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Metrology and Quality

MSC 2010 Technical Program

Day	Time	Track A	Track B	Track C	Track F	Track G	Track H
Thursday 25 March	10:45 AM to 12:15 PM	Legal Metrology	Pressure and Vacuum	Metrology Education	NCSLi Web 2.0	Z540.3	RF Measurements
	2:00 PM to 3:30 PM	Humidity	Temperature	Accreditation in University Testing Laboratories	Metrology R&D	Applied Analytical Metrology	Electrical Measurements
	4:00 PM to 5:30 PM	Humidity Forum	Applied Temperature	Mobile Calibration Facilities	Metrology R&D II	Measurements in the Marketplace	More Electrical
Friday 26 March	8:30 AM to 10:00 AM	Analytical Metrology	Flow	Chemical Detection	CMM Theory	Future Workforce	Lab Processes
	10:45 AM to 12:15 PM	Uncertainty	Flow Again	Biological Measurements	CMM Applications	Healthcare Metrology	Quality
	2:00 PM to 3:30 PM	Statistical Processes Panel	Flow III	ASQ - Certified Calibration Technician Exam - Six Years Later	Proficiency Testing	Bio/Pharm/Medical Metrology Committee	Metrology Over the Horizon

Thursday, Mar 25

10:45 AM - 12:15 PM

A1: Legal Metrology
Ballroom A
Emil Hazarian (Chair), *U. S. Navy*

10:45 AM

County of Los Angeles Metrology Laboratory
Donald G. Franks, *County of Los Angeles Metrology Laboratory, USA*

The role of the Los Angeles County (LAC) Metrology Laboratory is similar to that of any of the state metrology laboratories. Indeed, LAC participates in the Western Regional Assurance Program (WRAP) guided by the National Institute for Standards and Technology (NIST). Interactions among WRAP members include annual meetings, inter-laboratory comparisons of measurements made on circulated masses and vessels; and formal training

sessions at the NIST campus in Maryland. The Laboratory maintains mass and volume standards, with traceable calibration reports from various laboratories; and mass comparators from heavy capacity to micro-balances. Therefore the Laboratory can provide traceable calibration reports over a broad scope to LAC Weights and Measures Inspectors, as well as external commercial customers. Measurements and data analysis within the Laboratory are part of the ongoing process of quality assessment. Planning for the future with an opportunistic outlook furthers this process towards the goal of improving service. Donald Franks Metrology Technician I Metrology Laboratory County of Los Angeles Department of Agricultural Commissioner/Weights and Measures

11:15 AM

The Los Angeles County Weights and Measures Bureau: Who We are and What We Do
Jeff Humphreys*, Los Angeles County Department of Agricultural Commissioner - Weights and Measures, USA*

The Los Angeles County Department of Weights and Measures was formed in 1915. In 1984, the Department was merged with another to become the Department of Agricultural Commissioner/Weights and Measures. The primary goal of the Weights and Measures Bureau is to ensure that businesses that charge their customers for commodities using weighing or measuring devices compete on an equal level. Using mass and volume field standards traceable to the Los Angeles County Metrology Laboratory, and ultimately to NIST, Bureau staff inspect and test almost 30,000 commercial weighing devices and over 200,000 commercial measuring devices. In addition to ensuring the accuracy of weighing and measuring transactions, the Bureau checks packaged products to determine whether the net content statements reflect the actual net contents of the packages. During 2002, at the request of the Board of Supervisors, the Department instituted a program to test the price accuracy of those retail stores using electronic price look-up systems (scanners, with the intent of ensuring shoppers are not charged more than the store's lowest posted or advertised price.

B1: Pressure & Vacuum
Ballroom B
Mike Holleron (Chair), *NPSL, USA*

10:45 AM

Developing Typical Pressure Measurement Uncertainty Specifications for Pressure Transfer Standard Products from Low Absolute to 280 MPa
Michael Blair, *Fluke, USA*

Calculating uncertainties in pressure for a transfer standard can be considered relatively straight forward. Doing the same for a population of pressure transfer standards with state of the art precision presents an abundance of challenges previously not experienced by this author. This paper examines the efforts to develop these specifications for Q-RPTs (resonating quartz reference pressure transducer) that are installed in a number of types of pressure calibration devices. The uncertainties are identified, broken down, analyzed, and built back up to create a system of specifications that cover a wide range of applications and also to meet a pre-determined reliability. Finally the specifications are used to define a calibration support system with hope of meeting requirements set forth by ANSI/NCSLI Z540-3.

11:15 AM

Long Term Stability of High Accuracy Pressure Sensors
Timothy Francis, *GE Sensing, USA*

The output of a pressure sensor will tend to drift over time. This drift is often referred to as the long-term stability and can be a large contributor to the overall uncertainty of the measurement. The stability is also one of the biggest factors when determining the calibration interval of the instrument. For these reasons, proper determination of the long-term stability specification is integral for good metrology practice. This paper reviews and analyzes multiple years of calibration data for a large population of instruments. The calibrations in question are of high-end, digital transfer standards of varying sensor technologies with full-scale ranges from 7 kPa (1 psi) to 275 MPa (40 000 psi). This full, in-depth analysis provides users with the ability to more properly determine the long-term stability specifications for their own equipment.

11:45 AM

Transportable NIST Traceable Vacuum Standard for Secondary Cal Labs based on MEMS Technology
Jay Hendricks, Timothy Gooding and Douglas Olson*, NIST, USA*

In the mid 1990's the development and use of micro electro mechanical systems (MEMS) enabled pressure sensor technology to make significant advances in both precision and accuracy. Resonant Silicon Gauges (RSGs) are MEMS sensors that are manufactured by micromachining silicon to produce silicon diaphragms nominally a few millimeters square by a fraction of a millimeter thick. Over the past decade, NIST has calibrated these gauges and has found them to be very stable, rugged, and ideally suited as core technology for a high-stability precision pressure standard that can be calibrated against the NIST primary pressure standards [1]. The RSGs use two single-crystal silicon resonators encapsulated in a vacuum microcavity. Changes in pressure on the diaphragm are determined by measuring strain-induced changes in the two resonant frequencies [2]. Since each resonant element is encapsulated in a vacuum, the most critical part of the sensor is never in direct contact with the calibration gas which makes the pressure sensor gas species independent. The RSG sensors are commercially available and NIST has performance data dating back over 9 years on one sensor that has been calibrated 18 times, and has a demonstrated average calibration shift of only 0.008% [3]. NIST has developed and built a Resonant Silicon Gauge Transfer Standard Package (RSG-TSP) with a range of 100 Pa to 130 kPa. NIST scientists recently completed a long-term stability study of this transfer standard, demonstrating that the uncertainty due to stability is only a few ppm at 130 kPa, increasing to 0.01 % at 100 Pa (k=1). This standard is expected to find applications in national "round robin" and international key comparisons of pressure standards, and is ideally suited for use as a "high end" precision pressure standard for secondary calibration laboratories. [1] Hendricks, J.H. et.al. Metrologia 44 (2007) 171-176. [2] Harada, K. et.al. 1999 Sensors and Actuators 73 261-266. [3] NIST internal calibration report NC212.

C1: Metrology Education
Ballroom C
Gloria Neely (Chair), NSWC, Corona, USA

10:45 AM

Statistics and Metrology: Rich Interplay of Ideas
Alan E Scrivner, *NSWC, Corona Division, USA*

Modern metrology and the development of measurement standards was given its birth out of the French Revolution with the creation of the metric system and the beginning, of mass production using interchangeable parts. At about the same time, Carl Friedrich Gauss, was unwittingly giving birth to modern statistics by investigating how to obtain estimates of the orbital parameters of heavenly bodies on the basis of a set of observations that included errors. metrology, the development of measurement standards, and statistics have been inseparable and ideas from one field often influenced the other. In this paper we explore the rich interplay of ideas.

11:15 AM

Full Time Student and Employee
Brittney Woode, *Department of Defense Metrology Engineering Support Branch, USA*

This paper will be about the fun and stress a full time employee and student goes through. I will explain that I am an electrical engineering major working as a full time calibration technician. I am 21 years old and have a year left of school. This means I am in the higher level courses. I own a house and try to have a life between work and school. Currently I have a 3.1 GPA. I will explain how work has helped me with the hands on and physical understanding of what I learn in school.

11:45 AM

My Journey From Physics 101 to the Navy Calibration Lab at Patuxent River and The Sustainment of a Talented Workforce
Charlie Stroup, *NAVAIR, USA*

My higher education got off to a rocky start at a small liberal arts college where my performance was less than impressive. However, through encouragement, perseverance, and learning from my mistakes, I turned my early struggles into a very successful education culminating in a masters in mechanical engineering from the University of North Carolina at Charlotte and starting my career with NAVAIR – Navy Calibration Lab at Patuxent River. Along that road, I learned many lessons on becoming a successful engineer by observing those around me and through overcoming adversity. In this paper I present what I have learned along with my ideas on the sustainment of a talented pool of engineers in the metrology and engineering community.

F1: NCSL Web 2.0
Ballroom F
Charles A Motzko (Chair), *Troy University & C. A. Motzko and Associates, USA*

10:45 AM

WEB 2.0 and Metrology Panel
Charles A Motzko, *Troy University, USA*
Georgia L Harris, *NIST, USA*
William Hinton, *NextEra Energy Resources, USA*
Craig Gulka, *NCSLI, USA*
Elizabeth Gentry, *National Institute of Standards and Technology, USA*
Derek Porter, *Boeing, USA*

On Thursday July 30, 2009, Panel Session 10A titled Stalking your NCSLI Buddies (Web 2.0) was hosted by Derek Porter (Boeing) at the NCSL International Workshop and Symposium in San Antonio, TX. According to Derek Porter, "You can find your NCSLI buddies in Web 2.0. They share media on the photography websites (try NCSLI in the Picasa search). They share micro blogs in the social networking sites (try NCSLI in Facebook search). They are well beyond the web 1.0 pictures and bios on the ncsli.org site. NCSLI supports Web 2.0 and offers the international metrology community the same tools as the mammoth providers on the web. We're looking for you and know you can help us improve our metrology community." An article, summarizing all of the points cover, in the NCSLI METROLOGIST magazine, followed this Web 2.0 Panel. Based on this theme, the MSC 2010 Web 2.0 panel will discussed a number of ways and means that can be, or are already, deployed to sustain a viable on-line metrology community, in all its forms. This panel will present a brief (4 min) video and a small PowerPoint presentation to set the framework to the discussion and a "Question and Answer" session.

G1: Z540.3
Ballroom G
Steve Doty (Chair), *US Navy, USA*

10:45 AM

A Study Of And Recommendations For Applying the False Acceptance Decision Risk Specification of Z540.3
Jack Somppi and David Deaver, *Fluke Corporation, USA*

Recommendations on how to apply the requirements of the minimizing the risk of the probability of a false accept decision, to a maximum of 2%. The Z540.3 standard states: False Acceptance Decision Risk Specific application (5.3): "Where calibration provides for verification that measurement quantities are within specified tolerances, the probability that incorrect acceptance decisions (false accept) will result from calibration tests shall not exceed 2% and shall be documented." This paper reviews application guidelines from the Z540.3 Handbook for this requirement and makes the recommends using the root difference of squares implementation of Method 6 for most calibration laboratories.

11:15 AM

Implementing Z540.3: Lessons from NASA
Scott Mimbs, *NASA, USA*

ANSI/NCSL Z540.3 is being added to the newest revision of NASA's Metrology and Calibration policy. Prior to the NASA-wide adoption, NASA's Kennedy Space Center (KSC) placed Z540.3 on it Center-wide institution contract that went into effect in October 2008. KSC's experience implementing Z540.3 is the focus of this paper, with an emphasis on the technical lessons-learned. The discussion topics center on implementing Z540.3's new calibration quality metrics into a large legacy system that was operating to ANSI/NCSL Z540.1. These topics include procedures, measurement uncertainty, reliability data, and managing the data required for compliance to the 2% false accept risk.

11:45 AM

Z540.3's Measurement Decision Risk and EOPR
Scott Mimbs, *NASA, USA*

The in-tolerance reliability, called end of period reliability (EOPR) measures the ability of an instrument to hold its accuracy between calibrations. EOPR can be an asset in the implementation of ANSI/NCSL Z540.3's measurement decision risk (MDR) requirement. This paper discusses the inter-relationship of EOPR, measurement uncertainty, and false accept risk. The focus will be in Z540.3's implementation in legacy systems, using available EOPR data. Using concepts introduced NCSL International's Handbook for the Application of ANSI/NCSL Z540.3-2006, topics will cover using EOPR to estimate test point uncertainty, "true" versus reported EOPR, and how reliability data can be used to estimate decision risk.

H1: RF Measurements
Ballroom H
Phillip Banks (Chair), US Navy*, USA*

10:45 AM

Accurate Noise Figure/ENR Measurement
Iraj Vasaeli, *Northrop Grumman, USA*

Using state of art test equipment and few off shelf devices you can build a precision Noise Figure system to measure or calibrate Noise sources and Amplifier from 10 MHz to 110 GHz. With today's complex applications in satellite and communication businesses there is a need for more accurate Excessive Noise Ratio "ENR" measurement. Manufacturers are at the edge of technology today and trying to create better communication system with lower Noise Figure. One dB reduction of ENR in a receiver system will save 40% of total cost to transmit a communication signals. To meet these challenges we as Metrologist must step up our calibration process for faster result and lower measurement uncertainty. In this article we are going to talk about improving calibrate and measurement uncertainty.

11:15 AM

A Comparison of Two Wideband Coaxial Power Measurement Systems
Li Pi Su, *US Army*
Dexter Shelton and Garrett Barksdale, *US Army Primary Standards Laboratory*

The US Army Primary Standards Laboratory (APSL) is committed to providing services to its customers which are accurate, traceable to the National Institute of Standards and Technology (NIST), delivered on-time, and continuously improving. The APSL currently has four Direct Comparison Measurement Systems (DCMSs) configured: one is set up for waveguide power measurements; one is set up for 2.4mm coaxial power measurements using the 8474E-K01 2.4mm thin film mounts, and the other two are set up for Type N coaxial power measurements from 100 KHz to 18 GHz using CN mount standards and NIST calibrated Tegam M1100 Series thermistor mounts. There are 6 CN mount standards in the APSL. This study is to determine whether the two Type N DCMSs and the 6 CN mount standards (range 0.01 to 18 GHz) provide consistently accurate measurements for our customers. This report will provide the results of the study. One of the main results will show that the measurement differences between two DCMSs and 6 CN mount standards are much less than 0.25%. The other result will show that for the thermistor mount standards only at 0.01 GHz the (measurement difference / average measurement) % is greater than 0.25%.

11:45 AM

Test Procedure and Signal Source Performance Considerations for Spectrum Analyzer Harmonics Calibration
Paul Roberts, *Fluke Precision Measurement Ltd, United Kingdom*

Harmonic performance is an important specification for spectrum analyzers as users need to be confident the analyzer itself is not significantly contributing to any measured harmonic content during use. Spectrum analyser harmonic performance is mainly determined by the performance of its first mixer, and a harmonics test is considered an essential requirement for an adequate calibration. The relevant harmonic specifications can be quoted as harmonic suppression (in dBc) for a given mixer level or as a mixer level independent intercept point (in dBm). In some cases both are specified. Recommended harmonics calibration procedures also vary. Some measure harmonic suppression under specific conditions and quote the suppression result directly, others determine the intercept point. These differing approaches can place different requirements on the signal source used for performing the harmonics calibration. This paper explores the relationship between spectrum analyzer harmonic specifications, the underlying mixer performance characteristics and the impact of the test method on requirements for signal sources used for harmonic calibration.

2:00 PM - 3:30 PM

A2: Humidity
Ballroom A
Toni Reilley (Chair),*NAVAIR, USA*

2:00 PM

The Challenges Of Maintaining And Improving The Uncertainty Of An Industrial Humidity Calibration Laboratory
Jack Herring, *Michell Instruments Inc., USA*
Andrew Stokes, *Michell Instruments Limited, United Kingdom*

The paper describes the issues associated with maintaining a busy industrial humidity calibration laboratory and the challenges faced in trying to maintain the laboratory measurement uncertainty whilst achieving a throughput of thousands of sensors per year. The humidity calibration facility of Michell instruments is essentially split into two parts – a UKAS (EA) accredited laboratory for high level measurements with direct traceability and audit path to NPL and NIST standards, and a commercial laboratory providing lower level tertiary calibration of tens of thousands of dewpoint sensors per annum. The UKAS section focuses on excellence rather than on volume – hence the processes and procedures are largely manual and quite time-consuming, whilst the commercial section is there to handle large volumes of sensors automatically and with the minimum of human intervention. The two therefore require very different approaches in terms of equipment, procedures and analysis and the uncertainty levels achieved reflect the type of operating model used in each case. Humidity calibration systems used by secondary laboratories have tended to be constructed either as clones of National Standards, using a two-pressure or two-temperature generation method, or as simple divided flow systems utilising calibrated vertical tube flow meters. The former are very expensive to produce and have certain limitations in terms of usability. The latter are cheaper to produce, but also suffer from inflexibility and difficulty in automation. Furthermore, these systems tend to offer varying flow rates dependent on the generated humidity level. The humidity calibration system described in this paper

provides accurate and highly repeatable humidity generation using a combination of liquid and gas mass flow controllers. It allows automated use through the integration of a precision chilled mirror dew-point hygrometer that provides both the control feedback to the generator and traceability to National Humidity Standards. The paper describes the two processes, provides a practical consideration of the component uncertainties and explores ways in which these uncertainties can be refined and minimised through improved procedures, better equipment and careful operation. Also provided are detailed calculations of the liquid and gas mass flow ratios used to derive appropriate humidity levels in the measurement chamber. A novel technique to ensure sensitivity and stability of the generated humidity is described, along with the techniques employed to ensure homogeneity of the humidified air. The paper also describes the physical design and construction challenges that were overcome in producing a fully integrated system. An uncertainty budget for the whole system is provided, indicating the key contributory factors and suggesting ways in which the measurement uncertainty can be minimised.

2:30 PM

Humidity Measurement of Compressed Nitrogen
Peter Huang, *National Institute of Standards and Technology, USA*

Compressed hydrogen is one of the most important utilities in gas industry. For the specification of nitrogen quality and for the design of humidification equipment, knowledge of the equilibrium water content of nitrogen as a function of temperature and pressure is desirable. Many applications in gas industry require reliable measurements and control of water content in nitrogen as a carrier gas. For instance, an effective photo-resist coating system used widely in semiconductor industry requires optimal water vapor determined by the thermodynamic properties of N2-H2O mixture flowing onto the system. For quantitative accuracy, especially at high pressures used in compressed gas industry, it is necessary to consider the deviation of the equilibrium moisture content from that which would be given by an ideal calculation based only on the vapor pressure of water. This non-ideality can typically be represented at the level of the second virial Bnw(T) coefficient, representing the first-order correction to the ideal-gas law, for the interaction between water and nitrogen molecules. This paper will describe the approach to derive highly accurate potentials for pairs of relatively small molecules, such as hydrogen and water, to compute Bnw(T) from first principles, comparing the calculated values with the experimental data. These results are then used to solve the equation of state of nitrogen-water vapor mixture for the mole fraction of water and water vapor concentration in grams of water vapor per kilogram of dry nitrogen at a given pressure up to 100 atmospheric pressures and a saturation temperature in the range of –100 °C to 20 °C. A simple presentation in chart form is usually adequate for most applications and such a chart has been prepared based on the information on the water vapor content of a hydrogen-water mixture.

B2: Temperature
Ballroom B
Gregory Strouse (Chair), *NIST, USA*

2:00 PM

Uncertainty Budgets for IR Temperature Measurement – An Overview
Frank Liebmann, *Fluke Corporation, USA*

In the field of infrared (IR) temperature measurement, accuracy of

temperature measurements has not been as good as it is in contact temperature measurement. To determine the accuracy of measurements, it is necessary to calibrate the measuring instrument. Just as important is creating an uncertainty budget for that instrument's calibration. The calibration gives the instrument an agreement to an established standard. The uncertainty budget tells the user how close to that agreement the user can expect his instrument to be on a repeated basis. This paper discusses the elements needed for an IR thermometry uncertainty budget. It introduces a measurement equation and discusses how to apply that equation to measurements made with IR thermometers. It discusses how to a structure an IR thermometer uncertainty budget. The structure discussed follows current standards relating to IR and radiation thermometry.

2:30 PM

Thermal Analysis of Refrigeration Systems Used for Vaccine Storage
Gregory Strouse, *NIST, USA*

Each year, billions of dollars of vaccines are stored in refrigerators at the facilities of a variety of medical providers. Many vaccines must be maintained in the range 2 °C to 8 °C to retain product potency. We have tested the performance of two types of household refrigerators to determine if these refrigerators are suitable to this task, and to identify proper storage and temperature monitoring methods. Nineteen calibrated Type T thermocouples, distributed through the refrigerator interior, served as reference thermometers. Attachment of thermocouples directly to vaccine vials gave accurate measurements of the vaccine temperature, which often differed from the air or interior wall temperatures during door openings or defrost cycles. A household, full-size freezerless refrigerator [capacity = 0.473 m3 (16.7 cu. ft.)] proved fully adequate at maintaining vial temperatures within the desired 2 °C to 8 °C range, independent of how the refrigerator was loaded. Tests of intermittent and continuous door opening and of simulated power outages demonstrated the value of adding water bottles to the door as a thermal ballast. The performance of compact, dormitory-style refrigerators suffered from drift of the refrigerator set point, sensitivity to load density, and high temperature non-uniformity. These problems make the dormitory-style refrigerator [capacity = 0.077 m3 (2.72 cu. ft.)] unsuitable for vaccine storage. We tested four electronic data loggers as a means of continuously logging refrigerator temperatures. Properly located, data loggers accurately monitored vial temperatures for extended periods.

3:00 PM

Aligning a Fixed-Point Furnace: A Process to Remove the Guesswork
Thomas Harper, *Fluke Corporation, USA*

In using fixed-point cells in a realization furnace, it is very important to properly align the vertical gradients to protect the cell from breakage and to allow the cell to perform in the way that it was intended. This process can be very confusing and time consuming without a proper approach. This paper will discuss two tools to assist the user in the alignment of a Fluke 9114 three-zone furnace. First, a height gage to ensure the precise placement of an SPRT in the fixed-point cell. Second, an algorithm that has been developed that will allow the user to systematically determine a range of settings that will optimize the performance of the furnace. Utilization of these tools will eliminate the confusion and reduce the time requirement to properly align the furnace.

C2: Accreditation in University Testing Laboratories
Ballroom C
Hershal Brewer (Chair), *International Accreditation Service, USA*

2:00 PM

Panel discussion: Accreditation and Measurements in University Test Labs
Hershal Brewer, *International Accreditation Service, USA*

A panel discussion regarding the benefits and importance of proper measurements and of accreditation in the University test laboratories, and the ultimate effect and influence on the public, who are the ultimate end users of the research and advances generated by these laboratories. The panel will represent accredited University test laboratories in fields that impact scientific research and public safety.

F2: Metrology R&D
Ballroom F
Robert W. Nickey (Chair), *Naval Surface Warfare Center Corona, USA*

2:00 PM

Metrology R&D
Robert W. Nickey, *Naval Surface Warfare Center Corona, USA*
Marie G. Juliano, *US Navy, USA*

Research and development in metrology is vital to keeping abreast of global measurement technology advancements, which affect parameters necessary for verification of product performance. Two sessions are devoted to these metrology R&D pursuits. Metrology R&D I introduces the two sessions. The introduction will be followed by a Program Manager's overview of the U.S. Navy Metrology R&D Program. The mission of the U.S. Navy Metrology R&D program is to develop unique calibration solutions for our Warfighters through innovative research and development for emerging requirements. This ensures accurate, precise, reliable, and cost effective metrology support for weapons and systems. The U.S. Navy's Metrology R&D program is fully integrated with the larger DoD Metrology R&D Program, directed by the Joint Logistics Commanders. One purpose of the DoD program is to avoid possible duplication of R&D projects by military services in their development of new calibration standards and capabilities that meet measurement and accuracy requirements demanded by the introduction of new or improved system and equipment technologies. The DoD coordinated program also allows timely sharing of the benefits of R&D projects across military services. The overview is followed by presentations from R&D project team leaders describing two current R&D projects.

2:30 PM

Fiber Optic Calibration Requirements and Standards in the Department of Defense
Lance Doddridge, *NSWC Corona, USA*

Fiber optic technology continues to increase in applications in weapons systems as well as communication systems within the Department of Defense. Fiber optic test instruments increasingly are being used to maintain and troubleshoot fiber optic installations. The Navy Metrology Research and Development has developed fiber optic measurement standards to support the performance and accuracy of the instruments that maintain the weapons systems and communications systems that depend on fiber optic

technology. This paper presents some of the work accomplished by the Navy Metrology R&D program to support fiber optic metrology.

3:00 PM

Reflective Attenuators for High Energy Laser Measurements
John Lehman, *NIST, USA*

A high-energy laser attenuator in the range of 250 mJ (20 nsec pulse width, 10 Hz repetition rate, 1064 nm, 1574 nm wavelengths) is described. The optical elements that constitute the attenuator are mirrors with relatively low reflectance, oriented at 45° angle of incidence. By combining three pairs of mirrors, the incoming radiation is collinear and has the same polarization orientation as the exit. We present damage testing and polarization-dependent reflectance measurements for 1064 nm and 1574 nm wavelength laser light at 45° angle of incidence for germanium, tungsten, molybdenum, silicon carbide and copper mirrors. The combination of tungsten and silicon carbide provides a single attenuator having approximately 300x attenuation at 1064 nm and 100x attenuation at 1574 nm. We also present 600x and 1000x attenuator results.

G2: Applied Analytical Metrology
Ballroom G
Marcio Chinn (Chair), *NPSL, USA*

2:00 PM

A Quantitative Comparison of Calibration Interval Adjustment Methods
Mark Kuster, *Pantex Metrology, USA*
Howard Castrup, *Integrated Sciences Group, USA*
Gregory Cenker, *Southern California Edison, USA*

NCSLI Recommended Practice RP-1, “Establishment and Adjustment of Calibration Intervals” describes three algorithmic (A1, A2 & A3) and three statistical (S1, S2 & S3) calibration interval adjustment methods. The paper, “Calibration Interval Adjustment: The Effectiveness of Algorithmic Methods,” presented at the NCSLI 2009 Workshop & Symposium, evaluated the performance of Methods A1, A2, and A3 via simulation against a simple metric, assuming an exponential reliability model and an optimal reliability target. The metric represented the excess cost a test and measurement program bears due to suboptimal calibration interval analysis. The results showed that methods A1 and A2, though easy to implement, incur a high cost penalty for long term use. The results for Method A3 were more promising, especially when used with groups of similar instruments. This paper presents refinements to the simulation methodology, proposes enhancements to Method A3, and gives more detailed performance data regarding the optimal parameter values for each method.

2:30 PM

Data Consistency Testing for Calibration Intervals
Steven Dwyer, *NSWC Corona, USA*

It is often possible to improve an estimate for a calibration interval by combining calibration results data from different model numbers, date ranges, or other groupings. However, it is only valid to combine data of homogeneous data sets. In these instances, the data sets need to be evaluated for homogeneity or "consistency." This paper examines the revised section in RP-1 on Data Consistency Testing and looks forward to

other approaches for grouping calibration results data.

3:00 PM

Mean Value Control
Ted Lin, Lin Engineering, USA

In manufacturing, the mean value is adjustable and controllable within the machine's capability. Allowing it to shift the mean value by 1.5 sigma from the spec center ruins production yield. For instance, a manufacturer has the process capability Pp = 1. The defects are 2,700 PPM if the mean value is on the spec center. To allow a shift of the mean value by 1.5 sigma from spec center, the defects will be 66,803 PPM which is 25 times worse than 2,700 PPM. To control the mean value right on the spec center is impossible, but shifting 1.5 sigma is ridiculous for manufacturing. Based on the empirical data, we found that shifting within 0.5 sigma is reasonable and in?achievable. This is the concept of Lin's mean value control system. 4.5 distribution in statistic in terms?4.5 ?Lin's 4.5 sigma system is the same as of the process capability, except that it is allowed to shift the mean value by . The actual mean value can never really be located at the true center? 0.5 ? ? 0.5 ?point of the tolerance zone consistently, but it is controllable within in?in manufacturing. We called this Lin's process sigma. Therefore, the 4.5 the new system represents –4 ? / +5 ?, or –5 ? / +4 ? in statistical ?" sign. The defects in 4.5 ?distribution and is never specified with the " = 6.8? 4.5 ?(Lin's Process Sigma) = 32 PPM while the defects in statistics PPM.

H2: Electrical Measurements
Ballroom H
Jessica Liss (Chair), *Navy Primary Standards Laboratory, USA*

2:00 PM

Electrical AC Impedance Technique is a Viable Tool for Many Nondestructive Tests (NDT)
Mohammad Amin, Pradip Dey and Bhaskar Sinha, *National University, USA*

Characterization of the nature of engineering materials is of primary importance to material scientists and engineers. Once the nature of a material is understood, models can be developed that allow the relationships that exist between composition and processing, and the properties and performance of materials to be defined. Impedance spectroscopy and equivalent electrical circuit modeling are valuable tools in this endeavor. This study is a review of different applications of AC Impedance Technique in various fields. This paper also emphasizes the importance and the potential of AC Impedance Spectroscopy for designing different types of NDT probes to obtain information about test objects without impairing their characteristics and intended usages. This impedance technique can be used as a viable tool for many nondestructive testing methods including, but not limited to: solderability, printability, dimension tolerance, freshness of fruits and vegetable, fat measurement of human body, cellular membrane structure, tooth cavity, measurement of horning in motor oil, heterogeneous materials characterizations, etc. Finally, a conclusion will be made based on some supporting data which were published earlier.

2:30 PM

Electronic Verification of Vector Network Analyzers
Ron Ginley, *NIST - Boulder, USA*

The National Institute of Standards and Technology (NIST) has recently introduced a new method for the verification of Vector Network Analyzers (VNAs). The technique is based on the new electronic calibration units that are available from several manufacturers. Using data obtained from different states of the electronic calibration unit the user can compare their measurements against those of NIST with NIST's uncertainty identified. Additionally, the users can compare the calibration based on their data against NIST's calibration based on the same electronic calibration unit. The resultant is a single figure-of-merit that incorporates the entire measurement process. In this paper we will cover a detailed description of the new technique, results from trial runs that have been conducted and a brief discussion of repeatability studies for the electronic calibration units.

3:00 PM

Establishment of Capacitive Voltage Divider Method for the Calibration of Voltage Transformers
Sita Ram Gupta, *National Physical Laboratory, New Delhi,India, India*

The objective is to render calibration service for the traceable measurements of the voltage ratio and phase angle between the secondary and primary voltages of voltage transformers of any voltage ratio from 100V/100V to 100kV/100V at 50 Hz. This facility has been upgraded and established only recently after seeing the increasing demands of medium scale industries and utilities of power sector in India. The method employed makes use of CVD along with an EVD. This service for voltage transformers supports & provides a metrological back up for the bulk power energy metering upto 165kV/?3 / 110V/?3. This ensures the uniformity of measurements which ultimately increases the confidence in the correct assessment of the quality & quantity of electric power produced, transmitted, distributed and consumed. At National Physical Laboratory of India, a current comparator is used to compare the Voltage Transformers used for revenue metering purposes against a capacitive voltage divider of accurately known uncertainties. For most practical purposes this role has been adequately met earlier by reference standard precision grade inductive voltage transformers and more recently by capacitive voltage divider. The statistical analysis of the calibration data assigns the uncertainties to the voltage transformers under calibration. For routine calibrations uncertainties of ± 60ppm for ratio and ± 70 ? radians for phase angle are reported in the calibration certificates.

4:00 PM - 5:30 PM

A3: Humidity Forum
Ballroom A
Peter Huang (Chair), *National Institute of Standards and Technology, USA*

4:00 PM

Humidity Forum
Peter Huang, *National Institute of Standards and Technology, USA*
Nobuo Takeda, *Ball Semiconductor Inc., USA*
Gerald Schultz, *Edgetech/Sunwise Turn Consulting LLC, USA*

In line with the theme for the 2010 Measurement Science Conference, Global Measurement Economy & Technology, this forum will be focused on (1) advances, (2) issues, (3) collaborations in the area of humidity

measurement. Humidity measurement and control are crucial for modern technologies such as hydrogen fuel cell, semiconductor and nano technologies.

Questions to be considered include:
1) What techniques can be used to measure humidity for these areas of technology?
2) What methods can be used to calibrate sensor s for these areas of technology?
3) What is the humidity critical to these areas of technology?
4) What is the sensitivity of a particular technology to the humidity?
5) What is the range of interest? What is the accuracy required?
6) What other measurement techniques could be appropriate?

Additional Speakers/Authors:
Dr. Nobuo Takeda, *Ball Semiconductor Inc.*
'Fast Response Hygrometer of Spherical SAW Device'
Dr. Gerald Schultz, *Edgetech/Sunwise Turn Consulting LLC*
'P205 Sensor Technology - Fundamental Principles and Practical Applications'

B3: Applied Temperature
Ballroom B
Shayson Edwards (Chair), *University California Riverside, USA*

4:00 PM

The Environmental Stress Screening Integration System
Nghiem V. Nguyen, *Raytheon Company, USA*

The Environmental Stress Screening Integration System has been designed for Environmental Stress Screening (ESS) test to test objective is to validate proper manufacturing and find any manufacturing defects in a flight unit before delivery using temperature modulation and vibration simulations. The ESS test performs temperature cycling and employs random vibrations to test the reliability of the unit. Temperature regulation is also provided via the poly-alpha-olefin (PAO) coolant flowing through the unit under test (UUT), which is controlled by a cooling system. The UUT is electronically stimulated and monitored by a Test Bench designed for functional testing of the article and depending on the test requirements, the satellite tracking capability can be conducted by a satellite simulator or live satellites. A summery of this paper expressed a general method to understand the Environmental Stress Screening testing to be performed on early deliveries of GPS Sensor Electronic Unit, Line Replaceable Component, when approved variance calls out limited ESS. Most of the flight unit was required ESS test which was the test using to test an objective to validate proper manufacturing and find any manufacturing defects. The Environmental Stress Screening Integration System will be an excellent technical paper which contributes to MSC for most of Engineering fellow as well as to all segments of industry relating to the Environmental Test Facility.

4:30 PM

Selecting Possible Alternatives to Mercury Thermometers
Gregory Strouse, *NIST, USA*

Due to the fact that mercury is a powerful neurotoxin, the use of mercury liquid-in-glass (LIG) thermometers in industry is slowly being replaced by alternative non-toxic thermometers. The environmental remediation costs

from a broken mercury LIG thermometer can be as large as $20,000. The two most likely replacements are organic LIGs thermometers and digital electronic thermometers. The selection of a replacing a mercury LIG thermometer with an alternative non-toxic thermometer is constrained by several factors including: operating environment, measurement method requirements, traceability, stability, uncertainties and in some cases current standards and regulations. In most cases, the measurement requirements do not create significant issues for selecting an alternative non-toxic thermometer and direct replacements are readily available. However, for some cases either the operating environment or current standards and regulations can create a challenge in finding a suitable replacement. We present a flowchart decision tree that can be used to help identify which thermometer type is a suitable candidate. Examples of these technical challenges that are often encountered in transitioning from the mercury LIG thermometer to a non-toxic alternative are given. Additionally, we explore the differences between thermometer types in uncertainties, costs, methods of use and validation techniques.

5:00 PM

A Critical Look at Type T Thermocouples in Low Temperature Measurement Applications
Don Dowell, *Lockheed Martin USA*

Type T thermocouples are common in industrial measurement applications due to their accuracy relative to other thermocouple types, low cost, readily available measurement equipment. Users of Type T thermocouples should be aware that typically they do not conform to the published reference function describing their performance when used to measure temperature in the range of -100°C to -200°C. This paper looks at the reasons for this, some data on a number of samples, and some methods of mitigating this effect.

C3: Mobile Calibration Facilities
Ballroom C
Phillip Banks (Chair), *US Navy, USA*

4:00 PM

Legal Calibration in Mission
Gerhard Mihm, *German Armed Forces, Germany*

In the past, during crisis and war, but also nowadays in military missions or operations within a multinational environment with specialist forces from different countries working together, mutual support and supply are provided on contractual basis. Goods delivered and supplied to and from troops have to be measured and will be paid on the measurement results. In Afghanistan German forces are operating out of stationary field camps, where e.g. fuel is delivered by local tradesman (and paid for by the quantity received) and will be supplied to all entitled parties. The local gas station, operated by the German forces therefore has to be legally calibrated. This calibration in home basis has to be provided by institutions, manned by civil servants and authorized by the ministry of commerce. As civil servants are not available to do this work in a hostile environment, calibration of gas stations e.g. has to be done on a legal basis by authorized specialists with combatant status. German Armed forces are entitled for doing legal calibrations and are in a process to build up specialist teams for doing legal calibrations. The presentation will cover the basic statues for legal calibration within Germany show up the development and determined needs and targets of military

metrology that are in progress.

4:30 PM

Development of Mobile Calibration Laboratories
Peter Jaeger, *German Armed Forces, Germany*

If the customer does not come to the calibration laboratory, the calibration laboratory must come to the customer. The German Armed Forces, too, have to deal with this fact. Whether in operations or in units with critical equipment, mobile calibration laboratories will be the solution to meet calibration requirements on site . The implementation of such mobile laboratories should be cost-effective – special vehicles have been and continue to be too expensive. Therefore the Bundeswehr developed mobile laboratories on the basis of commercial thermo trailers and has had them built. The fleet of mobile Bundeswehr calibration laboratories includes fully equipped calibration laboratories that are also consistent with EN ISO 17025 requirements. The laboratories of the Bundeswehr are equipped with climate control chambers, workplaces for pressure, force, mass, torque, flow and temperature, but also for all electrical parameters such as current, voltage and resistance. This enables calibration of almost the entire range of equipment – from multimeter to spectrum analyzer, from torque key to hydraulic ground carts for aircraft. Due respect had to be paid to the suitability for daily use and to the development of the pool of measuring devices. The laboratories should be suitable for flexible adaptation to new requirements to be able to react to metrological developments. The presentation will show the requirements, development stages and implementation of the "electronics" and the "physics" lab versions.

F3: Metrology R&D II
Ballroom F
Robert W. Nickey (Chair), *Naval Surface Warfare Center Corona, USA*

4:00 PM

Design of a Dual Wavelength Peak Power Low Level Laser Radiometer
Daniel King, *NSWC Corona, USA*

Laser rangefinders and designators in the military have been designed to operate in the 1.064?m wavelength. The new “eye safe” rangefinders using 1.54?m and 1.57?m lasers and receivers will also require support. This necessitated the design of a radiometer that could accurately detect and calibrate the low signals used by test sets that support these weapon systems. This paper describes the requirements for and design of the Navy’s 1.5?m Low Level Laser Peak Power Radiometer referred to as the 1.5ESR, and the dual wavelength model referred to as the Dual ESR, or D-ESR. This effort was funded through the Navy's Metrology R&D Program sponsored by NAVSEA 04RME.

4:30 PM

Photometric Standards for Corrosion Control in the Department of Defense
Cameron Miller, *National Institute of Standards and Technology, USA*
Maria Nadal and Rui Qi, *NIST, USA*

Coating shipboard tanks is the Fleet’s primary maintenance cost. Extending coating service life is the most promising strategy to lowering this cost. The key to extending coating service life is to eliminate coating defects during the coating application. To this end, NAVSEA has developed and demonstrated

a fluorescent coating technology that improves the quality of tank coating applications in the field. A Navy Metrology R&D project funded the National Institute of Standards and Technology to develop a standardized testing method for coating applications, allowing NAVSEA to specify the coating application in contracts and take advantage of the cost savings.

5:00 PM

A Progress Report on Measuring the Surface Energy of Solids
Alan E. Scrivner, *NSWC Corona Division, USA*

The surface energy of solids has proven to be difficult to understand and measure despite its wide applicability in manufacturing and production processes. In this paper we will detail progress on a new technique for measuring surface energy that depends on the fracture characteristics of thin adhesive films. This technique should lend itself to the development of a device that will be inexpensive to manufacture, easily portable for field applications, and uses no toxic materials.

G3: Measurements in the Marketplace
Ballroom G
Paul Selzer (Chair), *Abbott Labs, USA*

4:00 PM

Measurements In The Marketplace:
Real-life Applications for Student Outreach
Elizabeth Gentry, *National Institute of Standards and Technology, USA*

The 164 Education Liaison and Outreach Committee will host an interactive session where participants will learn more about becoming a Metrology Ambassador and gain experience with several classroom measurement activities that can be used by Metrology Ambassadors - measurement scientists that volunteer in their community to educate students, parents, educators, and others about basic principles and careers in Metrology. This session is not your typical conference session – participants move between several hands-on stations that focus on real life measurements in the marketplace, have access to activity worksheets that correspond to the fun and easy activities, and intermingle with others interested in influencing the next generation of Metrologists. Several of the marketplace measurement activities were developed by the National Institute of Standards and Technology (NIST) Weights and Measures Division (WMD) and have proven popular with students and teachers who have participated in NIST sponsored education outreach events such as “Take Your Sons and Daughters to Work Day,” the Girl Scouts “Science Get Psyched” event, and the Summer Institute for Middle School Science Teachers. Other activities have been developed by Metrology Ambassadors to illustrate additional measurements important to students and their every day life, such as consumer package labels, forensic science, or food safety.

H3: More Electrical
Ballroom H
Greg Miller (Chair), *NAVAIR, USA*

4:00 PM

Metrology Impacts of Digital Systems
Edward Trovato and Kenneth Simpson, *NSWC Corona Division, USA*

Digital systems, aka solid state electronics systems increasingly dominate military test equipment and calibration standards. These systems present new challenges to metrologists, including but not limited to legal impacts such as proprietary interest in software code, configuration control over hardware, firmware and software, and policy and security impacts relating to implementing these systems. this paper will discuss an overview of the current and near future state and propose a possible metrology position relative to digital systems.

4:30 PM

Analysis of Two Dual Axis Accelerometers Using a Mobile Robot
Tarek Mohammad, *University of Western Ontario, Canada*

In this paper, two dual axis ADXL321 accelerometers were used to enable a three axis accelerometer system. Using a FANUC robot as the true value of acceleration, velocity and displacement it was proven that high accelerations, low velocities, and large displacements provide the most accurate acceleration, velocity and displacement respectively. Further analysis shows that high acceleration and high velocity will give you a more accurate result compared to a high velocity and low acceleration system. When gravity was exerted on the X, Y, Z axes of the accelerometers there was an average error of +0.1099 m/s2. As the ambient temperature increased the thermal drift time period decreased due to the fact that the accelerometers took less time to get to its optimum thermal temperature. Through a wide range of different accelerations it was concluded through analysis that the relationship between voltage and acceleration is 59.31 mV/g compared to the ADXL321 data sheets relationship of 57 mV/g. More care should be taken when routing the sensor cables from the accelerometers to the data acquisition system. This small change can minimize the noise in the cables. Since a robot uses a 3 axis gyroscope which produces the pitch, roll, and yaw it can be said that with proper compensation on gravity, the 6 axis accelerometer system can be an inexpensive replacement for the 3 axis gyroscope.

5:00 PM

A NVLAP Accredited Process for Transfer of Calibration to High Energy Laser Probes
Shaun Hampton, *National Securities Technologies, LLC, USA*
Michael Charest, *National Security Technologies LLC, USA*
Kent Marlett, *National Security Technologies, USA*

Experiments conducted at national user facilities, such as the National Ignition Facility at Lawrence Livermore National Laboratory, employ state-of-the-art instrumentation including optical and X-ray streak cameras, gated imagers, CCDs, and diodes. These instruments are calibrated to ensure the diagnostics perform reliably, and data collected during their use will be traceable to relevant standards. A NVLAP accredited process was developed for transferring the calibration of pulsed high energy laser probes from a NIST calibrated standard to additional energy probes for use as general working standards. We will discuss the unique challenges of developing the measurement methodologies associated with this calibration transfer, and the analysis of error propagation as it pertains to the expanded uncertainty of the calibration measurements.

Friday, Mar 26

8:30 AM - 10:00 AM

A4: Analytical Metrology
Ballroom A
Ding Huang (Chair), *US Navy, USA*

8:30 AM

Threshold Analysis
Dennis H Jackson, *NSWC Corona Division (US Navy), USA*

Calibration procedures often require testing a threshold such as a minimum power requirement or a maximum value for some nuisance parameter such as stray voltage. Because the information provided for such threshold tests is so different from the usual two-sided tolerance tests, it is often difficult to define such basic terms as UUT measurement uncertainty, TAR, TUR, and measurement decision risk. As a result, it can also be difficult to determine and defend the choice of a calibration standard or test instrument for such test steps. This paper describes how to calculate UUT measurement uncertainty, TAR, TUR, and decision risk for threshold test steps. This will also provide insight into how to approach the design and analysis of single-sided tolerance test steps.

9:00 AM

A Welch-Satterthwaite Relation for Correlated Errors
Howard Castrup, *Integrated Sciences Group, USA*

The Welch-Satterthwaite relation provides a useful tool for estimating the degrees of freedom for uncertainty estimates for measurement errors comprised of a linear sum of s-independent normally distributed quantities with different variances. Working from a derivation for the degrees of freedom of Type B uncertainty estimates, a variation of the Welch-Satterthwaite relation is developed that is applicable to combinations of errors that are both s-independent and correlated. Expressions for each case are provided for errors arising from both direct and multivariate measurements.

9:30 AM

Monte Carlo Uncertainty Analysis Spreadsheet Template; The How-To Guide
Heather Truax, *Raytheon Space and Airborne Systems, USA*

There are many forms of uncertainty analyses being used in the world of metrology today. Analyses range in accuracy from very rough estimates with wide guard bands and lower confidence levels to very in depth, lengthy, statistical analyses, which provide a more accurate error values with smaller guard bands and increased confidence. The former are kept basic to render the analysis applicable to a wide variety of calibration scenarios. Unfortunately, the later, are usually only applicable for one specific scenario and are difficult to modify at the bench level (i.e. an expert on the analysis would be needed to make modifications). A “plug-and-play” Microsoft Excel worksheet has been created to bring quick-n-easy analysis together with high accuracy uncertainty estimates. This template will perform a detailed statistical uncertainty analysis using the Monte-Carlo method. The analysis is applicable to a wide variety of scenarios and requires little modification. When modification is required, instruction is provided within the analysis

worksheet. Perhaps the most notable advantage to this template is it eliminates the need for calculating difficult partial derivatives in the case of non-linear measurement equations (equations with dependent variables), an important step that is often ignored in simple uncertainty analyses.

B4: Flow
Ballroom B
Jessica Liss (Chair), *Navy Primary Standards Laboratory, USA*

8:30 AM

Thermal Sensor Transient Response Characteristics
Chiun Wang, *Cardinal Health, Inc., USA*

The transient characteristics of a thermal sensor in response to sudden changes in the gas flow is investigated. Not only the thermal sensor's own heat capacity and thermal conductivity affects its speed of response. The sensor's mechanical construction as well as the electronic excitation circuit together determines the sensor's operational transient characteristics. By mathematically analyzing the sensor's heat transfer process, the impact of the sensor's mechanical and electronic design on its transient response behavior is explored. The mathematical solution compares well with transient response data collected from a thermal mass flow sensor. It is then used to demonstrate how the constant temperature excitation electronic circuit helps to both significantly reduce the sensor time-constant and to modify the sensor characteristics from a second-order to a first-order system behavior.

9:00 AM

Ray Tracing in a Wind: Beam Curvature Effects in Ultrasonic Flowmeters
Thomas O. Maginnis, *Physics of High Performance Sensors, USA*

Ultrasonic Time of Flight Flowmeters have become the de-facto dominant technology for gas flow measurements in large line sizes. These meters have some ability to compensate for flow profile variations by employing multiple chordal paths for the sound transmission paths. It is usually assumed in the elementary theory of these meters that the sound propagates along straight lines that connect(wetted) sending and receiving transducers. In fact, the acoustic ray path is slightly curved by any vorticity that exists in the flow field. (Even for laminar flow profiles there is an azimuthal vorticity component in the flow field that bends the sound rays as they pass through the pipe boundary layer.) This effect is much stronger for gases than liquids, and can result in beam walkoff and loss of signal at high flow rates with low sound velocity gases. This effect also causes systematic discrepancies between theoretical flow-induced upstream/downstream time differences and actual measured time of flight differences. This paper will present the theory of the vorticity beam curving and some puzzling liquid timing data that may be explained by this effect.

9:30 AM

Improved NIST Airspeed Calibration Facility
Iosif Shinder, Michael Moldover and James Hall, *NIST, USA*

The National Institute of Standards and Technology (NIST) uses a laser Doppler anemometer (LDA) as a standard for airspeed calibrations. The traceability of airspeed to the primary standards of length and time (frequency) is accomplished by calibration LDA against a rotating disk with

known dimensions at several rotation frequencies. Improved procedures for calibrating the LDA against the rotating disk reduced the uncertainty of the LDA calibration from 0.26% to 0.10% (k=2). In order to improve the LDA signal in the wind tunnel, we replaced our water seeding system with an oil seeding system. Using only 2-3 grams of oil per 3-hour-long calibration, the oil system generates an LDA data stream rate of 100 to 10,000 Hz, depending upon the wind speed. New software automates the airspeed setting, oil-seeding rate, data-collection time, instrument averaging time, etc.

C4: Chemical Detection
Ballroom C
Michael Bishop (Chair), *Naval Surface Warfare Center, Corona, USA*

8:30 AM

Scanning Laser Infrared Molecular Spectrometer: Instrument Development for Chemical Sensing
David Scott, Joel Steinkraus, Kelly Rickey, Alexander Ksendzov, Warren George and Aljabri Aljabri, *Jet Propulsion Laboratory, USA*

The ability to observe and identify the presence of trace gases within an environment is a paramount capability needed to advance earth and planetary atmospheric research. Detection of trace levels of gases is also of interest in defense, industrial, security, medical, and environmental health applications. Current scientific objectives largely focus on identifying the presence of specific gases and isotopologues found in planetary atmospheres within our solar system. The presence and relative amounts of these gases allows scientists to deduce history of the planetary atmosphere and the likelihood that life has or could exist there. One challenge is accurately acquiring the data needed to make reliable conclusions when some of the target gas molecules are present in trace quantities of 10 parts per billion (ppb) or less. Laser gas spectrometers are effective ways of collecting in situ gas measurements, but their precision is directly proportional to the path length of the optical system. The Scanning Laser Infrared Molecular Spectrometer (SLIMS) is a novel solution that achieves very long effective path lengths, which yield ppb and sub-ppb measurements of trace gases. It can also accommodate multiple laser channels covering a wide range of wavelengths resulting in detection of more chemicals of interest. The mechanical design of the mirror cell allows for the large effective path length within a small footprint. The same design provides a robust structure which lends itself to being immune to some of the alignment challenges that similar cells face. The continued forward progress of the SLIMS project will rely on optimizing the optical paths and optical alignment geometries.

9:00 AM

Microcontroller Based ISFET pH Measurement System with Wireless Communication
Gaytri Gupta and Rahul Verma, *Amity University, India*

This paper describes the experimental setup of pH measurement system which can be used for our everyday life. pH represents potential of hydrogen which is used as the unit of measure to express the degree of acidity of a substance is defined as the negative logarithm of the hydrogen ion concentration. There is a wide variety pH measurement system. The paper presents an attempt to develop an in-house low cost product for pH measurement. The heart of this device is the ADuC814 microcontroller chip. The sensor used in this device is an ISFET sensor. This type of ion-sensitive

sensor is derived from the MOSFET (metal oxide semiconductor field effect transistor). In this setup pH value can be measured and continuously monitored on the LCD and by using the RF modem the pH values can be continuously monitored on the PC also. All setups was verified and tested on all standard solutions and proved to be accurate.

9:30 AM

Traceable Methods for Calibration and Testing of Chemical Warfare Agent (CWA) Detectors
Christopher Clark, Mary Graupmann and Michael Bishop, *Naval Surface Warfare Center, Corona, USA*
Christin Schliemann, *Computer Sciences Corporation, USA*

Two systems have been designed, constructed, and tested to provide a known concentration of chemical warfare agent (CWA) simulant to a Mark 4 Joint Chemical Agent Detector (JCAD). The M4 JCAD is a hand-held ion mobility spectrometer that alerts the warfighter to the presence of a CWA. The current M4 JCAD iteration is commercially available from Smiths Detection under its trade name Light-weight Chemical Detector (LCD) 3.2E. Although the detector is not considered to make a quantitative measure of CWA concentration, it alarms at a threshold value and this value requires calibration. Calibration is defined here as a comparison of detector response to a known traceable concentration. Two options for CWA detector calibration are explored. The first uses Kin-tek vapor generators in conjunction with a 6-port valve and Agilent 7890/5975 gas chromatograph-mass spectrometer (GC/MS) to assure the concentration delivered to the JCAD is precise and accurate. This method attains its traceability to mass through preparation of liquid solutions, using a traceably calibrated balance, to obtain a GC/MS response factor. The second method uses a Kin-tek vapor generator in conjunction with a Fourier Transform Infrared Spectrometer (FTIR) affixed with a gas cell with a 2m optical path. The FTIR system provides traceability to mass through the use of the NIST certified infrared database. Though the work reported here was conducted with simulant compounds, either method may be adapted to use with chemical agents to establish measurement traceability to national standards. These traceable test methods allow better testing which will drive down performance testing costs and allow the warfighter an assurance that their detector is accurate.

F4: CMM Theory
Ballroom F
Jon Baldwin(Chair), *MetroSage LLC, USA*

8:30 AM

3D Volumetric Positioning Error Measurement and Compensation Over Part
Charles Wang, *Optodyne, USA*

To improve the volumetric-positioning accuracy of machine tools and to machine parts with consistent and tighter tolerances, 3-D volumetric measurement and compensation is essential. Twenty years ago, the largest machine tool positioning errors are lead screw pitch error and thermal expansion error. Now, most of these errors have been reduced by better ball-screw or linear encoder and pitch error compensation. Hence, the largest machine tool positioning errors become squareness errors and straightness errors. Until recently, measuring volumetric errors has been time-consuming and costly. Furthermore, high-end controllers capable of 3D error compensation are expensive and rare. For these reasons, 3D

volumetric measurement and compensation have not been widely used. Recently, Optodyne has developed a new revolutionary laser vector measurement technique capable of measuring the 3 D volumetric positioning errors in a short time. Furthermore, compensate the part program or G-code makes it unnecessary the need of a high-end controller. Hence a low cost CNC machine can perform as a high cost machine. To demonstrate the viability of this technique, the 3D volumetric positioning errors were measured by the laser vector technique over a test part working volume of a machining center. Based on the measured 3D positioning errors, a test part program was compensated. Two test parts were machined, one without compensation and one with part compensation. The accuracy of these 2 parts was measured and their errors compared. Reported here are the basic theory, measurement of 3D positioning errors, the test part program without compensation and with compensation, and the measured accuracy of these 2 parts. The improvement of the part accuracy is significant.

9:00 AM

Got a CMM (Coordinate Measuring Machine)... Now What?
Stephen A. Long, *Owner,3rd Realm, USA*

The adoption of unfamiliar and complicated nanometer resolution coordinate measuring systems, at both industry and government facilities, is reviewed. Difficulties of personnel training, adoption and acceptance will be focused on, with real world examples of correlation with traditional techniques. The problems that were encountered and the solutions pursued, which culminated in the approval and expansion of CMM adoption at these facilities is discussed, as well as the future prospects of these organizations.

G4: Future Workforce
Ballroom G
Bob Williams (Chair), *NSWC, Corona, USA*

8:30 AM

RP on Laboratory Workforce Development Planning
Gloria Neely*, NSWC, Corona, USA*

This RP addresses the issues of hiring and retaining qualified employees. In the field of metrology, selecting appropriate personnel is especially critical. Skilled employees are paramount to the success of an organization. Retaining valuable employees can often be more challenging than hiring. Skilled and motivated employees in the private sector often leave to pursue other endeavors, creating a void in the company skill set. Even more critical are those who retire and leave the workforce altogether. Providing an incentive to retain employees is often viewed as impractical or unfeasible. The relatively small scale of the metrology field makes finding a qualified individual to fill the technical void difficult; therefore, a serious focus on investing in employee training, retention, and succession plans is paramount. Long-term retention planning, combined with succession planning, helps a company to provide a high level of customer support, even in the event of personnel turnover. This Recommended Practice provides an approach to develop training, retention, and succession plans that will meet the needs of today's high tech calibration and testing laboratories.

9:00 AM

Metrology Human Resources Handbook
Caroline L. Dixon, *NSWC, Corona, USA*

This Handbook contains the essential items needed by a Human Resources professional to evaluate three positions relative to metrology: (1) calibration technician, (2) calibration engineer, and (3) metrologist. Included in the Handbook are industry accepted job descriptions, salary information, career statistics, educational opportunities, and reference materials in support of standardized job descriptions for the metrology profession. Until now this essential information could only be found in limited published format. The accepted information on metrology professions by government agencies has been consolidated into one reference document. The information identified within this document was consolidated from data found in the joint American Society for Quality, Measurement Quality Division (ASQ-MQD) and National Conference of Standards Laboratories International (NCSLI) 2006-07 Metrology Job Description Initiative, the 2007 NCSLI Benchmarking Study, and two published papers that are included as appendices.

H4: Lab Processes
Ballroom H
Kevin Abercrombie (Chair), *NAVAIR AIR-4.12.9, USA*

8:30 AM

How to Setup a Dedicated Repair Area in Your Calibration Laboratory
Stephen M Silvati, *Naval Air Warfare Center Patuxent River, USA*

This paper discusses the basic requirements to start-up a repair area/facility within a calibration lab. The discussion includes concepts, and essential initial resources. Additional consideration will be given to the following topics: Facility/Space /Environmental concerns, Scope of repair capabilities, Cost/Income – ROI, Dedicated space & personnel, Technical competence, MFR vs. in-house repairs, and Quality Assurance/Controls. All of these topics are essential prior to initiating a repair area.

9:00 AM

Earned Value Management in Metrology
Chet Franklin, *CSC, USA*

What is Earned Value Management (EVM)? Can it be applied in the metrology business arena? This paper will attempt to answer both questions. Very simply stated, EVM is a project management toolset comprised of a set of metrics which can be employed to compare the planned performance of a project to the actual performance. It can be used to track individual tasks or the overall project. EVM metrics will provide the project manager, or team leader, with a clear picture of financial performance to-date, schedule performance to-date, and the value of the work accomplished to-date. It provides opportunities to identify risk areas. It provides metrics which can be used to predict the cost to complete a project, and compare those to the originally planned cost to complete it. The project leader has real-time information on cost and schedule variances. Earned Value Management can be scaled to fit projects of any size or complexity; regardless of business type. It can be used in manufacturing businesses, service businesses, and yes, even in the metrology business. One of the principles of quality management is that work is accomplished through a set of process steps. If the work to be accomplished is new or unique then developing and establishing the new set of process steps for that work can be managed in a manner similar to managing a project.

9:30 AM

Calibration Recall System Design and Deployment
George Jannison, *Department of Navy, USA*

The need to track the status of items calibrated by a laboratory begin with the fact that periodic calibrations of standards and test equipment is required to ensure accurate measurements are being made. If you need to build or buy an inventory or recall system how do you determine the requirements the software system must support. Does the software need to drive or support the quality system, or do you just need to notify the instrument owner that their calibrated equipment us due? How much data needs to be kept and who can see it. Is this to support internal or external customers? Will you 'manage' standards or just test equipment? The paper will describe a method to identify the options and describe some of the limits that may be face in testing and deploying an efficient and effective recall or inventory management system.

10:45 AM - 12:15 PM

A5: Uncertainty
Ballroom A
Don Dowell (Chair), *Lockheed Martin, USA*

10:45 AM

A Paradox in Measurement Uncertainty Analysis
Hening Huang, *Teledyne RD Instruments, USA*

This paper reveals a paradox in the current uncertainty analysis: the expected value of the Student's t approach estimated uncertainty is inconsistent with the true uncertainty, or the Type A evaluation of uncertainty is inconsistent with the Type B evaluation, particularly for small samples. The paradox may be resulted from the mix of the mathematical definitions of uncertainty. Mathematically, the true uncertainty defined by the Law of Probability of Errors (LPE) is the half-width of the constant confidence interval of measurement errors. It may be considered as the measurement "error limit", which is a measure of the measurement precision. The uncertainty defined by the Student's t approach is the half-width of a realization of the random confidence interval of measurement errors. It cannot be considered as the measurement "error limit" and is not an unbiased estimate of the true uncertainty. The quantity that is really of interest in measurement practice is the true uncertainty or "error limit". The problems associated with the use of the Student's t approach are discussed. An alternative approach, named as the Craig approach, is presented. The Craig approach estimated uncertainty may be considered as a good, unbiased estimate of the true uncertainty, resulting in no paradox. Uncertainty of the uncertainty is discussed. The concept of uncertainty consists of two parameters: uncertainty and its confidence level. These two parameters cannot be accurately determined at the same time unless the population standard deviation is known. When the population standard deviation is unknown and is estimated from a sample standard deviation, only one of the two parameters can be accurately determined. An uncertainty analysis was conducted for two field data sets. The results for small samples indicate that the Student's t approach estimated uncertainty is apparently paradoxical, while the Craig approach or Bayesian approach estimated uncertainty agrees reasonably well with the approximate true uncertainty.

11:15 AM

Comparison of Methods for Establishing Confidence Limits and Expanded Uncertainties
Suzanne Castrup, *Integrated Sciences Group, USA*

In reporting measurement results, it may be necessary to include an interval that contains the true value with some specified confidence level or probability. The interval may be reported as confidence limits, with an associated confidence level, or an expanded uncertainty, with an associated coverage factor. This paper examines three methods for computing confidence limits and expanded uncertainties: 1) Monte Carlo Simulation, 2) Convolution and 3) Coverage Factor. The first two methods involve the combination of error distributions via a numerical or mathematical approach. The third method involves the calculation of the effective degrees of freedom for an uncertainty estimate for a combined error. Several measurement scenarios are evaluated and the intervals computed from each method are compared.

11:45 AM

Calibration Intervals By Bayesian Approach: Information Management
Ding Huang, *US Naval Air Systems Command (NAVAIR), USA*

Bayesian statistical framework are presented for computing calibration intervals. The methodology provides impersonal uniform and non-uniform priors and constructs posterior distributions for out-of-tolerance rate and reliability function. It generates Bayesian intervals with P% confidence to contrast to confidence Intervals based on the conventional statistical framework. The methodology uses all information in hand, including binary statistical calibration records and non-statistical data.

B5: Flow Again
Ballroom B
Kevin Abercrombie (Chair), *NAVAIR AIR-4.12.9, USA*

10:45 AM

Uncertainty and Characterization of NIST's 20 L Piston Prover for Hydrocarbon Liquid Flows
Aaron Johnson, *National Institute of Standards and Technology, USA*

The National Institute of Standards and Technology (NIST) uses a bi-directional piston prover as its primary standard for measuring hydrocarbon liquid flows ranging from 1.86 × 10-5 m3/s (0.3 gpm) to 2.6 × 10-3 m3/s (41 gpm). An uncertainty analysis will be presented that shows that the uncertainty over this flow range is 0.09 % (k = 2). As a verification of the uncertainty analysis NIST will show comparison results between its new standard (i.e., the 20 L piston prover) and its older standard (i.e., a Cox Bench dynamic weighing system) using a dual rotor turbine meter as the transfer standard. Furthermore, NIST will investigate the feasibility of using mixtures of propylene glycol and water (at the same kinematic viscosity) in place of the traditionally used Stoddard solvent (i.e., MIL-C-7024C).

11:15 AM

The Effect of Using Real Gas Absolute Viscosity and Isentropic Exponent on Orifice Flow Measurement: Proposed Adoption of REFPROP 8

as the Standard for Calculating Thermodynamic and Thermophysical Properties for the Natural Gas Industry
Bill Johansen, Colorado Engineering Experimental Station Inc., USA
Aaron Johnson, National Institute of Standards and Technology, USA

Orifice meters have been used to measure natural gas for nearly 100 years. Improvements in natural gas property calculations have led to improvements in orifice based flow measurement. Constants are currently used for natural gas absolute viscosity and isentropic exponent. Improvements in natural gas thermodynamic and transport property calculations make the use of constants for absolute viscosity and isentropic exponent unnecessary. REFPROP 8 incorporates most of the recent improvements in natural gas thermodynamic and transport property calculations. This paper investigates the impact of real natural gas property and transport property calculations on orifice based flow measurement. The effect of real gas absolute viscosity calculations on Reynolds numbers will be discussed in terms of the effect on orifice discharge coefficient calculation and the calibration range of other meter types. The effect of real gas isentropic exponent on the Buckingham expansion factor and the new orifice expansion factor under consideration for AGA Report No. 3 will be examined.

C5: Biological Measurements
Ballroom C
Mary Graupmann (Chair), *Naval Surface Warfare Center, Corona, USA*

10:45 AM

Detecting Median Mononeuropathy and Carpal Tunnel Syndrome Through Radiometric Thermal Imaging
Shayson Edwards, *University California Riverside, USA*

The primary objective of this study was to determine if radiometric thermography could detect Median Mononeuropathy in the articulatio radiocarpalis. A secondary objective was to establish the efficiency of thermal imagery as a viable technique for establishing the trends of Carpal Tunnel Syndrome and Median Mononeuropathy. Whereas an x-ray indicates structural anomalies, thermography can point out functional anomalies. In this study, participants were instructed to use their dominant hand to repetitively squeeze a rubber ball for a brief period of time. A thermal imager was then used to image and record temperatures across the subject's wrist area. Subjects known to have carpal tunnel syndrome or Median Mononeuropathy exhibited elevated temperatures in the wrist area. Similar results were observed in subjects with compromised circulatory systems even though they had not been previously diagnosed as having carpal tunnel syndrome or Median Mononeuropathy. This research suggests that thermal imaging offers potential to identify predisposition to Median Mononeuropathy not related to repetitive motion.

11:15 AM

Characterization of Photomultiplier Tubes Using Synchrotron Radiation
Lindsay Hum and Michael Bishop, *Naval Surface Warfare Center, Corona Division, USA*
Ping-Shine Shaw, Zhigang Li and Keith Lykke, *NIST, USA*

Low-light detectors, such as photomultiplier tubes (PMTs), are crucial in detecting biological agent attacks that can be catastrophic to the joint forces. Several biological agent detection systems rely on PMTs to detect very low levels of elastically scattered light and fluorescence. The accuracy and

reliability of the measurement of light depends critically on the stability, absolute responsivity, and degradation rate of the PMTs. In this study, PMTs were characterized using synchrotron radiation at the National Institute of Standards and Technology (NIST) Synchrotron Ultraviolet Radiation Facility (SURF III). Measurements were performed using SURF III Beamline 4, which monochromatizes the radiation from SURF III with a 2-m monochromator and uses the resulting UV radiation for radiometric measurements of detectors. Beamline 4 is capable of calibrating detectors in the ultraviolet (UV) with a scale traceable to a cryogenic radiometer. For low-light level detectors, the responsivity scale is realized using the fact that synchrotron radiation is directly proportional to the electron beam current in the storage ring. The ability to calibrate low-light detectors in the UV makes Beamline 4 ideal for characterizing PMTs used in biological detection systems. We measured the linearity, spatial uniformity, and absolute spectral responsivity of several PMTs. Newly purchased commercial PMTs and PMTs that were used in within a biological detection system were studied. Comparison of these two groups of PMTs demonstrated the degree of degradation after prolonged hours of field use. Our measurement results illustrate our calibration capability and the severity of the UV PMT degradation process within biological detection systems. This work provides validation that absolute calibration and general characterization of PMTs can be achieved using SURF III.

F5: CMM Application
Ballroom F
Jon Baldwin (Chair), *MetroSage LLC, USA*

10:45 AM

Applications of Computer Simulation to CMM Uncertainty Evaluation
Daniel Campbell, Jon Baldwin and Kim Summerhays , *MetroSage LLC, USA*

In the past few years, we have observed increasing appreciation of the importance of reliable measurement uncertainty statements to the quality and commercial viability of manufactured products, to the point that one now routinely sees measurement results accompanied by credible and reasonably rigorous documentation of the associated uncertainty. However, uncertainty evaluations for complex, multi-parameter measuring systems, of which coordinate measuring machines (CMMs) are the principal instance, remain problematic due to the number, ranges, interactions and generally unknown sensitivity coefficients of the parameters that can influence the measurement result. The situation is particularly difficult when a task-specific uncertainty is required and poses problems for both auditors and metrology practitioners. Auditors often lack satisfactory tools for a comprehensive assessment of a client's claims of traceability. Measurement professionals, similarly, have difficulty demonstrating compliance with measurement traceability requirements and, in addition, can find themselves at a real economic disadvantage if reliable measurement uncertainties are not known. In this paper, the historical perspective of, the motivations for, and the necessity of task-specific uncertainty evaluations are briefly discussed. This is followed by a presentation of the requirements and desirable features of a credible method for task-specific CMM uncertainty evaluation. Next, a description of the major design features of a practical software application for evaluating uncertainties of CMM measurements is presented. This is concluded by presenting several application examples and case studies which demonstrate that, in the arena of task-specific CMM uncertainty evaluation, simulation methods exhibit notable strength and versatility.

11:15 AM

Measuring the Geometry of 3D Irregular Particles
Michael Taylor, *Graniterock, USA*

Irregular 3D particles are utilized in many fields. The properties that are of interest include volume, surface area, shape etc. Until recently such properties were not amenable to measurement without complex and expensive equipment. And since the numbers of particles used are often in the trillions, there is a powerful need for such data to permit statistical data to be obtained to aid engineers in their use. The development of CT scanners and surface scanners has now filled this need. Particles from an (almost) unlimited upper size down to approx. 50 microns can now be measured with equipment that is of reasonable cost, and can be operated with little training. The paper presents the results of measurements of the Volume, Surface Area, Density and Shape for over 100 rock particles ranging in “size” from 5 cm to 2mm and over 300 particles of “sand” sizes (4mm down to 100 microns). The three types of equipment used were a CT machine, a micro-CT machine and a laser surface scanner.

11:45 AM

Evaluating the Economic Impact of CMM Measurement Uncertainty
Jon Baldwin, Kim Summerhays and Daniel Campbell, *MetroSage LLC, USA*

Product metrology has been regarded, in the conventional view of many US manufacturing operations, as a necessary cost of doing business, the expense of which should be minimized in the interest of greater profit. Recent years have seen the beginnings of a shift to a more critical approach to this topic. A careful look at the risks of incorrect accept/reject decisions due to measurement errors and the associated costs of those errors reveals that the traditional approach is often not the economically most advantageous. Thus, more production operations are beginning to critically examine the economic consequences of measurement and, particularly, the cost of undiscovered measurement errors. Translation of uncertainty-related risks into economic outcomes is an extremely situation-dependant exercise and is particularly involved when considering the application of complex, multi-parameter measuring systems such as CMMs. In this talk, we will focus on the complexities inherent in the analyzing the economic implications of CMM measurements for product evaluation. We will discuss the technical and economic factors that must be evaluated and included in a consideration of optimum product acceptance strategies, and will illustrate their interactions with a simple cost model that will be helpful to measurement specialists and product managers who must make decisions about the acquisition and application of measurement resources.

G5: Healthcare Metrology
Ballroom G
Sharon Nicholas (Chair), *NSWC Corona, USA*

10:45 AM

Healthcare Metrology: An Industry Synopsis and Forward Paths
Marcus McNeely, *Blue Mountain Quality Resources, USA*
Cesar Bautista, *Genzyme Corporation, USA*

This Panel overviews the results of a Healthcare Metrology industry survey, over viewing current practices, concerns, interpretation of uncertainty budgeting, traceability, interval analyses, metrological standards, etc. Metrology in the Healthcare Industry is often approached as a maintenance-concentric entity with little return on investment, and little understanding of

its necessary body of knowledge or potential. This paper explores the current perceptions of healthcare metrology, and discusses existing tools and approaches to allow for greater transparency of our true value to the overall business operation. The format will continue as an open forum in which the panellists will first present a short opening statement about the survey results, the issues they face with respect to their metrology communities, and how they are addressing those issues. The panel will then respond to audience questions and comments. As always, please come to this session to ask questions, raise issues and share your experiences from an industrial perspective. All are welcome! DISCLAIMER: The discussion at this panel session should not be construed to represent the current policy of the companies represented by the panellists, not does it portray the corporate directives or opinions within the panellist's parent companies.

H5: Quality
Ballroom H
Toni Reilley (Chair), *NAVAIR, USA*

10:45 AM

ISO 10012 Beyond the Cal Lab
Bill McCullough, *CSC, USA*

This paper presents an overview of ISO 10012 and that standard's approach to measurement systems as used outside of the calibration laboratory. While rooted in time proven metrological principles, 10012 extends those principles to whatever and wherever quantitative measurement are made. While my previous 10012 paper was directed to calibration usage of the standard, this paper takes the standards and its metrological principles to the production floor and other test uses. ISO 10012 provides guidance and tools to help fulfill customers' requirements that product conform to determined requirements and provides producer opportunities for improvement in the measurement process.

11:15 AM

A Navy Metrology Engineering Quality Management System
Jeff Porter, *US Navy, USA*

This paper details recent initiatives taken at NSWC Corona to improve the quality of products and services provided to the Navy Metrology and Calibration Program. Application of concepts in the Navy Performance Excellence Guidebook (Baldrige based), the NSWC Corona Strategic Plan, 2007 -2010, ISO 9001-2008 and Z540.3 are described. Progress described here will focus on the 'key processes' of Instrument Calibration Procedure development, Calibration Interval maintenance, Calibration Standards development, Calibration Requirements Analysis, and Metrology Product distribution.

2:00 PM - 3:30 PM

A6: Statistical Processes Panel
Ballroom A
Ding Huang (Chair), *US Navy, USA*

2:00 PM

Panel Discussion: Reliability Target by End Use Perspective
Ding Huang, *US Navy, USA*
Steven Dwyer, *NSWC Corona, USA*
Mark Kuster, *Pantex Metrology, USA*

In the Metrology and Calibration (METCAL) community, management seeks to optimize costs for determining reliability target. The goal is to trade off consequential cost due to test decision risks and calibration support cost. This Panel facilitates multiple criteria to address reliability target issue. The result will benefit managers in either community of maintenance or centralized reliability management of Metrology.

B6: Flow III
Ballroom B
Greg Miller (Chair), *NAVAIR, USA*

2:00 PM

Anemometer Calibration for Wind Energy Applications
Rachael Coquilla, *Otech Engineering, Inc., USA*

Quality wind measurements are critical in evaluating wind turbine power performance, wind energy site assessments, and wind plant operations monitoring. In a wind turbine power performance evaluation, wind speed readings are matched with corresponding turbine power measurements in order to produce a power curve of a turbine. Power curves are used as a method of presenting the performance of a particular wind turbine model. For site assessment, the distribution of measured wind speed is used to determine the predicted annual energy production, a critical value used in power purchases. Since wind power is proportional to the cube of the wind speed, a slight error in the wind measurement could translate to a much greater error in the predicted wind power, which emphasizes the importance of having accurate wind speed readings. In wind plant operations, wind speed measurements are used to validate the power output of the turbine and are also used for controlling the start-up and shut-down of a turbine. For some large turbines, it is necessary to provide a “kick-start” once atmospheric winds are potential for wind power generation. When the winds are too strong, a rotating turbine becomes a safety hazard, thus requiring a shut-down. To acquire precision and to lower uncertainty in wind data, it is recommended that individually calibrated anemometers be employed. In the wind power industry, the most commonly referred standard is IEC 61400-12-1: “Power Performance Measurements of Electricity Producing Wind Turbines”, originally introduced by MEASNET (the international Measuring Network of Wind Energy Institutes). This particular document provides the steps in conducting the performance evaluation of a wind turbine. It also discusses the procedures in performing a cup anemometer calibration along with the various tests that would evaluate the instrument’s sensitivity to certain terrain and atmospheric conditions. Since IEC 61400-12-1 only defines the calibration method for cup anemometers deployed for wind turbine performance testing, other standards are also referenced for general meteorology applications of both rotating and sonic anemometers. Such standards include: ASTM D 5096-02, “Determining the Performance of a Cup Anemometer or Propeller Anemometer” ISO 17713-1, “Meteorology – Wind Measurements Part 1: Wind Tunnel Test Methods for Rotating Anemometer Performance” ASTM D 6011-96, “Determining the Performance of a Sonic Anemometer/Thermometer” ISO 16622, “Meteorology – Sonic Anemometers/Thermometers – Acceptance Test Methods for Mean Wind Measurements” Calibration of an anemometer relates the raw output from the anemometer under test to a corresponding

measure of a controlled reference wind speed. All of the above standards require that calibrations are to be performed in a controlled uniform-flow wind tunnel. Of the five standards listed above, IEC 61400-12-1 requires that the reference wind speed is to be measured using a Pitot-static tube system and that the uncertainty of this reference wind speed be presented in calibration reports. This paper discusses the anemometer calibration methodology defined in IEC 61400-12-1 combined with recommendations from general meteorology standards. It also includes a detailed uncertainty analysis of the reference wind speed and, for future work, an extended uncertainty analysis that takes into account the uncertainty in the anemometer output signal and in the calibration transfer function.

2:30 PM

Considerations for Calibrating a Laser Doppler Anemometer
Michael Duncan and Joseph Keck, *Oak Ridge National Laboratory, USA*

Laser Doppler Anemometers have long been the device-of-choice for air velocity measurements due to their avoidance of turbulence induced by insertion-method air velocity measurement devices. At first glance, the use of a Laser Doppler Anemometer (LDA) for calibrating air velocity meters appears to be a relatively simple and straightforward process. As is typical in most metrological applications the process becomes much more complex when attempting to use the apparatus to make high-performance, metrology measurements. This paper focuses on the considerations for calibration of a LDA beginning with a discussion why an LDA needs to be calibrated. Other areas of discussion include alignment of the optics, dealing with imperfections in the alignment process, establishing the traceability of measurements from the apparatus and design and development of and experiences with using a calibration apparatus.

C6: ASQ - Certified Calibration Technician Exam - Six Years Later
Ballroom C
Dilip Shah (Chair), *EMC3 Solutions, USA*

2:00 PM

The ASQ Certified Calibration Technician (Cct) Exam – Six Years Later
Dilip Shah, *EMC3 Solutions, USA*

The CCT exam is now over six years old and over 1000 candidates have passed the exam. This session discusses the CCT exam history, CCT body of knowledge, maintaining CCT certification and the future of the exam in a hosted panel discussion with presentations by subject matter experts who have been actively involved in the CCT exam development process. Short presentations by subject matter experts followed by a hosted panel discussion shall provide the audience the opportunity to learn more about the ASQ certification exams and how to get involved in the certification process.

2:30 PM

Third Party Testing Laboratories and Measurement Quality
Robert DeRemer, *CSA International, USA*

The quality of measurements is important in all aspects of manufacturing. In many cases, manufactured products must be tested and certified by an independent third-party laboratory. This paper deals with the importance of measurement quality from the standpoint of an independent third party

testing laboratory. Topics covered will include measurement quality as it pertains to safety testing and performance testing.

F6: Proficiency Testing
Ballroom F
Phillip Banks (Chair), US Navy*, USA*

2:00 PM

Round Robin-Proficiency Test,
A Four Year Effort to Enhance Navair Metrology
Mike Cruz, *Self, USA*
David T. Ruff Sr., *NAVAIR METCAL Program, USA*

Naval Air (NAVAIR) Systems Command successfully instituted a proficiency testing program based on a four year initiative to develop an effective measurement quality monitoring process for NAVAIR calibration laboratories world-wide. The three phased project concluded with a final round robin measurement proficiency series that took 18 months to complete. This final effort included eleven depot level calibration laboratories, using 20 artifacts with 67 measurement points, generating over 6,000 measurements. This paper will include the development and implementation of this process, logistical aspects, uncertainty analysis, results and conclusions of the effort.

2:30 PM

Report of an Interlaboratory Comparison
of High Value Resistance Measurements
Nathan Shattuck, *US Army Primary Standards Laboratory, USA*

This paper will report on an interlaboratory comparison (ILC) of high value resistance measurements (HVRM) in the range of 1 to 100 G?. The ILC was conducted in conjunction with the National Institute of Standards and Technology (NIST), Ohm-Labs, Inc., Measurements International, the Canadian National Research Council (NRC, two laboratories), Sandia National Laboratories, the Air Force Primary Standards Laboratory. This will provide an appraisal of the capabilities and degree of equivalence of the participant laboratories by measuring a Guildline model 6636 resistance standard. The measurements were performed on three of the six internal resistors (1 G?, 10 G?, and 100 G?). This report will provide the results of the ILC which demonstrated proficiency of HVRM operators in the context that they can produce measurement results consistent with other comparable laboratories.

3:00 PM

Sneak Preview of New Standard for Proficiency Testing
Carroll Brickenkamp, Sharrill Dittmann and Ernest Garner,
The Pi Group, Inc., USA

The ballotting for ISO/IEC 17043 "Conformity Assessment -- General Requirements for Proficiency Testing" ended in April of 2009. The resulting new international standard is expected to be published by the end of 2009 or early 2010. This new standard is expected to impose new requirements on proficiency testing providers, and the organizations that depend upon their results, including Assessment Bodies that accredit laboratories, such as the National Voluntary Laboratory Accreditation Program (NVLAP), the American Association of Laboratory Accreditation (A2LA) and others. Because it is a significant modification of the old ISO/IEC Guide 43 on

Proficiency Testing, it is likely that organizations will have a number of years to conform to the new standard. And because it is such a significant modification, no one can afford to ignore the new requirements too long, because it will take proficiency test providers some time to conform, just as it has taken some number of years for measurement and testing laboratories to design and conform to ISO/IEC 17025 for laboratories. So come and get up to speed on this major new standard and its likely effect on you and your measurement organization!

G6: Bio/Pharm/Medical Metrology Committee
Ballroom G
Sharon Nicholas (Chair), *NSWC Corona, USA*

2:00 PM

Overview of Current FDA 483 Citations in the Healthcare Metrology Industry – Presentation and Panel Discussion
Cesar Bautista, *Genzyme Corporation, USA*
Marcus McNeely, *Blue Mountain Quality Resources, USA*

This Panel is an expansion of a well-received annual update within the 151 Healthcare Metrology Committee of current FDA 483 citations received within the regulated Healthcare Metrology industry. A presentation of current FDA Form 483's, resulting from the inspection of Healthcare Metrology organizations, will be followed by a Q&A session hosted by industry professionals having experience in regulatory and internal audits. The Healthcare industry as a whole gauges a sizeable portion of its forward quality scope on the trending of current regulatory inspection. This panel presentation focuses chiefly on 483's cited in Healthcare Metrology, using a broad array of sources available through the US Freedom of Information Act. The format will continue as an open forum after the summarization of current 483's, where the panellists will discuss perceived trends and resulting action plans based upon these trends. The Panel will then respond to audience questions and comments. Please come to this session to ask questions, raise issues and share your inspection experiences from an industrial perspective. All are welcome!
DISCLAIMER: The discussion at this panel session should not be construed to represent the current policy of the companies represented by the panellists, not does it portray the outcome of regulatory inspections that have occurred within the panellist's parent companies.

2:30 PM

Uncertainty Analyses in Healthcare Metrology: A Simplistic Approach to its Application in Field Calibrations for True Traceability
Marcus McNeely, *Blue Mountain Quality Resources, USA*

The incorporation of simple Type A and B model uncertainty analyses in Healthcare Metrology field calibrations is commonly overlooked in favor of 'accuracy' specifications, where accuracy and TARs are often based solely upon 'blind faith' engineering data. Many organisations have ample field data, where most of the work lies, but are uneasy about uncertainty budgeting. This abstract details simplistic approaches to implementing uncertainty analyses in Healthcare Metrology field calibrations to collect meaningful statistical data. This statistical data may in turn segue to the implementation of TUR (Testing Uncertainty Ratios), statistics-based risk and interval analyses.

H6: Metrology Over the Horizon

Ballroom H
Chet Franklin (Chair), *CSC, USA*

This session will take a look at what the future might hold for the calibration business community - lab owners, lab managers, technicians, and oh yea, don't forget the customers. How will test equipment technology, global trade, information technology and new business/economic models affect the appearance and operations of what has been the traditional calibration and testing laboratory; and maybe more specifically those who work in them? Will calibration requirements change? Will procedures change? Of course they will! The question is; how will they change? Will these changes be driven by the economy, by new technology or other factors? Will business processes be implemented that were once not part of laboratory operations? How rapidly will these changes occur? How about factors such as: education, or training, or the retiring of an experienced workforce? For those who remember the appearance of the transistor radio, (1950s) compare that to today's iPod! Now using that occurrence as a model compare the calibration business of thirty years ago to what it might look like in the next ten, or twenty years. Can parallels be drawn? If we can see parallels, how do we establish strategic plans to deal with them?

2:00 PM

Calibration: to Infinity and Beyond
Chet Franklin, *CSC, USA*

It is not a debatable concept that measurement processes, especially calibration processes, are going to be affected by both economic and technological factors which will be global in magnitude. The time is here to analyze the ways in which they will affect the global measurement system as well as the local calibration laboratory. This paper is an attempt to look into the future; To Infinity and beyond, as Buzz Lightyear says. This paper will explore change from the concepts of paradigm shifts to breakthroughs. Both concepts incorporate the question, "What is it that we cannot do today, but if we could do would drastically change our business"? Technology growth is a rapidly accelerating phenomenon. Technology advancements today proceed at twice the rate of a few years ago, and at least at twice the cost. At the same time the business model is changing, seeking shorter Return on Investment periods. All of this is compounded by the loss of expertise through encouraged retirement of our most experienced workers. This paper offers many questions but few, if any, answers.

2:30 PM

US Navy Metrology in 2035
Edward Trovato, *NSWC Corona Division, USA*

An historical retrospective of the trends, initiatives, and other forces that have shaped U.S. Navy Metrology from 2010 to 2035. Specifically digital systems, unmanned vehicles, tactical and strategic changes, policy revisions, next generation acquisition reforms, and projections for the future impacts of these forces upon U.S. Navy metrology.

3:00 PM

Calibration of Embedded Sensors for the Future Navy
Harold Glick, *NSWC, USA*

For the future Navy, calibration is becoming an increasing burden that runs

counter to the Navy's intent to reduce the shipboard workload. However, increased ship embedded sensorization is seen as the solution to monitoring of shipboard functions and to providing the accurate data needed to support the mathematical algorithms for Condition Based Maintenance (CBM) and Prognostic Health Maintenance (PHM). This paper will present the background and issues for Design for Built-In Calibration (BIC) for MicroElectroMechanical System (MEMS) sensor calibration methods being developed, which will reduce the sensor calibration requirements to miniscule levels.

NOTE: Certain characters used in formulae, etc. don't have web-friendly counterparts. You may find question marks, 'blank' spaces and unusual markings scattered through some abstracts, because of the difficulty in translating these characters to web-readable text.
