from 10 micro ohms to 100 Tera Ohms and will discuss various measurement systems and techniques. A section will be dedicated towards laboratory measurement standard characteristics, including drift, temperature coefficients, power coefficients and Measurement System characteristics. The tutorial is targeted towards the meteorologist making the measurements in the laboratory, from new hires to grizzled veterans. This knowledge will improve their understanding of the measurements being made in the lab.

SUNDAY, JULY 19, 2015 | 8:00 AM – 12:00 PM
T12 - Force Calibration
Henry Zumbrun, Bill Lane, Morehouse Instruments, Inc.
This course will cover applied force calibration techniques and will include live demonstrations using secondary standards to exhibit potential measurement errors made in everyday force measurement. The measurement errors demonstrated and discussed will include errors associated with improper alignment, use of different and/or incorrect adapter types, thread depth and thread loading as well as some load cell troubleshooting techniques. This course will also cover the importance of calibrating force measurement devices in the manner in which they are being used to reduce measurement errors and lower uncertainty. Recommended skill level for the course is anyone who has experience with force equipment and wants to learn how they can minimize potential measurement errors.

SUNDAY, JULY 19, 2015 | 8:00 AM – 12:00 PM
T13 - High Current DC measurements and Safety Considerations
Tim Stark and Richard Timmons, Guildline Corporation
This workshop will cover DC high current measurements using a 300A current source, several different current shunts and associated cabling. Participants will be able to use different setups so they get hands-on practice and can see how different setups affect measurements. Since safety is an important consideration of high current measurement, safety considerations shall also be covered.

SUNDAY, JULY 19, 2015 | 1:00 PM – 5:00 PM
T14 - Dynamic Sensors & Calibration
Eric Seller, The Modal Shop
This four-hour tutorial on vibration calibration will dive into calibration theory, standards, and methodology for dynamic sensors as well as explanations of different sensor types and the operational theories behind them. Target audience is beginner to intermediate level.

MONDAY, JULY 20, 2015 | 8:00 AM – 5:00 PM
Mark Ruefenacht, Heusser Newhey and Val Miller, NIST
This tutorial is designed for the beginner to advanced user of balances, calibration managers, quality managers, ISO/IEC 17025 assessors, and those wanting a better understanding of accurate weighing methods where analytical weighing is an integral part of operations.

MONDAY, JULY 20, 2015 | 8:00 AM – 5:00 PM
T16 - Root Cause Analysis
Ashley Carter, A2LA
This one day tutorial will focus on internationally recognized approaches to conducting effective internal audits. The techniques learned promote the involvement of laboratory personnel. It will include easy-to-implement methods for continual improvement and preparing for external assessments. Also, we will discuss when root cause analysis is required and provide tips and tools that can be used to identify the true root cause for identified problems/non-conformities. Many standards such as ISO/IEC 17025 and ISO 9001 require your quality management systems have a procedure for investigating and eliminating the root cause of a non-conformance during the corrective action process. At the end of this course you should be able to identify potential root causes using the tips and tools provided. With a good root cause analysis you should be able to implement an appropriate corrective action to avoid recurrence of non-conformities.

MONDAY, JULY 20, 2015 | 8:00 AM – 5:00 PM
T17 - Applying LEAN in a Calibration Laboratory Environment
Dean Williams, Duke Energy and Tom Knight, Invistics Corporation
This updated, hands-on, and practical interactive one-day tutorial provides participants with a basic knowledge of the history and principles of LEAN and how those principles can apply to a calibration laboratory environment. Learning is enhanced by interactive exercises and teams “running” a simulated calibration lab and experiencing the results from applying LEAN tools and techniques. The tutorial provides insights and examples from recent LEAN initiatives applied at a number of both in-house and commercial calibration laboratories. These initiatives helped reduce waste and shorten calibration turn times while streamlining overall operations. The participants will then use this background knowledge to identify and develop strategies for application to their own specific calibration operation. All participants will be provided with a student workbook which documents the information that was presented, contains useful exercises, and provides a list of helpful resources for future reference and study.
Monday, July 20, 2015 | 8:00 AM – 5:00 PM
T19 - Intermediate Dimensional Metrology
Ted Doiron, National Institute of Standards and Technology (NIST)

There are a large number of books on dimensional metrology, and a few classes and tutorials, but nearly all of them are at the beginner level - how to use the instruments for inspection. Thermal expansion, elastic deformation, stability, refractive index of air, closure and reversal methods, and the large collection of tricks-of-the-trade that make up Dimensional Metrology are generally ignored. This tutorial will be an overview of important techniques and concepts not covered in books and classes. Each concept will be presented with examples of how the techniques make measurements more accurate, and in some cases, more efficient.

Monday, July 20, 2015 | 8:00 AM – 12:00 PM
T20 - Fundamentals of Torque Calibration
Henry Zumbrun and Bill Lane, Morehouse Instruments, Inc.

This presentation is a review of the fundamentals of torque calibration. Topics include an overview of torque standards including ASTM-E2428 and B578/82, uncertainty of torque calibration standards, Type A and B uncertainty analysis, torque calibration equipment, calibration and testing of torque transducers, proper calibration techniques, error sources associated with torque calibration, and why proper torque measurement is more than just a traceable length and mass calibration.

Monday, July 20, 2015 | 8:00 AM – 12:00 PM
T21 - Fundamentals of Temperature Calibration
Mike Coleman, Fluke Calibration

This presentation is a review of the fundamentals of temperature calibration. Topics include calibration equipment, calibration techniques, curve fitting issues, and the mathematics important to thermometry. Types of thermometers covered include platinum resistance thermometers, thermistors, thermocouples, and combined thermometer/readout systems. This segment is intended for those who are new to temperature calibration, those who need to validate what they already know, or those who just have some nagging questions that need to be answered.

Monday, July 20, 2015 | 8:00 AM – 12:00 PM
T22 - Humidity Calibration Tutorial
Jeff Bennewitz, Mike Hamilton, Thunder Scientific Corporation

This tutorial will provide an overview of basic information regarding humidity definitions, dew point, frost point, and relative humidity. Participants will practice humidity calculations and conversions using the HumiCalc humidity conversion software. Instructions will be given for the humidity calibration technique using the 2 pressure humidity calibration standard. The instructor will demonstrate a typical calibration setup of a hygrometer and dew point instruments. Discussion will be held regarding response time and calibration procedure using the 2 pressure humidity standard. Calibration and maintenance of the 2 pressure humidity calibration standard will be discussed in detail.

Monday, July 20, 2015 | 8:00 AM – 12:00 PM
T23 - Microwave Measurement Basics
Ron Ginley, National Institute of Standards and Technology (NIST)

Do you want to learn more about microwave measurement techniques? This session is the place to be! An introduction to the measurement concepts for microwave power and scattering-parameters will be covered. Specific topics covered will include transmission line theory, practical handling of the do's and don'ts for transmission lines and microwave connectors, Vector Network Analyzer calibration/measurements and real world sources of uncertainties, microwave power detectors types, power measurements and uncertainties, and the session will conclude with a discussion of verification techniques for microwave measurements.

Monday, July 20, 2015 | 1:00 PM – 5:00 PM
T25 - Advanced Topics of Temperature Calibration
Mike Coleman, Fluke Calibration

This course continues to build on the principles established in the Fundamentals of Temperature Calibration course. The objective of this course is to deliver the concepts needed to help a metrologist or calibration professional to design an accredited temperature calibration process. The calibration process design will be presented and explored by assembling a GUM compliant uncertainty analysis. In addition, other advanced concepts such as thermocouple theory and ITS-90 fixed-points and mathematics will be presented to provide additional background knowledge and techniques. It isn't required to attend the Fundamentals of Temperature Calibration course before this course but familiarity with fundamental concepts is necessary.

Monday, July 20, 2015 | 1:00 PM – 5:00 PM
T26 - Microwave Power Sensor Calibration
Andy Brush, Charlie Sperrazza and Adam Fleder, Tegam Inc.

- Understand the types of RF power sensors
- Traceability of RF Power
- Background in RF Power flow
- The process of Calibrating a Power Sensor
- Creating uncertainty budget for Power Sensor Calibration

Monday, July 20, 2015 | 1:00 PM – 5:00 PM
T27 - Fundamentals of Radiation Thermometry Calibration
Frank Liebmann, Fluke Calibration

This presentation is an overview of the basic knowledge necessary to perform radiation thermometer calibrations. The presentation is divided into two parts. The first part is a lecture covering the basics of radiation temperature measurement and infrared thermometry calibration. The second part is a hands-on portion which covers the steps necessary to make a calibration measurement, plus a number of tests to determine measurement uncertainty, and the computation of uncertainties following international standards. The attendee will be provided with a spreadsheet to facilitate the computation of uncertainty. The type of radiation thermometer covered in this presentation is an infrared thermometer with a thermopile detector and an 8-14 µm bandwidth. However, the principals taught are applicable to other classifications of radiation thermometers to include radiation thermometers with pyroelectric detectors and thermal imagers. The presentation is geared to those who are new to radiation thermometer calibration, those who need a refresher on the subject, and to those who would like to perform better calibrations.
Micrometer Proficiency Testing

LIVE MICROMETER PROFICIENCY TESTING AT THE NCSLI WORKSHOP & SYMPOSIUM THIS SUMMER!

Members $25 | Non-Members $50

Sign up when registering for the NCSLI Workshop & Symposium.
Participation is limited and time-slots are expected to fill-up fast.

NCSL International (NCSLI) is introducing an exciting new reason to attend their 2015 Workshop & Symposium — an opportunity to participate in a proficiency test (PT) and at a small fraction of the typical cost. At this summer’s event, July 19-23, 2015 in Grapevine, Texas, the NCSLI Dimensional Committee is organizing the first ever PT to run live during the NCSLI Workshop & Symposium. At the edge of the exhibit hall, in a mini-lab courtesy of Precision Environments, attendees will have the opportunity to complete a PT using an outside micrometer. The results will be compiled and presented on the last day of the Workshop & Symposium during one of the technical sessions. Anonymity will be protected, and all participants will receive a formal PT report highlighting their individual results.

The target audience for this PT is laboratories that perform calibrations of outside micrometers, in particular ISO/IEC 17025 accredited labs that have requirements for PT participation. This PT is a collaborative idea from members of the NCSLI Dimensional Committee and will run differently than the commonly available PT for calibration of hand-held measuring instruments like micrometers and calipers. In those PT’s, the results are often clouded by limited resolution, instrument errors, and large uncertainties.

The primary goal of this PT is to test the skills of the calibration technician, which is often a major concern when calibrating manually operated measuring instruments. While the results of this PT should be extremely interesting and educational, this PT is not a training session – all participants should be skilled in the calibration of micrometers. The measuring equipment being used will include a 0-1” digital outside micrometer and several gage blocks courtesy of Mitutoyo America. Another driving factor for the choice of a micrometer for this PT was the publication of the revised U.S. national standard for micrometers, ASME B89.1.13-2013. This standard includes a new approach to measurement uncertainty which has not been widely adopted yet. The NCSLI Dimensional Committee hopes this PT will bring about more awareness of this new standard and the key concepts as well as provide some publicly available data that can be used when discussing the concepts. The new micrometer standard also introduces the concept of a “reasonably trained and skilled operator,” but that concept is not thoroughly defined in the standard. As operator skill is related to measurement uncertainty, the NCSLI Dimensional Committee hopes the results of this PT will provide some experimental support to the assumptions in the new standard as well as provide a framework for others who wish to run similar PT in the future.

Anyone interested in participating in this micrometer PT is encouraged to sign-up when registering for the annual Workshop & Symposium. Participation is limited and time-slots are expected to fill-up fast. The PT is estimated to take about 20 minutes to complete, and practice time will be available. While this PT is being organized with the intent of meeting some accreditation requirements for ISO/IEC 17025 accredited calibration labs, the suitability of this PT cannot be guaranteed for every lab, as requirements vary between accreditation bodies.

Register online with your conference registration.
Questions: Jim.Salsbury@mitutoyo.com | info@ncsli.org
## TECHNICAL PROGRAM

### Amazing Stories of Measurement

#### WITH FEATURED ENERGY TRACK

**TUESDAY, JULY 21, 2015**

**SESSION 1 | TUESDAY, JULY 21 | 10:30 AM - 11:30 AM**

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<td>1A</td>
<td>Amazing Stories of Measurement I</td>
<td>Forensic DNA Quality and Metrology</td>
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<td>John Butler, National Institute of Standards and Technology (NIST)</td>
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<tr>
<td>1B</td>
<td>Panel: Active Test Asset Management</td>
<td>Elements of Active Test Asset Management in Laboratory Operations</td>
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<td>James E. Smith, Lab Test Operations, Boeing Test &amp; Evaluation Asset Management</td>
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**SESSION 2 | TUESDAY, JULY 21 | 1:00 PM - 2:00 PM**

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<td>Amazing Stories of Measurement II</td>
<td>The Planned Redefinition of the Metric System: Made Easy</td>
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<td>Alan Steele, National Research Council Canada (NRC)</td>
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<td>Carl Williams, National Institute of Standards and Technology (NIST)</td>
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<td>Global Metrology</td>
<td>Insight into the APLAC Member Survey on Report Credibility</td>
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<td>Wanji Yang, Taiwan Accreditation Foundation</td>
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<td>Developing a Common Global Laboratory Quality System</td>
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<td>Steven Stahley, Cummins, Inc.</td>
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<td>2C</td>
<td>Chemical Metrology</td>
<td>Use of Nuclear Magnetic Resonance (NMR) for Certified Reference Materials</td>
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<td>Sheila Crain, National Research Council Canada (NRC)</td>
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<td>Substitution Method for Liquid Density Measurements by Vibrating Tube Densimeter</td>
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<td>Salvatore Lorefice, Istituto Nazionale di Ricerca Metrologica (INRIM)</td>
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**SESSION 3 | TUESDAY, JULY 21 | 2:30 PM - 4:00 PM**

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<td>Roberto Benitez Chavez, Etalons, S.A. de C.V.</td>
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<td>Dosimetry for LDR Brachytherapy</td>
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<td>Hong Shen, National Research Council Canada (NRC)</td>
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<td>Calibration of Defibrillator Analyzers at the HKSARG Standards and Calibration Laboratory (SCL)</td>
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<td>Steven Yang, The Government of the Hong Kong Special Administrative Region</td>
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<td>3B</td>
<td>Dimensional Metrology I</td>
<td>Design of Fixtures for Calibration</td>
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<td>Hy D. Tran, PhD, PE, Sandia National Laboratories</td>
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<td>ISO/IEC 17025 Requirements for Dimensional Testing</td>
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<td>Shawn Mason, Medtronic, Inc.</td>
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<td>Dimensional Metrology, Intermediate Precision and Uncertainty</td>
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<td>Ted Doiron, National Institute of Standards and Technology (NIST)</td>
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<td>Calibration Intervals</td>
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<td>Gerhard Mihm, Technical Center for Information Technology and Electronics-WTD 81</td>
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<td>Calibration Interval Adjustment Methods</td>
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<td>Mark Kuster, Pantex Metrology</td>
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<td>Vilayanur Viswanathan, Pacific Northwest National Laboratory (PNWNL)</td>
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<td>Phasor Measurement Units Traceable Type Acceptance Testing in Compliance with IEEE C37.118</td>
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<td>Jeffrey Guigue, Consumers Energy Co.</td>
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<td>Allen Goldstein, National Institute of Standards and Technology (NIST)</td>
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TECHNICAL PROGRAM

WEDNESDAY, JULY 22, 2015

SESSION 4 | WEDNESDAY, JULY 22 | 8:30 AM - 10:00 AM

4A Amazing Stories of Measurement III
What’s Your Poison? Addressing the Biotoxin Measurement Challenge
Pearse McCarron, National Research Council Canada (NRC)
Measurements & Standards to Create a Nationwide Public Safety Communications Network
Kent Rochford, National Institute of Standards and Technology (NIST)

4B Lab Recovery from Disaster, Relocation or Redesign
Laboratory Remodel, Challenges and Solutions
Garret Brown, State of Alaska
Panel: Writing team for LM Document covering Lab Recovery from Disaster, Relocation or Redesign

4D Energy II
High-Accuracy AC Power Measurements Using a Digital Simultaneous Sampling Technology Technique
Roberto Roca Profet, Measurements International Ltd.
Influence of Harmonics on Billing Revenue Meter Accuracy
Peter Back, Radianti Research, Inc.
High Res Waveform Capture w 1PPS GPS Synch for Precision Power Quality Analysis
Marcus Zickefoose, Radiant Research, Inc.

SESSION 5 | WEDNESDAY, JULY 22 | 10:30 AM - 11:30 AM

5A Amazing Stories of Measurement IV
Smart Grid Metrology: How Measurements Keep our Society Up and Running
Gert Rietveld, Dutch Metrology Institute (VSL)

5B Metrology Potpourri
Summary Result of 2014 Outside Micrometer Calibration Proficiency Testing in Taiwan
Paul Kam-Wa Lui, Industrial Technology Research Institute (ITRI)
Metrology in Manufacturing
Michael Dobbert, Keysight Technologies

5C Temperature I
Characterizing SRPT Drift
Michal Chojnacky, National Institute of Standards and Technology (NIST)
A Statistical Approach to Primary Radiation Thermometer Drift Quantification with an Example Application
Tom Kolat, Fluke Calibration

SESSION 6 | WEDNESDAY, JULY 22 | 1:00 PM - 2:00 PM

6A Training Tools
Utilizing a 3-D Printer to Improve Learning of Metrology and GD&T
Joseph Fuehne, Purdue University College of Technology
Practice in the Industry as a Means of Social Integration of Metrologists
Flora Mercader Trojo, Polytechnic University of Santa Rosa Juaregui

6B Electrical I
A 100 Ampere Intercomparison using Precision Resistors
Marlin E. Kraft, National Institute of Standards and Technology (NIST)
How Effective is Self-Calibration in Precision DMMs
Gary Bennett, National Instruments Corporation

6C Mass
Properties of Tungsten Mass Artifacts
Ilko Rahneberg, Technische Universitat Ilmenau
The CCM Roadmap for a Redefinition of the Kilogram in 2018
Philippe Richard, Federal Institute of Metrology METAS

6D Metrology of Fluids
Accuracy of Liquid Delivery Using Pipettes – Reproducibility of Calibration is THE Missing Piece
George Rodrigues, Artel USA, Inc.
Establishment of the Gas Flow Calibration Facility at CSIR- NPL, India
Shiv Kumar Jaiswal, CSIR-National Physical Laboratory

SESSION 7 | WEDNESDAY, JULY 22 | 2:30 PM - 4:00 PM

7A Healthcare Metrology II
Leveraging Integration of Calibration Management Systems in Healthcare Metrology
Marcus McNeely, Blue Mountain Quality Resources, Inc.
The Uncertainty Budget: A Powerful Tool
Finn Christensen, Novo Nordisk A/S
The Top 10 FDA Warning Letters
Walter Nowocin, Medtronic, Inc.

7B Electrical II
HVDC Reference Step Calibration
Dr. Harold Parks, National Research Council Canada (NRC)
A Study of Wye-Delta Networks for High Resistance
Dean G. Jarrett, National Institute of Standards and Technology (NIST)
The North American 1 Ohm Inter-Laboratory Comparison Final Report
Kai Wendler, National Research Council Canada (NRC)

7C Mass|Force
Refinement of Forces Realized in a Deadweight Force Standard Machine
Rick Seifarth, National Institute of Standards and Technology (NIST)
Efficient Mass Calibration with SW
Felix Mathis, Mettler Toledo AG Switzerland
Calibrating Non-Automatic Weighing Instruments – Recent Developments re Harmonization
Klaus Fritsch, Mettler-Toledo AG

7D New Challenges and Developments
Update on GUM and VIM Revision
Dr. Charles D. Ehrlich, National Institute of Standards and Technology (NIST)
Cyber-Security in the Industrial & Government Supplier Test Lab Environment
Lee Johnson, Boeing Test & Evaluation Asset Management
The Role of Measurement in Experimental Research, Development and Innovation
Salvador Echeverria-Villagomez, Centro Nacional de Metrologia (CENAM)
MEASUREMENT SCIENCE plays multiple roles in all aspects of the energy industry.

THE ENERGY SESSIONS will focus on topics unique to the energy industry, such as battery storage, electric and gas metering, and measurements of hydrophobicity retention.
TUESDAY, JULY 21 | WEDNESDAY, JULY 22

A New Approach to Calibrate Amplitude Modulation Receiver
Woo Chi, Naval Air Systems Command

The Effects of Applying LED Lamps
Ana Maria Ribeiro Franco, INMETRO - National Institute of Metrology

Automation Design of Multiple Intelligent Integration System
Nghiem Nguyen, Raytheon Co.

Uncertainty Evaluation of Dial Indicator Calibrator Calibration Using Laser Interferometer
Paul Kam-Wa Lui, Industrial Technology Research Institute (ITRI)

How Accreditation Improves our Quality of Life?
I-Jhen Lin, Taiwan Accreditation Foundation (TAF)

Promote our Quality of Life by Accurate Measurement Through Traceable Calibration
Joshua Yang, Taiwan Accreditation Foundation (TAF)

Optimization of Thermal Radiation Source for High Temperature Infrared Thermometer Calibration
Frank Liebmann, Fluke Calibration

Calibration of Broadband Sound & Vibration Devices Using Narrowband Reference Devices
Kacey Redmond, The Modal Shop, Inc.

An Electronic Label and Its Compliance in a Quality System
Dimaries Nieves, National Instruments Corporation

Thermocouple Data Analysis Methods and the Mathematics Used to Report Calibration Results
Tom Kolat, Fluke Calibration

Test Lab Asset Utilization; Methods to Maximize Your Asset Budget
Leah Lindstrom, Boeing Test & Evaluation Asset Management

Metrological Investment Projects
Salvador Echeverria-Villagomez, Centro Nacional de Metrologia (CENAM)

Transducer Calibration
Andy Cogbill, Vibration Research

Best Practices in Validation of Automated Calibration Procedures
Suresh Ramachandran, National Instruments Corporation

Information Based Interpretation for Reliability Goal
Ding Huang, Naval Air Systems Command

New Developed Technique and Methods to Manage Measurement Risk and Sampling
Teruhisa Tsuru, Murata Mfg. Co., Ltd. Yasu Plant

Developing Acceptance Tests and Uncertainties for CMMs
Jacqueline Carlson, Consolidated Nuclear Security Y-12, LLC

Is Hardware Abstraction a Pipe Dream?
Logan Kunitz, National Instruments Corporation
Measurement Science plays multiple roles in all aspects of the energy industry. The energy sessions will focus on topics unique to the energy industry, such as battery storage, electric and gas metering, and measurements of hydrophobicity retention.

**Traceable Synchrophasors**

*Allen Goldstein, National Institute of Standards and Technology (NIST)*

The IEEE synchrophasor standard requires that Phasor Measurement Units compliant to the standard be traceable. Limits of performance are prescribed under steady state conditions over frequency and magnitude ranges and in the presence of potentially interfering signals, and under dynamic conditions including ramp of system frequency plus modulations and steps in phase and magnitude. In support of the IEEE Synchrophasor Conformance Assessment Program, a traceable system for measuring the performance of Phasor Measurement Unit calibration systems has been developed at NIST. An overview of the effect of calibration system uncertainty on PMU test results will be presented.

**Phasor Measurement Units Traceable Type Acceptance Testing in Compliance with IEEE C37.118**

*Jason Watson and Jeffrey Guigue, Consumers Energy Laboratory Services*

The availability of electricity in the United States at the flip of a switch is assumed and taken for granted until interruptions occur. Electricity is generated by a variety of methods including nuclear, coal, natural gas, wind, solar, biomass, and hydro; but they all must use the same infrastructure of transmission and distribution wires to deliver the electricity to the consumer. This presentation will address the definition of a synchronized phasor, time synchronization, application of time tags, method to verify measurement compliance with the standard, and message formats for communication with a phasor measurement unit (PMU).

**Conformity Assessment of E-Storage**

*Vilayanur Viswanathan, Pacific Northwest National Laboratory (PNL)*

Increasing energy, environmental and economic challenges have increased the interest in the development and deployment of new technologies in the process of energy delivery and use. This presentation will focus on energy storage technology and the current codes, standards and regulations in the U.S. applicable to energy storage systems and the role third party testing and certification agencies play in the deployment of the technology. This will focus on both the traditional testing and listing to published codes and standards but also how third parties play a role in the acceptance of energy storage systems in advance of the publication and adoption of codes and standards specifically covering energy storage technology.

**Influence of Harmonics on Billing Revenue Meter Accuracy**

*Pete Dack, Radian Research*

Revenue billing meter accuracy is supported by the requirements defined in ANSI C12. Recent attention to meter accuracy, under real world conditions, has generated interest in modifying C12 to include harmonics. This paper reviews the results from a sampling of meters tested under specific harmonics on the Current and Voltage axis, as well as the necessary Reference Meter measurement requirements to provide traceability.

**High Resolution Waveform Capture with 1PPS GPS Synchronization for Precision Power Quality Analysis**

*Marcus Zickefoose, Radian Research*

The constraints on implementing power quality algorithms in a traditional Power Quality analyzer design are “Time and Space” constrained. With Hardware, there is a finite amount of time available to complete the calculations and a limited amount of memory for the executable code, working variables and data storage. The fundamental challenge for Power Quality Equipment designers is to implement the power quality algorithms in real time. New techniques utilizing a 1PPS synchronized data capture allow for precision hardware to focus on measurement and opens up a multitude of software packages to analyze the results.
High Accuracy AC Power Measurements Using a Digital Simultaneous Sampling Technology Technique

Roberto Roca Profet, Andrew Wachowicz, Measurements International

This paper presents an overview of a new measurement method of electrical AC power which has shown to improve the performance of power measurement instrumentation by a factor of 4 or more. Tests show this technique improves performance from the existing levels of 0.02 % to better than 0.005 %. This applies to AC power at normal mains frequencies of 50 or 60 Hz, and extending to higher frequencies, up to the 25th power line harmonic. The paper describes a measurement concept using a 3 channel, 24 bit low noise A/D converter, termed a Digital Simultaneous Reading Wattmeter (DSRWM). Included are examples of actual measurements and associated errors and uncertainties. This paper also discusses the applications DSRWM technology in instrumentation for power measurements over the full power factor range. These usages include measurements of single phase or line-to-line power, including both sinusoidal and non-sinusoidal voltage and currents with a fundamental frequency of 15 to 420 Hz.

Thermal Mass Flow Meters

Robert DeRemer, CSA Group

Manufacturers of thermal-type mass flow meters provide lists of Gas Correction Factors that allow the flow meters to be used on a wide range of process gases, while being calibrated on one gas. These Gas Correction Factors work well when the particular process gas properties are fairly constant over the range in temperatures and pressures that are encountered in the process. This paper deals with a situation where the process gas properties vary significantly over the range of process conditions. Fundamental operating principles of thermal-type mass flow meters will be presented, along with an analysis of how variations in the process gas properties have an impact on the apparent accuracy of the flow meter.

Calibration of Flicker Meters

Steven Yang, Hong Kong, The Government of the Hong Kong Special Administrative Region

The Standards and Calibration Laboratory (SCL) has set up calibration facility for calibration of flicker meters. Flicker is a measure of the visual disturbance of the lighting system experienced by a human observer due to power supply fluctuation. It is in effect a measure of the voltage fluctuation of the power supply. Flicker meters are used to measure the amount of flicker. Flicker meters are calibrated by applying a voltage waveform with known fluctuation to the meter and comparing the meter’s readings against the known voltage fluctuation values. Statistical analysis is then performed to the measured voltage fluctuation to obtain the short term flicker severity and the long term flicker severity. The applied waveform can either be a sinusoidal or a rectangular modulated waveform of the supply voltage.

Measurements of Hydrophobicity Retention on Outdoor Insulators

Refat Ghunem, National Research Council Canada (NRC)

Excessive leakage currents across the high voltage insulators in the power network can cause unplanned outages with huge financial costs on power utilities. In order to suppress these leakage currents, room-temperature vulcanizing (RTV) silicone rubber coating materials have been widely applied on in-service ceramic insulators. These coatings possess hydrophobic surfaces, on which wet contaminants tend to form in a bead-like shape, thereby, suppressing the development conductive paths for leakage current. Most importantly, when the hydrophobicity is lost due to continuous wetting, the unique hydrophobic retention property of silicone rubber, due to the diffusion of low-molecular-weight (LMW) silicones from the bulk to the surface, washes off the contaminants and retains the hydrophobicity of the insulation housing material. However these coatings have a limited lifetime. With continuous wetting and thus the depletion of the LMW fluid, the rate of hydrophobicity return is reduced until reaching the end-of-life stage at which the loss of hydrophobicity is imposed for longer durations, leaving the insulation housing vulnerable to leakage current formation.
World Metrology Day is an annual celebration of the signing of the Metre Convention on May 20. The Metre Convention was signed by representatives from seventeen nations at the Convention of Paris in 1875. It created the International Bureau of Weights and Measures (BIPM) and laid the framework for global collaboration in the field of Metrology. It established an international standard of measurement and put in place a permanent organizational structure through which matters relating to measurement and units of measurement could be governed. Every year, World Metrology Day is recognized jointly by BIPM and The International Organization of Legal Metrology (OIML), which works to develop international recommendations with the aim of aligning and harmonizing requirements for instruments of measurement all over the world.
This year, World Metrology Day is aligned with the International Year of Light and Light-based Technologies proclaimed by the General Assembly of the UN and organized by UNESCO. Events in 2015 will celebrate the central role of light to life, whether as a source of energy, as the basis for photonic technologies or as being a source of wonder and excitement.

Metrology plays a central role in enabling the application of light-based technologies, for example:

• as new forms of efficient lighting are developed new measurements are needed to quantify their efficiency and the influence they have on the appearance of objects,
• decisions to invest in solar photovoltaic technologies are based on accurate data for their efficiency and lifetime,
• direct measurements of the sun made from satellites are essential to underpin our understanding of solar irradiance and its contribution to climate change.

In turn, light is at the heart of many of the most important new elements of leading-edge measurement technologies. For many decades, the most accurate length measurements have depended on highly-stable lasers and many highly-sensitive chemical measurements use tunable lasers that can sense individual transitions in target molecules. The capabilities of stable lasers now extend to providing the most accurate “optical clocks” which depend on the light emitted from single atoms which have been slowed down and trapped by laser beams.

I hope that the celebration of World Metrology Day on 20th May 2015 will trigger new liaisons between the metrology community and those who work to develop and exploit light-based technologies. It is the opportunity to show that just as life depends on light, so the safe, efficient and effective supply of light depends on measurement.

As we begin our preparations for World Metrology Day, 2015 and as we consider this year’s theme, Measurements and Light, I think about how this current theme is very closely related to those of previous World Metrology Days:

• light is important in everyday life (the theme for 2013);
• workplace and street lighting benefit both our health and our safety (the themes for 2006 and 2012 respectively); and
• with the increasing economic growth in many areas of our planet, the demand for more light and therefore more electricity certainly creates a global energy challenge (the theme for 2014).

We live in a highly visual world. Each day we see the sun rising, providing the essential requirements for life itself. Each day a large percentage of the world is able to simply flip a switch and turn on an electric light.

However, a recent article in the Washington Post identified a significant challenge: “The rate of growth in global electrification is slower than the rate of growth of the population”. A report from the IEA and the World Bank states: “With regard to universal access, business as usual would leave 12 percent … of the world’s population in 2030 without electricity…”.

Without a significant increase in spending or a new direction to solve the problem, this will not change. To compound this issue the UN is also trying to address climate change at the same time – and prevent global temperatures from rising by more than 2 °C. To satisfy both goals, nations around the world would need to improve their energy efficiency and bolster the amount of clean energy they produce and use. This will require

• more measurements to understand and improve the efficiency of electrical appliances,
• an increase in the amount of clean energy produced and consumed, and
• additional international standards that apply directly to this area.

Light can behave either as a wave or a particle, or sometimes as both. This is quite remarkable. Also, as metrologists, we think of light as something that is measured, but we also use it to make measurements, again quite remarkable.

The speed of light in vacuum, commonly denoted $c$, is a universal physical constant which is important in many areas of physics. Its defined value is exactly 299 792 458 m/s, as the SI metre is defined from this constant. Distance, speed, temperature, the composition and contaminants in our food and environment, common measurements to legal metrology, can all be measured using various forms of light.

I hope that these initial thoughts that I continue to consider with great wonder the phenomenon which we enjoy every day as light. The legal metrology community is pleased to join with UNESCO in marking the International Year of Light and I wish you immeasurable happiness and a very bright future.
Measurements and Light

This year, World Metrology Day is aligned with the International Year of Light and Light-based Technologies proclaimed by the General Assembly of the UN and organized by UNESCO. Events in 2015 will celebrate the central role of light to life, whether as a source of energy, as the basis for photonic technologies or as being a source of wonder and excitement. Metrology, the science and application of measurement, plays a central role in enabling the application and advancement of light-based technologies, whether for more efficient energy production, a better understanding of climate change, or optimal lighting of our cities and towns. In turn, light is at the heart of many of the most important new elements of leading-edge measurement technologies.

Across the world, national metrology institutes continually advance measurement science by developing and validating new measurement techniques at whatever level of sophistication is needed. They also participate in comparisons coordinated by the Bureau International des Poids et Mesures (BIPM) to ensure the reliability of measurement results worldwide.

Many measuring instruments are controlled by law or are subject to regulatory control, for example the scales used to weigh goods in a shop, instruments to measure environmental pollution, or meters used to bill energy. The International Organization of Legal Metrology (OIML) develops international Recommendations, the aim of which is to align and harmonize requirements for these types of instruments worldwide.

World Metrology Day recognizes and celebrates the contribution of all the people that work in intergovernmental and national organizations throughout the year on behalf of all.

About the BIPM

The signing of the Metre Convention in 1875 created the BIPM and for the first time formalized international cooperation in metrology. The Convention established the International Bureau of Weights and Measures and laid the foundations for worldwide uniformity of measurement in all aspects of our endeavors, historically focusing on and assisting industry and trade, but today just as vital as we tackle the grand challenges of the 21st Century such as climate change, health, and energy. The BIPM undertakes scientific work at the highest level on a selected set of physical and chemical quantities. The BIPM is the hub of a worldwide network of national metrology institutes (NMIs) which continue to realize and disseminate the chain of traceability to the SI into national accredited laboratories and industry.

About the OIML

In 1955 the International Organization of Legal Metrology (OIML) was established as an Intergovernmental Treaty Organization in order to promote the global harmonization of legal metrology procedures with the Bureau International de Métrologie Légale (BIML) as the Secretariat and Headquarters of the OIML. Since that time, the OIML has developed a worldwide technical structure whose primary aim is to harmonize the regulations and metrological controls applied by the national metrological services, or related organizations.
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NRC CELEBRATES

“Year of Light”

By National Research Council Canada

Dr. Andrew Todd and Don Woods using the NRC high-temperature blackbody as a reference source to calibrate an optical pyrometer for measuring melting temperatures of a series of eutectics being investigated for use as future high-temperature standards.

Credit: National Research Council Canada Photo
The United Nations has proclaimed 2015 as the International Year of Light and Light-based Technologies (IYL 2015) to “highlight to the citizens of the world the importance of light and optical technologies in their lives, for their futures, and for the development of society.”

In celebration of IYL 2015, the National Research Council of Canada (NRC) has dedicated the month of May to recognizing the importance of “light for quality standards”. The theme is in line with this year’s focus for World Metrology Day: Measurements and Light.

The term ‘quality standards’ conveys ideas of high accuracy (via standards that are traceable to the International System of Units - SI) and reliability (through the development of quality system procedures and demonstration of technical competence from international measurement comparisons) which are the essence of NRC Measurement Science and Standards. NRC’s physical metrology disciplines use optical methods to develop, maintain, improve and disseminate standards for characteristics including whiteness, photometry, radiometry and radiation thermometry, and colour quality.

**LIGHT TO ESTABLISH WHITENESS STANDARDS**

White means big money in the pulp and paper industry. The “whiteness” of paper is a key component of its market value. NRC, which is recognized as the world authority in paper whiteness measurements, developed the reference instrument that establishes the absolute whiteness level for various types of paper. For almost two decades, NRC has been the world’s keeper of optical property standards for fluorescently-whitened paper as set by the International Organization for Standardization (ISO). Paper companies around the world trace their whiteness measurements back to ISO-authorized labs such as FPInnovations in Canada, and these labs in turn trace their standards back to the measurement science labs at NRC.

NRC works with FPInnovations and the other four ISO-authorized laboratories in the U.S., Sweden, Finland and France to make sure companies around the world have access to the highest quality standards for paper whiteness. NRC and FPInnovations are also working with the International Commission on Illumination (CIE) to improve the lab methods used to measure whiteness of paper. This will benefit not only the paper industry but a wide variety of other manufactured white products that contain fluorescent-whiteners, such as fabrics, laundry detergents, soaps, plastics and cosmetics.

The “whiteness” of paper is a key component of its market value. NRC, which is recognized as the world authority in paper whiteness measurements, developed the reference instrument that establishes the absolute whiteness level for various types of paper.

Credit: National Research Council Canada Photo
Measuring ultraviolet (UV) light is critical for a wide range of environmental and health issues, emerging industrial technologies, and regulatory requirements pertaining to global trade. NRC’s ultra-high temperature blackbody is one of the world’s most accurate ways to measure UV light. A blackbody is a perfect emitter, so when it is heated, at any particular temperature, it emits a distinct amount of energy at each wavelength of light. Thus, if you know the blackbody’s temperature, you can use a physics calculation to determine the amount of light being emitted at any wavelength.

The state-of-the-art equipment, built in Russia and installed in part by two technicians from Russia’s National Metrology Institute in Moscow, addresses a growing Canadian demand for more accurate UV measurements. In order to deliver these measurements, UV lamps must be calibrated against a known source. This is where the high-temperature blackbody comes in. Its known UV radiation is used to calibrate NRC UV standards, which will then be used by NRC staff to calibrate commercial UV equipment.

Along with improving the ability to measure in the UV range, the high-temperature blackbody improves the accuracy of NRC light measurements for a wide variety of photometric and radiometric applications over the entire optical wavelength range.

The core of the high-temperature blackbody is a hollow tube of a form of graphite that can withstand intense heating. In order to produce the required UV radiation, the graphite core is heated to approximately 3230 °C, a temperature at which almost all metals melt. The graphite is gradually heated over the course of several hours by running an electrical current through it. The graphite core is insulated with many concentric layers of carbon cloth which are water-cooled.

At 3230 °C any oxygen would react instantly with the graphite, causing a fire. So, during operation the entire core is flushed with argon, a non-reactive gas. At operating temperature, the high-temperature blackbody produces an intense beam of light that’s emitted from a tiny eight millimetre hole. The energy of this wavelength of light is measured to determine the temperature within the blackbody.

The NRC high-temperature blackbody source is also being used to calibrate NRC primary radiation standards (pyrometers) for use in high-temperature metrology. NRC is participating in an international collaborative effort to investigate the reproducibility of the plateau temperatures of a series of high-temperature metal-carbon and metal-carbide-carbon eutectics. Specialized fixed-point blackbody sources are used as furnaces for preparing these eutectics and the NRC high-temperature blackbody is being used as a reference source to calibrate the NRC optical pyrometer for measuring the temperature of these eutectics. Eutectic-phase transitions are being considered for use as fixed points in future temperature scales, where light-based radiation thermometry methods will provide a high-temperature radiation scale (1000 °C and above). This will ultimately improve the extrapolation of the International Temperature Scale of 1990, ITS-90, which is defined in terms of fixed points of a series of pure materials.

---

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LIGHT TO ENHANCE THE QUALITY OF COLOURS

A decade ago, NRC developed a leading-edge gonioreflectometer — a highly sensitive instrument that can rapidly measure, in three dimensions, the reflectance properties of materials with a variety of colour attributes and surface characteristics. This benefits manufacturers of iridescent paints that reflect a range of hues and exhibit different surface texture or other spatial effects, when light hits them from different angles.

A gonioreflectometer consists of a light source illuminating the material to be measured and a sensor that captures the light reflected from that material as it rotates around a hemisphere. The rotation of the light source and the sensor around the target material is what allows for reflectance to be measured in 3D.

Cosmetics, cars, appliances, clothing and high-end packaging are some of the products for which the proper management of colour and appearance are critical for commercial success. NRC’s capacity to accurately measure 3D reflectance also serves other interests, such as anti-counterfeiting, remote sensing, cultural heritage and medical imaging applications, or the production of new geometry-sensitive materials, such as special effect pigments.

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NRC works with national metrology institutes around the world to maintain the global standards that are critical for international trade — everything from time, length and mass to novel measurements needed for medicine, nanotechnology and biotechnology. Light is just one of many tools at NRC metrologists’ disposal to determine and measure compliance to these important quality standards, helping Canadian industry to de-risk product development and add significant value to a wide variety of products.
Technical Exchange Review

By Mike Fritz

The NCSLI Technical Exchange returned to Raleigh, North Carolina for its fourth year on Wednesday and Thursday, February 11 – 12. This year’s Technical Exchange was our most successful exchange to date. The Measurement Training not only provides a forum for exchanging ideas, techniques and innovations, but also offers a valuable hand-on experience to participants.

With training covering two days, we had 162 tutorial registrations. Participants were provided in-depth information presented by instructors who are professionals in their fields.

The tutorials, this year covered a range of metrology topics including:

- An Introduction to Instrumentation Control and Calibration in Labview
- ISO/IEC 17025 Laboratory Accreditation
- Calculating Uncertainties in Testing Laboratories
- Precision DMM Measurements
- Thermocouple Theory and Practical Application
- Asset Management in a Test Lab Environment
- Record-Keepers and Record Seekers: Common Record-Keeping Mistakes
- Dimensional Measurements in an Industrial Testing Environment
- Industrial Pressure Calibration and Measurements
- Statistical Analysis of Metrology Data
- Temperature Measurement/ Temperature Metrology and Thermometer Calibration
- Application of Calibration Data in a Testing Lab
- Dynamic Sensors & Calibration
- Proficiency Testing
- Selecting Appropriate Calibration Intervals
- Process Calibration
- Microwave Measurement Techniques

Feedback from tutorial participants was very positive. Attendees said the tutorials presented great opportunities to interact with metrology experts and felt the courses were in-depth and presented well, providing fundamental information for all levels of measurement. Instructors were knowledgeable and attentive, staying after the class to answer questions.

Technical Exchange Exhibitors provided information on their respective companies and equipment and discussed their test and measurement challenges with attendees. Exhibitors this year were:


The 2016 Technical Exchange program is currently being developed please check the website at ncsli.org for current information. If you are interested in presenting a tutorial for this measurement training event please contact Mike Frisz.

mikefrisz@mintl.com
Exhibitors
Jeff Gust, NCSLI Standards and Practices Committee VP, and Tim Osborne, NCSLI VP of Operations, attended the inaugural meeting of the ISO/CASCO working group (WG 44) to revise ISO/IEC 17025 “General requirements for the competence of testing and calibration laboratories.” The meeting was held in Geneva, Switzerland from February 10-12, 2015 with 71 people in attendance including three (3) co-conveners, Messrs., Heribert Schorn, International Electrotechnical Commission (IEC), Warren Merkel, International Laboratory Accreditation Cooperation (ILAC), and Steve Sidney, South Africa Bureau of Standards (SABS). The objectives of the first meeting included:

• Establishing a common understanding of the roles and responsibilities of the participants/experts
• Agreeing to the track, i.e. length of time, to complete the revision
• Orienting the working group experts in regards to the ISO/CASCO processes
• Introducing the recommended structure for ISO/CASCO standards
• Arranging the current text of the standard into the agreed structure, and scheduling the next several meetings.

WG44 agreed to proceed with Track II, a 36-month review and approval cycle, for the revision of ISO/IEC 17025. Since the approval to revise the standard occurred in September 2014, the time of release for public use of the new revision is expected to be September 2017. The title of the document may change slightly to “Conformity Assessment – requirements for the competence of testing and calibration laboratories” to be in line with the other 17000 series ISO/CASCO documents (But the document may not have the conformity assessment moniker as it has been argued that the VIM definition of calibration is not conformity assessment). Although none of the requirements have been modified yet, other noticeable changes to the document include the adoption of the recommended ISO/CASCO structure and the inclusion of obligatory requirements on impartiality, confidentiality, complaints and appeals, and the management system into the document, as per QSPAS PROC-33, Common Elements in CASCO Standards. The first draft of this arrangement was completed. While there are obligatory element requirements, there are no new material requirements that have been added, at this point, to the draft. These elements were addressed in the present version of the standard, so all that was necessary was to move those requirements into these sections. As before, the document will stand silent on the issue of accreditation. Labs do not have to be accredited to claim compliance to the standard.
The Management and Technical Requirements sections have been expanded to reflect the recommended ISO/CASCO structure which includes:

- Structural requirements
- Resource requirements
- Process requirements
- Management system requirements.

The change to the 17000 series standards is intended to harmonize them with developments in the ISO 9000 series. This improvement applies a consistent logic to the 17000 series standards; the process inputs, the process, and the process products or outputs. In more familiar terms; the service request, the testing and/or calibration service, and the certificate or report. This recommended structure provides better value to the internal audit management review and external evaluations of the entire management system processes because it outlines the natural flow of the process. The CASCO structure affords the laboratory two options for implementing ISO 9001 or its elements: Option A utilizes the section 4 management requirements of ISO/IEC 17025:2005, and Option B capitalizes on the latest version of ISO 9001 (draft for comment). A laboratory that does not maintain or acquire ISO 9001 registration or certification may continue to use ISO/IEC 17025 as a standalone document and the elements that were similar to section 4 of ISO/IEC 17025 and any other requirements. Option B is available to organizations that maintain or may acquire ISO 9001 registration/certification where the ISO 9001 audit suffices for the assessment of the management system elements, which would reduce time required for an ISO/IEC 17025 assessment if the laboratory chooses accreditation.

The output of this meeting is a very rough first version of the working draft (WD) of the standard. The working group experts will have about five (5) weeks to review and comment on the content of the WD. In advance of the next meeting, ISO staff will collate the comments and the WG conveyors will prioritize the issues for further discussion. The WG will use the next meeting to discuss, negotiate and refine the text and to develop a second iteration of the WD.

The WG experts will have a second comment period, in preparation of the third meeting which is expected to result in a committee draft (CD). This will lead to the next phase, the Committee Draft Ballot, where member bodies will have two (2) months to solicit comments from their various stakeholders and to vote on the CD. As a result of the comments and next round of improvements, we will be working to reduce/eliminate soft terms such as “should” and “where appropriate” as well as any notes that add to variation in assessment of the requirements. This will have to be done with great forethought so that laboratories doing good work can still comply with the standard.

Second meeting: June 2-4, 2015
ISO headquarters in Geneva, Switzerland.

Third meeting: August 2015
ISO headquarters in Geneva, Switzerland.

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Register for the NCSLI ISO/IEC Workshop following the Workshop & Symposium!
Grapevine, TX • Friday, July 24th
Date: Friday, July 24th
Time: 8:00 am to 5:00 pm
Host: NCSLI International

Purpose:
- To introduce the ISO/CASCO process to NCSLI members
- To educate the members on the philosophy behind the structural changes to the document
- To provide the membership an opportunity to ask questions about the obligatory changes and 9001 options

Goal:
- To give the members a voice to the ISO/CASCO WG draft via the NCSLI Liaisons

Format:
- 1 hour Panel Discussion
- 2 hours Q&A
- 4 hours working group

RSVP online for this ISO/IEC Workshop and book your rooms in advance at: ncsli.org
AUTHORS NOTE:

It has been said that temperature is the most frequently measured of all metrological parameters. Although I can’t personally attest to the truthfulness of this comment I can tell you that the need for accuracy and traceability in temperature measurement is being advocated in many areas of our economy where it has been traditionally neglected. This reality, along with increasing state government regulation and the never ending search for efficiency has elevated the demand for quality thermometer calibration to levels we’ve not seen in the past. The marketplace is answering this demand with growth in temperature calibration services. There is, however, a problem in providing training to assist calibration technicians and metrologists to transition from other disciplines to temperature.

Over its history, the NCSLI has filled such gaps by providing training in many areas and on many topics where training was simply not available elsewhere. This tradition has been taken to the next level with the NCSL Technical Exchange Program through which in-depth training on a variety of topics can be made available throughout the year and across the country. I’m very pleased to participate in this program by providing an in-depth course on thermometer calibration.

In addition to the thermometer training course, we’re introducing a series of TechTips intended, in part, to introduce potential attendees to some of the topics covered in the training. Our goal is twofold; first, we hope to provide a level of stand-alone information that will prove helpful to the metrologist. Second, we hope to pique your interest enough to gain your participation in the Technical Exchange program. As thorough as we can make these TechTips, there is no substitute for face-to-face, hands-on education.
In simple terms, a contact thermometer is a device with a sensor that reacts to temperature. When the thermometer is calibrated this reaction is characterized. When the thermometer is used, the characterization is applied to convert what we measure to a temperature value. Although the sensor is the active element, it isn’t the only element – a thermometer is composed of many parts, each with its own thermal behavior. For example, a typical platinum resistance thermometer (PRT) consists of six parts: 1) the sensor, 2) a metal sheath, 3) insulation (usually crushed mineral), 4) connection leads, 5) a transition junction, and 6) the interconnect cable (figure 1).

Although not active per se, all of the immersed components affect what the sensor “sees,” and thus, the measurement. When a thermometer is immersed in a temperature to be measured, heat flows from the environment into the thermometer, up the thermometer stem, and out into ambient. If we think of this heat flow as a continuous phenomenon, it’s easy to envision the result as a thermal gradient along the length of the thermometer where the temperature is highest in the bottom of the thermometer and smoothly decreases toward the top. Finally, to add a little complication, the sensor itself is at a slightly higher temperature than its surroundings during a measurement because the current passing through it will cause the sensor to self-heat through the Joule effect (more on this later). The heat is partially sunk into the surrounding environment. What results are the heat flux and thermal profiles shown in figure 2.
When these issues are taken into consideration, we can see that the sensor “feels” a temperature related to, but different from that which we wish to measure. In thermometry, we sum this up by stating that a thermometer always measures its own temperature.

So, how do we know when the temperature felt by the thermometer matches the temperature we’re interested in? Fortunately, the solution is fairly simple and completely sensible. The thermometer needs to be immersed deep enough into the environment so that the sensor area doesn’t feel a thermal gradient along its length. Think about it this way, when the thermometer is sufficiently immersed, enough heat is flowing into the stem area above the sensor to offset any losses from the stem to ambient, thus, the sensor doesn’t experience a thermal gradient and is able to achieve thermal equilibrium with the surrounding environment. In terms of dimensions, this is usually achieved at a depth of immersion equal to 20 times the stem diameter plus the sensor length, or:

\[
\text{sufficient immersion} = 20 \times \text{stem Ø} + \text{sensor length}
\]

For a 6 mm probe with a 25 mm sensor we have:

\[
\text{sufficient immersion} = (20 \times 6 \text{ mm} + 25 \text{ mm}) = (120 \text{ mm} + 25 \text{ mm}) = 145 \text{ mm}
\]

This generalization works for most PRT assemblies. Refer to figure 3. In this example a 6 mm PRT is immersed in a 100 °C bath in 10 mm increments. The data shows that full immersion is achieved at about 140 mm – just about what we would expect from the above calculation. However, the data shows us something else equally important. It shows us the magnitude of error at depths of immersion less than what we would consider sufficient immersion. For example, at 100 mm immersion, the ΔT is less than 0.001 °C. Thus, if we are unable to achieve full immersion in a particular situation we can predict the error and consider this in the uncertainty analysis.

Finally, we have to consider self-heating. PRTs are temperature sensitive resistors and are subject to a resistance measurement during use. Like any other resistance measurement, the PRT is energized with a source current, or excitation current, during the measurement. Generally, the larger the current, the larger the voltage drop and the easier the measurement. On the other hand, nothing is free and the current causes the resistor to heat up. Ohm’s Law provides the mathematical relationship between power, current, and resistance:

\[
\text{power} = I^2 \times R
\]
For this we need to know the dissipation constant \( (d) \) of the PRT. This should be provided by the manufacturer of the PRT. For the sake of this discussion we will assume \( d = 25 \text{ mW/°C} \) (an approximate value for a metal sheath PRT in fluid). For a 100 Ω PRT being excited by 1 mA we have the following.

\[
\text{Power (W)} = (0.001A^2 \times 100 \Omega) = (0.000001 \times 100) = 0.0001 \text{ W} = 0.1 \text{ mW}
\]

And...

\[
\frac{0.1 \text{ mW}}{25 \text{ mW/°C}} = 0.004 \text{ °C}
\]

So, a current of 1 mA creates a self-heating of about 0.004 °C. This value may or may not be significant depending on the level of uncertainty we are trying to achieve. Also, keep in mind that this is an approximate value and should only be used to determine relative magnitude, never to make corrections to a measurement. In most cases, the PRT is used in a thermal environment very similar to the environment in which it was calibrated. If both systems apply the same level of excitation current this effect becomes a first order effect and is essentially negated. If, however the thermal environments are very different (PRT calibrated in fluid and used in air), or if the excitation current is very different (1 mA during calibration and 2 mA in use), this effect will have to be considered. For reference, figure 4 shows the \( R_{\text{tpw}} \) value of a high quality 100 Ω PRT at several levels of excitation current. Each measurement represents a power increase of 2x the previous measurement.

When the data is plotted as \( R_{\text{tpw}} \) vs. power, the linear relationship between power and resistance becomes clear. Refer to figure 5.
We can use this linear relationship to extrapolate to a value of resistance we would observe if we could make this measurement with 0 mA excitation current. This is referred to as the 0 power resistance or \( R_{TPW}(0mA) \). The equation is:

\[
R_{TPW}(0mA) = 2 \times R_{TPW}(1mA) - R_{TPW}(1.4142mA)
\]

Using real values we have:

\[
R_{TPW}(0mA) = 2 \times 100.00102\,\Omega - 100.00237\,\Omega = 99.99967\,\Omega
\]

This value is precisely where the lines in the graphs intersect 0.0 mA and 0.0 mW in figures 4 and 5 respectively. This calculation works for any 2 values of current so long as the second value of current represents a doubling of power relative to the first value of current. However, never exceed the levels of current recommended for the PRT being measured.

In summary, the temperature indicated by a PRT always represents the temperature of the PRT. For this temperature to represent the temperature of interest we must consider 1) heat flux, 2) immersion depth, and 3) self heating. For a good result we will first design our measurement to reduce the magnitude of these effects and then make sure we account for any remaining errors when we evaluate the measurement uncertainty. Only when this is done will you be on your way to making very precise temperature measurements.

Tom Wiandt is the owner of TrueCal Metrology LLC in South Jordan, UT. TrueCal Metrology is a metrology consultancy specializing in thermometry, laboratory management, uncertainty analysis, and accreditation. Tom is an ASTM fellow and chairman of ASTM Committee E20 on Temperature Measurement. He is active in NCSL, MSC, ASTM and ASQ.

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Reliable measurements have a fundamental impact on the quality of life of people on all levels of society.

What are the things required to improve the quality of our lives? Philosophically we think of more permanent things such as relationships. The physical aspects of quality of life, such as the air we breathe, the water we drink, the food we eat, good health, the energy and resources we need to create wealth and prosperity, are also very important. Reliable measurements are an integral requirement for the preservation, monitoring and enhancement of all these physical aspects required for the improvement of quality of life.

Measurements have an impact on our survival. The quality assurance performed on the production of the food we eat is based on measurement results. Also the monitoring of ambient air quality and water quality depends on measurement results. Primary health care is based on measurements, such as blood pressure, EKG, MR scans, etc.

Manufacturing and trade will not be possible without measurements, such as the dimensions of a spark plug, the octane number and volume dispensed by a petrol pump, the purity and accurate mass of an ounce of gold being traded on the stock exchanges of the world. Research and innovation also depends on an international system of units that are comparable between countries all over the world.

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Greetings colleagues and welcome back. This installment expands our discussion from last time—smart documents for accreditation scopes—to cover a couple real world examples.

**Scrubbing Steel**

The 2015 Measurement Science Conference wrapped up March 20th with an impromptu panel session on metrology trends and the future. The audience posed several questions, at least two of which struck me as particularly relevant to an MII.

In one case, a gentleman mentioned that his organization imports steel from various international sources, often for critical applications, and related his difficulties establishing and documenting the steel's required material properties. The panel had
noted the ILAC MRA\(^1\) and the trend toward more universal recognition for accreditation from an ILAC-recognized and MRA-signatory AB\(^2\). The panel pointed out that procurement contracts should specify the testing criteria or standard and require accreditation evidence for those tests—all well and good.

The gentleman’s further inquiry about how to easily identify and locate such laboratories, however, spotlighted the gritty fact that no such tool exists. The current arrangement has us select a country in which we might procure services, locate one or more appropriate MRA signatories for that economy, go to their web sites, and search for accredited labs in the parameter of interest. Since we might have the testing done in the originating or destination country or somewhere between, this likely means multiple searches on several AB sites. Lather, rinse, repeat . . .

Machines handle mindless repetition more effectively than us. One site, one search would provide a much cleaner solution. With such a tool, we might simply enter the desired countries and material test names once, receive a list of labs, and save valuable time for intelligently choosing among them.

We wonder (as the folks at our table did) why ILAC doesn’t aggregate AB databases on its site or simply provide a meta-search function that returns search results from all ABs. If we grant that NMIs provide services also, then the aggregation should include BIPM’s KCDB\(^3\).

Today’s technology should make that simple, and ILAC itself would seem the perfect venue to standardize the search parameters and terminology. Whether ILAC and BIPM do not think that part of their mission, ABs or their customers would worry about bias or language translations, someone perceives some other stumbling block, or no one considered it before, we do not know. If you know the reason or someone who does, please inform us.

Babbling Towers

Heather Wade raised another sticky dilemma: When we wish to purchase a particular accredited calibration, the ABs provide little or no standardized search terminology. We might search for “temperature” to find a dry well calibration, but that returns labs with all manner of irrelevant CMCs. If we search by “dry well” we will find some appropriate services, but also those that use dry wells in their process, not at all what we want, and worse, miss any number of labs that listed the appropriate temperature CMC some other way. “Hello, hello! I don’t know why you say goodbye, I say hello.”\(^4\)

That said, NCSLI Recommended Practice RP-9, *Measurement Capability Description* sets us on a path toward building the dictionary we want (see the January column). RP-9 specifies standard terminology such as activity type (temperature), general function (calibration), category, subcategory, object of interest (dry well), quantity of interest, range, quality indicator and measurement method for defining CMCs. Unfortunately, neither RP-9 nor ILAC G18:04/2010, *Guideline for the Formulation of Scopes of Accreditation for Laboratories*, offer standardized lists of language for those descriptors, though documents such as the ISO-IEC 80000 series may help.

Clean Language

But that’s not all folks. In previous installments, we sketched data models by which to encapsulate instrument specifications and capability scopes in smart, machine- and human-readable (MII) documents. Since MII instrument specifications and accreditation scopes will have hard links to precisely qualified and defined measurements, MII documents will not come to fruition without rigorously defining and implementing the associated vocabularies, thus solving the ambiguity issue for both manual and automated searches.

Under this strategy, ILAC might establish an MII registry of AB-referred web services, correlated to its MRA signatory list (and BIPM’s KCDB). MII-aware software, whether provided on the same web site or elsewhere, part of an organization’s enterprise management software, or another package, would then automatically find accredited service providers and query them for the desired capabilities.

With that in place, we would simply pull up the MII instrument specs for our dry well, click the desired measurement functions and ranges, and execute a search for matching accredited calibration services with high confidence that the results include all providers with the exact service of interest and no others. In a further step, MII software might generate the written statement of work for the procurement and issue an electronic (MII) service request to the vendor’s software.

Such a measurement information infrastructure also answers our steel-testing problem, without the explicit database aggregation, and more effectively than the simple meta-search feature we suggested. The MII-aware software and the web services that list, advertise and fully describe CMCs would give us the global search we want.

Rinse and Dry

The MII revolves around three major communication vehicles: instrument (or material) specifications, capability scopes, and test or calibration certificates. Certificates supply the white-glove test results tying accredited measurements to instruments and materials. In the next installment we hope to begin our data model for smart certificates.

An MII will depend on discussion and feedback. Please send your thoughts and ideas via email or the MII community discussion forum at www.ncsli.org.

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\(^1\) International Laboratory Accreditation Cooperation

\(^2\) Mutual Recognition Arrangement

\(^3\) Accreditation body

\(^4\) National metrology institutes

\(^5\) Bureau International des Poids et Mesures (International Bureau of Weights and Measures)

\(^6\) Key comparison database

\(^7\) Calibration and measurement capabilities

\(^8\) The Beatles, of course
The Institute of Environmental Sciences and Technology (IEST) in Liaison with NCSL International

By Robert Mielke
IEST Fellow, Principal Metrology Engineer, AbbVie Inc.

The Institute of Environmental Sciences and Technology (IEST) is an international technical society of engineers, scientists, and educators covering the fields of controlled environments as well as simulation, testing, modeling, and design applications. IEST consists of a Test and Reliability Institute; Contamination Control Institute; and Nanotechnology Institute.

In 1953, the Environmental Equipment Institute (EEI) was founded, which was the first parent society of the Institute of Environmental Sciences. The Institute of Environmental Engineers (IEE) formed in 1956 as a separate corporation from the Science Section of EEI. In 1959, IEE merged with IES to form a new Contamination Control (CC) Division within IES. IES then became the US member of the newly formed International Committee of Contamination Control Societies (ICCCS) in 1974. IES applied a major effort to the revision of MIL-STD-781 in 1975, and in 1982 the Design, Test, and Evaluation (DT&E) Division held a pre-release review of MIL-STD-810D.

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In 1990, IES officially became a member of the American National Standards Institute (ANSI), and in 1993 IES was named Secretariat for ISO Technical Committee 209, “Cleanrooms and associated controlled environments,” which began a mission of developing international standards for cleanrooms. In 1997, reflecting a renewed commitment of service to the technical community, IES became the Institute of Environmental Sciences and Technology (IEST). IEST serves its members and the industries they represent through education and the development of recommended practices and standards. The organization sponsors and participates in regular technical conferences, including ESTECH (IEST’s annual technical meeting and exposition); the Aerospace Testing Seminar (ATS); the Space Simulation Conference (SSC); the Reliability and Maintainability Symposium (RAMS); and the International Confederation of Contamination Control Societies (ICCCS). IEST’s membership is drawn from professionals in the environmental sciences from around the world.


Recently, IEST’s Working Group DTE022 produced the Recommended Practice (RP) “Multi-shaker Test and Control.” This RP (IEST-RP-DTE022.1) focuses on the selection of the proper exciters, fixtures, transducers, bearings, and controllers and how they can contribute to the successful performance of a multiple-shaker vibration test. The latest revision of MIL-STD-810G introduced Method 527, “Multi-Exciter Testing,” legitimizing for the first time the use of multiple exciters when conducting vibration tests. RP-DTE022 is designed to be used in conjunction with Method 527 to expand upon the fundamentals described therein.

To broaden understanding in the test and reliability fields, IEST often offers custom training on location at facilities worldwide and at its headquarters Training Institute. This training often includes hands-on demonstrations of equipment calibration and testing.

One of the most popular standards produced by IEST is IEST-STD-CC1246E: Product Cleanliness Levels – Applications, Requirements, and Determination. This standard is a revision of the former military standard MIL-STD-1246. IEST was granted stewardship by the U.S. government for the development of the revision, which provides methods for specifying and determining product cleanliness levels for contamination-critical products, with the emphasis on contaminants that can impact product performance.

With compliance a major concern in nearly every arena of production, IEST is emphasizing its role as educator regarding the application of several newly available standards. Through its ANSI standards accreditation, IEST is serving as the global focus for training and information on two newly revised standards that apply to cleanroom and controlled environment operations: ISO/DIS 14644-1.2—Part 1: Classification of air cleanliness by particle concentration, and ISO/DIS 14644-2.2—Part 2: Monitoring to provide evidence of cleanroom performance related to air cleanliness by particle concentration. On behalf of ANSI, IEST serves as the Secretariat and US TAG Administrator to ISO Technical Committee 209, which developed these standards. IEST provides statistical background information and educational courses to help industries adapt to the revisions. IEST also develops standards and courses on filtration and the operation and testing of cleanrooms.

In late April, IEST will showcase revolutionary technological advances in the environmental sciences during ESTECH 2015, the organizations 61st Annual Technical Meeting and Exposition. The theme of the conference, being held in the Boston area, is Fostering Revolutionary Thinking, with an expansive program that features training courses, conference sessions, and networking opportunities in the fields of design, test, and evaluation; product reliability; aerospace; contamination control; and nanotechnology. Annually one of the world’s largest gatherings of environmental science experts, ESTECH provides tools for professionals to hone their skills and for students to gain critical knowledge.
As an example, ESTECH attendees utilize the conference to acquire expert information directly related to their businesses, and also can take advantage of the opportunity to contribute to the development of Recommended Practices by attending Working Group meetings. IEST welcomes professionals to observe the meetings and to consider joining one of the Working Groups in their area of expertise. Many ESTECH attendees spend the entire conference contributing to document development.

Professionals seeking solutions to issues and to learn about new technologies can discover the latest developments and “lessons learned” by attending technical conference sessions. To illustrate this, the ESTECH Planning Committee has significantly expanded its outreach this year to bring in new speakers and present innovative sessions on hot topics, including: cleanroom design; filtration; USP 797; multiple-input and multiple-output (MIMO) concepts; accelerated testing; product reliability; managing a test lab; and much more for both contamination control specialists and test and reliability specialists.

Courses in IEST’s test and reliability and contamination control disciplines overlap with the industries served by NCSLI, as much of the equipment used in these fields requires calibration. Examples of DT&E division courses offered by IEST that are of vital interest to test and design operations include: “Mastering Vibration Testing Fundamentals,” “Weathering the Storm on Durability Testing,” and “Multi-Shaker Testing and Control Applications.” Contamination Control division courses include “Application of ISO 14644-3,” which provides an in-depth examination of test methods for characterizing the performance of cleanrooms, as outlined in ISO 14644-3: Cleanrooms and associated controlled environments—Part 3: Test methods. IEST also hosts a Vendor Exposition at ESTECH for an up-close, hands-on experience with the latest environmental science technology and services.

More information about IEST’s test and reliability and contamination control programs is available at www.iest.org. Contact IEST by e-mail at information@iest.org or call (847) 981-0100.

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Serving the World of Measurement
By Vernon Alt
NCSLI Learning and Development VP

MONDAY, MARCH 2, 2015, 10:22 AM
I just received a Facebook Message from my friend Chelo in Mexico; all systems are go for my Metrology Ambassador outreach event! I’ll be presenting my “Effects of Salt on Ice and Water” lab to Chelo’s two 6th grade classes on Thursday at the Elementary School where she teaches. On Friday I’m supposed to present to a 7th grade class at the Middle School. I’ve presented this lab a million times at School STEM Nights, a few National Electronics Museum STEM events and it was part of my first ever session presentation at the NCSLI Conference. I got the idea from Van Hyder a few years back and it’s worked great for ten minute to one hour experiment events.

TUESDAY, MARCH 3, 2015, 8:15 PM
I’ve finished packing everything I need for my outreach event in Monterrey Mexico. I checked Experimental Lab Kit 1 out of the Training Aids Library and confirmed the two stainless steel temperature probes and the LabQuest data recorder are working properly. I also packed two cups capable of holding one litre of water and a measuring cup for 30 ml of salt. I’ll get the salt, ice and water when I get to Mexico. Chelo tells me she has two classes of 6th graders with about 16 students in each class and there is about the same number of kids in the 7th grade class, so I’m taking 100 chameleon pencils with me so I’ll have a few extra. I also have a stack of Metric Conversion Pyramids that Elizabeth mailed to me. Not sure why the kids in Mexico would need to convert metric to English units since they are fully immersed in the SI, but we’ll see how it goes.

WEDNESDAY, MARCH 4, 2015, 6:05 AM
The temperature here in Maryland is 3 °C which is a bit warmer than the -13° C we had a few days earlier, however I have hopes of warmer weather in Mexico. Got to get to the airport, my flight leaves at 8:31 AM.

WEDNESDAY, MARCH 4, 2015, 11:35 AM
Feels like the cold Maryland weather is following me, oh well, next stop Monterrey Mexico. Really looking forward to seeing Chelo and her husband Roy, it’s been too many years since seen each other.warmer weather in Mexico. Got to get to the airport, my flight leaves at 8:31 AM.

WEDNESDAY, MARCH 4, 2015, 4:07 PM (MEXICO TIME)
Mexico time is the same as Texas time, right now, however when I return to Texas the U.S. will be on daylight savings time and Mexico will be on standard time. I should keep that in mind.

THURSDAY, MARCH 5, 2015, 6:45 AM
Chelo is driving me to the elementary school where she teaches, the Instituto Bilingue La Silla, where it seems she has informed everyone that I will be visiting.

THURSDAY, MARCH 5, 2015, 10:32 AM
Well I’ve made it through my first presentation and I’d have to call it a smashing success! Despite the fact that I speak absolutely no Spanish, I can’t claim there was a language barrier. These 6th graders not only learn their native Spanish, they also take French and English classes! Chelo’s command of English is quite impressive and between us we were able to conquer all challenges. I used a nine slide PowerPoint to describe NCSL International and my function as Learning
and Development VP. I asked for volunteers to read each line of our Vision and Mission statements and expounded on particular words to help them understand terms like “measurement science,” “skill development,” “member processes” and “documentary standards.” After explaining calibration I talked about traceability and showed a pyramid with BIPM at the top and NMI just below. The next slide listed four NMIs (National Metrology Institutes) with CENAM on the list to highlight Mexico’s NMI. Okay, so I butchered “Centro Nacional de Metrología” when I tried my best Spanish, but the kids got a good laugh and we moved on. I thought it would be a good idea to provide an example of when metrology goes wrong, so I showed a slide of the NASA Mars Climate Orbiter which crashed into Mars in 1999 when a contractor failed to use the SI units for force. Of course I showed a slide of the MetrologyCareers.com website and explained what they could find and went there. Of course I thought this would be a good segue to handing out the chameleon pencils. What a hit the pencils were; maybe too big a hit so I decided to hand them out at the end of my next presentation… Next I described the Joe D. Simmons scholarship and while I had a slide of the poster I really should have requested some posters from the business office to leave behind. Note to self: Contact Linda Stone for Simmons posters to send to Mexico (better late than never)

My next slide featured a picture of Omar Cardenas Reyes next to the Simmons scholarship poster. Omar won the Simmons scholarship in 2014 and attends the Polytechnic University of Santa Rosa Jauregui located in Queretaro Mexico. Here I was in Mexico standing in front of Mexican students, stating that one of their citizens had won $3000 US to attend a Mexican University and gain his Bachelor of Science degree in Industrial Metrology Engineering. My last slide presented the Learning Objectives for our experiment. Oops, it’s time to repeat the presentation and experiment for the second class of 6th graders.

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THURSDAY, MARCH 5, 2015, 2:37 PM

Back at Chelo and Roy’s home and boy am I whooped. The second presentation went great with some refinements after the first. I never seem to tire of this experiment no matter how often I perform it, which is good since I learned today that I’m not presenting to one class of 7th graders tomorrow, I’ll be presenting to two classes at once in two sessions. Each class today had 14 to 16 students; tomorrow each class will have about 30 students. I didn’t bring enough chameleon pencils and I think I’m short on Metric Conversion Pyramids! I’m anxious to see how the 7th graders like the experiment tomorrow, the 6th graders today were really fascinated and they asked some great questions. Describing the latent heat of fusion is nowhere near as interesting as actually seeing it happen.

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FRIDAY, MARCH 6, 2015, 2:48 PM

Back at Chelo and Roy’s home and once again I’m whooped. The 7th graders were a bit more intense with a few students in each session looking at me as though they were engaging in some kind of Vulcan Mind Meld to drain as much knowledge from me as they possibly could. That really makes these outreach events worthwhile for me. At all of the outreach events I’ve attended I’ve seen the range of totally engaged to totally disengaged and I’ve learned to reach a happy medium of not ignoring the disengaged and not over indulging the fully engaged.
FRIDAY, MARCH 6, 2015, 7:26 PM
I must say, since I arrived in Mexico I’ve been treated like royalty! Maru Elizondo, the English Coordinator at the elementary school, was the first person Chelo introduced me to. Maru sat in on my first session yesterday and escorted me from the elementary school to the middle school today. In between sessions I was treated to authentic Mexican cuisine with beef and chicken tamales set up in a room with a table for six. Not everyone at the table spoke English and yet I never felt alone or left out. I’m amazed at how many school Administrators, Principles and Teachers I was introduced to and the gratitude each expressed. The elementary school gave me a Science Fair Participation Certificate and the middle school gave me a Certificate of Recognition.

SATURDAY, MARCH 7, 2015, 7:26 AM
Slept in this morning, but it’s time to get ready for a day with Roy, Chelo and family. Sightseeing, food, relaxing and most of all being with friends!

SATURDAY, MARCH 7, 2015, 9:08 PM
I think I have almost everything packed for my flight tomorrow morning. The airport is at least 30 minutes away and I have to go through customs on the way out so Roy suggests we leave at 5:30 AM to ensure I make the 8:04 AM flight back to Dallas. I’ll set my iPhone for 4:30 AM so I’m sure to be ready to leave on time.

SUNDAY, MARCH 8, 2015, 4:46 AM
What was I thinking? I’m not supposed to wake up before 6:00 AM unless I’m going fishing!

Note to self: It is better to arrive late at night than it is to leave early in the morning!!!

SUNDAY, MARCH 8, 2015, 11:07 AM
Made it through both Mexican and Texas customs and now I wait for my flight to Charlotte. Must find chocolate or something a little healthier for lunch. It’s still cold in Dallas, can’t wait to arrive in Florida for some R&R in the sun!

SUNDAY, MARCH 8, 2015, 7:45 PM
My 7:10 flight has been delayed for at least an hour, but I’m too tired to write anything of substance so I’ll wait until I get settled in at my Sister’s in Florida before I start working on an article for Metrologist. I should tell the readers they can email me at vernon54@verizon.net if they want either my PowerPoint presentation or a copy of the experiment’s lesson plan.

SUNDAY, MARCH 8, 2015, 10:23 PM
These past several days have been spectacular for me; I have a habit of wanting to back out of these outreach events as the time approaches, I guess it’s a form of stage fright, but I always go through with it and it always hypes me up for the next one. It fills me with a feeling of “oh yeah, this is what it’s all about!” Next up is a STEM Fair at the Visitation Academy in Frederick, MD on April 18th. I did the effects of temperature and linear expansion last year; I think I’ll call a Metrology Ambassador like Van or Bill Hinton for new ideas. I think I’ll sleep well tonight...

vernon54@verizon.net
When is it cost-effective to write custom calibration software? This question becomes more relevant as customer calibration needs become more specific. At National Instruments (NI), we generally add automated calibration support to our Calibration Executive (CalExec) application software for new devices based on the availability of an approved calibration procedure document and scheduling priority. However, there are times when customer needs or service agreements require unscheduled or custom calibration support for a device. In these cases, we have multiple deployment methods to consider in order to provide the required support. Some of the major factors we consider when evaluating potential deployment methods are complexity, life expectancy, and resource availability. Examining these factors early on is imperative for a fiscally responsible and serviceable outcome.

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One method to address calibration support is for the operator to manually calibrate the device according to the published calibration procedure document. This is done by manually configuring the device under test and the calibration standards through test panels. Manual calibration can be a quick
Manual calibration can be a quick and reasonable option if there are few configurations and test points.

and reasonable option if there are few configurations and test points. Having to manually record all the measurement data is a major disadvantage of this option, and NI’s adjustment APIs are typically only accessible via software calls. In most cases, manual calibration is not ideal because of the tediousness of manually configuring the instruments for each test and every test point. Manual calibration for longer procedures requires a substantial number of man-hours to complete, which is not economically feasible.

Releasing a patch in the software framework is a popular method of deployment. However, patches create considerable overhead. A patch for the CalExec framework requires us to create documentation, perform regression testing, and build an installer. When released within this framework, we must ensure that the new procedure does not break any pre-existing procedures and that the code is robust enough to maintain in the long-term. This requires extensive code review and testing contributions from additional team members to help in the validation process. A patch also requires efforts from a team member with expertise in the build process to create and test an installer to deploy the software. Versioning concerns for the software environment going forward also pose an issue with this method. All of these steps can add significant time to the creation of a simple procedure.

Despite the overhead and framework considerations, patches provide some strong advantages. The familiarity and robustness of the GUI makes running the procedure less difficult for the operators. Pre-existing instrument drivers can be leveraged with interchangeable support for multiple acceptable calibration standards. Another benefit is that long-term support for this custom procedure is more maintainable within the software framework. Developing a custom procedure within the software framework and handing off a patch to a customer makes the most sense for a longer, complicated procedure that requires multiple complex instrument standards.

NI successfully used a patch to add support for a system that shared code with pre-existing CalExec procedures; this method allowed us to release the system within the two-month time frame. The patch allowed us to combine device verification into one system-level verification process, which reduced the verification time from 150 minutes to 45 minutes. This was a very complex procedure with over 5000 reported test points in the device verification test alone. Additionally, these tests were done across eight different channels, using four different instrument standards, and required numerous connection changes. Writing a robust framework to handle the memory implications of a procedure this complex would have been a monumental task with tremendous risk. The short timeline for the release also made writing new instrument drivers to support automation of the multiple calibration standards an unreasonable option. Therefore, we planned for out of cycle installer creation and reviews requiring additional resources to help release the procedure. This patch process proved to be the most efficient way to reuse the pre-existing code and saved over 100 minutes per system.

Another possible method for expedited calibration support is to write a custom stand-alone procedure. This method requires a developer with UI design experience and calibration frameworks knowledge to ensure that the architecture will meet any future extensibility concerns. The benefit of writing a stand-alone procedure is how little overhead is required. The deployment can be done with an executable, and regression testing is no longer a concern. The stand-alone will still have to be tested for performance and fault-tolerance but this should be minimal for shorter procedures. Developing a stand-alone for a complicated calibration procedure requiring multiple instruments for multiple test cases could potentially create more development and testing challenges than benefits. Additionally, if the employees who are familiar with the code are no longer with the team, the maintainability of the code can be difficult and costly.

Our team has written custom stand-alone procedures over the past couple of years on multiple occasions to mixed success. One procedure, needed in four weeks, was written to avoid replacing approximately 50 devices at $100k replacement cost. This procedure, with over 500 reported test points in the verification, had to be written programmatically. We decided to write a stand-alone procedure instead of a patch within CalExec to avoid the additional review, testing, and installer build time. Knowing that this stand-alone procedure would be used for other key opportunities over the next year also made the stand-alone a faster deployment method for providing service with minimal overhead. This stand-alone support was adequate until CalExec supported the procedure. Deploying the procedure as a stand-alone allowed us to quickly develop and release the procedure in time to meet the customer’s needs. This stand-alone procedure required about 6 weeks of combined developer efforts, but it saved the company approximately $100k in replacement devices.

On the other hand, a different stand-alone procedure that added two new verification steps to an existing procedure in CalExec did not result in similar success. These tests, which covered previously typical specifications, were estimated to require three weeks of developer effort. Development of the procedure went as planned, but when we began testing the procedure we ran into significant issues. Investigating the root cause of these issues resulted in major delays and ultimately in the stand-alone being dropped. We lost approximately six weeks of developer effort between the calibration and device hardware teams, and we still needed to research these issues and rewrite the new steps within the CalExec framework in the following release. Although writing the stand-alone procedure did not cause the issues we faced, the short time frame and inability to leverage robust code made the debugging efforts more challenging.
Developing a stand-alone for a complicated calibration procedure requiring multiple instruments for multiple test cases could potentially create more development and testing challenges than benefits.

Overall, writing custom calibration procedures is becoming more and more common. Customers are looking to reduce downtime due to calibration while still maintaining confidence that their devices perform as expected. This means custom calibrations, tailored to the customer’s requirements, are often requested and explored. Determining when these changes or updates will save considerable time for our services team and are, therefore, worth the developer investment, are key to planning these opportunities. Applying the most efficient deployment method can save time and money when executing these tasks. As this becomes more common, developing calibration software better suited to match these flexible needs is desirable and unavoidable.

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Recently I had reason to read Hammurabi’s code in its entirety (not a task for those easily bored). As a quick background, Hammurabi was a king of ancient Babylon. He lived around 1700 B.C. in a land now known as modern day Iraq. Hammurabi is best known for his surviving set of laws, once considered the oldest promulgation of laws in human history, known as Hammurabi’s Code. I was immediately struck by the code’s numerous edicts (282 of them) and the severity of punishments for infractions (often death). Like most readers I was familiar with the popular edict of the “eye for an eye”.

But I was unaware as to the code’s broader subject matter covering topics ranging from commerce transactions and personal liabilities, to penalties and reparations. As I read through the code I became aware of several measurement units I was unacquainted with. Being the metrology geek that I am I took note of these measurement units in order to research them later. The following are some of the code’s edicts which contain measure units.

{196. If a man put out the eye of another man, his eye shall be put out.}

{56. If a man let in the water and the water overflow the plantation of his neighbor, he shall pay ten gur of corn for every ten gan of land.}

Gur: Volumetric unit of measurement equivalent to about 80 U.S. gallons (302 liters) 
Gan: Area unit of measurement. After a rather exhaustive internet search I was only able to find vague references to “a measure of area” but no specific value and assume that its definition has been lost in antiquity.
59. If any man, without the knowledge of the owner of a garden, fell a tree in a garden he shall pay half a mina in money.

Mina: Standard weight measurement, among the earliest of all known weights. One surviving form weighed about 640 grams (about 23 ounces) and in another about 978 grams (about 34 ounces). Archaeologists have also found weights of 5 minas, in the shape of a duck, and a 30-mina weight in the form of a swan. One mina is equal to 60 shekels, roughly equivalent to a pound. Sixty minas made up one talent.

111. If an inn-keeper furnish sixty ka of usakani-drink to... she shall receive fifty ka of corn at the harvest.

Ka: Volumetric unit of measurement equivalent to about 2 liters

204. If a freed man strike the body of another freed man, he shall pay ten shekels in money

Shekel: Mass unit of measurement equivalent to about 180 grains, 11 grams or 0.35 troy ounces

276. If he hire a freight-boat, he shall pay two and one-half gerahs per day.

Gerah: Mass unit of measurement equivalent to one-twentieth of a shekel

It is interesting to note that over 3700 years ago the people of Babylon realized the importance of a system of standardized measurement units. I would not be surprised if someday archeologists uncover the remnants of an antediluvian calibration laboratory; somebody had to be measuring those shekels.

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Citations:
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Online Encyclopedia Britannica: Measurement Systems, Written by: Lawrence James Chisholm
Keeping Eyes on the Prize

Metrology Job Descriptions Submittal for the 2018 Standard Occupation Classification (SOC) Listing

By Christopher L. Grachanen

Many readers may remember the united effort by NCSL International and the American Society for Quality (ASQ) Measurement Quality Division (MQD) to have the job descriptions for Calibration Technician, Calibration Engineer and Metrologist added to the 2010 SOC (I can’t believe it’s been over 10 years since this effort was first proposed in 2004). As background (from the SOC website), the SOC is:

System used by Federal statistical agencies to classify workers into occupational categories for the purpose of collecting, calculating, or disseminating data. All workers are classified into one of 840 detailed occupations according to their occupational definition. To facilitate classification, detailed occupations are combined to form 461 broad occupations, 97 minor groups, and 23 major groups. Detailed occupations in the SOC with similar job duties, and in some cases skills, education, and/or training, are grouped together.

Currently the SOC does not recognize job descriptions for Calibration Technicians, Calibration Engineers or Metrologists which means demographic information such as:

- How many people are currently in the profession,
- How many people are entering/ exiting the profession,
- What is the geographic dispersion of people in the profession,

is not being collected. Additionally there are no U.S. standardized definitions of the aforementioned job descriptions which could otherwise be used to homogenize these descriptions across civil and governmental contracts, pay grades scales, position qualifications, etc. It is also important to note that to assist young adults in making well informed career decisions, educators frequently reference U.S. Department of Labor publications in order to provide information about professions and forecasts of future job growth. An excellent primer for young adults on Metrology careers may be found at: http://www.metrologycareers.com.

In anticipation of the 2010 SOC, NCSLI and ASQ-MQD developed the job descriptions of Calibration Technician, Calibration Engineer, and Metrologist. These job descriptions may be found in NCSLI’s “Metrology Human Resources Handbook” 2010, pg. 6. The narrative in creating these job descriptions was documented in NCSLI’s Metrologist
After submission of the aforementioned job descriptions to the SOC, SOC administrators recommended combining the Metrology Job descriptions of Calibration Engineer and Metrologist into a single occupation category due to overlapping core job attributes in order to have a better chance of acceptance. These descriptions were combined and resubmitted along with an updated calibration technician job description (these changes are discussed in detail in ASQ's article published in “The Standard,” “Metrology Job Description Initiative – The U.S. Dept. of Labor’s Decision”).

**METROLOGISTS AND CALIBRATION ENGINEERS**

Apply measurement science, mathematics, physics, and engineering principles to develop and/or design and support measurement systems, processes, and procedures for calibration of inspection, measurement, and test equipment (IM&TE) based on analysis of measurement problems, accuracy and precision requirements. Use statistics to analyze calibration standards and processes. Evaluate new calibration methods and procedures. Recommend calibration standards. Monitor compliance with calibration laboratory and/or departmental quality systems. May develop software to assist in calibration laboratory and/or departmental processes. May perform laboratory and/or departmental administration and management.

**Work Duties:**
- Develop and/or design and support systems, processes, methods and procedures for calibrating IM&TE based on analysis of measurement problems, accuracy and precision requirements;
- Analyze calibration standards and processes using statistics;
- Evaluate new calibration methods and procedures;
- Research calibration requirements in order to recommend calibration standards;
- Monitor compliance with laboratory and/or departmental quality systems;
- May develop software to assist in calibration laboratory and/or departmental processes; and
- May perform laboratory and/or departmental administration and management.

**CALIBRATION TECHNICIANS**

Apply knowledge of measurement science, mathematics, physics, and electronics to calibrate inspection, measurement, and test equipment (IM&TE) to ensure measurement accuracy. Identify and utilize appropriate calibration standards and procedures. Perform corrective actions to address identified calibration problems. Adapt equipment, standards, and procedures to accomplish unique measurements. Maintain calibration standards. Perform laboratory and/or departmental housekeeping.

**Work Duties:**
- Perform calibrations on IM&TE to ensure measurement accuracy;
- Identify and utilize appropriate calibration standards and procedures;
- Perform corrective actions to address identified calibration problems;
- Adapt equipment, standards, and procedures to accomplish unique measurements;
- Maintain calibration standards and associated support equipment; and
- Perform laboratory and/or departmental housekeeping.

Despite the volunteer efforts of literally hundreds of individuals supporting the creation and submission of the aforementioned job descriptions, the SOC committee made its final decision to exclude Metrology occupations in the 2010 SOC. The following explains the committee’s reasoning published in the Federal Register, Vol. 74, No. 12, Wednesday, January 21, 2009, Notices, Pg. 3923;

In cases involving requests for occupations already covered in the existing SOC, the SOCPC often altered definitions and titles of existing SOC occupations to clarify where the workers specified in a particular comment should be classified. One example involves the many requests the SOCPC received to add one or more metrology-related occupations. The SOCPC’s research found that the number of workers performing metrology and calibration tasks as their primary activity is not substantial enough to support new detailed occupations, and that metrology occupations are dispersed across many industries.
Although there is no minimum required employment number, from a practical standpoint, occupations must be large enough to collect and publish at national, regional, State, and local levels. The current definitions of Engineers and Engineering Technicians meet those “publishability” goals. In contrast, metrology and calibration tasks may be performed by workers in several Engineering and Engineering Technician occupations, and calibrating is often a task performed in conjunction with other tasks. Therefore the definitions and titles for various engineers, engineering technicians, and production workers were modified to clarify coverage of metrology and calibration tasks.

Multiple dockets requested new detailed occupations, or modifications to existing SOC definitions, in order to improve classification of metrology-related workers. Proposed new occupations included: Calibration Engineers, Calibration Technicians, Instrument Engineers, Instrument Technicians, Metrologists, Metrologists and Calibration Engineers, Metrology Engineers, Metrology Specialists, and Quality Engineers.

The SOCPC did not accept the recommendations for new detailed occupations based on Classification Principle 1 which states that occupations are assigned to only one occupational category and Classification Principle 9 on collectability. Metrology and calibration
functions or tasks may be performed by workers in several occupations, such as Electrical Engineers, Industrial Engineers, Mechanical Engineers, Aerospace Engineering and Operations Technicians, Electrical and Electronic Engineering Technicians, Electro-Mechanical Technicians, Industrial Engineering Technicians, and Mechanical Engineering Technicians. The number of workers performing metrology and calibration tasks as their primary activity is not substantial enough to support new detailed occupations. The SOCPC reviewed and modified definitions for engineers, engineering technicians, and production workers, to clarify coverage of metrology and calibration tasks. Also, the SOCPC recommended removing “Calibrators” from the title of 51-2093 “Timing Device Assemblers and Adjusters.”

Essentially the two main hurdles to be overcome for the aforementioned job descriptions to be accepted by the SOC are:
1. Workers performing metrology and calibration tasks as their primary activity is not substantial enough to support new detailed occupations, and that metrology occupations are dispersed across many industries
2. The number of workers performing metrology and calibration tasks as their primary activity is not substantial enough to support new detailed occupations.

To this ends, Steve Stahley has accepted the challenge of championing an effort to submit Metrology job descriptions for inclusion in the 2018 SOC. Steve will be assembling a steering committee to facilitate this effort. Progress on this effort will be published in future editions of Metrologist and ASQ MQD’s The Standard.

Side Note:
In the fall of 2009 The Occupational Outlook Quarterly published an article entitled, “Metrology Career Occupations” which introduces Metrology as a career field. Some salient points discussed in the article are:

- Because metrology work is often interspersed with other job duties and occupational titles, the U.S. Bureau of Labor Statistics (BLS) does not collect employment or wage data specifically on Metrologists. Metrology, however, is critical to the success of many different industries.
- Classifying metrology jobs is difficult because of these workers’ varied skills, educational levels, and positions. There are also some occupations in which metrology skills are only part of the job.

The Occupational Outlook Quarterly is published by the Bureau of Labor Statistics, a division within the U.S. Dept. of Labor.

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The Atlanta section held its spring meeting on April 2, in Alpharetta, Georgia hosted by Trescal, Inc.

Our goal was to bring Atlanta’s metrology leaders together to share ideas and best practices and to expose attendees to experts in fields relative to test and measurements.

Our first speaker was John Busald of Fluke Calibration. John presented a high level presentation on spectrum analyzer calibration, which generated a lot of interest by the attendees involved in this type of calibrations. John did an excellent job and is always willing to present at our meetings.

Next up was Greg Strickland from Oak Ridge National Laboratories. Greg presented on laser thermometers measurements and calibration. Greg’s presentation and speaking style, coupled with the obvious expertise of the material was very impressive and very relevant to the majority of the attendees. It was very well received.

Third up was Joe Keck from Oak Ridge National Laboratories. Joe presented a high level presentation on wind tunnel operation.

Trescal were terrific hosts. Their new facility was fantastic, easy to get to, and had plenty of room. I would like to thank the attendees for coming out and supporting the meeting and to the speakers for their great presentations.

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The Central Texas section 1321 winter meeting was held on February 19, 2015 at the Marriott Courtyard in Richardson, Texas. The meeting was sponsored by Keysight technologies and Trescal Inc.

Jorge Martins, National Instruments and NCSLI section coordinator welcomed attendees and presented the meeting announcements. Next up Paul Packebush, NCSLI Conference VP discussed the NCSLI board highlights and future initiatives.

Following the introductions we had four outstanding speakers with talks that covered different metrology disciplines. Our first presentation started with Dimaries Nieves, National Instruments – Metrology Group on “Calibration Requirements and Good Practices for Modular Instruments.” Dimaries went through the calibration requirements and considerations that may impact the quality and confidence of the end results for a modular instrument calibration process.

Next Eric Seller, The Modal Shop, Application Specialist presented “Accelerometer Construction, Theory of Operation, Calibration and Uncertainties.” Eric discussed how shock and vibration phenomena are present around us in everything that moves and that accurate accelerometer calibration is a way to provide physical meaning to this electrical output and it is a prerequisite for quality motion measurements. The presentation discussed the construction and theory of operation for many of the common accelerometers in use today as well as how these sensors should be calibrated. The presentation covered many of the common contributors to uncertainty and modern methods for eliminating them.

Bob Stern with Keysight Technologies presented on “Leveraging automation to assure the quality of calibration results and why it matters.” Bob discussed calibration labs that strive to meet ISO/IEC 17025 either as an accredited laboratory or via self-compliance, have an established plan to address “Assuring the quality of test and calibration results” (Paragraph 5.9). Keysight recently has been able to apply near real-time statistical analysis for quality process control in their calibration labs resulting in significant improvements when combined with periodic proficiency testing. Bob covered how the process works and a number of real-life examples since they turned on the new approach to quality monitoring.

Bob also reviewed the ISO/IEC 17025 revision. He presented slides on the NCASI position so far and led an open discussion about which paragraphs in ISO/IEC 17025 should be prioritized for revision and asked the question “If you were King, which paragraphs of ISO 17025 would you revise and why?”

Lastly, Logan Kunitz, National Instruments presented “Avoiding Measurement Errors from Manipulating Data in Software.” The objective was to explore the various ways that software can introduce errors and uncertainty into measurements, with the purpose of raising awareness for developers about the choices that can be made when manipulating measurement data in software. His paper investigated several sources of software error that apply across different programming environments, including excel, text-based, and graphical programming environments.

There was good interaction between the attendees and presenters as well as animated discussions, in particular during the lunch break. After the meeting, a tour of the Keysight Service Laboratory in Richardson was offered and many attendees took the opportunity to visit the new facility. Mensor, TestEquity and Fluke Calibration were in the venue, presenting their products.

It was suggested by a number of attendees to have the fall meeting in the Oklahoma area.

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Accreditation: Supporting the Delivery of Health and Social Care
Accreditation: Supporting the Delivery of Health and Social Care

June 9, 2015 marks World Accreditation Day as a global initiative, jointly established by the International Accreditation Forum (IAF) and the International Laboratory Accreditation Cooperation (ILAC), to raise awareness of the importance of accreditation. This year’s theme focuses on how accreditation can support the delivery of health and social care.

The successful provision of health and social care is one of the greatest challenges today. Whether caused by expanding global population growth or increased life expectancy, the need to provide reassuring, consistent and cost-effective health and social care will only grow in its magnitude and complexity.

The health and social care sector is not unique in its goal of striving to deliver a balance of quality, economic, social and environmental needs, ultimately aiming for excellence. Health and social care excellence is driven by the need to provide confidence in the delivery of a competent service to patients, families, regulators and commissioners.

Accreditation within the health and social care sector supports this assurance. It provides an essential tool for healthcare providers to demonstrate that they have undergone a rigorous process to ensure that their patients consistently receive high quality services delivered by competent staff working in safe environments.

What are the issues?

- Is the provision of health and social care safe, for patients and staff?
- Just how accurate and reliable are the outcomes or test results?
- Are there measures in place to prevent misdiagnosis?
- What proof is there that confidential information is handled appropriately and remains confidential?
- Are any complaints taken seriously and acted upon?
- Is high quality, cost effective care achievable?
- What reassurance is there that the correct patient care pathway is being followed?
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