Technical Program Abstracts

At the Forefront of Advanced Technology: A Spectrum of Metrology

MONDAY, August 18, 2003
9:00 AM - 10:00 AM Keynote Speaker, Keynote
Steve Stahley
President, NCSL International
Arden L. Bement, Jr.,
National Institute of Standards and Technology

Whether it's the routine calibration of a conventional surveyor's tape via laser interferometry, or the hyper-precise characterization of an electronic oscillator frequency using reference signals derived from global positioning system satellites, the measurement services that enable the nation's vast technological infrastructure are a sustaining, critical national enterprise that must be continually assessed and evaluated in order to ensure that all important metrology needs are met at an appropriate level and in a timely fashion.

At the National Institute of Standards and Technology (NIST), as with other organizations that provide measurement service to industry, scientists, engineers, technicians, and support personnel are vigorously engaged in the business of developing and providing a vast array of measurement services. These measurement services address needs ranging from present industrial and scientific measurement requirements, including mature services dealing, for example, with the measurement of mechanical and thermodynamic parameters, to the development of state-of-the-art, cutting-edge instrumentation addressing the measurement of fundamental physical characteristics from which will be born the next generation of "conventional" measurement services.

Regardless of its specific nature and application, however, measurement science is the driving force that enables the advancement of science and technology. Indeed, technological progress can proceed only as fast as measurement science permits, whether it be the development of a novel certified reference material that supports a new capability within an otherwise established industrial process, or the development of a new calibration process that permits certification of instruments operating on the outer fringe of what is (presently) technically possible. As described in this talk, NIST, as the Nation's metrology institute, is firmly committed to meeting emerging measurement service needs of government, industry, and academia.

The Basics and Benefits of ASQ Certification

MONDAY, August 18, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 1, 1A
Certified Calibration Technician
Sally Harthum,
American Society for Quality (ASQ)

Metrology Training and Certification

MONDAY, August 18, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 1, 1A
Certified Calibration Technician
Dilip Shah,
E = mc3 Solutions

Training is an important Human Resource component of any organization, specially those seeking ISO 17025 laboratory accreditation. Few formal certification programs exist that test the baseline knowledge of a currently employed Metrologist or a potential hire. The American Society for Quality (ASQ) operates the largest and most successful program in the world for certifying professionals in the quality and related fields. The Certified Calibration Technician (CCT) program approved by the ASQ board of directors in May 2002 establishes a peer recognized benchmark certification program for metrology professionals.

ASQ's Certified Calibration Technician Body of Knowledge

MONDAY, August 18, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 1, 1A
Certified Calibration Technician
Chris Grachanen,
Hewlett-Packard Co.

The American Society for Quality (ASQ) has created a peer recognition certification program for calibration technicians. The foundation of Certified Calibration Technician (CCT) program is the CCT exam. The CCT exam is designed to test one's comprehension regarding a body of knowledge deemed appropriate for mid-level calibration practitioners. The CCT body of knowledge embodies the contributions of hundreds of calibration practitioners from academia, governmental agencies and small and large industries. How the CCT body of knowledge was developed and details of its final content will be discussed.

TBD

MONDAY, August 18, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 1, 1A
Certified Calibration Technician

Frost Point Intercomparison with NIST within the Range –90 to –10 C
MONDAY, August 18, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 1, 1B
Humidity I
Bob Hardy,
RH Systems

Intercomparisons were recently performed at NIST involving a Thunder Scientific Model 3900 Low Humidity Generator, two RH Systems 373LX Chilled Mirror Hygrometers, and the NIST Low Frost Point Generator (LFPG). As with many unique tests, this one was not without its problems. Some of the difficulties that were encountered were solved and corrected during the course of the testing. Those difficulties ranged from unexpected water vapor permeation into the process gas stream, to serious equipment malfunction. In addition to the problems that could be solved, there were also some that could not. It appears that one problem is likely due to equipment design and choice of components. Another difficulty encountered was a single unexplained short-term, several hour-long drift then subsequent recovery of one of the four test instruments. While the ultimate and final goal of this week-long testing was to provide direct traceability to an equipment owner, the focus here is to detail the setup and methods employed, the testing protocol, the encountered difficulties and their practical resolutions, and finally the analysis of the electronically gathered results.

Cavity Ring-Down Spectroscopy For Trace Gas Detection
MONDAY, August 18, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 1, 1B
Humidity I
Wen-Bin Yan,
Tiger Optics, LLC
Cavity Ring-Down Spectroscopy (CRDS) is laser absorption technique with great sensitivity for trace gas detection. In CRDS, the decay rate of light coupled into the high-finesse optical resonator determines the sample's concentration. CRDS obeys Beer's Law and provides an absolute and highly accurate concentration determination. The effective pathlength of a CRDS device is nearly 105 larger than the physical size of the unit's cell due to the use of highly reflective dielectric mirrors. Current practical CRDS uses continuous wave (CW), single mode, near-infrared diode lasers that are easily available today thanks to the advancement in telecommunications industry. The near-IR region contains rich vibrational overtone and forbidden electronic transitions of many atmospherically important species. Fast trace gas impurity measurement of critical molecules, such as H2O, CO, NH3, HF, HCl, CH4, and C2H2, is now possible with CRDS detection in seconds. After several years of research and development, we have introduced the first commercial product based on CRDS, capable of measuring trace moisture concentration from sub-ppb to ppm levels. Recently we introduced another CRDS device that measures trace methane with a lower detection limit of less than 2 ppb. This paper will describe the principle of operation of CRDS, and discuss the performance of current commercial CRDS instrument as well as potential applications and future development of the technology.

Solving Humidity Calibration Challenges In Today's Metrology Lab
MONDAY, August 18, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 1, 1B
Humidity I
Jeff Bennewitz,
Thunder Scientific Corporation
Two-pressure humidity calibration technology has long been the recognized standard for on site instrumentation calibration, test and verification. This type of calibration is a fundamental technology traceable to NIST. But, how does it benefit you as a metrologist when facing daily real world challenges in your lab? How well do you really understand what makes this type of equipment work? How do you validate the accuracy of the calibration system itself; i.e. calibrate the calibration system? What advances have been developed to make portable calibration equipment more "user friendly" in the last decade?
Designed to be a practical guide, this paper will answer these questions and others in a direct, "problem-solution" manner. It will detail how this technology offers simple in-house calibration to the most rigid standards and will point out some example applications across diverse industries. To round out the subject, the paper will briefly cover the history of the two-pressure humidity generation principle and also explain the theory of operation of the latest in portable two-pressure humidity generator equipment in use today by calibration laboratories, worldwide.</p>

Constant-Pressure Provers: From the Standards Lab to the Shop Floor
MONDAY, August 18, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 1, 1C
Flow I
Harvey Padden,
BIOS International Corporation
Field-rugged primary gas flow measurement devices have long been needed for diverse applications, such as calibration of environmental air samplers at 1% accuracy and manufacture or field service of mass flow meters and controllers at 0.25% accuracy. Constant-pressure provers have a long history as primary flow calibrators. At the national lab level, they reach standardized accuracies of 0.1% in the form of bell and piston provers. However, such systems are historically large, expensive, and immobile, requiring extensive user training. The challenge has been to evolve such instruments into a form practical for field use. Bell provers were evolved into wet test meters, where compartments in hollow immersed drums are sequentially filled, rotating the drum. These devices are somewhat portable and user-friendly. Piston provers originally took the form of soap films that blocked a calibrated burette, with their transit time measured manually. These were later partially automated for lab use, and then miniaturized for applications at the 1% volumetric level, such as calibration of environmental samplers. Laboratory piston provers evolved into automated systems with solid, mercury-sealed pistons. These are still the most common primary flow calibrator at the national lab level. Our challenge was to migrate the mercury-sealed technology into devices suitable for field use without seriously compromising accuracy. To miniaturize the instrument, we needed high piston velocities and small measurement distances. Sealing the piston using the viscosity of the gas under test was a critical innovation. The required close clearances are very difficult to achieve. However, they permit minimal piston rocking, allowing the piston to be directly detected with great accuracy. The small cylinder diameters allow simple LED/photodiode detectors. The small size also minimizes temperature variations within the cylinder, enhancing standardization

accuracy. Operation can be totally automated. We will describe the design of our automatic 0.2% portable dry piston provers from this perspective. As a necessary accompaniment, we will also present a comprehensive uncertainty analysis and the results of comparative testing to date.

An Improved Method for Calibrating Hydrazine Monitors in the United States Air Force Inventory
MONDAY, August 18, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 1, 1C
Flow I
Kofi Korsah,
Oak Ridge National Laboratory
This paper discusses an improved method for calibrating MDA 7100 hydrazine monitors in the United States Air Force inventory. The calibration system consists of a Kintek 491 reference gas generation system, a humidifier/mixer system which combines the dry reference hydrazine gas with humidified diluent or carrier gas to generate the required humidified reference for calibrations, and a gas sampling interface. The Kintek reference gas generation system itself is calibrated using an ORNL-constructed coulometric titration system to verify the hydrazine concentration of the sample atmosphere in the interface module. The Kintek reference gas is then used to calibrate the hydrazine monitors. Thus, coulometric titration is only used to periodically assess the performance of the Kintek reference gas generation system, and is not required for hydrazine monitor calibrations. One advantage of using coulometric titration for verifying the concentration of the reference gas is that it is a primary standard (if used for simple solutions), thereby guaranteeing, in principle, that measurements will be traceable to SI units (i.e., to the mole). The effect of humidity of the reference gas was characterized by using the results of concentrations determined by coulometric titration to develop a humidity correction graph for the Kintek 491 reference gas generation system. Using this calibration method, calibration uncertainty has been reduced by 50% compared to the current method used to calibrate hydrazine monitors in the Air Force inventory and calibration time has also been reduced by more than 20%.

The Challenges of Measuring and Calibrating Micro-Flow Devices & Leak Testing Instruments
MONDAY, August 18, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 1, 1C
Flow I
Hemi Sagi,
ATC, Inc
The demand for micro-gas flow measurement and calibration is rapidly increasing. Increasing demands for tighter leak flow testing, micro-nozzles and MEMS flow measurements have lead to rapid improvements in the micro-gas flow measurement and calibration. Stringent environmental specifications in the automotive and refrigeration industries, as well as increasing demands for non-destructive sterility testing in the medical industry resulted in tighter leak test specifications. The tighter the requirements are, the bigger the confusion and measurement misconceptions. The paper will describe some of those issues. Newly developed sensors and standards for micro-gas flow measurements will be presented. The measurement principals of these sensors in the slip flow regime and transition / molecular flow regime will be described, including typical measurement uncertainties. These sensors are capable of measuring micro-gas flow as small as 1x10 std. cc/sec. Calibration set up will be suggested to help reduce common errors in calibrating leak test instruments, such as helium mass spectrometers and pressure decay systems.

The Technical Challenges for EUROMET
MONDAY, August 18, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 1, 1D
Regional Metrology Organization Strategies
Paul Hetherington,
EUROMET
Enterprise Ireland

SIM, The Inter-American system of Metrology: Myth or Reality
MONDAY, August 18, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 1, 1D
Regional Metrology Organization Strategies
Felipe Urresta,
SIM
SIM, the Inter American System of Metrology, is the single largest metrological Organization in the Americas. SIM objectives are: establish national and regional measurement systems, establish a hierarchy of the national standards of each country and their linkage with other regional and international standards, training of technical and scientific personnel, collect and distribute technical and scientific information and documentation, link with BIPM and other international metrology organizations. The fulfillment of these objectives is a critical issue if all of these countries want to participate with a equal foot in the 2005 Free Trade Area of the Americas (FTAA). This paper discusses the major results of implementing this metrological program in three SIM regions. Detailed results obtained through several metrics of the metrological situation in Central America, Caribbean and Andean countries will be presented and also discuss the immediate future of SIM.

Metrology In The European Research Area: The Mera Project
MONDAY, August 18, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 1, 1D
Regional Metrology Organization Strategies
Andy Henson,
National Physical Laboratory
In Europe, as in the USA, innovation and development in virtually all scientific and technological fields depends on the ability to make leading edge measurements. The EUROMET strategy identifies the need to meet new metrological demands from emerging areas like nanotechnology and

biotechnology whilst still supporting traditional areas of work. However the ability to deliver state-of-the-art measurement capability with the confidence necessary to underpin research, innovation, development and trade, is dependent on the metrology infrastructure being able to meet ever-growing demands with resources that are not increasing at a comparable rate. Increasing the impact from the available resources is therefore essential for the future of European metrology and the wide range of users that benefit from it. The MERA project (partly funded by the European Commission) supports the EUROMET strategy to overcome the fragmentation in European metrology and is developing the plans to optimise and increase significantly the impact of European metrology research and exploitation by strengthening the coherence of national and EU funded activities. The project involves an evaluation of the current collaboration, the development of common metrics and decision-aiding tools to unlock the potential for increasing collaboration and analysis of national metrology priorities, identifying those best addressed collaboratively. Stakeholders will be consulted and the special circumstances of the Newly Associated States considered, ensuring appropriate balance. Scenarios for greater collaboration in research, the shared use of facilities and increased mobility of researchers, as well as more effective exploitation of research are all being explored.

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100 GHz Through-Line Sampler System with Sampling Rates in Excess of 10 Gsamples/second

MONDAY, August 18, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 1, 1E
Ultrafast Measurements
Kipp Schoen,
Picosecond Pulse Labs, Inc

A through-line electrical sampler with 100 GHz of bandwidth, sampling rates in excess of 10 Gsamples/s, and a linear dynamic range of 2 Vpp has been fabricated and characterized. GaAs Schottky diodes are used for the sampling diodes and in the Non-Linear-Transmission-Lines (NLTL) that provide precision time delay and generate the high-speed LO strobe. The sampler was characterized in a measurement system that combines a 0.5 ps FWHM, 25 MHz repetition rate pulse laser source, an Optical-Electrical step generator, and several other components to generate synchronized RF and LO strobe inputs. The IF output of the sampler is connected to a unity gain buffer amplifier and digitized with an A/D converter.
Linearization of the timebase is performed in software and applied to the voltage controlling the precision delay line via a D/A converter. The typical measured falltime (90% to 10%) of this system is 4.3 ps and includes the effects of the stimulus, sampler, and total system jitter. Characterization of the system jitter in a 70 kHz IF bandwidth system yielded jitter below 100 fsec RMS. Assuming an equal contribution to the fall time from the stimulus and sampler with a negligible jitter contribution, a fall time of 3 ps is estimated for the sampler. This corresponds to a –3 dB bandwidth of 113 GHz. Although the sample rate for the system evaluation was 25 MHz, the LO drive and NLTL strobe generation are capable of sample rates in excess of 10 GHz.

Ultrafast optical techniques for the characterization of microwave components and broadband oscilloscopes

MONDAY, August 18, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 1, 1E
Ultrafast Measurements
Uwe Siegner,
Physikalisch-Technische Bundesanstalt

The transfer characteristics of high-frequency electronic components can be determined from the analysis of ultrashort voltage pulses before and after propagation over the device under test. This time-domain approach complements frequency-domain measurements with network analyzers and has the potential to extend the accessible spectral range to THz frequencies. The time-domain method relies on the generation of ultrashort voltage pulses with planar photoconductive switches excited by femtosecond laser pulses. Optical sampling methods, such as electro-optic sampling, are used to measure voltage pulse shapes. Usually, these techniques are applied to planar structures. In this paper, we focus on the characterization of non-planar structures, such as microwave probes. It will be shown that the complex transfer function of microwave probes can be determined with ultrashort pulses and optical sampling techniques up to 300 GHz. Moreover, reflection and transmission coefficients of line discontinuities can be determined by time-domain measurements. The microwave probes allow for the transfer of ultrashort electrical pulses from coplanar structures to coaxial connectors. We discuss how the pulse shape at the coaxial connector can be determined. From the analysis a pulse width of 4 ps is obtained in our experiments. The generation of ultrashort pulses at coaxial connectors and reliable analysis of these pulses are prerequisites for a trustworthy measurement of the transfer characteristics of devices with coaxial input, such as broadband sampling oscilloscopes. We will present the transfer function, impulse response, and step response of a 50 GHz oscillocope. The risetime and its uncertainty have been determined from this data.

Accurate Measurements of the Response of High-Speed Pulse Generators and Samplers

MONDAY, August 18, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 1, 1E
Ultrafast Measurements
N. G. Paulter,
Electricity Division, National Institute of Standards and Technology

The National Institute of Standards and Technology (NIST) provides a service for measuring the values of parameters associated with the step response of high-speed samplers and the output signals of high-speed pulse generators. This measurement service is used by the military and aerospace, telecommunications, test equipment, and computer industries to satisfy traceability requirements for the waveform parameters of transition duration (also known as rise time and/or fall time), waveform amplitude, overshoot, and undershoot (also known as preshoot). The term “high-speed” refers to a continually changing definition, and therein lies much of the challenge in developing measurement techniques. For our purpose, “high-speed” means the lower limit of the range of output pulse and step response transition durations for which we are willing to provide an uncertainty estimate. Presently, the service will provide measurements of pulses or step responses with transition durations ³ 7 ps. The primary challenges in developing a system for measuring these waveform parameters is in developing an appropriate uncertainty analysis, in obtaining accurate estimates of the sampler step response when measuring high-speed pulse generators, and in obtaining accurate estimates of a reference pulse when measuring step responses of high-speed samplers. In this paper, we describe our measurement system, the steps used to calibrate the different components of the system, and the uncertainty analysis.

TBD
MONDAY, August 18, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 2, 2A
Metrology in the Marines

TBD
MONDAY, August 18, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 2, 2A
Metrology in the Marines

TBD
MONDAY, August 18, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 2, 2A
Metrology in the Marines

Pratical Implementation of ISO/IEC 17025 in an Accredited Humidity Calibration Laboratory
MONDAY, August 18, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 2, 2B
Humidity II
Tomás Vicente,
Instituto Nacional de Técnica Aeroespacial
Over the last decade it has been apparent that the demand for calibration of humidity instruments has increased enormously as quality management systems have been implemented throughout industry as companies sought certification of systems and products. As the initially primitive quality systems, in many instances were conceived by external consultants, reach maturity and the user gains increasing awareness, he is no longer satisfied with the previously accepted common industrial implementation of the concept of traceability, once satisfied by "having a calibrated instrument". In this sense the user is now aware of the benefits of using the services of an accredited calibration laboratory, where the technical competence of the Laboratory, within its scope of accreditation and best measurement capability, has been evaluated to demonstrate dissemination of the imported traceability through to the final product or service. The implementation of the new international standard, ISO/IEC 17025, sets out the general requirements for the competence of testing and calibration laboratories. The practical implementation of the technical and other requirements aimed at satisfying the needs of the customer are discussed in the specific context of a laboratory seeking accreditation to the new international standard. Particular emphasis is placed on the new requirements that were not necessarily met by previous accreditations to EN 45001.

Improving Humidity Traceability and Accuracy in Industrial Calibration Laboratory
MONDAY, August 18, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 2, 2B
Humidity II
Mr. Antero Pitkäkoski
Measurement Standards Laboratory
At Vaisala the humidity traceability has traditionally been maintained by means of calibrated Dew-Point Meters and Saturated Salt Solutions. Both methods are time consuming and the accuracy reached does not completely fulfill the modern requirements. An alternative method for maintaining traceability would be the use of Humidity Generator as the reference instrument instead of the Dew-Point Meter. Unfortunately the performance of the commercially available generators has not been good enough to accept them to be used as Primary Standards. At Vaisala we made a study for one humidity generator in order to improve the performance of the generator and then validated it to be used as Primary Standard for humidity. In this work we first investicated the operation of the generator, improved the performance with several modifications and finally validated it to be used as Primary Humidity Standard. Several other laboratories have recently made studies for similar generators and made improvements for the performance of their generators, we learned from the papers published and added our own knowledge to the existing information. As result of this work we introduce a humidity generator capable of realizing dew-point temperature for calibration of our in-house Dew-Point Meters to be used as working standards for dew-point and relative humidity calibrations.

Humidity – “How Hard Could It Be?”
MONDAY, August 18, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 2, 2B
Humidity II
Kevin Bull,
Veriteq Instruments Inc.
Relative humidity (RH) measurement and calibration are growing disciplines requiring specialized knowledge and systems. Gaining that knowledge and determining which system is best is a challenge facing many companies who wish to save time and money by bringing their processes in-house. Salesmen and marketing materials can help, but a practical review of systems by people who have actually used the equipment may be far more useful. Veriteq, a manufacturer of compact humidity data loggers, has firsthand experience with the difficulties associated with RH sensors and calibration.
Beginning with a dream of an “ideal” system (accurate, inexpensive, quick, easy to operate, and highly reliable), this presentation tells the story of the Veriteq’s challenges and experiences with humidity measurement and various calibration systems. The lessons learned and the obstacles overcome. Humidity may seem simple at first, but in reality there are many factors at play, and many, less than obvious, error sources to deal with. In short, this presentation offers a practical perspective on some of the intricacies of humidity sensors and the challenges involved in achieving accurate sensor calibration.

1/f Noise Floor of Solid-State Voltage Standards
MONDAY, August 18, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 2, 2C
DC Electrical
Yi-hua Tang,
National Institute of Standards and Technology
It is often important to characterize the noise performance of solid-state voltage standards (Zener standards). This cannot be adequately specified without taking into account the 1/f nature of Zener noise. In contrast to white noise, 1/f noise indicates a rather strong correlation among successive measurements. In the latter case, the statistical analysis usually applied to electrical measurements is incorrect because it ignores correlations. The Allan variance and power spectral density take into account correlation in serial measurements and provide powerful tools to investigate noise. Zener measurements are ultimately limited in precision by 1/f noise that is conveniently specified by the constant value, termed the 1/f noise floor, taken on by the Allan variance.
This paper discusses two methods to measure the noise floor of Zener standards using either a pair of Zener standards or using a Josephson voltage standard to measure Zeners individually. Results for one type of Zener standard are consistent with early work at the BIPM. Noise floors for another type of Zener are presented for the first time. The results can be used to design experiments such as interlaboratory comparisons of Josephson voltage standards using Zener traveling standards or routine Zener measurements in a calibration laboratory.

Using High Resistance Meters Effectively
MONDAY, August 18, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 2, 2C
DC Electrical
Lawrence Heal,
Guildline Instruments Limited
You have a high resistance meter (typical measurement range of 1 megaohm to 100 petaohm), but want to obtain more repeatable resistance measurements from it. This paper describes new developments in the features of high resistance meters that improve the meter's measurement uncertainty. However, to make effective use of such a meter, the operator must follow stringent measurement procedures to minimize total measurement uncertainty. Appropriate measurement techniques are presented to characterize the performance of the meter and to use the meter effectively to perform resistance measurements or calibrations.

Proficiency Testing Program for DC Voltage
MONDAY, August 18, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 2, 2C
DC Electrical
Kowsalya Varadan,
Electronics Test & Development Centre
The testing and calibration laboratories complying to the new International standard ISO/IEC 17025-'General Requirements for the Competence of Testing & Calibration Laboratories', are now required to prove their competence through their satisfactory performance in the proficiency testing (PT) programs for accreditation by National/International accreditation body. These programs are normally organized by the accreditation body to monitor the performance of the laboratory and to ensure that the measurements carried out by the laboratories for the same parameter of a physical quantity have close agreement. Satisfactory performance in the PT program provides an objective evidence of traceability to a common reference, and builds up customers' confidence in the services provided by the laboratories. Thus satisfactory performance in the PT program is vital not only for accreditation of the laboratory but also for existence in the competitive environment.
For this purpose the National Accreditation Board for Testing & Calibration(NABL) has identified few of the accredited laboratories as the nodal agency for organizing these programs. For the parameter AC/DC voltage, the High Precision Calibration Laboratory at Electronics Test & Development Centre Bangalore has been identified as the nodal agency. The program is recognized & funded by NABL; 24 laboratories have participated in the program. The program included 5 test points for DC voltage and 9 test points for AC voltage. This paper covers the performance of the laboratories for only the DC voltage part of the program. The details of the process followed by the nodal laboratory in organizing the program, analysis of the results of the participating lab, and evaluation of their performance form the subject matter of this paper.

Accreditation Standards: Recent Developments
MONDAY, August 18, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 2, 2D
Policy Issues in Accreditation
Peter S. Unger,
American Association for Laboratory Accreditation (A2LA)
The process of determining whether products, processes, systems or people meet specified requirements has been given the name, conformity assessment. The term covers such activities as inspection, testing and certification. Certification should not be confused with accreditation. Accreditation is defined as a procedure by which an authoritative body gives formal recognition that a body or person is competent to carry out specific tasks. Certification is defined as a procedure by which a third party gives written assurance that a product, process, or service conforms to specified requirements. Accreditation bodies, in effect, supervise the proper implementation of standards by the conformity assessment bodies (e.g., certification bodies and laboratories) and identify their competence to perform specific tasks, such as testing, measurement, calibration, inspection and certification for given methods and product areas. The Committee on Conformity Assessment (CASCO) of the International Organization for Standardization (ISO) provides many of the accreditation and conformity assessment standards on this subject. The laboratory accreditation standards have recently been given much attention. ISO/IEC 17025:1999, "General requirements for the competence of calibration and testing laboratories," is being amended to align with the principles of ISO 9001:2000. ISO/IEC 17011, General requirements for bodies providing accreditation of conformity assessment bodies" is replacing ISO/IEC Guide 58, general requirements for laboratory accreditation bodies. This paper provides an overview of recent activities of ISO CASCO, particularly the changes affecting the requirements, principles and practices of laboratory accreditation.

Collaboration between BIPM and ILAC: An Update
MONDAY, August 18, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 2, 2D
Policy Issues in Accreditation
Andrew Wallard,
BIPM

TBD
MONDAY, August 18, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 2, 2D
Policy Issues in Accreditation

Anatomy of an International Peer Evaluation
MONDAY, August 18, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 2, 2D
Policy Issues in Accreditation
Ramona J. Saar,
American Association for Laboratory Accreditation

The International Laboratory Accreditation Cooperation (ILAC) was established in 1978 and has since emerged as the foremost authority on laboratory accreditation issues. ILAC members include laboratory accreditation bodies throughout the world and other interested stakeholders from governments, private organizations, and laboratories. ILAC focuses on the development of harmonized procedures for laboratory accreditation activities and works to bring to the attention of the international community the importance of laboratory accreditation as a tool to facilitate trade, and in particular the acceptance of data from accredited laboratories to reduce or eliminate re-testing and re-calibration. ILAC's greatest achievement in recent history was the October 2000 signing of the first international mutual recognition arrangement (MRA) in laboratory accreditation. Forty-four accreditation bodies throughout the world signed this arrangement and by doing so, agreed to formally recognize and promote the equivalency of the test and calibration reports issued by laboratories accredited by the other signatories. This created the first comprehensive global network of accredited laboratories. Prior to then, two regional networks existed through the European Cooperation for Laboratory Accreditation (EA) MRA and the Asia Pacific Laboratory Accreditation Cooperation (APLAC) MRA. The magnitude of the commitment signatories make is remarkable. By signing the MRA, each signatory is in effect agreeing that organizations that could be potential competitors in the laboratory accreditation market (other signatories) are doing their job at least as good as the signatory accreditation body is doing it. How can these organizations have such confidence in the other signatory accreditation bodies? The answer lies in the peer evaluation process that accreditation bodies are subjected to in order to become eligible for signatory status. The process includes a rigorous weeklong evaluation of the accreditation body's operations, its laboratories, and its assessors by a team of international accreditation experts and a critical review of the evaluation results by established committees before a decision can be rendered. This paper will explore the peer evaluation process as recently experienced by the American Association for Laboratory Accreditation during its March 2002 multi-regional international peer re-evaluation for renewal as a signatory to the MRAs for ILAC, EA, APLAC, and a new regional cooperation, the Inter-American Accreditation Cooperation (IAAC).

Biotech SRMs Designed for the Rapidly Evolving Forensic DNA Human Identity Community
MONDAY, August 18, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 2, 2E
Biotechnology/SRMs
Margaret Kline,
National Institute of Standards and Technology

The National Institute of Standards and Technology (NIST), issued its first Biotech related Standard Reference Material (SRM) for the forensic DNA human identity community in 1992. SRM 2390, DNA Profiling Standard is for Restriction Fragment Length Polymorphism (RFLP) analysis. In 1995 SRM 2391, PCR-based DNA Profiling Standard, was released. SRM 2391 components were certified for the Variable Number of Tandem Repeats (VNTR) genetic Locus D1S80 (pMCT118), with additional information values for four “new” Short Tandem Repeat (STR) genetic loci, and commercially available HLA-DQ alpha dot blot and “polymarker” systems. By mid 1998 an additional twelve STR loci were certified. In 2000 SRM 2391a (renewal of 2391) had certified value assignment for 21 STR loci. SRM 2391b has added one additional STR.
Mitochondrial DNA sequencing became part of the Forensic community’s arsenal and in late 1999 SRM 2392 Mitochondrial DNA Sequencing Standard (human) was issued. SRM 2392 included the entire sequence of the mitchondrial DNA for three cell lines. This SRM is being updated with a fourth cell line favored by the forensic community.
As the advances in technology are applied to human identification we have designed newer SRMs to assist in the quality assurance programs for the forensic communities, they include: 1) SRM 2395 Y chromosome microsatellites, 2) 2372 Human DNA Quantitation Standard. We will focus on the certification of SRM 2395 for Y-STRs and Y-single nucleotide polymorphisms (Y-SNPs) as well as the need for SRM 2372 human DNA quantitation standard currently in progress.

The Standardization of Molecular Diagnostic Assays in a Rapidly Changing Technological Era
MONDAY, August 18, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 2, 2E
Biotechnology/SRMs
Catherine O’Connell,
National Institute of Standards and Technology

An expansion of the NIST Biotech Standard Reference Material (SRM) program from the initial needs identified by the forensic DNA community has resulted in a measurement and standardization program for molecular diagnostic assays and the underlying technologies used for these assays. In developing this program, NIST has sought input from the clinical laboratories requesting reference materials, governmental entities responsible for ensuring the quality of such assays, and industrial laboratories developing assay platforms and specific genetic tests. The NIST program focuses on the

sensitivity and specificity of molecular genetic tests that measure fixed mutations resulting in qualitative, quantitative or size variation in human DNA. The development of two reference materials will be discussed: TP53 and Fragile X.
The TP53 measurement program is a prototype for measuring qualitative changes in DNA. A panel of clones, each containing a specific mutation in the human TP53 gene, has been developed and validated using three scanning technologies for detecting mutations, as well as direct sequencing. These materials will be available for use by both research and clinical communities.
The fragile X measurements have focused on the amplification and separation technologies commonly used for detecting normal, pre-mutation, and fully mutated fragile X alleles. Coriell cell lines from fragile X families were used for these studies. As fragile X syndrome is associated with the amplification of a trinucleotide repeat element (CGG), this program is a prototype for other molecular genetic tests requiring size discrimination of repeat elements, including; Huntington's disease, Myotonic dystrophy, Friedrich's ataxia, and the Spinocerebellar ataxias.

Measurements and Standards for Biotech Crops (aka Genetically Modified Organisms) – A Different Kind of Challenge
MONDAY, August 18, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 2, 2E
Biotechnology/SRMs
Marcia J. Holden,
National Institute of Standards and Technology
US farmers have, in large numbers, replaced some of their traditional commodity crops with genetically modified varieties. The most commonly grown biotech crops or GMOs include corn, soybean and cotton. To genetically modify a plant, specific genes are incorporated into the genome along with control DNA sequences. This very specific alteration is designed to impart a new property to the plant, such as herbicide resistance or insect resistance. International trade requirements are central to the need for measurement technologies and standards in this area. What is needed are reliable ways to identify the precise genetic alteration or addition and secondly to quantify the amount of the GMO present in a batch of seed or processed food. The two approaches are detection of the engineered DNA or the protein product of the gene that DNA represents. We focus on DNA detection since measurements of protein content are unsuitable for quantification requirements. The current state of the art for DNA detection is copying or amplifying the DNA using the Polymerase Chain Reaction (PCR). With carefully designed testing protocols and suitable material to assay, accurate and reliable detection is possible even when the GMO constitutes less than 1% of the total content on a mass basis. There are lots of pitfalls, however, and the issues increase in magnitude when quantification is attempted using Real Time quantitative PCR. Defining the requirements for accurate measurements and types of standard reference materials required will be addressed in this presentation.

Transformation in Measurement Requirements
TUESDAY, August 19, 2003
8:30 AM - 10:00 AM - PARALLEL SESSIONS - SESSION 3, 3A
National Measurement Requirements
Jeff Walden and Les Peer,
Naval Surface Warfare Center (NSWC)
Technological Transformation, i.e. changing technology, is of concern to everyone working in technology related fields. As new technology is incorporated into the market place measurement science is challenged to meet these changes with new, or improved, measurement methods, equipment and support structure. New measurement requirements need to be identified as early as possible in the development and deployment cycle of new technologies in order that the products can be measured to ensure compliance with requirements. Part of the NCSLI Mission statement is, "to advance technical and managerial excellence in the field of Metrology". This Technical Session is intended to contribute to that mission. This will be a combination panel and workshop, hosted jointly by two NCSLI Committees, the U.S. MRC (131) and the Canadian MRC (132), for the purpose of exploring both present and future measurement requirements. Two results are expected: the first being the identification of definable present, and future measurement needs; and the second being improvements in the process for the continuous assessment and analysis of stated measurement requirements.
The workshop process will begin with a short, one-page questionnaire on measurement requirements that will be inserted with the Symposium and Workshop attendee handouts. Opening announcements will include a brief reminder to attendees to complete the form and place it in the collection box in the registration area. One of the door prizes drawn at the end of the symposium will be drawn from the names on these questionnaires. The panel activities will be summarized during the closing session of the conference. The first part of the Technical Session will be a presentation by panel members regarding measurement survey processes, which they use to identify present or projected needs. This will be followed by a question and answer period, based on the panel member's presentations. The second part will be a workshop environment intended to encourage attendees to participate in the discussion of measurement requirements, and the challenges presented by emerging technology that will be driving changes in measurement science. The end-of-the-day questions are: 1. "What does our community have to gain by assessing future measurement requirements?" 2. "How can this assessment process advance the NCSLI Mission?"

On the Modeling of Test Ports in Microwave and Millimeterwave Vector Network Analyzers Calibrations
TUESDAY, August 19, 2003
8:30 AM - 10:00 AM - PARALLEL SESSIONS - SESSION 3, 3B
Microwave
Godfrey Kwan,
Agilent Technologies
In this paper we present the results of a study on different configurations of the test port of a microwave/millimeterwave Vector Network Analyzer(VNA) and how it may affect calibrations and measurements performed on such configurations. Our study is based on 1-port devices and measurements. These are devices that can be hooked up and measured by making only one single connection. Specific coaxial connector style and center conductor contact combinations such as Type N 50 Ohm or 2.4 mm, slotless or slotted center conductor contacts, are examined. Coaxial 1.85 mm slotted center conductor contact is also used as an example in this study. As it turned out, delicate tradeoffs exist between different designs of coaxial connections.
Because of the limited availability of devices, it was not possible to examine all different possible combinations of connector styles and center conductor contacts in the present study. However, based on the data we have collected using an HP8510C system and an HP8510XF system, we are able to summarize some of the advantages and disadvantages of coaxial connector styles in regards to their center conductor contacts. The theoretical aspects of connector design, mating surfaces and transitions are also discussed.

ISO/IEC 17025-based Quality Systems: Waveguide Attenuation Measurement Systems
TUESDAY, August 19, 2003
8:30 AM - 10:00 AM - PARALLEL SESSIONS - SESSION 3, 3B
Microwave
Li Pi Su,
US Army Primary Standards Laboratory
The Electromagnetic Standards Laboratory (ESL), US Army Primary Standards Laboratory, APSL, is always committed to provide services to the warfighter and its customers with accurate equipment/products which are traceable to the National Institute of Standards and Technology (NIST), delivered on-time, and continuously seeking for innovative ways to achieve excellence in laboratory performance. Since 1998, the APSL has obtained the accreditation, based on ISO/IEC 17025 Quality System, from the American Accreditation of Laboratory Association (A2LA). Many measurement parameters in the ESL have obtained the A2LA accreditation. This paper will provide the ISO/IEC 17025-based Quality System of the X, P, K, and R Band, 30 MHz, Intermediate Frequency (IF) Substitution Attenuation and Impedance Measurement Systems. This report will just focus on the technical areas: the measurements uncertainty analyses, measurements assurance, interlaboratory comparison, measurement uncertainty control and management, and statistical process control.

How to Compute Uncertainty for ANA Based on the ISO TAG 4 Guideline
TUESDAY, August 19, 2003
8:30 AM - 10:00 AM - PARALLEL SESSIONS - SESSION 3, 3B
Microwave
Yeou-Song (Brian) Lee,
Anritsu Company
In this paper, the authors will present the performance verification for the automatic network analyzer (ANA) and its measurement accuracy. The computation of the uncertainty for this type of products is usually implicit to the users. The correct interpretation of the verification of the standards and accuracy is included. The following outline will be presented. What is ANA? How is its performance defined? 1. Traceability; 2. Calibration standards; 3. Measurement System Characterization; 4. Verification process and standards- repeatability from customer standpoint; 5. Quantification of measurement accuracy: worst case scenario and ISO Tag-4 example. This is followed by a discussion, summary, conclusions, and acknowledgement.

Navy Calibration Interval Analysis: A Bayesian Approach
TUESDAY, August 19, 2003
8:30 AM - 10:00 AM - PARALLEL SESSIONS - SESSION 3, 3C
Current Navy Interval Analysis
Ding Huang,
Navy METCAL
The Navy METCAL Program recently underwent a paradigm shift in calculating calibration intervals. Now calibration intervals are based on an integrated analysis of statistical calibration data and an engineering evaluation. Formerly, calibration intervals were based on a dichotomy of either engineering judgment or statistical analysis. With sufficient calibration data, engineering data would not be used, and limited calibration data would be ignored until additional data points were accumulated. Unfortunately, this approach afforded no check on the quality of the calibration data or the engineering information.
The new integrated statistical analysis is based on Bayesian statistical theory, where the subjective engineering data is treated as a prior probability distribution of what the correct interval should be. Statistical data is then used to update the prior distribution into a new posterior distribution for the calculating the new calibration interval. Both the engineering data and the statistical data are always used, regardless of the amount of statistical data available. More statistical data simply translates into a heavier weight for the statistical interval estimate compared to the subjective engineering estimate.
The engineering data also serves to improve confidence in the statistical data in two ways. First it helps interpret the meaning of the data. Second, the prior distribution can be used to test the reasonableness of the calibration data.

Navy Calibration Interval Analysis: Practice of the Bayesian Approach
TUESDAY, August 19, 2003
8:30 AM - 10:00 AM - PARALLEL SESSIONS - SESSION 3, 3C
Current Navy Interval Analysis
Sharon Nguyen,
Navy
This paper describes a practical approach for integrating statistical calibration data with subjective engineering information to determine calibration intervals. It applies the integrated Bayesian interval analysis to the real world. To make the statistical theory work, the engineering data and subjective judgments need to be translated into usable quantitative data. The process first gathers the relevant data describing the nature of the calibrated equipment, the calibration process, and how the calibration results are reported. These factors can all affect the meaningfulness of the calibration data and is used to interpret the calibration data. The engineer then must provide an estimated calibration interval independent from evidence provided by the calibration data. The statistical data is then tested against the engineering estimate for compatibility. If this test fails, a resolution process proceeds to uncover any problems with either the statistical estimate or the engineering evaluation. Examples of this process illustrate how calibration intervals are made more meaningful and how insight is gained for the evaluation of calibration intervals in the future.

Calibration Failure Mode Analyses
TUESDAY, August 19, 2003
8:30 AM - 10:00 AM - PARALLEL SESSIONS - SESSION 3, 3C
Current Navy Interval Analysis
Craig Stewart,
NSWC Corona Division
A Calibration Failure Mode Analysis (CFMA) is a process, which involves the research of a model or groups of models that have a high out of tolerance rate and a very short calibration interval. It is the duty of the interval analyst to perform a thorough investigation with not only the data but with the Instrument Calibration Procedure (ICP) and to determine the reasoning for the failure rate being so high. This discussion will go into detail about the CFMA process and will also include some examples of test equipment that underwent this process.

Calibration Interval Models: How Robust?
TUESDAY, August 19, 2003
8:30 AM - 10:00 AM - PARALLEL SESSIONS - SESSION 3, 3C
Current Navy Interval Analysis
Steve Dwyer,
NSWC Corona Division
The most direct way verify a given measurement reliability target is to observe the percentage of instruments in tolerance, but this provides little predictive value. Various reliability models and algorithms predict reliability as a function of time, usage, and other factors. Statistical tests and data-outlier identification criteria have been introduced to select data to better fit these models. Human judgment and technical insight are used either to replace or to complement calibration data modeling. Each feature added to a calibration system can enhance the system's ability to better predict reliability from data generated by the modeled patterns of measurement behavior, data reporting practice, or changes in technical or business practices. But how well does such a system predict reliability from data generated by a process not being specifically modeled? If the system offers multiple models or approaches, how well can it pick the correct model to use? What is the risk of choosing an approach that gives the wrong interval? This paper examines the relative strengths of various calibration interval approaches. The key questions are (1) how robust is the calibration interval system to predicting measurement reliability when the data is mis-specified, and (2) how well does the system distinguish between competing interpretations of the available data. Examples are presented to demonstrate the issues.

Do You Really Need a 17025 Accredited Calibration?
TUESDAY, August 19, 2003
8:30 AM - 10:00 AM - PARALLEL SESSIONS - SESSION 3, 3D
Practical Issues in Accreditation
Dave Abell,
Agilent Technologies
The conference theme this year is "The Spectrum of Metrology: From the State-of-the-Art to the Everyday." But what do you do if your everyday measurement uses a state-of-the-art electronic instrument like a microwave spectrum analyzer? How much calibration is enough to assure it meets the needs of your application? In most countries, accreditation under ISO 17025 has evolved an academically rigorous approach to analyzing each parameter and assures a high degree of confidence in the results. This in-depth approach derives from high-level standards lab methodologies but can be inappropriate for everyday calibration of electronic instruments. These devices are often used in non-critical measurement situations such as research and development or field service. Even if the instrument is pushing the envelope of measurement technology, is a laboratory level accredited calibration what the end user needs? End users want to be assured that the instruments they use meet the specifications the OEM claimed when the test equipment was delivered from the factory, but most Accrediting Bodies don't allow the laboratory to make a statement of whether the instrument is 'in or out' of specification. Accredited calibrations as they have evolved meet a need when it is critical to know the characteristics of an instrument, but fall short in providing a cost effective answer to the question 'is it ok to use?' This paper describes one approach to balance a laboratory-grade calibration with an affordable alternative that respects the fundamental principles of 17025.

EUROLAB: Its Views on Accreditation Bodies and Proficiency Testing
TUESDAY, August 19, 2003
8:30 AM - 10:00 AM - PARALLEL SESSIONS - SESSION 3, 3D
Practical Issues in Accreditation
Horst Czichos,
EUROLAB

Third Party Accreditation of the Quality System or Self Declaration; Which Way To Go As An NMI: The PTB View
TUESDAY, August 19, 2003
8:30 AM - 10:00 AM - PARALLEL SESSIONS - SESSION 3, 3D
Practical Issues in Accreditation
Michael Kühne,
Physikalisch-Technische Bundesanstalt
With the CIPM Mutual Recognition Arrangement (CIPM-MRA) the National Metrology Institutes (NMI) have done an important step towards a harmonised global metrology system. Membership of the MRA requires the NMI to participate in key comparison to establish the degree of equivalence of their national standards. It provides them with the possibility to declare their calibration and measurement capabilities (CMC) and to have these listed in the key comparison data base of the BIPM. In order to establish the necessary mutual confidence in the CMC data (clause 7.3 of the MRA) the NMI are required to operate a suitable quality system for the declared calibration and measurement services and to send their CMC for review to the local Regional Metrological Organisation (RMO). In order to fulfil the requirements regarding the operation of a suitable quality system the MRA provides the options of third party accreditation or self-declaration: In both cases the demonstration of competence and capability may require visits and examinations of procedures by an NMI and/or by peers selected by the local RMO. The advantages and disadvantages of both options to comply with

the MRA requirements regarding quality system operation will be discussed using the example of PTB. The decision of PTB to choose the self-declaration option will be explained.

Specifications and Uncertainties of Hygrometers
TUESDAY, August 19, 2003
8:30 AM - 10:00 AM - PARALLEL SESSIONS - SESSION 3, 3E
Humidity III
Bob Pragnell
With most types of scientific instrument the specifications given by the manufacturer are fairly reliable. The instruments perform close to specification, at least when new and under ideal conditions. This paper discusses special difficulties which are encountered when calibrating hygrometers, and relates them to the manufacturers' specifications, which are often not met, even when instruments are new, and when measurements are performed under the ideal conditions of the calibration laboratory. It attempts to answer the question: "Why do hygrometers often fail to meet specifications by a wide margin?" It concludes by suggesting questions which users can ask manufacturers to establish whether they really have the data to justify their claims.

Primary Methods for Generation and Measurement of Low Concentrations of Humidity
TUESDAY, August 19, 2003
8:30 AM - 10:00 AM - PARALLEL SESSIONS - SESSION 3, 3E
Humidity III
Joseph T. Hodges,
National Institute of Standards and Technology
The measurement of trace quantities (10 mmol mol-1 to less than 0.1 nmol mol-1) of water vapor in various gaseous media is a practical problem of increasing importance. Applications abound in semiconductor and photonics manufacturing, pharmaceuticals, atmospheric science and other fields where the quantification of such low concentrations of gaseous H2O is required. To address these needs, various measurement techniques and hygrometer technologies have been developed: a representative list includes those based upon mass spectrometry, laser absorption spectroscopy, electrochemical effects, chilled mirror methods, and microbalance techniques. Further, because of strong interactions between water vapor and technical surfaces used in flow manifolds and sampling cells, the generation and delivery of controlled quantities of humidity is especially difficult for the low concentrations considered here. Such effects make it difficult to separate measurement and sampling errors, and underscore the need for primary methods of humidity generation, which complement and support primary measurement techniques.
In this paper, we discuss the complementary methods of low-concentration humidity generation and measurement that are currently implemented at NIST. Humidity generation methods include thermodynamic-based standard humidity generators, and high-precision dilution systems suitable as transfer standards. We also address primary humidity measurement methods including chilled mirror hygrometers and those based upon laser absorption spectroscopy. Finally, we discuss how such standards can be disseminated to users via calibrated portable humidity generators and reference standard hygrometers

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The European Accredited Infrastructure for Calibration of Humidity Measuring Instruments
TUESDAY, August 19, 2003
8:30 AM - 10:00 AM - PARALLEL SESSIONS - SESSION 3, 3E
Humidity III
Robert Benyon,
Instituto Nacional de Técnica Aeroespacial
Centro de Metrología y Calibración, Ctra.
National Physical Laboratory, Humidity Standards
Accreditation delivers confidence in certificates and reports by implementing widely accepted criteria set by the European (CEN) or international (ISO) standardisation bodies. The standards address issues such as impartiality, competence and reliability; leading to confidence in the comparability of certificates and reports across national borders. Governments have confidence in testing and certification in support of regulatory functions.
The branches of European national accreditation bodies joined to form European Accreditation (EA), established in June of 2000 as a legal entity according to Dutch Law, and which now covers all European conformity assessment activities: testing and calibration, inspection, certification (management systems, products, personnel), and environmental verification.
Whilst it is true to say that EA offers a service to the European market and governments, primarily within the extent of the Multilateral Agreement (MLA), it also functions within the wider framework of the International Accreditation Forum (IAF) and the International Laboratory Accreditation Co-operation (ILAC), promoting the development outside of Europe of regional groupings of accreditation bodies by signing bilateral agreements with such groups or with individual national accreditation bodies.
The number of Laboratories now accredited for the calibration of humidity measuring instruments and climatic chambers has grown almost tenfold since the first survey performed in 1995. The extent of services offered by calibration laboratories accredited by EA-member accreditation bodies for calibration in the field of humidity are presented and discussed. Recent examples of comparability of measurement results obtained at extreme levels of relative humidity and temperature between two top-level UKAS (UK) and ENAC (Spain) accredited laboratories, consistent with their accredited best measurement capabilities, are presented.

Towards a National Measurement Services Strategy
TUESDAY, August 19, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 4, 4A
National Measurement Strategy
James M. Adams and John Rumble, Jr.,
National Institute of Standards and Technology
As mature technologies evolve and new technologies emerge, the measurement services needed to support the U.S. technology infrastructure also transform. Clearly, new technical ability developed by scientists and engineers working within the realm of measurement science enables progress in technology. Indeed, technological progress can proceed only as fast as measurement science permits. Yet investments in measurement science should not occur "in a vacuum;" rather they should be made in an informed fashion, responding to the essential needs of industry. Those who manage

measurement science R&D must listen critically to the views of those who deliver technology to consumers to ensure that efforts are appropriately guided and that the measurement service activities undertaken are derived from careful consideration of the Nation's inherent interests.
Both NCSLI and NIST maintain ongoing efforts to assess the measurement service needs of U.S. industry through a variety of mechanisms. The panel assembled for this meeting continues these efforts, where specific focus is placed on the following topics: (1) how industry and the providers of measurement services can work together to meet future needs arising from technological breakthroughs, and (2) the concerns and consequences that arise when demands for new measurement services are considered vis-à-vis the continuing demands for existing services. We anticipate that these insights will help lead the way for enhanced strategic planning for measurement services on a national basis, whereby all stakeholders are made well aware of new needs and can readily address areas important to them.

Experimental Comparison Among The Psychrometer And The Two Pressure Humidity Generator And The Dew Point Hygrometer
TUESDAY, August 19, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 4, 4B
Humidity IV
Jinpeng Fan,
Beijing Institute of Applied Meteorology
An accurate experimental research to check the psychrometer coefficient A has been made in the Beijing Institute of Applied Meteorology. Three ventilated psychrometers were compared with the two-pressure humidity generator and with the precise dew point hygrometer. The results for dry bulb temperature from 12C to 30C and the relative humidity in the range 20 to 70% (or the wet bulb temperature from 4C to 26C) give an average value of A near 6.28x10-4 K-1 with the uncertainty of ±1.5%. The result confirms the psychrometer coefficient A given by Dr. Wylie and Lalas, which in the meteorological range varies little from 6.21x10-4 K-1, and supports the conclusion of Wylie that the true values of A for well-designed ventilated psychrometer approximate this value rather than the value of 6.62x10-4K-1 which are in general use. This difference of value A creates a 1.5%rh error at 20C and 50% RH. The theoretical formulation of psychrometer coefficient based on modern progress of the heat and mass-transfer processes is involved and the differences between Dr. Wylie and Dr. Sonntag for the Assman and other type psychrometers is discussed.

Dew Point Measurement Using Image Analysis
TUESDAY, August 19, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 4, 4B
Humidity IV
David Egan,
General Eastern Instruments
The principle of measuring dew point using a chilled mirror hygrometer has been in place for nearly sixty years. Initial sensors required the user to detect the presence of condensation using a sight glass. As technology evolved, LED optical systems were built into the sensors as a means of detecting the condensation and providing closed loop control for dew point measurement. This method was a big improvement over the existing technology but still contained opportunity for improvement. It is the purpose of this system to address areas of improvement with the current means of condensation detection and to create a technology gap between itself and existing methods. The system that is described in this paper is a new, intelligent means of condensation detection on a target surface. An imaging system and imaging analysis system will replace the optical system present in existing systems typically consisting of a digital emitter and a photo detector. The camera is mounted in the sensor sample cavity such that it can view the condensation surface. The camera system establishes a base image of a condensation surface that has been heated above the surrounding dew point to establish a reference image for further analysis. As the condensation surface begins to cool, the software interrogates the images of it and detects the presence of condensation as a change from the reference image. Data produced by the imaging system is used in a real time control loop to seek out the dew point and reach steady state conditions.

Repeatability and reproducibility uncertainty in the measurement of trace moisture generated using permeation tubes
TUESDAY, August 19, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 4, 4B
Humidity IV
Raghu Kacker,
National Institute of Standards and Technology (NIST)
Permeation-tube moisture generators are used in industry as calibrated sources of water vapor and carrier gas mixtures. Measurements were made using three permeation-tube moisture generators of the type used in the semiconductor industry. This paper describes repeatability and reproducibility uncertainties in measurement with these generators in the range 10 nL/L to 100 nL/L. Repeatability refers to measurements within a system and reproducibility refers to measurements between systems. Two independent methods were used to measure the realized concentration of water vapor. The measurement from first method, referred to here as calculated value, was determined using calibrated permeation rate of permeation-tube and flow rate of dry carrier gas. This is the industrial method of determining moisture concentration. The measurement from second method, referred to here as measured value, was determined using the low frost-point generator at the National Institute of Standards and Technology (NIST) and a quartz-crystal-micro-balance. Four pairs of independent measurements for each generator and for six nominal levels in the range 10 nL/L to 100 nL/L were made. The characteristic used to quantify repeatability and reproducibility uncertainties in industrial measurements is the calculated value minus the measured value. Repeatability uncertainty ranges from 1 nL/L to 2 nL/L approximately. Reproducibility uncertainty ranges from 2 nL/L to 8 nL/L approximately. The documentary ASTM standard E691-99 was used for statistical analysis.

Calibration Intervals for Multipoint Transfer Standards
TUESDAY, August 19, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 4, 4C
New Interval Analysis
Chuck Antoniak,
NSWC Corona Division
This paper presents a proposed statistical methodology for reporting the characterization of multipoint transfer standards and determining the appropriate calibration interval from the record of past characterizations. It is generic in approach and illustrates the principles involved with real data

from three case studies: an accelerometer; a black body; and a radiometer. It clarifies the subtle distinction between ordinary y on x regression and the so-called inverse regression of x on y, which is often more appropriate for calibration. Both of these regressions may be related to an underlying mathematical structural relationship illustrated in this paper by Hooke's law for springs as it applies to calibrating scales for measuring weight. The differences between the two regressions are also examined as a function of whether the Unit Under Test is a measuring instrument, like a voltmeter, or and application tool, like a torque wrench.

Binary Data Calibration Interval Analysis Using Generalized Linear Models
TUESDAY, August 19, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 4, 4C
New Interval Analysis
Dennis Jackson,
NSWC Corona Division
The U.S. Navy generally gathers binary data (success-failure) for the results of calibration tests. This paper will describe analysis methods to be used that are based on binary methods. The analysis methods will be based on the use of intercept reliability models and Generalized Linear Models analysis. Confidence intervals and decision making techniques will be discussed.

Using Indicator Variables to Model Changes in Measurement Reliability
TUESDAY, August 19, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 4, 4C
New Interval Analysis
Thi Tang,
NSWC Corona Division
Calibration intervals need to reflect current measurement reliability. Any permanent change in measurement performance affects the most appropriate calibration interval. For example, a change in calibration tolerances could cause current data to indicate a different reliability curve compared to prior years data. One method to model such changes involves the use of an indicator variable. The use of a "dummy" variable, or indicator variable, is a way of quantitatively comparing two categories. I will illustrate the use of indicator variables to include or exclude prior years' data in Generalized Linear Model Analysis of calibration histories of Navy Test Equipment.

Improving Dialogue Between The European Regulatory Bodies and The National Metrology Institutes Through The Regmet Project
TUESDAY, August 19, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 4, 4D
Metrology, Accreditation, Regulators
Fiona Redgrave,
National Physical Laboratory
Just as is the case in the USA the European regulatory infrastructure depends on measurements and tests, which need to be reliable, trusted internationally and which do not form a barrier to trade. Although broadly harmonised, differences in measurement practice amongst regulators and associated bodies still exist even within the EU. This is partly because the approach by the regulatory community in Europe is still influenced by historical practice and awareness of measurement issues varies significantly, and partly due to the complexity of the measurement and conformity assessment issues involved. The difficulties are not all one way; the development of national measurement capability in Europe does not always take optimum account of the regulatory perspective.
With partial support from the European Commission a partnership of nine European National Metrology Institutes, the EC Joint Research Centre and the European Organisation for Conformity Assessment are engaged in the RegMet project with the regulatory community to overcome this historical legacy. The project has initiated and evolved the concept of a "template for regulators" aimed at ensuring measurement issues are appropriately addressed at the earliest stages of regulatory development. The template has the potential to positively influence regulations in Europe (and beyond) at the highest level, and to support efforts to improve transparency of the regulatory process, supporting the efforts of the trade negotiators to reduce technical barriers to trade. This paper describes the results of the RegMet project, including identified areas of best practice, the template concept and operation.

Global Compliance and Standardization in an Enterprise Calibration Management System
TUESDAY, August 19, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 4, 4D
Metrology, Accreditation, Regulators
Jim Erickson,
Blue Mountain Quality Resources, Inc
The need for standardization and the need to maintain compliance have never been greater. Companies are consistently looking for ways to improve productivity and ultimately add to the bottom line. As mandated by ISO 9000, ISO 17025, and the FDA, calibration management is an integral part of the metrology process. With the tremendous advances in Information Technology (IT), enterprise calibration management systems (CMS) have become an excellent enabler of cost effective global compliance and standardization. In an enterprise installation, the CMS is hosted on centralized IT servers, configured and controlled by a corporate Quality or Metrology group and used by working groups throughout the entire global enterprise. The software enables each working group to have its own dataset configured to its specific needs, whether it is field labels, languages or time zones, while centralizing the overall implementation configuration. This paper will discuss the issues of implementing an enterprise calibration management system. Site-by-site licensing often promotes redundant activities, such as several installations, trainings, and configurations. Calibration procedure writing and management is also duplicated at each site. Through cost reductions in application licensing costs, corporate IT resources, validation costs, training and internal auditing, the enterprise CMS provides the lowest total cost of corporate calibration compliance and maximizes the ROI.

Regulators and The Issue of Traceability in Laboratory Medicine
TUESDAY, August 19, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 4, 4D
Metrology, Accreditation, Regulators
Andrew Wallard,
Bureau International des Poids et Mesures
Up until relatively recently, metrology tended to be the domain of physics and engineering. This changed in the 1990s when metrology in chemistry was recognised as an important extension of the SI system and since then, metrological concepts have begun to be adopted in other disciplines. Amongst the newest of these is the whole area of laboratory medicine that is becoming very much more concerned with how to demonstrate traceability and uncertainty in laboratory medicine and related measurements. This has been driven by the requirements of the European Union's Directive on In-Vitro Devices but, in addition, several key bodies active in the field have begun to collaborate on a common approach. These bodies include: the World Health Organisation; the International Laboratory Accreditation Co-operation; and the International Federation of Clinical Chemists. Together with the BIPM, they have set up a Joint Committee to identify appropriate reference materials and processes that will enable manufacturers to meet the requirements of the Directive. The presentation will review the current state of the art in this rapidly moving initiative to encourage the industry and the users to adopt best measurement practice.

Traceability of ac voltage in the mV-range
TUESDAY, August 19, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 4, 4E
AC/DC Transfer
Karl-Erik Rydler,
SP Swedish National Testing and Research Institute
Last year an international key comparison on ac-dc transfer difference in the millivolt range started with SP as the pilot laboratory. In the preparation of the comparison a traveling standard was evaluated and the ac-dc transfer standards of SP were re-evaluated in the mV-range. At SP the traceability of ac-voltage in the mV-ranges is established by using micropotentiometers and resistive voltage dividers. In addition, thermal voltage converters are used in a step-down procedure from the reference level, maintained by a group of multijunction thermal converters, to the 100 mV-level. Different sources of uncertainty have been evaluated, like loading errors and level dependence due to dc effects and low frequency effects. This paper will give a brief presentation of the key comparison and its goal and of the result of the evaluation of the thermal transfer standard with amplified mV-ranges that is used as traveling standard. The paper will concentrate on the methods used at SP to establish traceability, the procedures and the sources of uncertainty.

AC-DC Voltage Transfer Standards with Thin-film Multijunction Thermal Converters and Planar Resistors
TUESDAY, August 19, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 4, 4E
AC/DC Transfer
Hector Laiz,
Instituto Nacional de Tecnología Industrial (INTI)
This paper discusses recent results of ac-dc voltage standards with thin-film multijunction thermal converters (PJMTC) and planar serial resistors for the frequency range from 10 Hz up to 1 MHz and for the voltage range from 100 mV to 1000 V. The standard PTB/IPHT PJMTC is well established and fabricated on a silicon chip with a thin dielectric membrane on an anisotropically etched window in the silicon. A thin-film bifilar heater and up to 100 thermocouples are sputtered on a Si3N4/SiO2/Si3N4 sandwich membrane. A small obelisk of silicon is left underneath the heater during the etching process to increase the thermal time-constant.
Capacitances in the heater area, the loss factor of the membrane, the residual conductance of the silicon underneath the membrane, and skin effect in the leads are the main causes for the ac-dc transfer differences increasing to higher frequencies. A trade-off was found with a heater resistance of 190 W at which the different effects compensate each other. The design of a new generation of PMJTCs on quartz membranes and on quartz crystal chips improves the frequency response. The voltage coefficient is the main source for the ac-dc transfer differences at frequencies below 100 Hz. It is correlated with the power coefficient of the sensitivity. Some tools to compensate the power coefficient were investigated. An optimum compensation is achieved with thermocouples from CuNi44/BiSbTe. For the serial high voltage resistors from 100 V to 1000 V new planar resistors with negligible voltage dependence have been fabricated on AlN substrates.

Ac-dc Difference at Cryogenic Temperatures
TUESDAY, August 19, 2003
10:45 AM - 12:15 PM PARALLEL SESSIONS - SESSION 4, 4E
AC/DC Transfer
Thomas E. Lipe,
National Institute of Standards and Technology
We are developing a primary standard of ac-dc difference based on a resistive transition-edge sensor (TES) that operates at cryogenic temperatures where errors due to thermoelectric effects are minimized. The most recent improvements to the Cryogenic Thermal Transfer Standard (CTTS) include on-chip magnetic shielding which has reduced the coupling of magnetic fields from the heaters into the TES; however, measurements indicate that errors still persist in the CTTS. To isolate these effects, we are redesigning the system to measure two TES chips inside the cryostat, the first measurement of ac-dc difference at cryogenic temperatures. This paper will discuss the redesigned CTTS and present results from the in situ measurement of the two TES chips. We will also discuss future plans for the CTTS, and the prospect of using the CTTS as a primary standard for extremely low power voltage and current measurements.

Too Much Calibration?
TUESDAY, August 19, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 5, 5A
Management I
Todd Wendle,
Agilent Technologies
The conference theme this year is "The Spectrum of Metrology: From the State-of-the-Art to the Everyday." Today's world is filled with electronic devises. Each of those devises is expected to perform as described by their individual specifications. That performance has to be measured and more importantly, measured in such a manner that the one can feel confident the results of the testing are accurate enough to declare the device is working correctly and is ready for use. Calibration is an exercise that increases that confidence that one is shipping a product that meets or exceeds stated specifications. There in lies the confidence conundrum. Just how confident does one need to be? The "level" of calibration service one receives plays a very important role in establishing an adequate level of confidence. The key word is adequate. Metrologists, like statisticians, error on the side of high confidence low risk exacting results. This level of rigor collides head on with the real world of device testing. Synonymous with high confidence and low risk are higher costs, greater downtime, and lower yields. Everyone understands "the best". But in many instances "the best" is too much. It is not needed. And the word adequate appears again. Calibration is shades of gray, not black and white. The application should drive the "level" of calibration service required. It is a continuing battle of confidence level versus cost. In the end the question remains, 'is it ok to use?' This paper describes some of the variables and their effect on that balance between "95% confidence limits" and "Is it okay to use?

Lean Metrology TM – Honeywell's approach to streamlining the Metrology Process
TUESDAY, August 19, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 5, 5A
Management I
Steve Dale,
Honeywell Technology Solutions, Inc.
If you're like everyone else, your metrology costs are too high… There are significant costs associated with metrology. But at HTSI, we use Lean Metrology TM, a metrology-specific application of the Six Sigma and Lean Manufacturing philosophies, interwoven with the calibration and manufacturing processes to help manage those costs. Six Sigma Plus enables world-class quality and continuous improvement by using data and statistical tools to improve and sustain process improvements. Lean Metrology TM breaks down the reshaping of the metrology process into six simple phases: (1) the recall system; (2) personnel skills mix and workload evaluation; (3) fostering customer "ownership" of metrology; (4) integration into manufacturing; (5) control of sub-contractors; (6) controls and monitoring. Lean Metrology TM could be your ticket to a more cost effective metrology program… while still maintaining or improving your overall quality.

A Conceptual Overview of a Hand-Held Wireless Application For Use by the Mobile Calibration Technician
TUESDAY, August 19, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 5, 5A
Management I
Rob Bossler,
Techno Media, LLC
Wireless (Roamable™) hand-held computer applications promise to greatly enhance the efficiency of mobile field service calibration and maintenance activities. Remote assignment of Work Orders, data, image, and voice communication, libraries of technical information, internet access, GPS routing, and even the location of the nearest McDonalds™ are only a small fraction of what wireless technology brings to mobile technicians, whether the geographic region is a single industrial campus or a multi-national conglomerate. Wireless technology, as envisioned in this paper, provides a way of maintaining close management oversight over a remotely deployed field service organization, while eliminating bottlenecks created by traditional paper-driven systems. A host of problems associated with "Central Office" command and control issues are readily solved using this technology. This paper discusses the advantages of a hypothetical wireless system in terms of productivity and cost control, management and technical support, quality control, accounting, economics, technology, and data security and integrity. Discussion focuses on the intrinsic value of real-time communication with the Central Office or with any other field deployed technician or manager, access to a digitized technical library at the Central Office or elsewhere, and access to OEM internet sites via a live internet link, all through the handheld unit. This paper also predicts the successful solution platform, which likely includes a distributed database technology with a data exchange server, active service registration for auto synchronization, and data encryption and decryption capacity, since mobile users need to transmit and receive secure data seamlessly as they travel throughout the geographical service area.

The Calibration of Harmonic Analysers Using Fluctuating Harmonic Waveforms
TUESDAY, August 19, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 5, 5B
Harmonics
Paul S. Wright,
AC Power and Voltage Measurements
National Physical Laboratory
International regulations limit the harmonic currents on the electricity supply caused by electrical appliances. Before a new electrical appliances can be sold in Europe, it must conform to these standards. This involves type-testing the appliance against a calibrated harmonic analyser. Failure of this test can have severe financial implications for appliance manufacturers and calibration of the analyser under realistic conditions is therefore required to underpin the regulations. When the appliance has a variable duty cycle (e.g. a washing machine), it will cause the harmonic currents to fluctuate. These fluctuating harmonics are difficult to measure and the special techniques employed by the harmonic analyser equipment will be described. These techniques give rise to an inherent variation in results; this result distribution and its implications will be discussed. For the calibration laboratory a distribution of results complicates the testing of a given analyser. A new calibration technique will be presented which uses multiple phase shifted harmonics to fit the analyser results to the expected results distribution. Results will be presented for analysers which have various error mechanisms.

Calibration of Distortion Meters
TUESDAY, August 19, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 5, 5B
Harmonics
Mr. Aaron Y. K. Yan,
Standards and Calibration Laboratory, HKSAR

A method of calibrating distortion meters is introduced. Two harmonically related signals are combined to produce a test signal of known distortion. Calibration is performed by applying the test signal to the input of the distortion meter under test and by comparing its readings against the known distortion of the test signal. The method has the following features: (1) a simple combining network is used; (2) a simple and accurate method is used to determine the resistance ratio of the combining network; (3) the input impedance of the distortion meter under test does not affect the calibration results. Description of the method, its mathematical derivation and detailed uncertainty analysis are presented in this paper.

Easing the problem of traceability for complex waveforms by optimising instrument design
TUESDAY, August 19, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 5, 5B
Harmonics
Geoff Ives,
Fluke Precision Measurement Limited
Instruments providing previously unavailable facilities often pose challenges for those responsible for providing measurement traceability. The main challenge in the case discussed in this paper was to measure the phase of up to eight channels of complex voltage and current waveforms with five to ten times better accuracy than available from commercially available systems. The resulting solution had to be cost effective for third party calibration facilities and those who maintain their own traceability. As is often the case, a simple solution turned out to be extremely effective but the implementation would not have been possible without early collaboration between metrology and instrument design functions. The paper describes how novel instrument system design allowed phase and amplitude of various harmonically distorted and amplitude-modulated waveforms to be determined with a single digitising DMM and a few voltage dividers and shunts. System traceability issues are discussed and comparison made with other potential measurement system architectures

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Uncertainty Analysis of a Wet Gas Test Facility
TUESDAY, August 19, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 5, 5C
Flow II
Thomas Kegel,
Colorado Engineering Experiment Station, Inc
A wet gas flow system has been operational at the CEESI Colorado facility since 1999. The flowing fluids are gas and liquid phase mixtures of natural gas components. For most of the testing the gas phase has been “pipeline grade” natural gas and the liquid has been pure decane. The system operates over a pressure range from 200 to 1200 psi. The dry gas velocity ranges up to 90 ft/s in a four-inch pipe and the liquid flowrate ranges up to 360 lb/min. This paper describes part of the rigorous uncertainty analysis of that system. Dry gas volume flowrate is measured with a turbine meter that has been calibrated in air over a 100 – 700 psi pressure range. The gas density is determined using an equation of state as a function of pressure, temperature and gas composition, the composition is measured with a gas chromatograph. A subsonic venturi is used as a check standard for the gas mass flowrate. The liquid mass flowrate is measured with one of two coriolis meters depending on the flowrate magnitude. The uncertainty analysis integrates effects due to the gas and liquid mass flowrate instrumentation, equation of state and possible phase changes

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Discharge Coefficients for Critical Flow Venturis – Theoretical vs. Calibrated
TUESDAY, August 19, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 5, 5C
Flow II
Richard W. Caron,
Colorado Engineering Experiment Station, Inc
Since 1988, Visteon Corporation has designed and fabricated over fifty (50) flow test stands that are used in the manufacturing and production of the mass air flow sensor (MAFS). The MAFS is used to measure the mass flow rate of air that is entering the internal combustion engine on each vehicle that Ford Motor Company manufactures. The flow stands incorporate more than 400 Critical Flow Venturis (CFV), and each CFV has been calibrated to NIST traceable standards. The CFV's have been designed and fabricated in accordance with the ASME/ANSI MFC-7M-1987 standard entitled "Measurement of Gas Flow by Means of Critical Flow Venturi Nozzles". A summary of the calibration data for all CFV's is presented. A large quantity of this calibration data is at throat Reynolds numbers less than 105, and demonstrates the behavior of the CFV at low throat Reynolds numbers. A comparison of the theoretical equation for Discharge Coefficient (Cd) vs. Reynolds numbers contained in the ASME/ANSI national standard for CFV's is made against the actual Discharge Coefficient (Cd) vs. Reynolds number calibration curves of the Visteon CFV calibration database. The actual Discharge Coefficient (Cd) vs. Reynolds number calibration curves of the Visteon CFV calibration database are also compared against a theoretical equation of Cd vs. Reynolds number developed at CEESI.

Recent Developments in the Realization of the International Scale for Kinematic Viscosity
TUESDAY, August 19, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 5, 5C
Flow II
M. Richard Hoover,
Cannon Instrument Company
Kinematic viscosity is an extremely important physical property relating to the function, formulation, processing, and use of liquid materials. International agreement as to the kinematic viscosity of the primary standard, water, and the precision and accuracy to which kinematic viscosity can be measured is

essential for international commerce. This paper describes historic and recent efforts in establishing international agreement for kinematic viscosity measurements and the uncertainties associated with those measurements. Data from the ASTM Cooperative Kinematic Viscosity program are presented along with a discussion of current international efforts to establish kinematic viscosity measurement in the Mutual Recognition Agreement (MRA) that is part of the Metre Convention.

Standardization of Moisture, Protein, Oil and Starch Measurements in Grain
TUESDAY, August 19, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 5, 5D
Comparisons I
G. Diane Lee,
National Institute of Standards and Technology
Grain is an essential source of the world's human and animal food supply. The production value of major grains in the United States is approximately 3.3 billion dollars of the 10.1 trillion dollars of the U.S. gross domestic products. Inaccurate grain measurements (moisture, protein, oil and starch) can have a large economic impact on the grain market. The 1990 amendments to the Grain Quality Incentives Act (the U.S. Farm Bill) authorized the United State Department of Agriculture (USDA), Grain Inspection Packers and Stockyards Administration (GIPSA) to work with the National Institute of Standards and Technology (NIST) and the National Conference on Weights and Measures (NCWM) to standardize commercial inspections of grain measurements. This authorization was given as part of the overall mandate to improve the accuracy of grain measurement in the United States. Since this time NIST, GIPSA, State agencies through work of the NCWM, and device manufacturers have worked together to identify inspection instruments requiring standardization, establish performance criteria for commercial grain inspection instruments, develop a national program to approve grain inspection instruments for commercial inspections and develop standard reference materials or other means necessary for calibration or testing of approved instruments. This paper provides an overview of the impact and importance of grain measurements, information on the grain measurement system before the collaborative efforts between NIST, GIPSA, State agriculture agencies, the NCWM, and device manufacturers and the coordination between these groups, improvements in standardizing commercial inspections of grain measurements and ISO 17025 compliance issues.

EUROMET Key Comparisons
TUESDAY, August 19, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 5, 5D
Comparisons I

Interlaboratory Comparison on the Calibration of three Mass Travelling Standards by Laboratories Accredited by Bodies that are Members of the North American Calibration Cooperation (NACC)
TUESDAY, August 19, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 5, 5D
Comparisons I
Jorge Nava-Martínez,
Centro Nacional de Metrología, CENAM
The main aims of the realization of comparison within NACC are to build up and maintain mutual confidence in the technical competence of NACC members and to work towards the development of multilateral recognition agreements both at the regional and international levels. Successful interlaboratory comparisons provide objective evidence that laboratories are competent and that they can achieve the level of accuracy for which they are accredited. One of the problems in running a comparison involving different economies is that each economy has different needs and thus different capabilities

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Some Recent Developments in Fiber Optic Temperature and Pressure Sensors
TUESDAY, August 19, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 5, 5E
Temperature I
Gary Pickrell,
Center for Photonics Technology
Virginia Polytechnic Institute and State University
Recent advances in optical fiber sensor technologies have expanded the field of potential applications to areas including long distance temperature and pressure sensing (in applications such as down-hole oil sensing where the distances may exceed 10 kilometers); harsh environment temperature sensing (in applications such as coal gasification where temperatures may exceed 1400 C, with alkalis, steam, and other corrosive agents present); and temperature and/or pressure measurement in industrial applications such as the glass melting, metal casting and power generation industries. In each of these applications, appropriate materials selection and packaging of the sensor components is critical to the successful implementation of the sensor systems. This paper will present an overview of the laboratory and field test data from some of these applications with an emphasis on application requirements, materials selection, packaging, experimental results and data analysis. Also, a new development in optical fiber fabrication, which may have significant potential for use in sensor applications, will be presented.

State-of-the-art level of accuracy achieved by realising low-temperature fixed points of the ITS-90 using sealed triple-point cells
TUESDAY, August 19, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 5, 5E
Temperature I
Bernd Fellmuth,
Physikalisch-Technische Bundesanstalt (PTB)
Below 273.16 K, the International Temperature Scale of 1990, ITS?90, has eight defining fixed points. The realisation of four of them causes special problems because they are the triple points of the cryogenic gasses hydrogen, neon, oxygen, and argon. In particular the very low thermal conductivity

of these non-metallic fixed-point substances and their small heat of fusion require to use special methods for determining the triple-point temperatures: The melting curves have to be measured under nearly isothermal conditions applying the calorimetric intermittent-heating method. Temperature and shape of the melting curves depend on the properties of the fixed-point samples (impurities, isotopic composition, crystal quality). Furthermore, they are influenced by static and dynamic temperature-measurement errors.
The state-of-the-art level of accuracy of fixed-point realisations at the four triple points is evaluated on the basis of theoretical models describing the effects, which influence the melting curves, estimates of uncertainty components considering the properties of the substances and results of an international intercomparison of sealed cells filled each permanently with one high-purity sample. Twelve metrological institutes have sent more than 50 cells to PTB. The cells are quite different with respect to design, age, gas source, and filling technology. This enables to investigate the different effects in detail since all cells have been compared at PTB directly applying the same experimental equipment and adhering strictly to a single investigation program as well as since the temperature-measurement errors have been estimated reliably using appropriate parameters to describe the thermal properties of the cells.

The Development of Radiation Thermometers Calibrated using Absolute Radiance Responsivity
TUESDAY, August 19, 2003
2:30 PM - 4:00 PM PARALLEL SESSIONS - SESSION 5, 5E
Temperature I
Howard W. Yoon,
National Institute of Standards and Technology
In the International Temperature Scale of 1990 (ITS-90), temperatures above the freezing temperature of silver are defined with radiation thermometers calibrated using spectral radiance ratios to one of the silver-, gold- or copper-freezing temperature blackbodies and the Planck radiance law. However, due to the use of spectral radiance ratios, the temperature uncertainties of the ITS-90 defined using these thermometers increase as the square of the temperature ratios. Using absolute radiometry, thermodynamic temperatures can be determined with radiation thermometers traceable to a cryogenic radiometer, and the resulting temperature uncertainties can be lower than those measured using the ITS-90 techniques. We describe the development and characterization of absolute radiation thermometers calibrated using detector-based radiometry. The absolute radiation thermometer can determine the thermodynamic temperatures of sources, such as blackbodies, without the use of fixed-point blackbodies. The absolute radiance responsivities are measured in the NIST Spectral Irradiance and Radiance responsivity. Calibrations using Uniform Sources (SIRCUS) facility. We describe our plans to build various types of absolute radiometers utilizing narrow-band interference filters and broad-band absorbing filters from 350 nm to 2.5 mm. Other characterizations of the radiation thermometer including size-of-source effect, linearity, and temporal stability will be described. The radiometers utilize an on-axis design with refractive optics for imaging a 3 mm to 0.75 mm diameter target areas. The size of the target area is chosen such that tungsten-strip lamps and fixed-point blackbodies may be compared to variable-temperature blackbodies with larger cavity diameters.

Managing Change in a Metrology Environment
WEDNESDAY, August 20, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 6, 6A
Quality
Harry C Spinks,
TechTrology LLC
In today's high-tech world there is one constant - change. And with the current economic situation we are required to do more with less. This puts a lot of pressure on management to meet organizational objectives and on the technicians for production and quality, while meeting and exceeding customers' needs. With everything we have to do on a daily basis, when will we have time to do it better? We need to make change and continuous improvement a part of our everyday activities and not something that we "intend to do someday" or just do once and forget about it. This is vital in order to keep up with the every changing technology and to remain in business. This paper will look at managing change and process improvement in a metrology environment for both the manager and technician with an emphasis on its practical application.

Realizing Integration of Metrology, Quality, and Instrument Development and Support with Information System
WEDNESDAY, August 20, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 6, 6A
Quality
Yeou-Song (Brian) Lee,
Anritsu Company
In this paper, the authors will report the system that involves the integration of the metrology work, quality and process improvement, process. With the statistical tools and information infrastructure, great teamwork and better products are demonstrated. We are able to present the added-value originated by the metrology activities. The essential metrology activities were identified through the instrument development and service/support cycle. These are the establishment of traceability, assurance of measurement process, repeatability and reproducibility study with six-sigma concept, re-engineering of business process with product life-cycle calibration service and support. Quality is a pivotal part of business success in today's competitive environment. In order to produce faster, cheaper, better instruments for our customers, we have chosen to implement quality tools such as process capability and process control with a statistical engine in our information system. Process variation, manufacturability, and support and service were dramatically improved with great teamwork, efficiency and effectiveness.

Proposal for a comprehensive program of education and training in metrology in Mexico
WEDNESDAY, August 20, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 6, 6A
Quality
Salvador Echeverria-Villagómez,
Centro Nacional de Metrología (CENAM),
To promote and improve the metrological culture in the country is one of the main functions of the National Center of Metrology (CENAM) of Mexico. CENAM has contributed to education and training in metrology in Mexico in several ways. Among them are the Continuous Education Program, the MESURA Training Modules, the MESURA Consultancy Modules, Technical Publications, CENAM and SIMET websites and continuous participation in

symposia and meetings. Despite these activities and programs, the rate of education and training in Mexico will not be enough to raise in a massive way the level of metrological culture in the country in a reasonable time period. Considering this situation, in 2001-2002 a study was carried out to analyze in a systematic way the different possibilities for training and education in metrology, and the various ways in which CENAM could explore and use them, everything oriented to specific needs of user sectors in society. The analysis considered as a main component for the final strategy, the integration of multiplying factors such as technologies, organization networks and national infrastructures. Among the technologies, videoconference and e-learning were analyzed; among the organizational networks, the MESURA Inter-Institutional Network and the National System of Technological Institutes were considered; among the infrastructures, communication networks tied to R&D centers and industrial groups were considered. The paper will show the methodology for this analysis, the resulting proposal and some of the actions that have been already implemented, as a Distance Education System coordinated with the MESURA Inter-Institutional Network and other associates.

Measurement Uncertainty Evaluation Involving Significant Uncorrected Systematic Errors
WEDNESDAY, August 20, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 6, 6B
Mechanical
Ricardo A. Nicholas,
The Boeing Company
In the field of Metrology, it is often necessary to evaluate measurement uncertainty in the presence of significant uncorrected systematic errors. This typically occurs with multifunction and/or multipoint measurement systems, such as digital multimeters and electronic balances, to name two. It is generally impractical to assign corrections for the many functions and ranges. As a result, these types of systems are usually evaluated with respect to a nominal value and assigned a bilateral confidence interval. In the strictest sense, evaluations of that sort are not in harmony with the GUM in the event of remaining uncorrected systematic errors of a significant magnitude relative to the performance specification assigned to the system. According to the GUM, those residual systematic errors must be corrected, in order to legitimately consider the remaining combined random errors as a standard or expanded uncertainty. A deeper look into the philosophy and intent of the GUM, however, reveals a methodology for combining significant uncorrected systematic errors with random errors and still legitimately consider the combination as a standard or expanded uncertainty, provided certain qualifications are made. This paper describes that GUM-consistent methodology, the necessary qualifications, and provides examples of application.

I Know Temperature is Important, But Why Be Concerned With All These Other Environmental Factors
WEDNESDAY, August 20, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 6, 6B
Mechanical
David W. Braudaway,
Metrology Consultant
Most metrologists are aware of the need for a stable temperature for maintaining their standards and for the artifacts and instruments they calibrate. However, the need for careful measurement and the effects of humidity, barometric pressure, gravity constant are less well understood. As humans, linear interpolation of measured values with power level and over time is easy and natural, but many standards display second order behavior with peaks in the response range, some have even more complex behavior. Some metrologists apply corrections from handbook formulas for the environmental factors but have no feel for the magnitude of the effects being corrected or if the calculated values are reasonable. Presented are examples of the effects of the various environmental factors throughout the measurement disciplines. Mass measurement usually is the difference in buoyancy from air density but pressure is affected by the full effect of air density and by the local gravity constant. Moderate accuracy resistors are usually treated as linear with temperature but there are complications. High accuracy resistance standards generally have a quadratic fit of resistance to temperature but may also be affected by pressure with different time responses for increased value and decreased value. But beware, some resistors change value with voltage, with humidity, with external electrical field and other factors. Care in use and measurement is necessary to minimize or accommodate the various effects.

Software Technology to Support Measurement Uncertainty for Complex Electronic Test Equipment
WEDNESDAY, August 20, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 6, 6B
Mechanical
Jon C. Moens,
Agilent Technologies
With the continued automation of testing for specifications the cost of software maintenance and enhancements becomes a critical issue. In today's environment of attempting to meet current production testing while continuing to develop new tests for new equipment the challenge is to maximize leverage of existing software tests. The challenge becomes more difficult with the rapid changes in software technology and the lack of software knowledge of the measurement designer. These tests must be designed to handle the customer's desire to perform equipment substitution, the substitution of their standards. Due to the complexity of calculating measurement uncertainties for complex electronic test equipment (ETE) the measurement engineers are usually not equipped with the skills of creating software that contains a high degree of leverage. Originally many of the software tests were written in simple interpreted languages such as BASIC or other scripting languages. Unfortunately this software is designed with little or no modularity and is highly coupled to the instruments used in the test. As new equipment evolves, leveraging these tests to utilize this new equipment becomes an extremely difficult task. The desire is to provide the measurement engineer the tools to capture the test methodology, which includes measurement uncertainty, in such a way that they may be able to leverage much of their measurement design against new equipment. This paper will explore the ways in which one equipment manufacturer, Agilent Technologies, is approaching in utilizing software technology and measurement design to create re-usable code that is 17025 compliant.

Drift of Type K and T Thermocouples During Calibration
WEDNESDAY, August 20, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 6, 6C
Temperature II
Karen M. Garrity,
National Institute of Standards and Technology
It is a known fact that the thermoelectric properties of base metal wire will vary with time and temperature of use, and the gauge size of the wire. One manifestation of this is drift or the change in emf with time of thermocouples with a constant measuring junction temperature. In this study, the drift of type K and type T thermocouples during calibration was measured by comparing the calibration results for thermocouples that are heated for up to eight hours and for thermocouples that are heated only briefly. In the first case, the thermocouples were immersed in the cold furnace and the temperature gradually increased to the temperature of study (heat method). In the second case, the furnace was brought to temperature, the thermocouple inserted, the emf measured and the thermocouple removed (plunge method). In addition to time at temperature, we looked at the effect of wire gauge on emf drift at 800 C to 1200 C for type K wire. Results of these experiments are used in the estimation of calibration uncertainties of these types of thermocouples.

A Study on the Stability of Standard Platinum Resistance Thermometers in the Temperature Range from 0 C through 720 C
WEDNESDAY, August 20, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 6, 6C
Temperature II
X. Li,
Hart Scientific
Stabilities of standard platinum resistance thermometers (SPRTs) were tested at their respective maximum temperatures. The stabilities of some 25-ohm SPRTs were excellent at their maximum temperatures. The drift rates of their resistances at the triple point of water (Rtp) during annealing at 675 C were as low as 0.5 mK/100 hours. But, the similar drift rates of Rtp during annealing at 250 C and at 450 C were much higher than at 675 C. Thus, the stabilities should be tested not only at the maximum temperature but also at a few other temperatures.
In order to investigate the stability of SPRTs over their full ranges, we made and tested five special SPRTs with different filling gases. These SPRTs were annealed at four different temperatures (720 C, 675 C, 450 C and 250 C) for up to 2000 hours. The results obtained are summarized in the paper. Improvement of SPRT stability over their entire temperature range is discussed.

An Investigation of Long-Term Stability of a Precision Platinum Resistance Thermometer up to 660 C
WEDNESDAY, August 20, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 6, 6C
Temperature II
Mingjian Zhao,
Hart Scientific
A new precision (secondary) platinum resistance thermometer with an upper temperature limit of 661 C and inconel protection sheath was developed at Hart Scientific five years ago. In order to verify the long-term stability of these thermometers at high temperatures, a few were tested for stability at 665 C over 20,000 hours. The drift of the thermometer's resistance at the triple point of water was as good as the equivalent of 0.002 C after the thermometers were exposed to 665 C for over 1000 hours. After long-term exposure to high temperature, the thermometers were calibrated to determine whether they still met the requirements of ITS-90. In this paper, the test results of some of these thermometers are presented. Some issues that may affect the stabilities of the thermometers are discussed. And the stabilities of some customers' thermometers returned for routine calibration are also reported.

TBD
WEDNESDAY, August 20, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 6, 6D
Legal Metrology

TBD
WEDNESDAY, August 20, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 6, 6D
Legal Metrology

Modelling and Uncertainty Evaluation in Calibration and Conformity Testing
WEDNESDAY, August 20, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 6, 6D
Legal Metrology
Klaus-Dieter Sommer,
Landesamt fuer Mess- und Eichwesen Thueringen (LMET)
Calibration certificates give the calibration result and the associated measurement uncer-tainty. To an increasing extend, the measurement uncertainty is taken into account when de-cisions are taken on the basis of these calibration results as to whether an instrument con-forms with (legally) prescribed or agreed requirements. According to the state-of-the-art, the necessary uncertainty evaluations are carried out in accordance with the Guide to the Ex-pression of Uncertainty in Measurement (GUM). The basic steps of the GUM procedure are: modelling of the measurement with a view to establishing mathematically the relationship between the measurand, e.g. the instrumental error, and all quantities which may contribute to the uncertainty associated with the measurement / calibration result, and description of the existing knowledge about these quantities by means of probability distributions. But the GUM does not provide any guidance on the modelling process itself. This lack of guidance on the most difficult task of uncertainty evaluation has often impeded everyday applications of the GUM procedure. In order to overcome this problem, a straightforward and widely applicable concept for the

modelling of calibrations and tests in the steady state, including the inclusion of the measurement uncertainty in the conformity decision, has been developed. It is based on both the idea of the classical measuring chain and the method of measurement / calibration used. The concept is demonstrated with examples of the most common calibration and testing procedures from various fields of metrology, along with the description of the uncertainty evaluation and the assessment of conformity of the results obtained, with the requirements to be met. It allows to analyse and to predict the measurement uncertainty which can be achieved depending on the method chosen, the standard used and the cali-bration / testing conditions.

Accurate Measurement of the Frequency Dependence of Impedance Standards from 1 kHz to 10 MHz

WEDNESDAY, August 20, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 6, 6E
Capacitance
Shakil A. Awan,
Centre for Electromagnetic and Time Metrology
National Physical Laboratory

Four terminal-pair bridge systems have recently been developed at the National Physical Laboratory, UK, to accurately measure the frequency dependence of impedance standards from 1 kHz to 10 MHz. The frequency dependence of air-dielectric, and ceramic NPO dielectric capacitance standards are reported here. The latter is finding more widespread use in the National Metrology Institutes because of its relatively small size, voltage coefficient, temperature coefficient and dissipation factor. We will also be reporting on a new technique which measures the 'equivalent' four terminal-pair resonance frequency of air-dielectric capacitance standards. A simple model of the standard enables the frequency dependence of the standard to be calculable from the measured alone (in the limit). Preliminary frequency dependence measurements of recently developed novel design four terminal-pair coaxial resistance standards will also be discussed. Work is currently being planned to extend present NPL capabilities from high-frequency impedance measurements to analytical modelling. This should aid in further improvements in the accuracy of high-frequency impedance measurement systems at NPL. The implications of these measurements for providing accurate traceability of LCR meters and network analysers over a broad range of frequencies will also be discussed.

Measurements of frequency dependence of fused-silica capacitors with respect to a 1 pF cross capacitor

WEDNESDAY, August 20, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 6, 6E
Capacitance
Yicheng Wang,
National Institute of Standards and Technology

We have recently put a significant effort on determining frequency dependence of transfer capacitors in the audio frequency range. This effort may in the next few years lead to improved calibration services from NIST for characterizing frequency dependence of commercial fused-silica capacitance standards. This effort is also aimed at addressing some concerns within the metrology community regarding two possible quantum representations of the Farad. For the electron counting capacitance standard which functions near DC, we need to characterize the frequency dependence of a cryogenic capacitor in order to use it for AC calibrations. For the Farad representation via AC Quantum Hall Resistance (QHR), a comparison between a frequency-characterized capacitor and an AC QHR through a multi-frequency quad bridge may help to resolve the origin of the linear frequency dependence observed in QHR devices. This paper first discusses several approaches we adopt to improve capacitance measurements at NIST. We then discuss the major results of measurements of frequency dependence of fused-silica capacitors with respect to a 1 pF cross capacitor.

Environmental Management in a Standards Room for Measuring Air Capacitors

WEDNESDAY, August 20, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 6, 6E
Capacitance
Makoto Kasuga,
Agilent Technologies Japan, Ltd

The Measurement Standards Center of Agilent Technologies Japan calibrates air capacitors for performance tests of LCR meters. Air capacitors have a high-integrity frequency characteristic. However a paper reported that the permittivity (capacitance value) of them is subject to differences in value depending on environmental factors (temperature, relative humidity and atmospheric air pressure). Consequently it is necessary to establish the traceability of environmental factors and manage them in a standards room to achieve high accuracy and low uncertainties for their calibration. The measurement capability of environmental factors in our standards room before was insufficient for air capacitor measurements. This paper describes the method for establishing a traceability system for environmental factors. Additionally this paper confirms the agreement with the result of a comparison between a theoretical formula on the permittivity of air and experimental data of capacitance value for this traceability system.

Modular System for the Calibration of Capacitance Standards Based on the Quantum Hall Effect

WEDNESDAY, August 20, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 6, 6E
Capacitance
Jürgen Melcher,
Physikalisch-Technische Bundesanstalt

Since 1990 the primary standard which provides the ohm is based on the quantum Hall effect (QHE). Calibration set-ups based on the QHE are used world-wide with great success in many National Metrological Institutes. Due to the metrological impact of the dc QHE, it seems to be obvious to use the quantum Hall effect also with alternating current in order to represent the unit of capacitance, the farad. The most favourable frequency range for this calibration purpose is about 1 kHz. The novel measurement system described here was developed by a group of seven partners: PTB (DE), NPL (UK), IEN (IT), METAS (CH), CTU (CZ), NML (IE), and INETI (PT) and funded by the European Commission. It establishes a new quantum standard based on the QHE for the calibration of decadic capacitance standards in the range 10 pF to 10 nF and should guarantee a relative calibration uncertainty of a few parts in 107. It follows a straightforward route: A QHE sample is com-pared with a 12.906 kW ac resistance standard by use of an ac 1:1 ratio bridge. The next step is a quadrature bridge which establishes a relation between the quantum Hall resistance, and two 10 nF capacitors. By use of a 10:1 ratio bridge a 10 nF capacitor is compared with a 1 nF capacitor and through further 10:1 steps the comparisons are continued down to 10 pF. This procedure realises the precise calibration of four decadic capacitance standards in terms of RK?90.

Operational Integration for Accreditation
WEDNESDAY, August 20, 2003
10:45 AM - 12:15 PM - PARALLEL SESSIONS - SESSION 7, 7A
Accreditation
James R. Cyre,
Corporate Calibration and Standards Laboratory
Philips Lighting Company
The Corporate Calibration and Standards Laboratory (CCSL) of the Philips Lighting Company is accredited by NVLAP under lab code 100399-0 and is certified by CSA. The CCSL is responsible for providing standard lamp artifacts to PLC laboratories throughout North America It also performs life testing activities and the testing necessary for qualifying the safety of incandescent and halogen lamps for Canada and the energy efficiency of lamps for the United States, Canada, and Mexico. A Quality System is obviously a necessity for obtaining certification or accreditation. Many quality systems are developed utilizing a simplified approach that describes how the organization meets each requirement of a particular standard. This format, while convenient, can result in the Quality System, and particularly the Quality Manual, becoming a distant reference to daily operations. The CCSL has taken a different approach. The CCSL has developed a dynamic quality system that is compliant to relevant clauses of ISO 17025; is user and maintenance friendly; and is fully integrated into daily operations. The system consists of utilizing client personnel within the audit process, thus giving a customer perspective to the audit as well as providing training opportunities to the clients. This paper provides information on the structure, operation, change management, and deployment aspects of the quality system at the CCSL in regards to ISO17025. It also provides information on the system integration including the required management review and periodic client involved audits

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The Directory of Accreditation Scope: A close look
WEDNESDAY, August 20, 2003
10:45 AM - 12:15 PM - PARALLEL SESSIONS - SESSION 7, 7A
Accreditation
Dr. Mahesh Chander,
Formerly: Head of National Calibration Programme
Presently: Free lance Consultant(calibration, laboratory accreditation)
It has now well recognised that in the global market place , the quality of test/calibration results from laboratories become the fore- runner means to overcome the non-tarrif type trade barriers. Consequently, the laboratory results for facilitating the cross border trade become acceptable only when they are reliable and globally equivalent. Laboratory accreditation ensures such requirements. The accreditation bodies are required to disseminate information about their accredited laboratories through periodic publication of list/ directory (ISO/IEC guide 58 1993 E: clause 7.4) containing sufficient details on the scope of accredited tests/calibrations. A close look into the contents of directories published so far realize many discrepancies and anomalies in their narration. The author points out some of them and recommends harmonised pattern of publicable information so that it could be easily understood and become directly comparable. Only then they will become 'equivalent' and provide true interpretation.

Laboratory Accreditation: Panacea or just the Flavor of the Month
WEDNESDAY, August 20, 2003
10:45 AM - 12:15 PM - PARALLEL SESSIONS - SESSION 7, 7A
Accreditation
Buddy Stricker,
Stabro Laboratories, Inc
Like many metrology professionals, I embraced the early announcements of laboratory accreditation in the United States. I personally advocated the accreditation process for my employer and worked at a grass roots level to educate industry. For once it seemed that the desire for quality would win out and that those organizations producing a substandard product would be the loser. Several years later, we could not be further from the truth. Accreditation in the United States has not had the impact that it has in Europe or other regions. The purpose of this paper is to present a strategy which would help Laboratory Accreditation fulfill its promise. It discusses the commitment level required from the metrology industry, and the objectives, which will have to be achieved in order to make this a reality. Accreditation can never be labeled a success until the automotive, aerospace, medical, and general manufacturing communities truly embrace it at the same level that metrology industry has. Additionally, the author discusses some of the experiences that have led him to this conclusion.

Determining Consensus Values in Interlaboratory Comparisons and Proficiency Testing
WEDNESDAY, August 20, 2003
10:45 AM - 12:15 PM - PARALLEL SESSIONS - SESSION 7, 7B
Uncertainty I
Dr. Henrik S. Nielsen,
HN Metrology Consulting, Inc
An important part of interlaboratory comparisons and proficiency testing is the determination of the reference value of the measurand and the associated uncertainty. It is desirable to have reference values with low uncertainty, but it is crucial that these values are reliable, i.e. they are correct within their stated uncertainty. In some cases it is possible to obtain reference values from laboratories that reliably can produce values with significantly lower uncertainty than the proficiency testing participants, but in many cases this is not possible for economical or practical reasons. In these cases a consensus value can be used as the best estimate of the measurand. A consensus value has the advantage that it often has a lower uncertainty than the value reported by the reference laboratory. There are well known and statistically sound methods available for combining results with different uncertainties, but these methods assume that the stated uncertainty of the results is correct, which is not a given. In fact, the very purpose of proficiency testing is to establish whether the participants can measure within their claimed uncertainty. The paper explores a number of methods for determining preliminary consensus values used to determine which participant values should be deemed reliable and therefore included in the calculation of the final consensus value and its uncertainty. Some values are based on impressive equations and others have curious names. The relative merits of these methods in various scenarios are discussed.

GUM Uncertainty Analysis with no Greek Letters
WEDNESDAY, August 20, 2003
10:45 AM - 12:15 PM - PARALLEL SESSIONS - SESSION 7, 7B
Uncertainty I
Robert L. Brown,
Agilent Technologies Standards Lab
Is it possible to create a GUM compliant uncertainty analysis without an advanced course in statistics and calculus? Is it possible to have uncertainties documented so that someone other than the author can read it? Yes! All that is needed is a tool. With this paper is provided a comprehensive Microsoft Excel™ customized spreadsheet that will do all of the required math and documentation for you. You can follow the examples on your own computer as we discuss the topics that matter to you such as: (1) Where do I get the information to enter into this analysis? (2) Often neglected contributors like stability, repeatability, reproducibility, and delta environment. (3) What controls need to be added to my procedure when assumptions are made? (4) How do I use this analysis for procedure validation, bounds testing and ILCs? Uncertainty analysis can stop being a pain and start being an important information resource for controlling your laboratory.

Specifying a Tolerance for your Process
WEDNESDAY, August 20, 2003
10:45 AM - 12:15 PM - PARALLEL SESSIONS - SESSION 7, 7B
Uncertainty I
L. David Duff,
A-Metrology-Z
In healthcare and other related process industries, many over-zealous production and quality managers sign off on the wrong tolerances for their processes. They have little or no regard for the recording and test equipment used to monitor the process to show the process is "in control" during the manufacture of their products. The paper will discuss: (1) Typical tolerances for the first four levels of standards; (2) Open and closed ended tolerances; (3) Instantaneous vs. average values; (4) Batches or lots vs. continuous production; (5) Redundant standards in critical applications; (6) Confidence limits and the use of "out of tolerance" codes; (7) Summarizing every process with a simple power point slide.

Angular Response Characteristics of Ellipsoidal Radiometers
WEDNESDAY, August 20, 2003
10:45 AM - 12:15 PM - PARALLEL SESSIONS - SESSION 7, 7C
Temperature III
Annageri Murthy,
Aero-Tech, Inc.
This paper presents an experimental study of the angular response of an ellipsoidal radiometer performed using a 25-mm diameter variable temperature blackbody as a radiant source. The radiometer consists of a highly reflective ellipsoidal cavity with a thermopile sensor at one focus, and the aperture located at the other focus. In a recent development, the ISO[1] standard for heat-flux meters calibration used in fire test methods envisages the application of an ellipsoidal radiometer in the measurement chain to separate radiation and convection contributions. However, in fire test methods, the radiometer aperture receives radiation over a limited view angle much less than the hemispherical (180), resulting in under-filling of the cavity. Also, the radiometer angular response will be different from the cosine response, and the responsivity substantially lower than that of the open-sensor. Depending on the measured angular response, correction to the radiometer output will be necessary to determine the incident radiant flux level at the aperture. An approach to correlate the open-sensor and the radiometer responsivity values, using the measured angular response, is proposed. The new approach specifies an appropriate reference flux level for the open-sensor cosine response to determine the correction corresponding to different view angles of the incident radiation.

A Manufacturers Investigation into the Calibration of Contact Surface Sensors
WEDNESDAY, August 20, 2003
10:45 AM - 12:15 PM - PARALLEL SESSIONS - SESSION 7, 7C
Temperature III
Kenneth C. Sloneker,
Electronic Development Laboratories Inc
Contact surface temperature measurements represent a significant portion of industrial measurements. This study explores various methods of calibrating surface sensors and attempts to better define the surface calibration process by empirical testing. True surface temperature is derived by extrapolation using two different methods. Statistical data for the testing is reported for a large group of sensors randomly sampled and tested over a two-month period. From this data the deviation from the true surface temperature as well as the sensor to sensor reproducibility is established and is correlated to the degree of surface disturbance that is dependent partially on the temperature of the sensor and its surroundings. The described calibration methods and resultant data support previously reported expected tolerances of one percent or better of reading.

Calibration of Standard Platinum Resistance Thermometers by Comparison
WEDNESDAY, August 20, 2003
10:45 AM - 12:15 PM - PARALLEL SESSIONS - SESSION 7, 7C
Temperature III
Douglas Gee,
Thermometry Group
National Research Council Canada
In order to take full advantage of the stability of Standard Platinum Resistance Thermometer they are usually calibrated in the ITS-90 fixed points. This can be both time consuming and costly. Many labs can benefit from the stability of a 25 ohm SPRT over a 100 ohm PRT with a lower cost, larger uncertainty 'calibration by comparison' in fluid baths.

The Role of Proficiency Testing in Calibration & Testing Laboratory Accreditation and Legal Metrology
WEDNESDAY, August 20, 2003
10:45 AM - 12:15 PM - PARALLEL SESSIONS - SESSION 7, 7D
Comparisons II
Hidetaka Imai,
AIST, Japan

The CIPM Working Group on Fluid Flow: Purpose, Plans and Progress Towards CIPM Key Comparison Tests
WEDNESDAY, August 20, 2003
10:45 AM - 12:15 PM - PARALLEL SESSIONS - SESSION 7, 7D
Comparisons II
George Mattingly,
NIST

TNMS Support to the Spectrum of Metrology in Taiwan And It's Impact to the Great China Economy
WEDNESDAY, August 20, 2003
10:45 AM - 12:15 PM - PARALLEL SESSIONS - SESSION 7, 7D
Comparisons II
Tzeng-Yow Lin,
National Measurement Laboratory
Center for Measurement Standards
The paper aims to study the support of the Taiwan's National Measurement System (TNMS) to the demands of spectrum in metrology, especially from the angles of Safety, Health, Environment and Trade. The TNMS has been established since 1987 in support of Taiwan's export-oriented economy. Besides its close link with the renowned IC foundry industry, the TNMS has essential contributions to the island's metrology infrastructure of everyday life. For instance, to ensure a safety drive primary accredited labs for calibration of alcohol breath tester and speedometer have been established with the helps from the police administration and the bureau of standards. Further, to enhance the interoperability of medical testing among hospitals, reducing the cost due to repeatable tests and for the safety and ease of patients, the conformance of medical testing of clinical labs has been noticeably improved and promoted with TNMS. The paper will also report the contributions of the TNMS to the metrology demands in the Great China Economy, especially the impact to the southeastern coast of the mainland including Hong Kong and Shanghai. With the westbound movement of Taiwanese companies to the mainland, the TNMS has actually provided technical supports to the traceability implementation of manufacturers, and improve the fabrication quality of companies by enhancing their inspection accuracy and capability. More than 30000 plants with half of a million Taiwanese gather along the Yangtze River and the Pear River Delta. Two examples in flow and vibration fields are given in the paper to demonstrate how the TNMS supports the metrology activities in the southeastern China.

Josephson Volt Interlaboratory Comparison at 10 V dc
WEDNESDAY, August 20, 2003
10:45 AM - 12:15 PM - PARALLEL SESSIONS - SESSION 7, 7E
DC Voltage
Stuart Kupferman,
Sandia National Laboratories
An interlaboratory comparison at 10 V dc has been made among 16 national, industrial, and military standards laboratories in North America using a set of four Zener dc reference standards that were specially selected for their stability and linear drift behavior. The standards traveled on a weekly schedule between the pivot (Sandia National Laboratories) and the participant laboratories in a daisy pattern with a return to the pivot laboratory after 2-5 shipments to participant laboratories. The minimum data set for ILC2002 is 32 measurements, 8 for each of the four Zener standards. The eight measurements are made as four +/- pairs using a manual reversing switch that attaches directly to the Zener terminals. In addition to the Zener measurements, each participant made 8 short circuit measurements using exactly the same procedure as that used in the Zener measurements. These short circuit measurements allow an independent evaluation of most of the sources of uncertainty in each participant's measurement system. Also traveling with the Zener standards were sensors to record temperature, humidity, and atmospheric pressure. Differences between each participant and the pivot laboratory were computed based on a pivot-point-to-pivot-point model that included time drift and atmospheric pressure dependence of the traveling standards. The differences and their uncertainties are reported and used to demonstrate equivalence between each participant and the pivot, and between each participant and the National Institute of Standards and Technology (NIST). All of the differences are less than 2 parts in 108 and fall within their k = 2 uncertainty.

Projecting Zener dc Reference Performance Between Calibrations
WEDNESDAY, August 20, 2003
10:45 AM - 12:15 PM - PARALLEL SESSIONS - SESSION 7, 7E
DC Voltage
Larry W. Tarr,
US Army Primary Standards Laboratory
Many standards laboratories rely on Zener reference standards for dc voltage and achieve traceability through periodic calibrations by a national metrology institute (NMI) or a Josephson standard. Typically, such calibrations give only a value and uncertainty at the time of test. This paper addresses the problem of predicting the value and uncertainty over the interval between calibrations. The approach is to examine a large representative sample of measurement data, and then to construct an empirical model that describes the data without making any assumptions about its statistics. For any given standard, the model uses the available calibration data to predict a value and the representative sample of data to predict two time-dependent uncertainties such that the predicted values fall within the uncertainty limits with a probability of 95% and 99% for all of the sample data and at all points within the calibration interval. Using data on 140 Zener reference standards, we develop a linear drift model based on two calibration points separated by at least 9 months. The data show that the uncertainty of this model is substantially better than the manufacturer's specification and that it is dominated by the seasonal humidity dependence that occurs in most of the standards in the study. The dominance of the seasonal humidity effect

suggests adherence to a one year calibration interval and special vigilance in cases where the environmental conditions in the calibrating laboratory may be significantly different than in the client laboratory.

AC/DC Transfer Standard Measurements Using an AC Josephson Voltage Standard
WEDNESDAY, August 20, 2003
10:45 AM - 12:15 PM - PARALLEL SESSIONS - SESSION 7, 7E
DC Voltage
Charles J. Burroughs,
National Institute of Standards and Technology
For a number of years, NIST has been developing a Josephson arbitrary waveform synthesizer as an ac Josephson Voltage Standard (ACJVS). The effort has primarily focused on increasing the output voltage to practical levels. Recent advances in circuit design and superconducting integrated circuit fabrication have enabled us for the first time to demonstrate waveforms with 0.242 mV peak voltage. This larger output voltage now allows us to perform practical metrology measurements with rms amplitudes up to 170 mV. The new system can generate a variety of precision voltage waveforms, including dc voltages as well as ac sinewaves so that the system can be used as a quantum-based voltage source for ac metrology. In this paper, we present experimental results using the ACJVS to measure an ac/dc transfer standard at audio frequencies on its lower voltage ranges, namely the 22 mV to 220 mV ranges where the transfer standard uses a high?impedance buffer amplifier on its input. We compare these results to values obtained using conventional calibration methods with thermal voltage converters. This work demonstrates the feasibility of a practical ac Josephson voltage standard based upon a quantum voltage source that delivers precisely calculable ac and dc rms voltages.

Automating Calibration and Certificate Generation
WEDNESDAY, August 20, 2003
2:30 PM - 4:00 PM - PARALLEL SESSIONS - SESSION 8, 8A
Software
Seamus Mc Namara,
Transtest Ltd
Many Calibration and Metrology laboratories use ExcelÔ as a basis for generating calibration “formats” and certificates. The flexibility of ExcelÔ coupled with the powerful functions for calculating uncertainties and limits on the fly represent an excellent tool for this function within laboratories. Transtest limited have developed software that enhances the existing power of ExcelÔ and allows instruments to be controlled automatically from within a spreadsheet. No programming skills are required and results can be automatically populated back into the calibration spreadsheet providing a full closed loop calibration cycle if required. “Manual” ExcelÔ calibration formats can be converted into fully automatic formats in a matter of minutes without loosing any of the flexibility and features available within ExcelÔ. In real world practical application this has reduced calibration times on some high-end instruments from several days down to a couple of hours. Automatic and semi-automatic calibration methods can be combined within the one spreadsheet and elimination of manual calibration setting and manual entry of result onto spreadsheets can be eliminated in the most efficient means possible by calibration technicians who have no knowledge of programming.

Cost Effective Calibration Management Through Reliability Analysis
WEDNESDAY, August 20, 2003
2:30 PM - 4:00 PM - PARALLEL SESSIONS - SESSION 8, 8A
Software
Gregory E. Cenker,
Southern California Edison
Over the years, the Metrology field has been in a constant state of change due to evolving technologies, practices, and methodologies. With the changing times, the advent of Accreditation and new ISO requirements, now more than ever, the integration of all metrology practices must be unified. This paper will address the importance, significance, and financial considerations of integrating uncertainty analysis, process metrology, Calibration Interval Analysis and Multiple Instrument Reliability by transforming them into real time calculations in an efficient medium. By embedding technical expertise within the confines of a software program and using various simulation methods, quality, consistency, and a highly evolved level of confidence are not only desirable but also a very tangible objective.

Customizing Automation in the Calibration Laboratory
WEDNESDAY, August 20, 2003
2:30 PM - 4:00 PM - PARALLEL SESSIONS - SESSION 8, 8A
Software
Tom Lipko,
BAE Systems Controls
I think the majority of calibration personnel would agree that automation in the laboratory is a tremendous asset. Some of the benefits of automation would be removal of operator bias, the ability of the technician to multitask and the ease of data collection just to name a few. These, along with other non-tangible assets, lead to cost savings and better efficiency. Of course these cost savings and efficiency come at a price so the pay back time of the purchased software and software maintenance contracts plays a role in determining these benefits. There are a number of manufactures and software companies that produce calibration automation software but what do you choose?
Some automation packages are custom and specific and only deal with specific calibration products that may limit what can be calibrated with that package. Another package offers you programmability but this is limited to the current drivers that are supported. I have always dreamed of having a calibration software package that would allow me to create a text file of an instrument's test aspects and accuracy and have the application read the text file and calibrate my instrument. This paper explains my solution to calibration automation.

Measurement uncertainty in torque wrench calibration
WEDNESDAY, August 20, 2003
2:30 PM - 4:00 PM - PARALLEL SESSIONS - SESSION 8, 8B
Uncertainty II
Luca G. Bochese,
Boch Metrology
Calibration procedures for torque wrenches (TW) (cut-off, slipper, dial) are defined by ISO 6789 standard. This report will discuss some points, which affect the significance of the calibration. ISO 6789 requires to operate the TW five times at the max torque value, without recording any value, then to record five consecutive measurements respectively at 20%, 60% and 100% of the TW max value. A “non conforming” TW has at least one point out of this range. Experience shows that cut-off points have a skewed non-normal distribution and that the first cut-off point is often outside the upper 4% tolerance limit. This evidence would suggest to operate the torque wrench at least one time, at each calibration step, before recording the measuring values, or, alternatively, to modify tolerance limits, adopting i.e. asymmetric limits with a larger upper limit, i.e. – 4%, + 6%. Research performed in our calibration laboratory analyzed also other sources (apart the relevance of the cut-off) which affect measurement uncertainty of torque wrenches, such as: temperature, arm length, position, user influence, cut-off speed, interval between cut-off points, surface and spring characteristics. These results, obtained applying also R&R and DOE studies, will help laboratories to understand the sources of variability in torque wrenches and develop a sound measurement uncertainty budget according to the EA-4/02 reference document (Expression of Measuring uncertainty in Calibration).

Low frequency absolute and comparison calibration of vibration transducers - Uncertainties and challenges.
WEDNESDAY, August 20, 2003
2:30 PM - 4:00 PM - PARALLEL SESSIONS - SESSION 8, 8B
Uncertainty II
Torben R. Licht,
Brüel & Kjaer Sound & Vibration Measurement A/S
An increasing demand for measurement of low frequency vibration has surfaced over the last few years due to a number of factors. The interest in quality of transportation and safety of transportation is among these. Furthermore large buildings and bridges have become more common, and safety issues more important. Also earthquakes and their effects are getting increasingly important. Recently a system was built based on a commercially available long stroke exciter (160 mm) and a commercially available laser vibrometer. This proved to be a very efficient way to provide accurate calibrations with available instrumentation. Good results could be obtained in the frequency range 0.1 Hz to 100 Hz. An uncertainty analysis of the calibrations will be presented and the challenges in creating such a system described. Results on servo accelerometers and other types of transducers will be presented. If available, results from a comparison calibration with an NMI will be shown.

Performance of Rockwell Hardness Testers That Meet Direct Parameters and Established Dwell Times
WEDNESDAY, August 20, 2003
2:30 PM - 4:00 PM - PARALLEL SESSIONS - SESSION 8, 8B
Uncertainty II
Robert A. Ellis,
David L. Ellis Company, Inc.
There is a need for testers that can be directly verified for loads and depth as well as having the capability of maintaining loading cycles. Closed loop load cell hardness testers meet these requirements and are readily available from several manufacturers. Also, diamond indenters with correct geometric shapes which when used with a closed loop tester, give results that are comparable to national standards around the world. In the 1980s, NIST (formally NBS) conducted an inter-comparison of Rockwell hardness test blocks used in the United States (NISTIR 4531) and concluded that there were significant differences Rockwell hardness values in industry. Older designs of Rockwell testers are incapable of controlling the direct parameters (load and depth) or loading cycles that affect the outcome of the hardness results. In the past industry has chased hardness numbers by adjusting loads, indenters and any other mechanical means to achieve results. This paper discusses the performance of the new Rockwell hardness testers compared to earlier designs. For this study, closed loop Rockwell hardness testers meeting all the ASTM parameters and an indenter with the correct 200-micron radius were used for all the diamond scales. This is consistent with national standardizing laboratories calibrating HRC and other Rockwell diamond scales throughout the world. In addition, some of the measurements in this study were performed on a primary dead weight standardizing hardness testing machine as a comparison. Finally, it will be shown that new testers can maintain national and international Rockwell hardness standards.

Bias, Uncertainty and Transferability in Standard Methods of Pipette Calibration
WEDNESDAY, August 20, 2003
2:30 PM - 4:00 PM - PARALLEL SESSIONS - SESSION 8, 8C
Chemical
George Rodrigues,
ARTEL
Two current standard methods of pipette calibration are considered in this paper. These are: ASTM E 1154 (1997); and a new ISO standard ISO 8655-6:2002. Both methods are based on the gravimetric principle.
This paper is divided into two parts. The first part compares and contrasts these two gravimetric standards. In this part, it is seen that the factors contributing to the uncertainty of pipette calibration can be divided into two classes. These are: factors that impact the uncertainty of the measurement method, and; those other factors that impact the uncertainty of the unit under test.
The second part of the paper presents experimental work to quantify the error contribution from some of the significant sources identified in part one. Regarding the uncertainty of the measurement method, the uncertainty introduced by the various methods of controlling, measuring and compensating for the effect of evaporation are evaluated. Data are presented to quantify the uncertainty in estimates of the evaporation rate, and the bias incurred as a result of neglecting evaporation (permitted by the ISO standard in some situations). The method used here to assess the bias due to imperfect evaporative compensation might also prove useful for those wishing to validate other gravimetric volume measurement methods.
Regarding the uncertainty attributed to the unit under test, experimental work is presented to confirm the significant impact that changes in environmental relative humidity and operator technique exert on the mean volume delivered by air displacement pipettes. In order to reduce evaporative loss, both the ISO and ASTM standard methods require conditions of high relative humidity. However, when pipettes are returned to working use there

can be a significant bias in the delivered volume due to a decrease in ambient humidity. In addition, details of operator technique (including some details not specified within the standard methods) can also impart significant bias. These two effects should be considered when evaluating whether the results of a pipette calibration are sufficient to demonstrate that the device is suitable for the intended use.

I helped Catch A Killer…The True Story of Calibration In DNA Testing!
WEDNESDAY, August 20, 2003
2:30 PM - 4:00 PM - PARALLEL SESSIONS - SESSION 8, 8C
Chemical
Jay L. Bucher,
Promega Corporation
Did I really help catch a killer? Directly - no. Indirectly - you betcha'! Discovering who committed a crime by determining their genetic identity (GI) through DNA testing has been at the forefront in solving rape, murder, and many other types of crimes since the late 80s and early 90s. It doesn't happen by waving a magic wand, or using a crystal ball. The use of calibrated test equipment in the design, manufacture, and production of GI test kits; the use of those kits in law enforcement crime labs; and the ability to consistently replicate those results time after time, have not only put the 'bad guys' behind bars; but also play a major role in releasing the innocent. The importance of using calibrated test equipment cannot be over emphasized. This paper gives an overview of how an extremely small sample of DNA is turned into a usable quantity for testing purposes, and the role test equipment plays throughout the entire process. By demanding an unbroken chain of comparisons during calibration back to a national standard, we have been able to meet the challenges of creating and producing the tools used in the small world of DNA identification. Every time a criminal is caught through their GI finger print, those of us ensuring traceable calibration in the world of biotechnology stand a little taller; knowing we played a critical role in helping to discover the truth…and possibly helped to catch a killer!

Traceable Calibration Procedures for the Measurement of pH and Electrolytic Conductivity
WEDNESDAY, August 20, 2003
2:30 PM - 4:00 PM - PARALLEL SESSIONS - SESSION 8, 8C
Chemical
Petra Spitzer,
Physikalisch-Technische Bundesanstalt (PTB)
For several years a traceability chain for pH and conductivity has been established within the German measurement infrastructure. The equivalence of the primary standards for these quantities is established by the Mutual Recognition Arrangement (MRA) for national measurement standards and for calibration certificates issued by national metrology institutes. For many years the DKD Calibration Laboratory DKD-K-06901 has been devoted to the implementation and transmission of pH to accredited laboratories, research facilities, institutes and the industry. Accredited in accordance with ISO/IEC 17025 it operates on the basis of national and internationally harmonized procedures. The experience gained in metrology at different levels and in a broad spectrum of applications will be described.

What needs to be traceable in a statement of traceability?
WEDNESDAY, August 20, 2003
2:30 PM - 4:00 PM - PARALLEL SESSIONS - SESSION 8, 8D
Traceability Panel
Charles Ehrlich,
National Institute of Standards and Technology
International Legal Metrology Group
This panel session is the second in what is planned to be a continuing series of panel discussions on current issues in traceability. The first session last year put forward a list of issues and questions, and concentrated on discussing two or three, namely: a) the relationship between "traceability" and "equivalence" (as described in the BIPM MRA) and how data in the key comparison database might be used to support traceability across international boundaries, b) what the role is of measurement uncertainty in establishing traceability (and vice versa), and c) the meaning and usefulness of the expression "Traceability to the SI". It was generally agreed that the key comparison database could be used in support of some types of traceability claims.
This second session will look at any new developments in the issues discussed last year (especially the relationship between "traceability" and "equivalence" and any trade-related issues that have appeared), but will primarily concentrate on the more technical question 'For measurement results where the measurand is a function of several input quantities (and influence quantities) is there the need for all of the measured values of these quantities to themselves be traceable to appropriate references?' There are different approaches being taken to answering this question that can have significant implications in the outcomes of laboratory accreditation and other types of audits. The panelists will focus their opening comments on this question, with subsequent open discussion of this question and, if time permits, of other traceability-related issues.
Additional topics in traceability that may be discussed include the variety of interpretations used as to what actually constitutes traceability of a measurement result, what the references can be (including how 'high' they must be, and whether 'intrinsic standards' and measurement processes or procedures are credible 'higher level' references) in a statement of traceability, how 'direct' the comparisons in a traceability chain have to be, and the implications of possible multiple chains for establishing traceability of the same measurement result. Future panels will continue to explore these issues, and the related question: When is it metrological traceability, and when is it something else?
NOTE: Definition of "traceability" from the International Vocabulary of Basic and General Terms in Metrology, ISO, 1993: "property of the result of a measurement or the value of a standard whereby it can be related to stated references, usually national or international standards, through an unbroken chain of comparisons all having stated uncertainties".

A Web Based Tool for Estimation of Gage R&R and Measurement Uncertainty
WEDNESDAY, August 20, 2003
2:30 PM - 4:00 PM - PARALLEL SESSIONS - SESSION 8, 8E
Precision Engineering
Dr. Jay Raja,
Center for Precision Metrology
The work presented in this paper deals with the development of a web based software system for the estimation of gage repeatability and reproducibility (Gage R&R) and measurement uncertainty. The industries today, practice a technique called Gage R&R to estimate the total variation in their measurement system and determine if the current measurement system is suitable for the intended application. With the advent of quality standards such as the ISO 9000 etc., the estimation of uncertainty in measurement has become mandatory. The estimation of uncertainty in measurement is essential to establish the traceability of the measurement results to those of the national or international standards. This paper discusses the design of a software system for the estimation of gage repeatability and reproducibility and measurement uncertainty using the principles of the unified software development process. UML (Unified Modeling Language) is used for the design of the software system as it is the most powerful and widely used of all the development processes available today. The software system is built in such a way that it can be remotely accessed from any location with the aid of a Java enabled web browser. This software system is a simple tool for easy and accurate estimation of variability of the measurement system or for preparation of error budget reports.

Calibrating High Precision Dimensional Instruments: Bringing State-of-the-Art to the Everyday
WEDNESDAY, August 20, 2003
2:30 PM - 4:00 PM - PARALLEL SESSIONS - SESSION 8, 8E
Precision Engineering
James G. Salsbury,
Mitutoyo America Corporation
The continued tightening of dimensional tolerances combined with the demand for accreditation of calibration services is pushing the limits of many organization's capabilities. This is particularly relevant when the cost of lowering calibration uncertainty is high. This paper explores the journey taken by one dimensional metrology manufacturer to develop cost effective, on-site, calibration procedures with measurement uncertainty that approaches, or sometimes is even lower than, the levels offered by the state-of-the-art procedures at the best national metrology institutes worldwide. The focus of this uncertainty improvement journey is the calibration of one particular type of dimensional form measuring instrument, the roundness measuring machine. For a common, industrial, off-the-shelf, measuring instrument, the roundness machine has some of the tightest specifications. On-site calibration of these instruments needs to be done with an uncertainty that is often lower than what is offered for the calibration of the appropriate reference standards at most national metrology institutes. The challenge faced by the manufacturer is to demonstrate traceability and achieve the required uncertainty given the demanding requirements. This paper will explore these challenges and present some novel solutions that allow state-of-the-art measurements to be economically reduced to the everyday.

The Influence of Thermistors on Temperature Measurements
WEDNESDAY, August 20, 2003
2:30 PM - 4:00 PM - PARALLEL SESSIONS - SESSION 8, 8E
Precision Engineering
K. Inampudi,
The Center for Precision Metrology
In this paper, we present results from our investigations on the surface temperature of aluminum and steel test pieces cooling in a laboratory environment. Standard bead-type thermistors are affixed to these test pieces in order to measure the temperature profile over time as the piece "soaks" in a laboratory setting. Three contributors to inaccuracies in experimental thermal data are discussed. These are the thermistor calibration, the time constants of the thermistors, and the influence of the thermistor on the test piece temperature. Using a commercial analysis package, we have studied the influence of a thermistor on the thermal state of steel and aluminum workpieces. The perturbation caused by the thermistor on the temperature field of the parts coupled with the time constant of the thermistor, will result in a bias in the data obtained from the part surface. This bias will depend on both the temperature of the part and the rate of change of the temperature. Our ultimate goal is to more accurately determine the temperature distributions in workpieces as they cool, and the influence of contact resistance between the piece and the fixture on which it sits. In order to effectively pursue this goal, we must first assess our ability to determine the temperature at individual points on the part surface.

Meet the NCSL International Board of Directors
THURSDAY, August 21, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 9, 9A
Meet the NCSLI Board
Steve Stahley,
SRS Technical Services

This Session will consist of a panel discussion with the current NCSL International Board of Directors. Please attend this meeting and bring your questions, comments, and ideas for the Board. The current NCSLI President, Steve Stahley, SRS Technical Services, will moderate the meeting.

Characterizations of Controlled Clearance Pressure Balance For The Hydrostatic Pressure Measurements Up To 500 Mpa
THURSDAY, August 21, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 9, 9B
Pressure I
Sanjay Yadav,
National Physical Laboratory New Delhi
For the hydrostatic pressure measurements, controlled clearance pressure balance is the ultimate instrument to be used as primary pressure standard and its use as reference or primary standard is well established and internationally accepted inspite of its complicated operation. The present paper

describes the results of a systematic study carried out to characterise such a controlled clearance pressure balance, recently established at NPL, India, in the hydraulic pressure region up to 500 MPa using pure J-13 and mixture of J-13 and aviation turbine fuel (ATF) (one part of J-13 and 2 parts of ATF) as pressure transmitting fluids. Although the present piston gauge is supposed to work up to 1 GPa, the limitation of the pressure transmitting fluid has prevented us to work up to maximum 700 MPa only. We have carried out a detailed study on the measurement of piston fall rate as a function of the applied jacket pressure (pj) for each of several loads (50 kg.). Following the method developed by Heydemann and Welch (1), we have plotted the cube root of the fall rate as a function of applied pj and extrapolating the linear portion of the curve to zero fall rate which provided us the values of pz for different loads. From the pz at different loads, we have determined the zero clearance between the piston and cylinder. The values of jacket coefficient are computed by analyzing the dependence of effective area and the jacket pressure, pj using: a) a theoretical method as suggested by Newhall et al (2) and b) an experimental method being used at NIST, USA (1, 3). Pressure induced viscosity effect of the pressure transmitting fluid will be discussed in reference to the uncertainty measurement of pressure up to 500 MPa.

Traceability Chain for Pressure Measurement from 10kPa – 280 MPa at the INMS/NRC
THURSDAY, August 21, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 9, 9B
Pressure I
Anil Agarwal,
Institute for National Measurement Standards
National Research Council Canada
The need for accurate measurement of pressure, over a wide range is important in many fields of science and engineering. The Institute of National Measurements Standards at the National Research Council maintains various pressure standards to measure pressures from about 10 kPa to 280 MPa. For measurement results to be consistent throughout this range, it is necessary that the results be accompanied with a statement of uncertainty that is based on an unbroken chain of comparisons from primary standards to secondary standards and working standards. In this paper, we will describe the calibration chain and estimation of uncertainty in order to establish traceability from the primary standard to various secondary standards.

Characterization of a 200 MPa Controlled Clearance Piston Gage
THURSDAY, August 21, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 9, 9B
Pressure I
A. K. Bandyopadhyay,
National Physical Laboratory New Delhi
National Institute of Standards and Technology

Controlled-clearance piston gages are used as primary pressure standards at many National Metrology Institutes. The National Institute of Standards and Technology, in collaboration with the National Physical Laboratory, is studying the performance of a new generation of controlled clearance gages that offer the potential for reduced uncertainties. The gages are also well suited for intercomparisons because of their smaller, integrated design, and use of existing mass sets. In this paper we present results of the characterization of a 200 MPa oil-operated controlled clearance gage using a 2.5 mm nominal diameter piston and cylinder. The gage is operated with an external cylinder pressure of 0 to 100 MPa. We present results of piston fall rate measurements, deformation measurements, and modeling calculations. We evaluate the uncertainties in the effective area and pressure.

Improved facility for optical detector characterizations
THURSDAY, August 21, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 9, 9C
Optics I
Tom Flournoy,
US Army Primary Standards Laboratory
The detector characterization and calibration facility of the Army Primary Standards Laboratory (APSL) has been extended. In addition to the traditional filter and monochromator based spectral measurements, laser-based sphere sources and high performance irradiance meters have been developed to extend the spectral coverage and signal dynamic range of detector and radiometer calibrations. The modulation of the laser sources provides a platform for extending the dynamic range of frequency dependent responsivity testing. The newly developed high accuracy radiometer standards make it possible to perform spectral power and irradiance responsivity measurements with an uncertainty of 0.5 % (k=2) or smaller.

Measuring the absolute optical power output of pulsed light sources
THURSDAY, August 21, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 9, 9C
Optics I
Helga A. Alexander,
Keithley Instruments, Inc.
Manufacturers of diode lasers and other light emitting devices are testing their products earlier in the production stage in order to sort out bad devices before incorporating them into expensive modules. These tests were previously performed later in the production stage in continuous wave (CW) mode while actively cooling the device. By performing these same tests in pulsed mode, damage due to self-heating of the devices at the wafer or chip level can be avoided even when active cooling is not an option. One such test is to measure the light output at various injection current levels. This requires the use of a calibrated detector assembly, usually a photodiode, or an integrating sphere with a built-in photodiode, with adequate sensitivity at the wavelength of interest. Calibrating such a detector system means to determine the photocurrent it is expected to produce for a given optical input power at a particular wavelength. Currently, calibration laboratories and NIST offer such detector responsivity calibrations performed in CW mode only. This paper discusses errors that can occur when a detector calibrated in this fashion is used to measure the absolute optical power of pulsed light sources. Suggestions are offered on how such errors can possibly be avoided.

Calibration of a Spectral Responsivity Transfer Standard
THURSDAY, August 21, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 9, 9C
Optics I
Dr. George P. Eppeldauer,
National Institute of Standards and Technology
A recently-developed pyroelectric radiometer was characterized and calibrated to extend the NIST spectral responsivity scale from the visible range to the ultraviolet (UV) and infrared (IR). The absorptance of the gold-black coated LiNbO3 pyroelectric material is proportional to the responsivity of the detector. The spectral absorptance was determined from spectral total reflectance measurements of the coating using integrating spheres and spectrophotometers. The relative spectral responsivity was determined from the UV to the IR. The relative spectral responsivity was converted into absolute spectral power and irradiance responsivities by measuring the power in stabilized laser beams. The reference device for absolute calibration was a Si trap-detector calibrated against the primary standard cryogenic radiometer. The calibrations were repeated and the long-term change in the reflectance was measured. The spectral power and irradiance responsivity scales of the pyroelectric radiometer have been realized between 250 nm and 2500 nm with a relative standard uncertainty of less than 0.7 % (coverage factor k=2).

What metrologists should learn from the ICT-world
THURSDAY, August 21, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 9, 9D
Improving Comparisons
Simon de Vries,
CalMetConsult Associates
Each measuring instrument is a reference, each measurement a contribution to a result. Purpose is not exactly know, how certain attributes are influencing, but insight enabling to perform better. A Talmudic dictum teaches: “Study is not the essence, but action”. Metrology is often perceived as a ‘Black art’ process that helps manufacturers to comply with directives and standards. Needs: A process-driven system that clearly defines if products meet requirements. Basis: A system that has proven its effect already in ICT where complex data transfer must be handled safe and secure. This paper explains a Metrology Infrastructure, based on a Metrology Maturity Model. Complying with EU-directives by Technical Construction Files means use of test-equipment. (1) Do manufacturers know & understand Metrology? (2) What managed attribute do they select to measure, on what level? (3) Is the criteria based on “necessity”, weighted, or just at fulfillment of rules?
A statement of competence is sufficient, if transparent to third parties. Accreditation requires records of detailed procedures, work instructions, assignment of specific jobs, responsibilities along with documentation, internal auditing. But the National Metrology Institute’s work proofs often to be unsuitable for ‘insight’ and ‘understanding’. The Metrology Maturity Model creates “recognition” of problematic measurements that lead to right actions that will correct and improve. Recognition comes from knowledge, not from measured data that is correct and traceable and based on a calibrator specification. Insight means the right processes to control and adjust. Without a visible “infrastructure” the metrology spectrum will be as thin as the “Calibrated” sticker.

Specifications Of a Common Result Format For Exchange of Measurement Results: A Progress Review
THURSDAY, August 21, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 9, 9D
Improving Comparisons
Jean-Claude Krynicki,
Agilent Technologies Service Solutions Unit
Compared to other fields of activities, metrology did not take full advantage of the communication revolution. Despite the consistency of the SI unit system, the coherence of measured parameters, all described by a dimensional equation, there is no common results format allowing universal data exchanges between members of the metrology community. Most measurement report data are archived to provide evidence to quality auditors therefore customers are challenging the need to spend so much money on calibration just for that. This progress review, results of shared ideas between a specialist of calibration software platform development and a metrologist, will propose the ideal specifications of a common result format standard. This data structure should facilitate the usage of error correction techniques, uncertainty improvement and statistical analysis. Information concerning several technical committees working in this area will be presented as well.

NMI Supply Chains – maximising economic impact through partnership with key industrial sectors
THURSDAY, August 21, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 9, 9D
Improving Comparisons
David Richardson,
National Physical Laboratory
National Measurement Institutes (NMIs) such as the UK’s National Physical laboratory (NPL) face the challenge of delivering, simultaneously, unimpeachable excellence in metrology and demonstrable economic impact for business and society. In pursuing the goal of maximum economic impact, NMIs deliver their knowledge product through a series of supply chains. In the UK these include a network of 400 calibration and 2000 test laboratories; and an instrumentation sector of 2,700 companies with an annual sales value of $7B. In this paper, David Richardson, Director of Marketing and Knowledge Transfer at NPL, will discuss the opportunities and issues involved in establishing and managing successful NMI-to-industry supply chain relationships. He will seek to demonstrate the significant potential of value chains to enhance productivity and competitiveness in NMI-partner companies; and their importance in directing an NMI’s research and mission. The paper will present case studies, reflecting real world experience over a 7-year period at NPL. Case studies will include the On Machine Measurement programme, in which NPL is partnering with leading instrumentation companies to support measurement upgrades in UK manufacturing companies. The project produced an 1800% return on investment in the first year.

Changes and Improvements in the 10 kohm Special Calibration Service
THURSDAY, August 21, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 9, 9E
Resistance Measurements
George R. Jones,
National Institute of Standards and Technology
The 1 kohm level of resistance has been the source of the lowest standard uncertainties for d.c. resistance calibrations. At the 10 kohm level, equally good transport standards are available and many laboratories also rely on these standards. NIST uses an automated Warshawsky-type guarded bridge circuit to compare these standards at the 10 kohm level, and cryogenic current comparators to maintain the working 10 kohm reference standards. These recent improvements allow a reduction in the quoted uncertainty of our 10 kohm level customer calibrations. We are working to duplicate the Warshawsky bridge and characterize additional standards to prepare for the relocation of this and other measurement systems, upon the opening of NIST's new Advanced Measurements Laboratory.

A Bridge for Scaling to Higher Resistance from the QHR
THURSDAY, August 21, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 9, 9E
Resistance Measurements
Randolph E. Elmquist,
National Institute of Standards and Technology
A two-terminal bridge for resistance scaling directly from the quantum Hall resistance (QHR) to higher-resistance values now provides a secondary starting point in decade scaling at NIST, beginning at the 1 MW resistance level. This cryogenic bridge has better repeatability and lower uncertainty than Hamon transfer standard scaling. Better scaling will support the high-resistance measurement service at 10 MW and above, for which NIST has constructed improved standards with low voltage coefficients. 1 MW standard resistors calibrated using this bridge have helped NIST provide better uncertainty for the ongoing NCSLI inter-laboratory comparison using air-type and oil-type 1 MW transfer standards.

Cryogenic Current Comparators for Resistance Measurements across the Range 100 micro-ohm to 1 Gohm
THURSDAY, August 21, 2003
8:30 AM - 10:00 AM PARALLEL SESSIONS - SESSION 9, 9E
Resistance Measurements
Nick Fletcher,
National Physical Laboratory
Cryogenic current comparators (CCC's) form the basis of the most accurate and sensitive dc resistance bridges. These bridges are used by a number of national measurement institutes for their top-level resistance calibrations, especially in the realisation of the Ohm from the quantum Hall effect (QHE). Over recent years, resistance bridges have been developed at the National Physical Laboratory (NPL) to extend the use of CCC technology to routine calibration work covering a wide range of resistance decades.
This paper describes two CCC resistance bridges that have recently been added to NPL's accredited measurement services. One system covers resistances from 1 W down to 100 mW at currents of up to 100 A and the other 10 kW up to 1 GW at voltages of up to 100 V. At opposite ends of this span of 14 decades of resistance value there are obviously different measurement conditions and design challenges. There are also fundamental similarities in bridge design and in the considerations required to achieve and demonstrate the desired degree of accuracy.
These new CCC systems are designed for regular laboratory use and enable NPL to offer their improved uncertainties directly to customers. Standard resistors all the way from 1 mW to 100 MW can now be calibrated with total relative uncertainties of less than 1 ppm (95% confidence level, traceable to the QHE). This improved accuracy ensures that NPL is able to keep up with the demanding requirements of modern industry.

Measurements in a Tire Plant
THURSDAY, August 21, 2003
10:30 AM - 12:10 PM - PARALLEL SESSIONS - SESSION 10, 10A
Management II
Raymond Perham,
Perham and Associates Consultants
What measurements are important in a Tire Plant? How does a tire manufacturing plant prove to its customers that the manufacturing processes are in control? How do you determine the quality of raw materials, semi-finished and finished materials? This paper discusses the measurements made in a typical tire plant to control the manufacturing process and provide data for a quality program. A product flow diagram will be presented identifying typical measurements. Several case study measurements will be discussed such as Rheometry, Rubber Profile, Curing and Final Inspection. The Author has over 40 years of Metrology experience and over 22 years experience with measurements in tire plant including: Field Service, Special instrumentation department manager, and Corporate Metrologist.

Experience in the Implementation of the Laboratory Metrological Structure of an Automotive Company to Meet the ISO/IEC 17025 Standard
THURSDAY, August 21, 2003
10:30 AM - 12:10 PM - PARALLEL SESSIONS - SESSION 10, 10A
Management II
Salvador Echeverría-Villagómez,
Centro Nacional de Metrología (CENAM)
Implementing metrological structures and infrastructures to meet specific needs within organizations, in an optimum way, maximizing the benefit/cost ratio is always a challenge. This is even more important in cases as when the field of action is a large automotive company, belonging to one of the leading consortia in the sector, with vanguard technology, a very mature Quality Management System and when the aim is to implement the ISO/IEC 17025 Standard in several metrology laboratories that support quality in the different processes of the production plant. The paper will present how the structured approach of the MESURA Program established by CENAM was applied, and what answers were given, in practice and in the field, to critical questions such as: (1) What is the tangible added value to a leading technology company of an accreditation according the ISO/IEC 17025? (2) Given

that most administrative and technical requirements were already met by the company, even if separately, how can the existing elements be organized and structured to comply with the standard in an optimum way to maximize the benefit/cost ratio? (3) And, after the process has been experienced: What lessons can be learned for the continuous improvement of the measurement systems of the company, and how can they be a support for technology and innovation? (4) And, finally: What is the benefit of the whole process and the resulting systems for clients, share holders and stake holders of the company? Some answers to this questions will be presented in the paper, and questions that remain open will also be presented for discussion.

A Multi-level Continuous Sampling Plan for Measurement Assurance
THURSDAY, August 21, 2003
10:30 AM - 12:10 PM - PARALLEL SESSIONS - SESSION 10, 10A
Management II
John Grajera,
Lockheed Martin Technical Operations
Strategic Weapons Facility Atlantic
To assure the quality of measurements as good Metrology practice, laboratories should develop a system to sample items that have been calibrated prior to being returned to the customer. To maintain impartiality, the sampling program is administered by the laboratory's quality manager. This is detailed in the quality manual. A sampling system, part of the SSP Navy calibration laboratory's quality assurance program for more than a decade was developed from military standards that outlined sampling definitions and requirements. The military standards are MIL-STD-1235B 10-Dec-1981 "Single and Multi-level Continuous Sampling Procedures and Tables for Inspection by Attributes" and the Department of Defense Handbook 106. These standards have been part of quality control programs for many military organizations and agencies having production processes. These standards were adapted and used to develop the current sampling program with the goal of ensuring the quality of calibration services. The plan randomly monitors a pre-determined percentage of laboratory output for conformance with laboratory specifications. Failed sampling results have an associated penalty phase. This paper will explore the main parts of the sampling system; definition of a sampling program, requirements for a sampling system, history of sampling program, how sampling is done, annual sampling percentage as a percentage of laboratory calibrations, and penalty phases for sampling failures. Some new approaches for continuous improvement of sampling systems for calibration laboratories will be presented. These methods easily extend to testing laboratories.

Pressure Balance Calibration at NIST Using the Transducer Assisted Crossfloat Method
THURSDAY, August 21, 2003
10:30 AM - 12:10 PM - PARALLEL SESSIONS - SESSION 10, 10B
Pressure II
Douglas A. Olson,
National Institute of Standards and Technology
A high precision pressure transducer can be used to measure the differential pressure between two pressure balances, thereby eliminating the mass adjustment process of a traditional "crossfloat" calibration. The two pressure balances are brought into only approximate pressure equilibrium, and are then sequentially connected to a single pressure transducer through constant volume valves. There is no requirement for establishing pressure equilibrium between the pressure balances. In this paper we discuss the application of this "Transducer Assisted Crossfloat" (TAC) technique to the NIST hydraulic pressure transfer standards. The measurement cycle and data acquisition at each pressure setting are automated, with a computer actuating the constant volume valves through solid state relays, and sampling the pressure transducer signal at appropriate intervals. Calibration results are presented comparing TAC to traditional methods.

Dual-Cistern Mercury Manometers: Valuable Tools in the World of Pressure Metrology
THURSDAY, August 21, 2003
10:30 AM - 12:10 PM - PARALLEL SESSIONS - SESSION 10, 10B
Pressure II
Rick Ohlendorf,
Schwien Engineering, Inc.
Pressure metrology began over 350 years ago, with Torricelli's discovery that the height of mercury in an inverted tube could be used as a measure of atmospheric pressure. Today, despite continuous improvements in pressure metrology, the Torricellian barometer (limited range manometer) remains the most accurate configuration of pressure standard. Manometer, as defined by Webster's Dictionary, is "an instrument for measuring the pressure of gases and vapors" and is by metrological definition a primary pressure standard. Manometers today, whether state-of-the-art, laboratory-grade or commercial-grade, can provide accurate, absolute or differential pressures with certain types of them capable of achieving extremely high accuracy. One of these high accuracy types is a dual-cistern mercury manometer. Dual-cistern mercury manometers are laboratory-grade manometers and are used by avionics manufacturers, the military, airlines, automated production lines, primary standards laboratories and R&D departments worldwide. Though a dual-cistern mercury manometer doesn't have state-of-the-art accuracy (parts-per-million total uncertainty) like the National Institute of Standards and Technology's ultrasonic interferometer manometer (UIM), it is still a precision primary pressure standard capable of measuring, generating and controlling pressures with extremely high accuracy (+/-0.0003 inches of mercury +/- 0.003% of reading) and unlike the UIM, it is easy and fast to operate and very portable with minimum laboratory down time. This paper will look at dual-cistern mercury manometers and their ability to provide highly accurate and stable absolute and differential pressures, making them one of the most valuable tools in the world of pressure metrology.

Pressure Calibration: Factors That You Can't Ignore
THURSDAY, August 21, 2003
10:30 AM - 12:10 PM - PARALLEL SESSIONS - SESSION 10, 10B
Pressure II
William R. Ormerod,
Procon Consulting
With the never-ending focus on performance and efficiency, companies are establishing that the final optimized results are usually a mix of the environment, operation and equipment design. To get the best out of any piece of equipment or system this has put an increased focus on the

"accuracy" of input sensors. Sensors now must be calibrated such that they follow the procedures and definitions of national standards groups and also meet the manufacturer's performance figures. In the case of pressure sensors, the incorrect procedure used to calibrate a sensor can produce final results that are well beyond the published performance.
This paper is for the calibration technician that will highlight the factors that affect the performance of a deadweight tester. We will detail an example that since pressure is a derived unit, that each variable associated with a DWT, if not considered carefully, can increase the final uncertainty by a factor of 10. Even more unsettling is that the calibration technician will have no visible sign that an error has been made. Differences will be detailed between different types of calibrators; deadweight testers, automatic digital pressure controllers and digital pressure standards. An explanation will be given of how the definition of the word "accuracy" varies between manufacturers, and even between different calibrators from the same manufacturer. By understanding both the sensor product data sheets and the pressure calibrator specifications, the technician will now be able to correctly use the calibrator to calibrate sensors to their rated specifications.

Traceability, calibration transfer and uncertainties evaluation in laser power measurements
THURSDAY, August 21, 2003
10:30 AM - 12:10 PM - PARALLEL SESSIONS - SESSION 10, 10C
Optics II
Dan G. Sporea,
National Institute for Lasers, Plasma and Radiation Physics
Our Laser Metrology Laboratory is already under the process to be accredited by the Romanian National Accreditation Body as a testing laboratory according to ISO 17025. As the laser-based products market develops in Romania (the proliferation of private, small health care / treatment centers and beauty saloons, the continuous extend of the optical fiber communication infrastructure, own both by the state – the electrical power distribution company, the Romanian railroad company, or by private communication companies - Orange, Connex, Romtelecom) we have to face the demand for calibration services.
The paper illustrates the way in which we are implementing a traceability scheme in the newly established calibration laboratory and how the calibration will be transferred for different wavelengths and laser power levels, as far as we have to cover a quite broad range of applications (? = 200 nm – 10 ?m; P = 100 pW to 100 W). In order to keep calibration costs as low as possible we are using three Si trap detectors, one electrically calibrated thermal detector and one transfer standard. Evaluation of the calibration uncertainties associated with the calibration transfer processes will also be described. We are using all these to extend the accreditation of pour laboratory also as a calibration laboratory.

Information sharing: The functionality and features of the Optical Technology Division's web presence
THURSDAY, August 21, 2003
10:30 AM - 12:10 PM - PARALLEL SESSIONS - SESSION 10, 10C
Optics II
John Hurlocker,
National Institute of Standards and Technology
The Optical Technology Division is one of six technical divisions in the Physics Laboratory at NIST. As a provider of standards, services, and research our customers, collaborators, constituents, and stakeholders are located virtually everywhere. The worldwide web continues to expand the reach and ability of the Division to provide information on a continuous basis. Our external web site provides an overview of the research programs, projects, facilities, activities, and accomplishments of the Optical Technology Division. We have included information regarding our products and services, NRC Postdoctoral Research opportunities, listings of upcoming workshops, conferences, and short courses, and have included PDF copies of our publications when they are available. We have also provided a staff directory and a technical point of contact on each web page to facilitate contacting our staff members. The external site consists of over three hundred pages. The number of visitors to the site has been steadily increasing. Over the past year, the Division's web presence has expanded into an internal web site. The internal website uses database technology to facilitate the maintenance of some of the individual pages and features. An on-line publications library has been developed as a new feature of the external website. Visitors to the website can search publications by author, title, and topic. Approximately 300 publications are available in PDF format. This paper will describe the functionality of the two web sites and will include examples of the features of the web sites.

The Quality System of the Optical Technology Division at NIST: A decade long and still going strong
THURSDAY, August 21, 2003
10:30 AM - 12:10 PM - PARALLEL SESSIONS - SESSION 10, 10C
Optics II
Sally Bruce,
National Institute of Standards and Technology
The Optical Technology Division of the Physics Laboratory at NIST documented its original Quality System in 1993 based on the ANSI Z540-1994-1, Calibration Laboratories and Measuring and Test Equipment--General Requirements, for the Calibration Services it offers. The first division at NIST to fully document its system, the Optical Technology Division has audited its system annually. In late 2002, NIST declared its quality system for calibration services based on the ISO 17025, General Requirements for the Competence of Testing, and Calibration Laboratories. The Optical Technology Division's quality system will evolve into compliance with the ISO 17025 during the 2003 calendar year. This paper will provide an overview of the development and implementation of the quality system, demonstrate examples of the quality system documentation, and will articulate lessons learned from the decade long quality journey.

Commercial Calibration Laboratories ;Issues and Challenges
THURSDAY, August 21, 2003
10:30 AM - 12:10 PM - PARALLEL SESSIONS - SESSION 10, 10D
Practical Metrology
Dr. S. L. Sarnot,
STQC Directorate, Department of Information Technology
Government of India
Electronics Regional Test Laboratory (North)
A measurement result is accepted to be valid only if it can be traced back to a common source of reference. This common source is generally a national standard or certified reference material. This applies to all measurements in trade, industry and testing laboratories at various accuracy levels. This is irrespective of nature of measurements whether involved in chemical analysis or quantifying physical properties of products. With increased bilateral trade among countries a need for global acceptability of measurements is becoming important issue particularly with under developed and developing countries. For this purpose, these countries need to strengthen their national measurement infrastructure for its credibility. An established network of accredited calibration laboratories that provide services to users of measurement results is an important element of national measurement systems.
In developing country like India there has been a sea change in the perception about calibration and measurement traceability in the last two decades. Contrary to earlier practice of government owned calibration laboratories, today a large number of these laboratories are being run by private operators. The demand for calibration services, in new technological areas with enhanced accuracies, is increasing rapidly. This is posing real challenge to these laboratories. The challenge pertains to development and validation of newer calibration methods, estimation of associated uncertainties etc. on one hand and economic viability of these laboratories on the other hand. The paper aims at describing the users requirements for calibration services, its quality, the issues and challenges before these commercial calibration laboratories.

I Don't Need No Stinking Metrology, Leave My Equipment Alone
THURSDAY, August 21, 2003
10:30 AM - 12:10 PM - PARALLEL SESSIONS - SESSION 10, 10D
Practical Metrology
Karl Wigdal,
Promega Corporation
Not all scientists in the biotechnology industry understand the basic concepts of metrology, traceability, accuracy, precision and why they are so important in relation to their experiments. Why? They were never taught about this in school! When Promega Corporation's metrology department first opened it's doors five years ago, some scientists even went so far as to state that they do not need the services of a metrology department and all that it has to offer! This misunderstanding is fairly common throughout the biotechnology industry and comes from the fact that some, but certainly not all processes used in the biotechnology industry have a wide range of conditions that will deliver some type of results, but not optimal performance. This paper will tell you how Promega's metrology department was able to teach the scientific staff about the importance of metrology, influence the purchase and use of test equipment and ultimately affect the bottom line of the company in a very positive way. After five years, we no longer hear "I don't need no stinking metrology, leave my equipment alone". Things are a lot nicer now.

Precision dc lf measurement equipment – migrating from classical to modern
THURSDAY, August 21, 2003
10:30 AM - 12:10 PM - PARALLEL SESSIONS - SESSION 10, 10D
Practical Metrology
Peter Dack,
Fluke Corporation
The calibration lab manager is continually challenged to maintain classical [established] yet obsolete dc lf measurement equipment. Reluctance to change is often driven by the effort required to modify yet maintain the integrity of existing procedural documentation, the task of evaluating suitable alternative measurement instruments, and determining the impact of changes in measurement uncertainty on workload. This paper compares alternative modern instrumentation and techniques against classical measurement equipment, and weighs the ongoing advantages of change-over versus the initial investment

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Calibration Techniques for Stopwatches and Timers
THURSDAY, August 21, 2003
10:30 AM - 12:10 PM - PARALLEL SESSIONS - SESSION 10, 10E
Time and Frequency
Robert M. Graham ,
Sandia National Laboratories
With all of the quality initiatives being implemented around the world (ISO 9000, ISO/IEC 17025, etc.), it is now necessary to calibrate and certify items that were previously assumed to be "good enough." Two items that historically fell into this category are stopwatches and timers. However, when they are used in a manufacturing or quality-control environment, traceable calibration becomes critical. This paper will discuss three different methods that can be used to calibrate these items. The required uncertainties, the type of unit being tested, and available test equipment will be the determining factors in deciding which method should be used.

Radio Controlled Clocks
THURSDAY, August 21, 2003
10:30 AM - 12:10 PM - PARALLEL SESSIONS - SESSION 10, 10E
Time and Frequency
Michael A. Lombardi,
National Institute of Standards and Technology
Radio controlled clocks have existed for decades, but their numbers have increased exponentially in recent years, mainly due to the large number of consumer products that receive the 60 kHz signal from NIST radio station WWVB. This paper explores the history of radio controlled clocks, the technology behind them, the types of radio signals that control them, and their applications in the metrology world.

Calibration of Police Traffic Speed Control Devices:LASER, RADAR, Photo RADAR, Red Light Camera, VASCAR, Pacing, & Visual Estimation of Speed
THURSDAY, August 21, 2003
10:30 AM - 12:10 PM - PARALLEL SESSIONS - SESSION 10, 10E
Time and Frequency
William Young,
Colorado Department of Agriculture
Since the readings on the subject devices determine the amount of a fine levied on drivers, many states require that state metrologists certify these devices. The only specification of a device that needs calibration is that which determines the accuracy of the reading. For RADAR guns, a certified tuning fork is used to test the gun's accuracy. LASER guns have a certified internal time base oscillator. Red Light Camera and VASCAR units (operating on the distance divided by time principle) need both a distance standard, checked by a certified tape measure, and a time standard, checked by a certified stopwatch. Pacing and Visual Estimation of Speed are inherently inaccurate and not considered metrologically viable.

2003 NCSLI Benchmarking Survey Results
THURSDAY, August 21, 2003
2:30 PM - 4:00 PM - PARALLEL SESSIONS - SESSION 11, 11A
Benchmarking
J. Wade Keith, III,
NCSL International Benchmarking Committee
The NCSLI Benchmarking Committee Chairman will lead a discussion to review and understand the results of the 2003 NCSLI Benchmarking Survey. The intent of the survey is to provide members with high quality data for use as a documented resource to baseline personnel compensation, laboratory performance, industry compliance, and continuous improvement objectives that apply across all businesses in our industry. The survey, which takes place every two years, is divided into five sections: Demographics; Capability; Productivity; Requirements / Compliance / Affiliation; and Personnel. As usual, the survey was further refined to offer increased clarity and data resolution. Take advantage of this unique opportunity to directly review and discuss the survey results with members of the Benchmarking Committee, as well as your NCSL International peers. In addition to the survey results, the discussion will also include information regarding philosophy, approach, anonymity, deployment, compilation, analysis, accuracy, and the general policy on data sharing. There will also be new metrics and charts that have been added based on member feedback from prior presentations and discussions. Your feedback from this session will be used to improve the next survey, which will take place in the second quarter of 2005.

Update on Recent Activities of the VIM and GUM Committees
THURSDAY, August 21, 2003
2:30 PM - 4:00 PM - PARALLEL SESSIONS - SESSION 11, 11B
VIM & GUM Update
Charles Ehrlich and Tyler Estler,
International Legal Metrology Group
The Joint Committee for Guides on Metrology (JCGM), coordinated through the Bureau Internationale des Poids et Measures (BIPM), officially came into existence in early 1997 as an outgrowth of an earlier ISO Technical Advisory Group 4 (TAG 4) on Metrology. The main function of the JCGM is to develop metrological guides for international use, in particular, to maintain and revise as necessary the Guide to the Expression of Uncertainty in Measurement (GUM) ISO, 1993 (corrected and reprinted 1995), and the International Vocabulary of Basic and General Terms in Metrology (VIM) ISO, 1993. The eight international organizations listed below are members of the JCGM, and T. Quinn, Director of the BIPM, is Chairman of the JCGM. The maintenance and revision of the GUM is the responsibility of Working Group 1 (WG1), the Convener of which is W. Bich of IMGC/Italy; and the maintenance and revision of the VIM is the responsibility of WG2, the Co-Conveners of which are P. Giacomo, BIPM (retired, ex-Director) and T. Quinn. The members of the JCGM are the BIPM, IEC (International Electrotechnical Commission), IFCC (International Federation of Clinical Chemistry and Laboratory Medicine), ILAC (International Organization for Laboratory Accreditation), ISO (International Organization for Standardization), IUPAC (International Organization of Pure and Applied Chemistry), IUPAP (International Organization of Pure and Applied Physics), and OIML (International Organization of Legal Metrology).
The JCGM WG1 ('GUM Committee') has four Subcommittees that are in the process of developing Supplements to the GUM. Subcommittee 1 is developing a draft on 'Numerical Methods for Propagating Probability Distributions', Subcommittee 2 on 'The Multivariate Case', Subcommittee 3 on 'The Incorporation of Uncertainty into Conformity Assessment Decisions', and Subcommittee 4 is developing two drafts on 'Modeling'. An 'Introductory Guide' is also being developed.
The JCGM WG2 ('VIM Committee') has three Working Groups (WGs) that are together working to develop a new version of the VIM. WG1 is responsible for revising Chapter 1, WG2 is responsible for revising Chapters 2, 3 and 6, and WG 3 is responsible for revising Chapters 4 and 5. In addition, a new Chapter 7 is anticipated that will contain terms corresponding to the 'Classical Approach to Measurement'.
This presentation will provide an overview of these activities along with an update on their anticipated timelines for completion.
DISCLAIMER: Material discussed during this presentation does not represent the current policy of the National Institute of Standards and Technology.

TBD
THURSDAY, August 21, 2003
2:30 PM - 4:00 PM - PARALLEL SESSIONS - SESSION 11, 11C
National Measurements Status