A DECADE FROM THE 21ST CENTURY

One of the principle projects I had last year as the Executive Vice President was to update the NCSL Long Range Plan (LRP). Putting together LRP-90, I reflected back to where NCSL has been; reviewed where NCSL is now; envisioned where NCSL might be going; and planned where NCSL needs to go during 1990. Now that I have completed a year of contemplation, evaluation, and prediction, I would like to share some of my thoughts with you.

The NCSL membership has continued to grow beyond all expectations. A little over a decade ago it was reported that there were 335 member delegates. There are now over 1000 members representing organizations with ever diversifying technical disciplines. Our organization represents a broad wealth of talent. As we approach the new year we are a decade from the 21st Century. During this decade our challenges will be many. I foresee 2000 members by the year 2000. Twice as many members; twice as many challenges; and if we all put something into NCSL we will reap twice the benefits.

The backbone of NCSL activities remain strong with the assistance of Past Presidents, a dedicated Board of Directors (BoD), Business Office Staff, Committee Chairman, and Regional/Sectional Coordinators. These individuals provide information on up-to-date subjects that concern you the most. Through newsletters, the annual workshop/conference, and regional/sectional meetings, subjects such as: What's going on at NIST, International Traceability, EC92, TQM, metircation, accreditation, educational programs, changes in the SI unit of the volt, ohm, mass, and temperature, and many other priority items that will be on the BoD agenda for discussion.

Putting together this year's LRP, I realized there wasn't enough time to formulate a workable plan longer than my year as your President. During 1990, I plan to devote a considerable amount of time analyzing: what we do well; what we don't do so well; and what we can do better as an organization and as a Board of Directors. It is my feeling that the key to tomorrow's organization is to concentrate on today's challenges and strategically address the solutions that will continuously improve our organization.

It must be obvious to you that I am enthusiastic about and very proud and privileged to be your President during this challenging year.

In closing, I would like to congratulate and welcome the newly elected 1990 Board of Directors. I would also like to thank those who have accepted special appointments to the Board: Tony Anderson in the challenging position of International Director and John Buck who will be the Director for Regions 6 and 9. I am honored to be the twenty-seventh President of NCSL, and look forward to working with the 1990 Board of Directors.

Bill Simmons, President
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EDITOR’S MESSAGE:

SHAKE, RATTLE AND ROLL!!

Well, the world-famous earthquake of Oct. 17 will give all of us who went through it
enough to talk about for years. In spite of its tragic side, the event was, in fact, an excellent
warning and dress rehearsal for the big one of 8.3+ that is sure to come. After all, the San
Andreas faultline has been moving for about 200 million years now, and big quakes of 8
plus have been fairly regular, with a period of from 75 to 150 years.

DID THE BOARD REALLY MEET?

Yes, there was a Board of Directors’ meeting this last quarter, somewhat delayed by
Hurricane Hugo, and thus the minutes were delayed. So we will just forego the highlights
for this issue. Some of the actions and communications will be included in other
department reports.

WHAT DO YOU THINK?

It’s important to revisit old decisions occasionally in order to make sure we’re meeting needs. One
old decision was to run attendance lists for all the board and regional meetings. Taken
together, those lists get pretty long and perhaps tedious. I decided to drop them this issue to
see if anyone yells (or whines). Seriously, if you have an opinion that the lists should be
replaced in the following issues, please let me know. It’s a judgement call.

MORE FEEDBACK NEEDED

Daw Lorentzen who publishes the great Training Directory is concerned about mailroom
"censorship" hitting his mailings. We all know that corporate mailrooms go through these
cycles where they just get mean to all mailings of 3rd and 4th class or "junk mail". Since
the Directory goes out in bulk mail, and should have been received by every member
delegate by this time, you might let the Secretariat know if you have not received yours.
That way they can get a feedback count, as well as sending out another.

PUBLICATIONS CLUB

Tony Anderson wants everyone to be aware of the NCSL Publications Club. The full story
is on page 36, but the idea is to offer regular mailings of sets of NCSL publications to more
of your corporate team, and not just to the member delegate.

(Cont’d on page 36)
1990 MEASUREMENT SCIENCE CONFERENCE
ANAHEIM MARRIOTT FEB 8-9, 1990

CONFERENCE THEME: MEASUREMENT SCIENCE – TECHNOLOGY FOR TQM

Keynote Speaker
Mr. Jack Strickland
Director of Industrial Productivity & Quality
Secretary of Defense Office
Topic: Total Quality Management

PARTIAL PROGRAM
The ITS of 1990
Paul Levine, Lockheed Missiles and Space Division
Sunnyvale, California

MIL-STD 45662A
David Mednick, U.S. Army Material Command,
Alexandria, Virginia

CMM Standards and Calibration
Ralph Veale, NIST, Gaithersburg, Maryland

Productivity and Quality
Jerry Nielsen, Honeywell Instrumentation and
Support Services, Littleton, Colorado

Making the Move to Total Quality Management
Gene Hepler, North Island NAS, San Diego, California
AC Metrology
Don Royster, Hewlett Packard, Fullerton, California

Pressure and Vacuum Measurement
David Workman, Martin Marietta, Denver, Colorado

Electro-mechanical Measurement Techniques
Jim Ungard, Rockwell International, Anaheim, California

Radiometry and Photometry
Michael Glaser, Scientific Spectrum Inc., Laguna Hills,
California

DC/Low Frequency Measurements
Woody Elke, Consultant, Rockville, Maryland

Dimensional Metrology
Ted Dorion, NIST Gaithersburg, Maryland

The Faces of Traceability
Rolf Schumach, Rockwell International, Anaheim,
California

Fiber-optic Measurement and Standards
Suzanne Kuroda, TRW, Redondo Beach, California

Statistical Process Control
Frank Capelli, John Fluke Mfg. Co., Everett, Washington

SRM's for the Measurement of Physical Quantities
Art McCoubrey, NIST, Gaithersburg, Maryland

RF/Microwave Measurement
Colette Landerville, Endevco, San Juan Capistrano,
California

The Legal Volt and Ohm in Practice
Norm Belecki, NIST, Gaithersburg, Maryland

Automating Calibrations
Jill Ryan, ATE Corp., San Diego, California

Mass Metrology
Rita Kirchgraber, TRW, Redondo Beach, California

Metric Transition
David Mednick, U.S. Army Material Command,
Alexandria, Virginia

CONTACT: Kevin Ruhl, (213) 812-1430

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IEEE INSTRUMENT & MEASUREMENT TECHNOLOGY CONFERENCE
FEBRUARY 13-15, 1990
RED LION INN, SAN JOSE, CA

CONFERENCE THEME: EMERGING MEASUREMENT TECHNOLOGIES TECHNICAL PROGRAM & EXHIBITS

Contact: Robert Myers
(213) 287-1463
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A NEW TEMPERATURE SCALE, THE INTERNATIONAL TEMPERATURE SCALE OF 1990, IS ADOPTED

B. W. Mangum
Temperature and Pressure Division
National Institute of Standards and Technology
Gaithersburg, MD 20899

A new temperature scale, the International Temperature Scale of 1990 (ITS-90), was officially adopted by the Comité International des Poids et Mesures (CIPM), meeting 26-28 September 1989 at the Bureau International des Poids et Mesures (BIPM). The ITS-90 was recommended to the CIPM for its adoption following the completion of the final details of the new scale by the Comité Consultatif de Thermométrie (CCT), meeting 12-14 September 1989 at the BIPM in its 17th Session. The ITS-90 will become the official international temperature scale on 1 January 1990, the same date at which changes affecting the use of some electrical units will be implemented. The ITS-90 will supersede the present scales, the International Practical Temperature Scale of 1968 (IPTS-68) and the 1976 Provisional 0.5 K to 30 K Temperature Scale (EPT-76).

The ITS-90 was developed because of the deficiencies and limitations of the IPTS-68. These IPTS-68 deficiencies and limitations include its lower limit of 13.81 K, its inaccuracy relative to thermodynamic temperatures, and it non-uniqueness and irreproducibility, especially in the temperature region from \( T = 93.89 \) K (630.74 °C) to \( T = 1337.58 \) K (1064.43 °C), the region in which the Pt-10%Rh/Pt thermocouple is the standard interpolating instrument.

The ITS-90 extends upward from 0.65 K and temperatures on this scale are in much better agreement with thermodynamic values than are those on the IPTS-68 and the EPT-76. The new scale has subranges and alternative definitions in certain ranges that greatly facilitate its use. Furthermore, its continuity, precision and reproducibility throughout its ranges are much improved over that of the present scales. The replacement of the thermocouple with the platinum resistance thermometer at temperatures below 961.78 °C resulted in the biggest improvement in reproducibility.

The change in the temperature scale will affect not only those involved directly in thermometry but also those involved with other reference standards, such as electrical standards, if those standards are sensitive to temperature. As examples, standard resistors and standard cells are sensitive to temperature and generally are maintained in constant-temperature environments, at least in national standards laboratories. At the present time, the temperatures of those environments are normally determined with thermometers that have been calibrated on the IPTS-68. A given thermodynamic temperature expressed on the ITS-90, however, has a value that is different from the value expressed on the IPTS-68, as indicated by the graph in Figure 1. This graph is reproduced from an article, entitled "News from the BIPM", by T. J. Quinn in Metrologia 26, 69-74 (1989). Since temperature values expressed on the two scales are different, if the temperature of the environment of a reference standard is changed so that its value when expressed on the ITS-90 has the same value as had been used on the IPTS-68, there will have been a change of the thermodynamic temperature and the reference standard will experience a change in its value. Of course, one may not want to change the thermodynamic temperature of the reference standard. In that case, the temperature, as expressed on the IPTS-68, can simply be expressed on the ITS-90 (a numerical value different from that on the IPTS-68) and the reference standards will be unaffected. For more details on the effects of changing the temperature scale on electrical standards, see National Institute of Standards and Technology (NIST) Technical Note 1265, entitled "Guidelines for Implementing the New Representations of the Volt and Ohm Effective January 1, 1990", by N.B. Belecki, R.F. Dziuba, B.F. Field, and B.N. Taylor.

In addition to reference standards being affected, all temperature-sensitive properties that are presently expressed on the IPTS-68 may require changes in values.

For details on realizing the ITS-90, changes from the IPTS-68, differences between \( T_0 \) and \( T_{s9} \) (and \( T_{s0} \)) and means of approximating the ITS-90, see NIST Technical Note 1265, entitled "Guidelines for Realizing the International Temperature Scale of 1990 (ITS-90)"; by B.W. Mangum and G.T. Furukawa.

DEFINITION OF THE ITS-90

The ITS-90 has been designed in such a manner that temperature values obtained on it do not deviate from the Kelvin thermodynamic temperature values by more than the uncertainties of the latter values at the time the ITS-90 was adopted. Thermodynamic temperature is indicated by the symbol \( T \) and has the unit known as the Kelvin, symbol \( K \). The size of the kelvin is defined to be \( 1/273.16 \) of the thermodynamic temperature of the triple point of water.

Temperatures on the ITS-90 can be expressed, in terms of the International Kelvin Temperatures, with the symbol \( T_0 \) or, in terms of the International Celsius temperatures, with the symbol \( t_0 \). The unit of the temperature \( t_0 \) is the degree Celsius, symbol °C. The relation between \( T_0 \) and \( t_0 \) is:

\[
\frac{t_0}{°C} = \frac{T_0}{K} - 273.15.
\]
The ITS-90 has alternative definitions of $T_\infty$ in certain temperature ranges and they have equal status. In measurements of the highest precision made at the same temperature, the alternative definitions may yield detectable temperature differences. Also, at any given temperature between defining fixed points, different interpolating thermometers that meet the specifications of the ITS-90 may indicate different temperature values. The magnitude of the differences resulting from these two sources, however, is sufficiently small to be negligible for all practical purposes.

Temperatures on the ITS-90 are defined in terms of the equilibrium states of pure substances (defining fixed points), interpolating instruments, and equations that relate the measured property to $T_\infty$. The defining equilibrium states of the pure substances and assigned temperatures are listed in Table 1.

**TEMPERATURE RANGE FROM 0.65 K TO 5.0 K**

Between 0.65 K and 3.2 K, the ITS-90 is defined by the vapor pressure-temperature relation of $^3$He, and between 1.25 K and 2.1768 K (the $\lambda$ point) and between 2.1768 K and 5.0 K by the vapor pressure-temperature relations of $^4$He. $T_\infty$ is defined by the vapor pressure equations of the form:

$$T_\infty / K = A_0 + \sum_{i=1}^{9} A_i \left[ (\ln p / Pa) - B \right] / C$$

with the values of the coefficients $A_i$, and of the constants $A_0$, B and C of the equations being specified and given in Table 2.

**TEMPERATURE RANGE FROM 3.0 K TO 24.5561 K**

Between 3.0 K and 24.5561 K, the ITS-90 is defined in terms of the $^3$He or $^4$He constant volume gas thermometer (CVGT). The thermometer is calibrated at three temperatures – at the triple point of neon (24.5561 K), at the triple point of e-H2 (13.8033 K) and at a temperature between 3.0 K and 5.0 K, the value of which is determined by using either $^3$He or $^4$He vapor pressure thermometry.

For a $^4$He CVGT, used between 4.2 K and the triple point of neon (24.5561 K), $T_\infty$ is defined by the equation:

$$T_\infty = a + b p + c p^2,$$

where $p$ is the CVGT pressure and $a$, $b$, and $c$ are coefficients that are determined by calibration at the three specified temperatures, but with the additional requirement that the calibration with the vapor pressure thermometer be made at a temperature between 4.2 K and 5.0 K.

For a $^3$He CVGT, and for a $^4$He CVGT used between 3.0 K and 4.2 K, the non-ideality of the gas must be taken into account, using the appropriate second virial coefficient, $B_3$ ($T_\infty$) or $B_4$ ($T_\infty$). $T_\infty$ is defined in this range by the equation:

$$T_\infty = \frac{a + b p + c p^2}{1 + B_4 (T_\infty) N / V}$$

where $p$ is the CVGT pressure; $a$, $b$, and $c$ are coefficients that are determined from calibration at the three defining temperatures; $B_4$ ($T_\infty$) refers to $B_4$ ($T_\infty$) or $B_4$ ($T_\infty$); and $N / V$ is the gas density in moles per cubic meter in the CVGT bulb. The values of the second virial coefficients at any given temperature are to be calculated according to equations specified in the official document of the ITS-90 and also in the NIST Technical Note 1265.

**TEMPERATURE RANGE FROM 13.8033 K TO 1234.93 K**

Between 13.8033 K (-259.3467 °C) and 1234.93 K (961.78 °C), the ITS-90 is defined in terms of the specified fixed points given in Table 1, by resistance ratios of platinum resistance thermometers (PRTs) obtained by calibration at specified sets of the fixed points, and by reference functions and deviation functions of resistance ratios which relate to $T_\infty$ between the fixed points.

Temperatures on the ITS-90 are expressed in terms of the ratio $W(T_\infty)$ of the resistance $R(T_\infty)$ at temperature $T_\infty$ and the resistance $R(273.16 K)$ at the triple point of water, i.e.,

$$W(T_\infty) = R(T_\infty) / R(273.16 K).$$

For a PRT to be an acceptable instrument of the ITS-90, its coil must be made from pure platinum and be strain-free. Additionally, the finished PRT must meet one of the following criteria:

$$W(302.9146 K) \approx 1.11807$$

$$W(234.3156 K) \approx 0.864235.$$  

An acceptable PRT that is to be used to the freezing point of silver must meet the following requirement also:

$$W(1234.93 K) \approx 4.2844.$$  

The temperature $T_\infty$ is calculated from the resistance ratio relation:

$$W(T_\infty) - W(T_\infty) = \Delta W(T_\infty),$$

where $W(T_\infty)$ is the observed value, $W(T_\infty)$ is the value calculated from the reference function, and $\Delta W(T_\infty)$ is the deviation of the observed $W(T_\infty)$ value of the particular PRT from the reference function value at $T_\infty$.

There are two reference functions $W(T_\infty)$, one for the range 13.8033 K to 273.16 K and the second for the range 273.15 K
to 1234.93 K. The deviation \( \Delta W(T_{90}) \) is obtained as a function of \( T_{90} \) for various ranges by calibration at specified fixed points. The form of the deviation function depends upon the temperature range of calibration.

**TEMPERATURE SUBRANGE FROM 13.8033 K TO 273.16 K**

In the range 13.8033 K to 273.16 K, the equation for the reference function \( W_r(T_{90}) \) as a function of \( T_{90} \) is given by:

\[
\ln [W_r(T_{90})] = A_0 + \sum_{i=1}^{12} A_i [\ln (T_{90})/273.16 K] + 1.5/1.5
\]

(10)

The specified inverse of this equation, equivalent to within \( \pm 0.0001 \) K, is:

\[
T_{90}/273.16 K = B_0 + \sum_{i=1}^{15} \frac{A_i}{B_i (0.35 - 0.65)}
\]

where \( n = 2 \). The coefficients \( A_i \) and \( B_i \), and the five \( c_i \)'s of the deviation function are obtained by calibration at all of the above eight temperatures, including that at the triple point of water. The values of \( W_r(T_{90}) \) are obtained from the reference function for this range. Although the official text of the ITS-90 does not assign subscripts to the coefficients \( a_i \) and \( b_i \), nor does it designate the deviation equations by the symbols \( \Delta W_{90} \) or \( (T_{90}) \), where in equation (14) \( m = 1 \), these designations will be used in this paper for clarity and for ease of reference. In any case, some such terminology must be used in PRT calibration reports and this was chosen for convenience.

**SUBRANGE FROM 24.5561 K TO 273.16 K**

The deviation function for calibration in this range is given by the relation:

\[
\Delta W_2(T_{90}) = W(T_{90}) - W_r(T_{90})
\]

\[
= a_2 [W(T_{90}) - 1] + b_2 [W(T_{90}) - 1]^2 + c_2 [\ln W(T_{90})]^{1+n},
\]

(15)

where the exponent \( n \) has the value \( n = 0 \). The coefficients \( a_2 \), \( b_2 \), and \( c_2 \) of this deviation function are obtained by calibrating the PRT at the triple points of equilibrium-hydrogen (13.8033 K), neon (24.5561 K), oxygen (54.3584 K), argon (83.8058 K), mercury (234.3156 K), and water (273.16 K), at two additional temperatures very close to 17.0 and 20.3 K. The temperatures of calibration at 17.0 K and 20.3 K may be determined using either a CVGT or the vapor pressure-temperature relation of equilibrium hydrogen. When the CVGT is used, the two temperatures must be within the ranges 16.9 K to 17.1 K and 20.2 K to 20.4 K respectively. When the equilibrium hydrogen vapor pressure thermometer is used, the two temperatures must be within the ranges 17.025 K to 17.045 K and 20.26 K to 20.28 K respectively. The temperatures of the equilibrium hydrogen vapor pressure thermometer are determined from the values of the hydrogen vapor pressure, \( p_i \), and the equations:

\[
T_{90}/K = 17.035 = (p_i/kPa - 33.3213)/13.32
\]

(12)

\[
T_{90}/K = 20.27 = (p_i/kPa - 101.292)/30.
\]

(13)

Depending upon the temperature range of application, PRTs may be calibrated from 273.16 K down to 13.8033 K (triple point of \( \sigma \)-H\(_2\)), down to 24.5561 K (triple point of neon), down to 54.3584 K (triple point of oxygen), or down to 83.8058 K (triple point of argon).
SUBRANGE FROM 83.8058 K TO 273.16 K

The deviation function for calibration in this range is given by the relation:

\[
\Delta W_{4}(T_{0}) = a_{4}[W(T_{0}) - 1] + b_{4}[W(T_{0}) - 1]2nW(T_{0}).
\]

The coefficients \(a_{4}\) and \(b_{4}\) of this deviation function are obtained by calibrating the PRT at the triple points of argon (83.8058 K), mercury (234.3156 K), and water (273.16 K). The values of \(W_{4}(T_{0})\) are obtained from the reference function.

TEMPERATURE SUBRANGE FROM 273.15 K TO 1234.93 K

In the range 273.15 K to 1234.93 K, the equation for the reference function \(W_{r}(T_{0})\) is given by:

\[
W_{r}(T_{0}) = C_{0} + \sum_{i=1}^{9} D_{i} \frac{T_{0}/K - 754.15}{481}.
\]

The specified inverse of this equation, equivalent to within \(\pm 0.00013\) K is:

\[
T_{0}/K - 273.15 = D_{0} + \sum_{i=1}^{9} D_{i} \frac{W_{r}(T_{0}) - 2.64}{1.64}.
\]

The values of the constants \(C_{0}\) and \(D_{0}\) and of the coefficients \(C_{i}\) and \(D_{i}\) for both equations are listed in Table 3.

If the PRT is to be used over this entire sub-range (273.15 K to 1234.93 K), it must be calibrated at the triple point of water (273.16 K) and at the freezing points of tin (505.078 K), zinc (692.677 K), aluminum (933.473 K), and silver (1234.93 K).

The deviation function is given by the relation:

\[
\Delta W_{6}(T_{0}) = a_{6}[W(T_{0}) - 1] + b_{6}[W(T_{0}) - 1]^{2} + c_{6}[W(T_{0}) - 1]^{3} + d[W(T_{0}) - W(933.473 K)]^{2}.
\]

The values of the coefficients \(a_{6}\), \(b_{6}\), and \(c_{6}\) are determined from the measured deviations \(\Delta W(T_{0})\) of \(W(T_{0})\) from the reference values \(W(T_{0})\) at the freezing points of tin (505.078 K), zinc (692.677 K) and aluminum (933.473 K). The coefficient \(d\) is determined from these values of the coefficients \(a_{6}\), \(b_{6}\), and \(c_{6}\) (determined as just described from measurements at the triple point of water and at the freezing points of tin, zinc and aluminum) and the deviation \(W(T_{0})\) of \(W(T_{0})\) from the reference value \(W(T_{0})\) at the freezing point of silver. The coefficient \(d\) in this equation is used only for those temperature measurements in the range from the freezing point of aluminum to the freezing point of silver. For temperature measurements below the freezing point of aluminum, \(d = 0\).

PRTS may be calibrated for use over the whole range (273.15 K to 1234.93 K) or for shorter ranges by calibrations at fixed points between 273.15 K and the upper limit of 933.473 K (freezing point of aluminum, 660.323 °C), of 692.677 K (freezing point of zinc, 419.527 °C), of 505.078 K (freezing point of tin, 231.928 °C), of 429.7485 K (freezing point of indium, 156.5985 °C), or of 302.9146 K (melting point of gallium, 29.7646 °C).

SUBRANGE FROM 273.15 K TO 933.473 K

For application in this range, the PRT is calibrated at the triple point of water (273.15 K), and at the freezing points of tin (505.078 K), zinc (692.677 K), and aluminum (933.473 K). The deviation function is given by the relation:

\[
\Delta W_{7}(T_{0}) = a_{7}[W(T_{0}) - 1] + b_{7}[W(T_{0}) - 1]^{2} + c_{7}[W(T_{0}) - 1]^{3}.
\]

The coefficients \(a_{7}\), \(b_{7}\), and \(c_{7}\) identical to \(a_{6}\), \(b_{6}\), and \(c_{6}\), respectively, are determined from the deviations \(\Delta W(T_{0})\) of \(W(T_{0})\) from the reference values \(W(T_{0})\) at the freezing points of tin (505.078 K), zinc (692.677 K), and aluminum (933.473 K).

SUBRANGE FROM 273.15 K TO 692.677 K

For application in this range, the PRT is calibrated at the triple point of water (273.15 K), and at the freezing points of tin (505.078 K) and zinc (692.677 K). The deviation function is given by the relation:

\[
\Delta W_{8}(T_{0}) = a_{8}[W(T_{0}) - 1]^{2}.
\]

The coefficients \(a_{8}\) and \(b_{8}\) are determined from the deviations \(\Delta W(T_{0})\) of \(W(T_{0})\) from the reference values \(W(T_{0})\) at the freezing points of tin (505.078 K) and zinc (692.677 K).

SUBRANGE FROM 273.15 K TO 505.078 K

For application in this range, the PRT is calibrated at the triple point of water (273.15 K), and at the freezing points of indium (429.7485 K) and tin (505.078 K). The form of the
deviation function is the same as that for the subrange 273.15 K to 692.677 K, i.e.,
\[
\Delta W_9 (T_{90}) = a_9 \left[ W(T_{90}) - 1 \right] + b_9 \left[ W'(T_{90}) - 1 \right]^2.
\] (23)

The coefficients \( a_9 \) and \( b_9 \) are determined from the deviations
\( \Delta W(T_{90}) \) of \( W(T_{90}) \) from the reference values \( W(T_{90}) \) at the
freezing points of indium (429.7485 K) and tin (505.078 K).

**SUBRANGE FROM 273.15 K TO 429.7485 K**

For application in this range, the PRT is calibrated at the
triple point of water (273.16 K) and at the freezing point of
indium (429.7485 K). The deviation function is:
\[
\Delta W_{10} (T_{90}) = a_{10} \left[ W(T_{90}) - 1 \right].
\] (24)

The coefficient \( a_{10} \) is determined from the deviation \( \Delta W(T_{90}) \)
of \( W(T_{90}) \) from the reference value \( W(T_{90}) \) at the freezing
point of indium (429.7485 K).

**SUBRANGE FROM 273.15 K TO 302.9146 K**

For application in this range, the PRT is calibrated at the
triple point of water (273.16 K) and at the melting point of
gallium (302.9146 K). The deviation function is
\[
\Delta W_{11} (T_{90}) = a_{11} \left[ W(T_{90}) - 1 \right].
\] (25)

The coefficient \( a_{11} \) is determined from the deviation \( \Delta W(T_{90}) \)
of \( W(T_{90}) \) from the reference value \( W(T_{90}) \) at the melting
point of gallium (302.9146 K).

**SUBRANGE FROM 234.3156 K TO 302.9146 K**

For application in this range, the PRT is calibrated at the
triple points of mercury (234.3156 K) and water (273.16 K),
and at the melting point of gallium (302.9146 K). The form of
the deviation function is the same as that for the subrange
273.15 K to 692.677 K, i.e.,
\[
\Delta W_5 (T_{90}) = a_5 \left[ W(T_{90}) - 1 \right] + b_5 \left[ W'(T_{90}) - 1 \right]^2.
\] (26)

The coefficients \( a_5 \) and \( b_5 \) are determined from the deviations
\( \Delta W(T_{90}) \) of \( W(T_{90}) \) from the reference values \( W(T_{90}) \) at the
triple point of mercury (234.3156 K) and at the melting point
of gallium (302.9146 K). The reference values \( W(T_{90}) \) must be
calculated from the relevant reference function, both
reference functions being required to cover this range.

**TEMPERATURE RANGE ABOVE 1234.93 K**

At temperatures above 123493 K, \( T_{90} \) is defined by the
relation
\[
\frac{L_\lambda (T_{90})}{L_\lambda (T_{90} (X))} = \exp \left[ \frac{c_2}{\lambda T_{90} (X)} \right] - 1,
\] (27)
\[
\frac{L_\lambda (T_{90} (X))}{L_\lambda (T_{90})} = \exp \left[ \frac{c_2}{\lambda T_{90} (X)} - 1 \right]
\]

in which \( L_\lambda (T_{90}) \) and \( L_\lambda (T_{90} (X)) \) are the spectral
concentrations of the radiances of a blackbody at wavelength
\( \lambda \) (in vacuum) at \( T_{90} \) and at \( T_{90} (X) \), respectively. \( T_{90} (X) \)
refers to either the silver freezing point \( T_{90} (Ag) = 1234.93 \text{ K} \), the
gold freezing point \( T_{90} (Au) = 1337.33 \text{ K} \) or the copper
freezing point \( T_{90} (Cu) = 1357.77 \text{ K} \). \( c_2 = 0.014388 \text{ mK} \).

Although the freezing-point temperature of silver is the
junction point of platinum resistance thermometry and
radiation thermometry, it is believed that the \( T_{90} \) values of
the freezing points of silver, gold and copper are sufficiently self-
consistent that the use of any one of them as the reference
temperature \( T_{90} (X) \) will not result in any significant
difference in the measured values of \( T_{90} \) from what would be
obtained if only the silver freezing point were used.

**CALIBRATION OF THERMOMETERS ON THE ITS-90**

The National Conference of Standards Laboratories (NCSL)
formed an Ad Hoc Committee on the Change of the
Temperature Scale at the beginning of 1988 in order to
publicize the new temperature scale and to facilitate its
implementation. At the NCSL meeting in July 1989, the Ad
Hoc Committee adopted a logo, available from the NCSL,
that may be affixed to thermometers that have been calibrated
on the ITS-90. The purpose of the logo is to indicate at a
glance, without having to refer to documentation, those
thermometers in a laboratory that have been calibrated on the
new scale. This is particularly useful for those laboratories
that have their thermometers calibrated on a prescribed
schedule.

The NIST offers calibration services on the ITS-90 for various
thermometers and pyrometers covering the range from 0.65 K
to 4200 °C. The Temperature and Pressure Division offers the
calibrations for contact thermometers covering the range from
0.65 K to 2400 K, and the Radiometric Physics Division offers the
calibrations for non-contact thermometers (pyrometers)
covering the range from 1234.93 K (961.78 °C) to 4200 °C.
The types of contact thermometers calibrated include
rhodium-iron resistance thermometers, germanium resistance
thermometers, standard platinum resistance thermometers,
thermocouples, liquid in-glass thermometers, thermists,
industrial platinum resistance thermometers, digital
thermometers, and other special thermometers that are
compatible with the NIST calibration equipment.
Table 1. Defining fixed points of the ITS-90.

<table>
<thead>
<tr>
<th>Material</th>
<th>Equilibrium State</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>He</td>
<td>VP</td>
<td>T&lt;sub&gt;90&lt;/sub&gt; (K)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 to 5</td>
</tr>
<tr>
<td>e-H&lt;sub&gt;2&lt;/sub&gt;</td>
<td>TP</td>
<td>13.8033</td>
</tr>
<tr>
<td>e-H&lt;sub&gt;2&lt;/sub&gt; (or He)</td>
<td>VP (or CVGT)</td>
<td>≈17</td>
</tr>
<tr>
<td>e-H&lt;sub&gt;2&lt;/sub&gt; (or He)</td>
<td>VP (or CVGT)</td>
<td>≈20.3</td>
</tr>
<tr>
<td>Ne</td>
<td>TP*</td>
<td>24.5561</td>
</tr>
<tr>
<td>O&lt;sub&gt;2&lt;/sub&gt;</td>
<td>TP</td>
<td>54.3584</td>
</tr>
<tr>
<td>Ar</td>
<td>TP</td>
<td>83.8058</td>
</tr>
<tr>
<td>Hg*</td>
<td>TP</td>
<td>235.3156</td>
</tr>
<tr>
<td>H&lt;sub&gt;2&lt;/sub&gt;O</td>
<td>TP</td>
<td>273.16</td>
</tr>
<tr>
<td>Ga</td>
<td>MP</td>
<td>302.9146</td>
</tr>
<tr>
<td>In*</td>
<td>FP</td>
<td>429.7485</td>
</tr>
<tr>
<td>Sn</td>
<td>FP</td>
<td>505.078</td>
</tr>
<tr>
<td>Zn</td>
<td>FP</td>
<td>692.677</td>
</tr>
<tr>
<td>Al*</td>
<td>FP</td>
<td>933.437</td>
</tr>
<tr>
<td>Ag</td>
<td>FP</td>
<td>1234.93</td>
</tr>
<tr>
<td>Au</td>
<td>FP</td>
<td>1337.33</td>
</tr>
<tr>
<td>Cu*</td>
<td>FP</td>
<td>1357.77</td>
</tr>
</tbody>
</table>

* e-H<sub>2</sub> indicates equilibrium hydrogen, that is, hydrogen with the equilibrium distribution of its ortho and para states. Normal Hydrogen at room temperature contains 25% para hydrogen and 75% ortho hydrogen.

b VP indicates vapor pressure point; CVGT indicates constant volume gas thermometer point; TP indicates triple point (equilibrium temperature at which the solid, liquid and vapor phases coexist); FP indicates freezing point and MP indicates melting point (the equilibrium temperatures at which the solid and liquid phases coexist under a pressure of 101.325 Pa, one standard atmosphere). The isotopic composition is that naturally occurring.

* Previously, these were secondary fixed points.

Table 2. Values of the coefficients A<sub>i</sub> and of the constants A<sub>i</sub> for the <sup>3</sup>He and <sup>4</sup>He vapor pressure equations and the temperature range for which each equation is valid.

<table>
<thead>
<tr>
<th>Coef. or</th>
<th>&lt;sup&gt;3&lt;/sup&gt;He</th>
<th>&lt;sup&gt;4&lt;/sup&gt;He</th>
<th>&lt;sup&gt;4&lt;/sup&gt;He</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.65K to 3.2K</td>
<td>1.25K to 2.1768K</td>
<td>2.1768K to 5.0K</td>
</tr>
<tr>
<td>A&lt;sub&gt;0&lt;/sub&gt;</td>
<td>1.053 447</td>
<td>1.392 408</td>
<td>3.146 631</td>
</tr>
<tr>
<td>A&lt;sub&gt;1&lt;/sub&gt;</td>
<td>0.980 106</td>
<td>0.527 153</td>
<td>1.357 655</td>
</tr>
<tr>
<td>A&lt;sub&gt;2&lt;/sub&gt;</td>
<td>0.676 380</td>
<td>0.166 756</td>
<td>0.413 923</td>
</tr>
<tr>
<td>A&lt;sub&gt;3&lt;/sub&gt;</td>
<td>0.372 692</td>
<td>0.050 988</td>
<td>0.091 159</td>
</tr>
<tr>
<td>A&lt;sub&gt;4&lt;/sub&gt;</td>
<td>0.151 656</td>
<td>0.026 514</td>
<td>0.016 349</td>
</tr>
<tr>
<td>A&lt;sub&gt;5&lt;/sub&gt;</td>
<td>-0.002 263</td>
<td>0.001 975</td>
<td>0.001 826</td>
</tr>
<tr>
<td>A&lt;sub&gt;6&lt;/sub&gt;</td>
<td>0.006 596</td>
<td>-0.017 976</td>
<td>-0.004 325</td>
</tr>
<tr>
<td>A&lt;sub&gt;7&lt;/sub&gt;</td>
<td>0.088 966</td>
<td>0.005 409</td>
<td>-0.004 973</td>
</tr>
<tr>
<td>A&lt;sub&gt;8&lt;/sub&gt;</td>
<td>-0.004 770</td>
<td>0.013 259</td>
<td>0</td>
</tr>
<tr>
<td>A&lt;sub&gt;9&lt;/sub&gt;</td>
<td>-0.054 943</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>7.3</td>
<td>5.6</td>
<td>10.3</td>
</tr>
<tr>
<td>C</td>
<td>4.3</td>
<td>2.9</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Figure 1. Differences between t<sub>90</sub> and t<sub>93</sub> as a function of t<sub>90</sub> labelled t°C. This graph was reproduced with permission from the article, entitled "News from the BIPM", by T. J. Quinn in Metrologia 26, 69-74 (1989).
Table 3. Values of the coefficients $A_i$, $B_i$, $C_j$, and $D_j$ and of the constants $A_o$, $B_o$ and $D_o$ in the reference functions, equations (10) and (18), and in the functions approximating them, given by equations (11), (19).

<table>
<thead>
<tr>
<th>Constant or Coefficient</th>
<th>Value</th>
<th>Constant or Coefficient</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_9$</td>
<td>-2.13534729</td>
<td>$B_0$</td>
<td>0.183324722</td>
</tr>
<tr>
<td>$A_1$</td>
<td>3.18324720</td>
<td>$B_1$</td>
<td>0.240975303</td>
</tr>
<tr>
<td>$A_2$</td>
<td>-1.80143597</td>
<td>$B_2$</td>
<td>0.209108771</td>
</tr>
<tr>
<td>$A_3$</td>
<td>0.71727204</td>
<td>$B_3$</td>
<td>0.190439972</td>
</tr>
<tr>
<td>$A_4$</td>
<td>0.50344027</td>
<td>$B_4$</td>
<td>0.142648498</td>
</tr>
<tr>
<td>$A_5$</td>
<td>-0.61899395</td>
<td>$B_5$</td>
<td>0.077993465</td>
</tr>
<tr>
<td>$A_6$</td>
<td>-0.05332322</td>
<td>$B_6$</td>
<td>0.012475611</td>
</tr>
<tr>
<td>$A_7$</td>
<td>0.28021362</td>
<td>$B_7$</td>
<td>-0.032267127</td>
</tr>
<tr>
<td>$A_8$</td>
<td>0.10715224</td>
<td>$B_8$</td>
<td>-0.075291522</td>
</tr>
<tr>
<td>$A_9$</td>
<td>-0.29302865</td>
<td>$B_9$</td>
<td>-0.056470670</td>
</tr>
<tr>
<td>$A_{10}$</td>
<td>0.04459872</td>
<td>$B_{10}$</td>
<td>0.076201285</td>
</tr>
<tr>
<td>$A_{11}$</td>
<td>0.18868632</td>
<td>$B_{11}$</td>
<td>0.123893204</td>
</tr>
<tr>
<td>$A_{12}$</td>
<td>-0.05248134</td>
<td>$B_{12}$</td>
<td>-0.029201193</td>
</tr>
<tr>
<td>$A_{13}$</td>
<td>-0.00640497</td>
<td>$B_{13}$</td>
<td>-0.091173542</td>
</tr>
<tr>
<td>$A_{14}$</td>
<td>0.001317696</td>
<td>$B_{14}$</td>
<td>0.000269326</td>
</tr>
<tr>
<td>$A_{15}$</td>
<td>0.026025526</td>
<td>$B_{15}$</td>
<td>0.026025526</td>
</tr>
<tr>
<td>$C_0$</td>
<td>2.78157254</td>
<td>$D_0$</td>
<td>439.932854</td>
</tr>
<tr>
<td>$C_1$</td>
<td>1.64650916</td>
<td>$D_1$</td>
<td>442.418020</td>
</tr>
<tr>
<td>$C_2$</td>
<td>-0.13714390</td>
<td>$D_2$</td>
<td>37.684494</td>
</tr>
<tr>
<td>$C_3$</td>
<td>-0.00649767</td>
<td>$D_3$</td>
<td>7.472018</td>
</tr>
<tr>
<td>$C_4$</td>
<td>-0.00234444</td>
<td>$D_4$</td>
<td>2.920828</td>
</tr>
<tr>
<td>$C_5$</td>
<td>0.00511868</td>
<td>$D_5$</td>
<td>0.005184</td>
</tr>
<tr>
<td>$C_6$</td>
<td>0.00187982</td>
<td>$D_6$</td>
<td>-0.005864</td>
</tr>
<tr>
<td>$C_7$</td>
<td>-0.00244472</td>
<td>$D_7$</td>
<td>-0.188732</td>
</tr>
<tr>
<td>$C_8$</td>
<td>-0.00046122</td>
<td>$D_8$</td>
<td>0.191203</td>
</tr>
<tr>
<td>$C_9$</td>
<td>0.00045724</td>
<td>$D_9$</td>
<td>0.049025</td>
</tr>
</tbody>
</table>

**BOARD MEETING CANDIDS, SAVANNAH, GEORGIA**

Graham Cameron (L) gets his 20-yr pin from President Del Caldwell.

A jovial Board thanks their lucky stars they weren't attending the meeting during Hurricane Hugo. As it was, it had to be rescheduled from Charleston to Savannah.
In this past quarter, there have been several Standardization Document Improvement Proposals offering various recommended changes to the publication, along with a few telephone inquiries requesting additional information concerning the intent and interpretation of various aspects of the MIL-STD. This column will address some of the more interesting and important issues raised during this period.

With regard to paragraph 5.2, Adequacy of measurement standards, there appears to be a tendency, on the part of the Government representative, to extrapolate the 4:1 test accuracy ratio (TAR) down to the relationship between the M&TE and product tolerance. If the MIL-STD identifies a 4:1 TAR relationship between the measurement standard and M&TE being calibrated, it is being interpreted, (or it is recognized as a standard practice within the auditor community), that this same TAR relationship must exist between the M&TE and product tolerance. This is definitely not the intent of the MIL-STD. It is important to note that the scope of the MIL-STD is to outline the fundamental requirements of a complete calibration system used to control the accuracy of measurement standards and measuring and test equipment only. The military standard neither extends down to, nor has it ever been applicable to test tolerances normally associated with product conformance. If required, the TAR between the M&TE and product must be stated separately in the contract.

Another area of the MIL-STD that has received several inquiries is paragraph 5.9, Records. The question most frequently asked is “How long should I keep my calibration records?” The primary purposes of the calibration records are to provide objective evidence that calibration schedules are being complied with for instrument recall, and provide a history of instrument stability and reliability which may be evaluated and used as a basis for adjustment of the calibration interval. Therefore, the period of time that the contractor should retain the individual record for each item of M&TE and measurement standard, which comprise their particular calibration system, may vary considerably, both between selected items of test equipment and the individual contractor. Based on the above, it would be impractical for the MIL-STD to provide specific disposition instructions for either the retention or destruction of calibration records. However, it would be of mutual benefit to both the Government and contractor to retain the calibration record as long as the M&TE and measurement standards are used on the current or other DOD contracts.

Editor’s Note: By now everyone should know that NCSL and the DOD worked together to publish the revised version of MIL-HDBK-52B, for use by government contractors. A number of personnel on both sides contributed to the final results which as I understand it are agreeable to all. All NCSL members were mailed advance copies, and the NCSL Secretariat has a limited supply of copies for interested parties.
EQUIPMENT MANAGEMENT FORUM

EQUIPMENT MANAGEMENT FORUM – REPORT

The San Francisco area earthquake shook up our first annual Equipment Management Forum (EMF) program schedule but not the spirit of the eighty-nine registered attendees representing 66 separate organizations.

The annual forum was held in Manhattan Beach, California on 18-20 October 1989. Our first two presenters could not fly out of San Francisco airport because of the earthquake. Fortunately we had a contingency plan which was implemented.

PROGRAM HIGHLIGHTS

An overview of Equipment Management at Boeing Aerospace & Electronics was shared with us by Arnie Doll of Boeing Aerospace & Electronics. Arnie guided us from the 1961 one man laboratory through today’s Test Equipment Management organization with its 44 million dollar general purpose test equipment inventory (GPTE).

Workshop continuum: Elements of an equipment database workshop was conducted by Chuck Van Winckle, EM Asset Information Management Coordinator. Chuck is with DALFII Inc. The result of this workshop which began at the 1987 EMF in St. Louis will be basis for a recommended practice and a section in the Equipment Management Handbook which is also under development.

Contingency planning was presented by Charles Motzko of Electro Rent. (How appropriate!) Charlie cited many current events where contingency planning or lack thereof played a major role in their outcome. Losses to both internal and external customers must be considered. Charlie contends that our first responsibility should be to help bring our customers back to normal.

Control & tracking of accessories was presented by John Lee of Telogy Inc. John highlighted the importance of accessories to test equipment users and equipment rental companies. Many of us could relate to the costs and problems associated with missing accessories. Many solutions have been tried such as accessory listings, packing slip listings and invoicing for missing accessories. None of these have stemmed the loss of accessories. With a new approach using a Kodak SV7500 still video disk system, Telogy now combines the accessories listing with pictures of accessories. For the brief period of time this process has been implemented, a 43% improvement in the number of returned accessories has been seen. The dollar savings achieved more than offset the startup cost for this new process. This has also improved customer relations since they no longer have to follow up on missing accessories.

Contribution of software to audit survival was presented by Glen Berry of the John Fluke Manufacturing Company. Glen indicated major audit problem areas to be record keeping, out-of-tolerance conditions and forward and backward traceability. Some of the key characteristics of a good computer system should include a multi-level security (password), enforcement of defined routines, simplicity of use, data validation and system flexibility.

Strategy and tactics for achieving Motorola’s six sigma quality objectives was presented by John Hathaway of Motorola’s Government Electronics Group. Motorola is the winner of the first annual "Malcolm Baldrige National Quality Award" administered by the National Institute of Standards and Technology (NIST). Motorola takes the position that high levels of performance cannot be achieved by merely managing quality. "Quality improvement is a war! A war that can only be won by applying sound strategies and tactics with powerful weapons under decisive leadership against clearly defined objectives! Although American industry has excelled in the development of the weapons of this war, the procedural and analytical methods of quality improvement, it has faltered in almost every other aspect. Objectives are nebulous and poorly defined. Managers are trying to live up to their namesake by managing rather than leading. Strategies and tactics are almost nonexistent. This presentation focused on the objectives of the quality improvement: defining its enemy and targets. More importantly, the focus was on the strategies and tactics required to bridge the implementation gap between the philosophy of improvement ("Quality is Free") and the weapons of improvement ("Xbar & R charts")."

Continuous improvement culture at the McDonnell Douglas Helicopter Company – Facilities Group was presented by Dale Kemper of McDonnell Douglas Helicopter Company. Their goal of total customer satisfaction requires continuous improvement in customer service, people development, process quality and cost optimization. Two basic requirements are developing the tools and development of the habit.

Tools include data gathering, Pareto charts, fishbone diagrams, run charts, C, etc. Using these tools they addressed employee injuries and achieved a reduction of over 25% in the injury rate.

In developing the habit, the focus was on "base hits" and not "home runs", informal and no pressure procedures. Examples of the "base hits" system are personal calling cards left when
Hard at it in workshops that are defining database elements for a recommended practice for equipment management systems.

A sincere thank you from Arnie Doll to Paul Chong for his efforts in hosting this year's forum.

work was done, set up "customer day"—take customer on your rounds, and automated record system. Bottom line—as the quality of service improves, the expectations of their customers will increase.

Introduction of VXI Equipment to the inventory was a joint presentation by Wendell Seal of TRW-Equipment Management Center and David Haworth of Tektronix Inc. and the VXI Consortium. This was a great platform to set the stage for the next day's panel discussions. Depending upon the users' application, calibrations may have to be performed at the systems level rather than on an individual card level basis. Reconfiguration may also effect the system's calibration integrity.

Barcoding in a Test Equipment Pool Operation was presented by Dale W. Wilken of Rockwell International's Collins Defense Communication Division. The introduction of barcode technology to equipment management has greatly changed the way property managers do business. Today the computer inputs and up-dates can be done electronically making it a "paperless environment." Significant labor savings and near zero errors are readily achievable. Periodic physical inventories of property are nearly error free and painless. Time to perform wall-to-wall inventory has been reduced by 80%. At Rockwell a barcoded "credit card" is used to ensure proper rental charges to the using department's overhead accounts. Credit cards are used on all test consoles, rooms, work benches and work areas. This is another example of their paperless process for managing their 29,000 item, $54 million inventory.

VXI technology panel discussions were moderated by Charles Motzko of Electro Rent. Other panel members included David A. Haworth of Tektronix Inc., Malcolm Levy of Ralco-
Dana, George Wolke of Colorado Data Systems and Larry Des Jardin of Hewlett Packard Company. The discussions were very active. Some of the issues raised were: no room for tagging, some units may not have side shields, some units may be mounted from the rear, temperature and airflow requirements, ROM for providing security password to store recall data, some boards will be a challenge to tag with either an asset or status label or both, consoles can verify the calibration dates of their instruments, tagging may be limited to the two handles and applications may effect the system's calibration or performance.

How to make the capital budget work for you was presented by Thomas Deem of McDonnell Douglas Helicopter Company. Tom pointed out that a key to making the capital budget work for you is to understand the process. Change it if it's not working and take responsibility for follow through.

TRW TOUR

The tour created much interest and discussion among the participants. My thanks to those members of the TRW-EMC organization who helped to make it happen: Keith Bentjen, Viet Do, Yas Komorita, Carl Lukka, Dan Martinez, Armando Moreno, Clete Reed, Kevin Ruhl and Dave Sturm.

EXHIBITORS


For further information on any specific subject, we suggest you contact the author directly. I also have a limited number of collected papers which I will send out if you call.

Ted Elms, EMF Committee
Hewlett-Packard (415) 857-3121

ATTENDEES

<table>
<thead>
<tr>
<th>Name</th>
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<tr>
<td>David Alexander</td>
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<td>R.M. Allen</td>
<td>Boeing Advanced Systems</td>
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<tr>
<td>D.C. Ayre</td>
<td>Ford Aerospace</td>
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<tr>
<td>Elizabeth Dixon</td>
<td>Martin Marietta-Radiation Monitor</td>
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<td>Arnie Doll</td>
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<td>Charles Hunter</td>
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<td>Hanif Jamal</td>
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<td>Leslie Jones</td>
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<td>Dale Kemper</td>
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<td>Lee Kenna</td>
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<td>Barry Kaplan</td>
<td>NAVSSES Philadelphia Naval Base</td>
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<td>William L. Knaack</td>
<td>Northwood Group</td>
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<tr>
<td>Vincent G. Kubilus</td>
<td>Hughes Aircraft/Space &amp; Communication</td>
</tr>
<tr>
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<td>Oak Ridge National Laboratory</td>
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<tr>
<td>John Lee</td>
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<tr>
<td>Jim Lemmon</td>
<td>TRW Inc-EPI</td>
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<td>Ron Lorenz</td>
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<tr>
<td>William Martin</td>
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<tr>
<td>Daniel Martinez</td>
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<td>G. Tom McGowney</td>
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<td>Mark Miller</td>
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<tr>
<td>Charlie Motzko</td>
<td>Electro Rent Corporation</td>
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<td>Al Naticchioni</td>
<td>M/A-Com</td>
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<td>Randy B. Ogle</td>
<td>Martin Marietta-Env &amp; Safety Act.</td>
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<td>Dave Orahood</td>
<td>Scientific Devices-West</td>
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<tr>
<td>Chuck Perston</td>
<td>Dalmo Victor Inc.</td>
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<tr>
<td>Ron Pogue</td>
<td>Canadian Standards Association</td>
</tr>
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</table>
1989 FORUM ATTENDEE EVALUATION

DID THIS FORUM DELIVER WHAT WAS PROMISED?
7% - Totally    76% - Close Enough    17% - Somewhat

WERE THE SESSIONS USEFUL TO YOU PROFESSIONALLY?
17% - Totally    71% - Close Enough    10% - Somewhat    2% - Not all

<table>
<thead>
<tr>
<th>SESSION RATINGS:</th>
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<th>GOOD</th>
<th>FAIR</th>
<th>POOR</th>
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<tr>
<td>Overview of Equipment Management at Boeing Aerospace &amp; Electronics</td>
<td>32%</td>
<td>60%</td>
<td>8%</td>
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<td>Workshop Continuum: Elements of an Equipment Database</td>
<td>19%</td>
<td>57%</td>
<td>3%</td>
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<td>Contingency Planning</td>
<td>26%</td>
<td>58%</td>
<td>11%</td>
<td>5%</td>
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<tr>
<td>Control &amp; Tracking of Accessories</td>
<td>50%</td>
<td>45%</td>
<td></td>
<td>5%</td>
</tr>
<tr>
<td>Contribution of Software to Audit Survival</td>
<td>29%</td>
<td>52%</td>
<td>14%</td>
<td>5%</td>
</tr>
<tr>
<td>Strategy &amp; Tactics for Achieving Motorola's six Sigma Quality Objectives</td>
<td>15%</td>
<td>75%</td>
<td>10%</td>
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<td>Continuous Improvement Culture at the McDonnell Douglas Helicopter Co.</td>
<td>25%</td>
<td>75%</td>
<td></td>
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<tr>
<td>Intro. of VXI Equipment to the Inventory</td>
<td>26%</td>
<td>58%</td>
<td>16%</td>
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<tr>
<td>Barcoding in a Test Equipment Pool Operation</td>
<td>32%</td>
<td>54%</td>
<td>14%</td>
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<tr>
<td>Panel - On VXI Technology</td>
<td>49%</td>
<td>40%</td>
<td>11%</td>
<td></td>
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<tr>
<td>How to Make The Capital Budget Work For You</td>
<td>17%</td>
<td>54%</td>
<td>14%</td>
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<td>Exhibits</td>
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<td>TRW Tour</td>
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<td>70%</td>
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LOGISTICS

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<td>67%</td>
<td>33%</td>
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<td>Lunches</td>
<td>59%</td>
<td>33%</td>
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<tr>
<td>Dinner</td>
<td>56%</td>
<td>36%</td>
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<tr>
<td>Hotel Accommodations</td>
<td>68%</td>
<td>32%</td>
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</table>

OVERALL RATING 28% 72%

ATTENDEES (Cont'd)

<table>
<thead>
<tr>
<th>Name</th>
<th>Company</th>
<th>Name</th>
<th>Company</th>
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<tr>
<td>Ed Priest</td>
<td>McDonnell Douglas</td>
<td>Neal Strub</td>
<td>General Dynamics</td>
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<tr>
<td>Wayne Ramm</td>
<td>Honeywell Inc-S.C.F.S.G.</td>
<td>David Sturm</td>
<td>MKS Instruments Inc.</td>
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<td>Howard Ream</td>
<td>Rockwell International</td>
<td>Lloyd Thomas</td>
<td>Argosystems Inc.</td>
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<td>Gary Robinette</td>
<td>GE Rental/Lease</td>
<td>Edward B. Tiemeyer</td>
<td>GTE TestMark</td>
</tr>
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<td>Michael Robinson</td>
<td>Racal-Dana Instruments Inc.</td>
<td>H. Bruce Turner</td>
<td>McDonnell Douglas Electronics Lab</td>
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<tr>
<td>George Sanger</td>
<td>Ford Aerospace</td>
<td>Robert Uchiyama</td>
<td>Hughes Aircraft-Space &amp; Commun.</td>
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<tr>
<td>Doug Schenck</td>
<td>Hewlett-Packard (Fullerton)</td>
<td>Charles Van Winkle</td>
<td>Dalil Inc.</td>
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<td>Ludwig Schmidt</td>
<td>Tektronix Inc.</td>
<td>Anita Wallace</td>
<td>Tektronic Inc.</td>
</tr>
<tr>
<td>Randy Seefeld</td>
<td>Navy Primary Standards Lab</td>
<td>Lee Washington</td>
<td>Naval Aviation Depot-North Island</td>
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<tr>
<td>L.E. Smith</td>
<td>E-Systems</td>
<td>Robert Williams</td>
<td>Naval Avionics Center</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gerald Wilson</td>
<td>Boeing Military Airplanes</td>
</tr>
</tbody>
</table>
METROLOGY CALENDAR

INDUSTRY MEETINGS

Jan. 23, 24, 1990 - GIDEP Management Meeting, Roanoke, VA.


Feb. 12-14 - IEEE Instrumentation & Measurement Technology Conference, Red Lion Inn, San Jose, CA; contact Robert Myers, (213) 287-1463.


Apr. 10-11, 1990 - GIDEP Management and Metrology Committee, Greenbelt, MD.

Apr. 30-May 1, 1990 - National Forum For Laboratory Accreditation, Washington D.C.

May 1, 1990 - A2LA, Membership and Board of Directors meeting, Washington, D.C.

June 11-14, 1990 - CPEM 90, Conference on Precision Electromagnetic Measurements, Westin Hotel, Ottawa, Canada; contact J. Vanier, (613) 993-9326.

REGIONAL MEETINGS SCHEDULE

REGION 1. Typically holds (2) meetings per year, a regional business meeting and a technical session.

REGION 2.

REGION 3.

Virginia Section, March 1990

REGION 4. Plans are to hold four (4) meetings each year.

Sept. 20, 1989 - Clearwater, FL, @ Holliday Inn

REGION 5.

April 5, 1990 - Indiana, TBA
April 12, 1990 - Dayton, TBA
April 19, 1990 - Cleveland, TBA
April 26, 1990 - Michigan, TBA
October 4, 1990 - Indiana, TBA
October 11, 1990 - Dayton, TBA
October 18, 1990 - Cleveland, TBA
October 25, 1990 - Michigan, TBA

REGION 6. The Central (Dallas/Fort Worth) Section: The Wednesday of the first full week of April and November, rotating between Tektronix's, Fluke's and Hewlett-Packard's facilities adjacent to DFW Airport between Dallas and Fort Worth.

April 4, 1990 - Tek
November 7, 1990 - Fluke
April 10, 1991 - HP.

South (Austin) Section: The Wednesday of the second full week of Jan. and July. Rotating between W.L. Gore & Assoc's, Austron's & Mensor's facilities in the Austin area.

Jan. 17, 1990 - W.L. Gore
Jul. 11, 1990 - Austron
Call Mark Thornton (512) 396-4200.

West (Boulder/Denver) Section: The Wednesday of second full week of March & September rotating between MKS & Storage Technology's, & Ball Aerospace's facilities in the Boulder/Denver area.

Mar. 22, 1990 - Storage Tech
Sept. 12, 1990 - Ball Aerospace
Call Deirdre Lavalie, (303) 449-6814.

REGION 7. All meetings are held in the San Francisco Bay Area.

REGION 8.

REGION 9. Plans to hold two meetings each year.

REGION 10. (INTERNATIONAL)

REGION 11. 1989 Schedule of Events:
Mar. 1990 - Teleconference.

---

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ANALYTIC MODELING FOR ELECTRONIC TEST EQUIPMENT ADJUSTMENT POLICIES

By Delbert H. Caldwell and John A. Ferling

ABSTRACT

Effects of adjustment policies on selected calibration program attributes are modeled. Concepts of adjustment decision criteria and limits are introduced in a tolerance test environment. Selected policies are analyzed to relate the effect of these adjustment policies on calibration quality, interval and cost. A variation in test accuracy ratio is introduced to assess the influence on test and adjustment policies and their impact on calibration attributes. The interrelationship of performance, test and adjustment limits is described in specific situations to demonstrate techniques to achieve calibration quality, interval and cost goals in various calibration and test equipment configurations.

INTRODUCTION

During the early 1950's, a number of papers [1, 2] were written to describe the effects of test quality on the quality of goods manufactured and delivered to consumers. These papers also addressed the quality of the products that were rejected during final testing and terms like consumer's and producer's risk were widely used in these descriptions. In the late 1950's, these concepts were used [3-5] to describe the effects of calibration quality on the quality of test equipment accepted by a calibration process and the nature of rejected units. The test quality concept coupled with the idea of managing the level of test equipment that are in- or out-of-tolerance during use, formed the foundation for most calibration programs in use today. As time has gone on, calibration of test equipment has become a significant element of most research, development, production and support operations and, as such, had been challenged in many ways to prove its value and cost effectiveness. As the need to exploit technology at an ever rapid pace, measurement and accuracy requirements are increasing and the calibration and test community are being challenged to continue to provide quality service in a cost effective manner.

Over the last decade or so, a small number of researchers [6-13] investigated test and calibration policies and processes in order to provide greater insight into managing the effects of various system elements on critical performance factors of interest to calibration system managers, their customers and the users of the final tested product or service. The results of the research provided new modeling concepts which improve on the earlier work by accounting for the closed-loop cycle of test equipment in a calibration system (and therefore the interaction of calibration elements) and by chaining test and calibration processes in a hierarchical network to obtain overall system performance. These modeling concepts also allowed for greater insight into the effects of varying system parameters such as test accuracy (uncertainty) ratio, measurement reliability targets, quality attributes and testing criteria.

This paper addresses some aspects of these modeling concepts by starting with a typical calibration-test equipment system, "the benchmark case". With a new requirement to calibrate more accurate test equipment, the accuracy ratio of the calibration process is reduced and calibration system parameters are impacted. Several approaches to restore selected calibration system parameters to the values provided by the benchmark case, while maintaining reported in tolerance conditions, are described.

THE CALIBRATION SYSTEM

In Figure 1, a closed loop calibration system is shown to consist of a calibration environment and a use environment.

![Closed-Loop Calibration System (Steady State)](image)

In this simple system, the inventory of test equipment is either in use or undergoing calibration. Calibration is shown to consist of a tolerance test where those that passed are returned for use and those that failed are adjusted, tested and returned for use. The time in use is referred to as the calibration interval or period and results from comparing the percent of test equipment found within test limits at the end of the calibration interval to a desired value (measurement reliability target (MRT), and adjusting the allowable in-use time until the desired value is obtained. The quality of the test equipment returned for calibration is the percent that are within the desired performance limits. This is shown as QEO (Quality, End of use Period) in Figure 1. The quality of the

Presented at the National Conference of Standards Laboratories Workshop and Symposium, 9-13 July 1989, Denver, Colorado
calibration service in this example is the percent of the test equipment that are returned for use within the desired performance limits. This is shown as QBOP (Quality, Beginning of use Period) in Figure 1. This simple closed-loop system requires calibration support and funding to operate the calibration system, adjust calibration intervals, and perform the test and adjustment functions.

A BENCHMARK

Most calibration systems operate with standard policies or goals that affect the cost and quality of the calibration service itself and the measurement quality of the test equipment. For this paper we have established a representative set of conditions which we will use as a "benchmark" for a calibration system. The performance of this benchmark system will give us a representative basis for examining variations to be introduced in the system. Our benchmark system policies and parameters are noted below.

BENCHMARK CALIBRATION SYSTEM POLICIES

* Performance, Test and Adjustment Limits are equal (P_L = T_L = A_L).

* Nominal Test Accuracy Ratio (NTAR) is 4:1.

* Test Equipment Measurement Reliability Target (MRT) (at end of use period) is 72%.

* Calibration Interval is one year.

* Adjustment Effectiveness is 99.3%.

* Benchmark calibration system probability of being in-tolerance at time of use is 0.9.

Given this information, the derived parameters for our benchmark system are:

BENCHMARK CALIBRATION SYSTEM PARAMETERS

* QBOP – The true in-tolerance percentage of test equipment returned for use in tolerance: 97.219%.

* QEEP – The true in-tolerance percentage of test equipment returned for calibration: 72.658%.

* Calibrations performed per hundred items of test equipment per year: 100.

* Adjustments performed per hundred items of test equipment per year: 28.

*Note: Throughout this paper, the number of significant digits will exceed the accuracy of the values of the parameters and other quantities. The precision is useful to assess changes and assure reasonable consistency throughout.

These parameters are shown in Figure 2.

Figure 2. Benchmark Calibration System (Steady State)

A description of these derived parameters is provided in the following:

QBOP –

In general, the quality of the test equipment leaving the calibration environment is less than 100% and is affected the most by the nominal test accuracy ratio (NTAR) of the tolerance test and the true mix of in-and out-of tolerance test equipment examined. It is also affected by the adjustment/retest process and the ability of the test equipment to "accept" the adjustments (adjustment effectiveness). For the benchmark system with 100 items tested, 72 are passed; of these, 69.415 are actually within the performance limits. Of the 28 items failed, 3.241 are actually within the performance limits, but as shown, all are adjusted and retested. As the adjustment effectiveness is limited to 99.3%, only 27.804 of these 28 are returned to use within the performance limits. Combining the failed but adjusted items with the passed items results in 97.219 leaving the calibration environment within the performance limits. Accordingly, QBOP is 97.219%.

QEEP –

In general, the quality of the test equipment operating at the end of the use period is a function of the quality of the test equipment at the beginning of the use period (QBOP), the behavior of the test equipment characteristic with time and the length of time in use (calibration interval). The nature of QBOP was described above. The behavior of the test equipment characteristic with time is the probability that the characteristic is outside the performance limit at various times and is determined in this paper by the exponential failure model. In the benchmark situation, the length of time in use is determined by the calibration interval adjustment process which compares the percentage of passed items to the MRT of 72% and adjusts the interval so that the percentage of
passed items is 72%. For the benchmark situation the calibration interval is 1 year and for each 100 items tested, 72 are passed; of these 69,415 are actually within the performance limits. For the 28 items that failed, 3,241 are also within the performance limits. Combining, the number of items tested that are within performance limits is 72.658. Accordingly, QEOP is 72.658%.

Calibrations performed per year — As it was a given that the calibration interval was 1 year; the number of scheduled calibrations performed each year for each item of test equipment is 1.

Adjustments performed per year — With the number of calibrations per year equal to 1 (see above) and a MRT of 72%, the fractional number of adjustments performed per calibration is 0.28.

Note the dynamic, closed-loop behavior of the benchmark calibration system. With the quality of the tolerance test (NTAR) less than perfect, every derived parameter seems to affect every other parameter. Also note that in the benchmark calibration system, the test and adjustment limits were both equal to the desired performance limits, typically the test equipment manufacturer’s specifications. This is the normal case as it is only natural to set the test and adjustment limits equal to the performance limit as any characteristic observed to be outside the manufacturer’s specifications would, typically, be unacceptable and an adjustment would be made.

SITUATIONS

In the following situational examples, we will explore the consequences of a low NTAR on the parameters associated with our benchmark calibration system and how by separating and choosing values for the test and adjustment limits, some undesirable and desirable results can be obtained. To clearly see the relative effects of these changes, the test equipment failure rate is considered to be constant.

SITUATION I DESCRIPTION

In this first situation you are being asked to calibrate a new item of test equipment with your existing calibration equipment. Comparing performance limits (manufacturer’s specifications) you realize that a NTAR of 2:1 would exist and this value is less than your laboratory’s minimum NTAR of 4:1. Being a conscientious metrologist you know that with the current test tolerance policy, where the performance, test and adjustment limits (P_L, T_L and A_L respectively) are the same, the output quality would be reduced to an unacceptable 95.359%. To avoid this you decide to reduce the test and adjustment limits (while keeping them equal to each other) to some point below the desired performance limits and improve the output quality. If you reduce them too far, you are aware that you probably will be adjusting more items than you should and probably increasing calibration costs. Your decision is to reduce T_L and A_L (with T_L = A_L) until the output quality (QBOP) in this situation is the same as that obtained in the acceptable benchmark system, i.e., 97.219%. With a NTAR of 2:1 and using Figure 3, T_L and A_L are reduced to 0.898 of the specified performance limits (P_L) and a QBOP of 97.219% is obtained.

![Figure 3. Calibration Quality With Reduced Test and Adjustment Limits](image)

NOTE: Other conditions apply, see text

Figure 3. Calibration Quality With Reduced Test and Adjustment Limits

SITUATION I ASSESSMENT:

The benefits of Situation I appear to the metrologist to be:

- Output quality (QBOP) is maintained at 97.219%.
- Calibration delays (to calibrate elsewhere or buy a new calibration equipment) are avoided.
- New calibration equipment and related support costs avoid being avoided or deferred.

The costs associated with this action relative to use of benchmark policies appear to be:

- More wrong test decisions will be made and the calibration interval would be reduced by about 34.8%.
- More items that do not need adjustment will be adjusted.

Test equipment out-of-service time, per year, would be increased.

The increase in the number of calibration and adjustments per year are 19.4% for the Trial* possibility and 53.3% for Situation I.

*NOTE: Trial is meant to indicate using the existing calibration equipment to calibrate the new test equipment with an NTAR of 2:1, and keeping P_L = T_L = A_L.
If the calibration time is equal to the adjustment time and this time is the same for each calibration approach the annualized service times would increase 19.4% and 53.3% for the Trial example, and Situation I, respectively.

These changes along with a look at the Trial example prior to $T_L$ and $A_L$ changing are summarized in Table I.

Table 1. Situation I, Calibration System Parameter Comparison

<table>
<thead>
<tr>
<th>Calibration System Parameter</th>
<th>Benchmark</th>
<th>Trial ($P_L = T_L = A_L$)</th>
<th>Situation I ($T_L$ &amp; $A_L$ Reduced)</th>
<th>Situation II ($P_L = T_L$, $A_L$ Reduced)</th>
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</thead>
<tbody>
<tr>
<td>NTAR</td>
<td>4:1</td>
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<td>2:1</td>
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<tr>
<td>MRT</td>
<td>72%</td>
<td>72%</td>
<td>72%</td>
<td>72%</td>
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<tr>
<td>PL</td>
<td>1</td>
<td>1</td>
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<td>TL</td>
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<td>0.898</td>
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<tr>
<td>QBOP</td>
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<td>95.359%</td>
<td>97.219%</td>
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<tr>
<td>QEOP</td>
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<td>33.445</td>
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</table>

SITUATION II DESCRIPTION

In this situation, you are somewhat unhappy with some of the results of Situation I and you decide to keep the test performance limits equal and attempt to regain some of the benefits of a longer calibration interval. You realize that the output quality can be improved by reducing only the adjustment limits to promote more adjustments per calibration. Again you realize that reducing the adjustment limits too far you could significantly increase calibration costs. Your decision is to reduce $A_L$ until QBOP in this situation is the same as that obtained in the acceptable benchmark system, 97.219%. With a NTAR of 2:1 and using Figure 4, $A_L$ is reduced to 0.869 of the desired $P_L$ and QBOP of 97.219% is obtained.

SITUATION II ASSESSMENT

Relative to Situation I, Situation II appears similar to benchmark in the following:

Output quality (QBOP) is the same and maintained at 97.219%.

Calibration delays are also avoided.

New calibration equipment and related support costs appear to be avoided or deferred.

However, relative to Situation I, Situation II provides the following benefits:

- Calibration interval is lengthened 38.5%.
- Calibrations per year per item is reduced about 27.8%.
- Adjustments per year per item is reduced about 10.3%

![Figure 4. Calibration Quality with Reduced Adjustment Limits](image)

NOTE: Other conditions apply, see text.

Table 2. Situation II, Calibration System Parameter Comparison

<table>
<thead>
<tr>
<th>Calibration System Parameter</th>
<th>Benchmark</th>
<th>Trial ($P_L = T_L = A_L$)</th>
<th>Situation I ($T_L$ &amp; $A_L$ Reduced)</th>
<th>Situation II ($P_L = T_L$, $A_L$ Reduced)</th>
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<td>2:1</td>
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</tr>
<tr>
<td>MRT</td>
<td>72%</td>
<td>72%</td>
<td>72%</td>
<td>72%</td>
</tr>
<tr>
<td>$P_L$</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>$T_L$</td>
<td>1</td>
<td>1</td>
<td>0.898</td>
<td>0.898</td>
</tr>
<tr>
<td>$A_L$</td>
<td>1</td>
<td>1</td>
<td>0.898</td>
<td>0.869</td>
</tr>
<tr>
<td>QBOP</td>
<td>97.219%</td>
<td>95.359%</td>
<td>97.219%</td>
<td>97.219%</td>
</tr>
<tr>
<td>QEOP</td>
<td>72.658%</td>
<td>74.728%</td>
<td>80.401%</td>
<td>80.401%</td>
</tr>
<tr>
<td>Cal Interval</td>
<td>1 yr</td>
<td>0.837 yr</td>
<td>0.652 yr</td>
<td>0.652 yr</td>
</tr>
<tr>
<td>Cal's/yr/100 Items</td>
<td>100</td>
<td>119.447</td>
<td>153.304</td>
<td>153.304</td>
</tr>
<tr>
<td>Adj's/yr/100 Items</td>
<td>28</td>
<td>33.445</td>
<td>42.925</td>
<td>42.925</td>
</tr>
</tbody>
</table>
Relative to Situation I, the attendant cost of Situation II is that the quality of the test equipment at the end of the use period (QEOPE) would decrease from 80.401% to 74.728% due to the increased $T_{l}$, but this is acceptably higher than the benchmark value of 72.219%.

If the calibration time is equal to the adjustment time and this time is the same for each calibration approach, the annualized service time would increase 16.6% relative to benchmark but would be reduced 24.0% relative to Situation I.

These changes along with information from Table 1 are summarized in Table 2.

SITUATION III DESCRIPTION:

In this situation the analyst who adjusts calibration intervals for the test equipment is not pleased with the effect that a lowered NTAR is having on QEOPE and, in turn, the calibration interval. The analyst is also not too pleased with the metrologists attempts at controlling the calibration quality (QBOPE) at the "expense" of QEOPE and, again, the accuracy of the assigned calibration interval. As the analyst's office manages test policy, a decision is made to change QEOPE by setting $T_{L} = A_{L}$ and increase both until QEOPE in this situation is the same as the benchmark level of 72.658%. With a NTAR of 2:1 and using Figure 5, $T_{L}$ and $A_{L}$ are increased to 1.040 of the desired $T_{L}$ and a QEOPE of 72.658% is obtained.

Calibrations can be performed with existing equipment (lower NTAR) and maintain an acceptable QEOPE of 72.658%.

Calibration delays are avoided.

New calibration equipment and related support costs appear to be avoided or deferred.

The costs associated with this action relative to use of benchmark policies appear to be:

Output quality (QBOPE) is reduced to an unacceptable 94.495%.

Calibration interval is reduced 9.7%.

Calibrations per year per item is increased 10.8%.

Adjustments per year per item is increased 10.8%.

If the calibration time is equal to the adjustment time and this time is the same for each calibration situation the annualized service time would increase 10.8% relative to benchmark.

Most metrologists faced with this situation are generally reluctant to "expand the test limits" as it is felt that the calibration laboratory is turning out less accurate test equipment which, in turn, may have a negative effect on the quality of the company's products.

The effects of this change are summarized in Table 3.

Table 3. Situation III, Calibration System Parameter Comparison

<table>
<thead>
<tr>
<th>Calibration System Parameter</th>
<th>Situation II ($T_{L} &amp; A_{L}$) Increased</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTAR</td>
<td>4:1</td>
</tr>
<tr>
<td>MTR (eq.)</td>
<td>72%</td>
</tr>
<tr>
<td>$P_{L}$</td>
<td>0.99</td>
</tr>
<tr>
<td>$T_{L}$</td>
<td>1.040</td>
</tr>
<tr>
<td>$A_{L}$</td>
<td>0.99</td>
</tr>
<tr>
<td>QBOPE (eq.)</td>
<td>97.219% (eq.)</td>
</tr>
<tr>
<td>QEOPE (eq.)</td>
<td>72.658% (eq.)</td>
</tr>
<tr>
<td>Cal Interval</td>
<td>1 yr (eq.)</td>
</tr>
<tr>
<td>CIS/Yr/100 items</td>
<td>100</td>
</tr>
<tr>
<td>Adj'S/Yr/100 items</td>
<td>28</td>
</tr>
</tbody>
</table>

NOTE: Other conditions apply, see text.

Figure 5. Quality of Test Equipment Returned for Calibration with Increased Test and Adjustment Limits

SITUATION III ASSESSMENT:

The benefits of Situation III relative to the benchmark appear to the analyst to be:
SITUATION IV DESCRIPTION:

In this last situation, the calibration system manager, who has been aware of the attempts by both the metrologist and the analyst to control their individual goals becomes aware of the opportunity to use both the techniques of Situations II and III to maintain QBOP and QEOP similar to the company benchmark policy and to keep related costs under control. The manager is aware that there may be costs associated with the new policy, but these costs may be lower than purchasing and supporting a new item of calibration equipment to restore NTAR to 4:1. As the manager recognizes the "closed-loop" nature of the calibration system, that changes made to $T_L$ and $A_L$ relative to $P_L$ are interactive and that perhaps several iterations are required to achieve the quality goals. The manager also confirms that the adjustment action does not affect the test equipment behavior with time or introduce instabilities.

To get to the punch line, $T_L$ is increased and $A_L$ reduced until both QBOP and QEOP of the final calibration system equal their counterparts in the desired, benchmark system, 97.219% and 72.658%, respectively. Values of $T_L = 1.040 P_L$ and $A_L = 0.862 P_L$ are found to achieve these quality goals.

The benefits of Situation IV relative to the benchmark appear to the calibration system manager to be:

- Calibrations can be performed with existing equipment (lower NTAR) while maintaining QBOP and QEOP at benchmark values of 97.219% and 72.658%, respectively.
- Calibration interval is maintained at 1 year.
- Calibrations per year per item are maintained at 1.
- Calibration delays are avoided.
- New calibration equipment and related support costs may be avoided or deferred.

The costs associated with this action relative to use of benchmark policies appear to be:

- The adjustments per year per item increased 32.3%.

If the calibration time is equal to the adjustment time and this time is the same for each calibration approach, the annualized service time would increase 7.1% relative to benchmark.

The effects of this test and adjustment limit structure on the calibration system parameters is shown in Table 4.

<table>
<thead>
<tr>
<th>Calibration System Parameter</th>
<th>Situation II (NTAR &amp; A_L) Increased</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTAR</td>
<td>4:1</td>
</tr>
<tr>
<td>MTR</td>
<td>72%</td>
</tr>
<tr>
<td>$T_L$</td>
<td>1</td>
</tr>
<tr>
<td>$A_L$</td>
<td>1</td>
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<td>QBOP</td>
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<td>1 yr</td>
</tr>
<tr>
<td>CI’S/Yr/100 items</td>
<td>100</td>
</tr>
<tr>
<td>Adj’S/Yr/100 items</td>
<td>28</td>
</tr>
</tbody>
</table>

To put this situation in bottom-line perspective, the calibration system manager notes that the annual service cost per item increases from $204.80 to $219.28 (using 4 hours to calibrate or adjust and a burdened labor rate of $40 per hour) for an annual cost increase of $14,480 (7.1%) for an inventory of 1000 items of test equipment. The following illustrates how this cost information could be used.

Compared to buying two new calibrators for a total of $150,000 and using existing support for these calibrators, use of the $T_L$ and $A_L$ changes would only serve to maintain quality of service until the calibrators could be obtained.

Compared to buying two new calibrators for a total of $150,000 and establishing improved support for a similar amount, it would seem that with only this example, the purchase decision could be deferred and the existing calibrators used.

Compared to not being able to purchase new calibrators or when state-of-the-art limitations exist, the changes to $T_L$ and $A_L$ would allow calibration services to be performed without a loss in quality or downtime with a 7.1% increase in service cost.

In a different situation where the expected new test equipment inventory would be low, the changes to $T_L$ and $A_L$ would allow calibration services to be performed without a loss in quality or downtime with a negligible increase in service costs.

*NOTE: It is assumed that calibration and adjustment times are the same for these comparisons. It is recognized there should be differences, especially for the high cost item.

A quick service cost comparison of all situations described that use existing calibration equipment is shown in the following, using these same calibration times, rates and inventory values:
As shown, the lowest annual test equipment service cost would result from using new calibrators that provided a NTAR of 4:1 excluding capital and other related costs. Of the calibration alternatives described, using the reduced test and adjustment limits (Situation I) is the most costly by 53.3\% and due to the short calibration interval it yielded the highest QBOP and QEOP. In this paper this is viewed as "excess quality relative to the benchmark policy. Situation IV, where $T_L$ was increased and $A_L$ reduced (relative to $P_L$), yielded the benchmark quality requirements at a 7.1\% annual service cost increase.

**SUMMARY**

Situations that were intended to describe the effect that test and adjustment policies have on calibration quality elements and related costs have been given. By means of examples it has been shown that changes of test and adjustment limits can compensate for a reduced test equipment to calibration equipment accuracy ratio. The same true in-tolerance percentages (QBOP and QEOP) as resulting from a higher accuracy ratio system can be achieved by these changes. A number of assumptions were made to illuminate benefits of varying $A_L$ in conjunction with $T_L$ but these assumptions, obviously, affects the utility of the practice. The validity of these assumptions has increased over the last 10 years or so, to make the practice increasingly viable. More and more instruments are able to accept numerical adjustments over the IEEE-488 or similar busses. For such instruments, the adjustment time is reduced or even negligible and adjustments tend not to affect their time-dependent behavior. With the increased attention on quality and the availability of low cost personal computers (PC), more calibration data is being analyzed, better information on test equipment behavior is beginning to be obtained, and more realistic test equipment quality models are being employed. With analytical metrology research results becoming more useable in the PC environment, models, such as those used in this paper, should increase in use and improve, and the trade-offs and decisions described may become commonplace.

**ACKNOWLEDGEMENTS**

The authors are indebted to Jerry L. Hayes for his definition of the critical policies affecting calibration systems and his vision and spirited support to research efforts in the analytical metrology field.

*Ed Note: I didn't print 2 Appendices & Glossary of Terms. Contact me for a copy if you have further interest.*

**REFERENCES:**


Providing total instrumentation support to over 900 biologists and chemists in the Research and Development division of Searle Pharmaceutical company in Skokie, Illinois, and assisting other Searle divisions worldwide in their metrology efforts is what Ralph Bertermann has been doing for 19 years.

As associate director of the Instrumentation and Metrology group, Ralph directs the activities relating to personal computer maintenance, repair, and networking; telephone installation and repair, audio visual and video teleconferencing support; terminal and printer repair, interface, and cabling; and metrology.

The metrology function, which was started by Ralph in 1978, supports 13,000 instruments with a staff on one engineer and four technicians. 1978 was also the year that Searle became a member of NCSL.

After a three year tour in the U.S. Marine Corps and graduating from the Milwaukee Institute of Technology, Ralph joined Argonne National Laboratory, Argonne, Illinois for over eight years, in the High Energy Physics division. Here his responsibilities as Assistant of Operations included the around the clock safe and efficient operation of the Zero Gradient Synchrotron, a 12.5 BEV proton particle accelerator.

His NCSL and professional activities have included the following: Information & Directory Committee Chairman, member and acting chairman of the Biomedical and Pharmaceutical Metrology Committee, member of the writing group for RP-6, past Director of old Region 5 and present Director of Regions 1 & 11. In addition, Ralph has been the past president of the Mid-America section of the Precision Measurement Association and has presented or published 18 papers covering a wide range of topics.

Ralph and Joyce, his wife of 25 years, live in Mt. Prospect, Illinois, approximately 10 miles north of O'Hare field near Chicago. They have three children, Dan (23), Kristen (20) and Rebecca (12). Ralph's leisure activities and hobbies include camping, stained glass, tennis, antique car restoration and flying.
A few years ago the Equipment Management Forum (EMF) held its meeting at the McDonnell Douglas Helicopter Company facility in Mesa, Arizona. That meeting wrapped up with a complete tour of the Mesa facility. I was impressed by the quality associated with that facility and its activities. For the members that did not attend the EMF we have a tour for them of McDonnell Mesa Metrology Laboratory.

The lab occupies 10,700 square feet of laboratory and equipment processing space. The laboratory areas are environmentally controlled to maintain applicable temperature requirements to within ± 1 degree f and relative humidity between 35% and 55%.

The Metrology Laboratory performs and maintains certification and/or testing of calibration and test equipment for all McDonnell Douglas Helicopter Arizona based programs. The laboratory also supplies special measurement tasks for other departments.

As a result, all measurements are objective and traceable to either the National Institute of Standards and Technology, or natural physical constants. This traceability is accomplished as a result of the following metrology tasks:

- Maintain measurement standards which are traceable to NIST or natural physical constants.

- Calibrate and/or certify all measurement and test equipment.

- Maintain a system of recall for periodic calibration and/or certification of MDHC Arizona measurement and test equipment.

- Assure continuing compliance with MIL-STD-45662A requirements.

- Develop and specify basic techniques used in standardization, calibration, and measurements.

- Evaluate special measuring equipment and commercial instruments.

- Provide measurement services support to Quality Assurance, Engineering, Manufacturing, and Product Support for new product development, failure analysis, and acceptance of critical product characteristics.

The Metrology facility is divided into five areas. Each area is listed with their individual capability:

- Electronic Metrology
  - Time/Frequency measurement
  - AC/DC measurement
  - AV/DV measurement
  - Resistance measurement
  - RF measurement
  - Power measurement
  - Automated calibration measurement

- Linear Metrology
  - Length measurement
  - Geometric measurement
  - Torque measurement
  - Coordinate determination

- Optical Metrology
  - Length measurement
  - Angle measurement
  - Flatness measurement
  - Boresight calibration/alignment
  - Optical quality measurement
  - Photometric measurement
  - Radiometric measurement
  - Coordinate determination

- Physical Metrology
  - Pressure measurement
  - Vacuum measurement
  - Mass measurement
  - Flow measurement
  - Temperature measurement
  - Environmental measurement

- Quality Equipment Room
  - Maintain automated recall system
  - Incoming/outgoing equipment processing
  - Coordinate vendor support
  - Maintain equipment history files

Equipment used to attain their measurement requirements includes the following:

- Radio frequency (RF) calibration system for high frequency measurement and evaluation.

- Air velocity calibration system for air flow measurements.

- Pneumatic/hydraulic dead weight testers for pressure measurements

- High precision mercury manometers for vacuum measurements
Touring Labs

- Environmental chamber for hygro/thermo device measurements
- Gage blocks for length standard measurements
- Thermocouple simulator with ice and fluidized sand baths for temperature measurements
- Collimator stand to measure optical line of sight, squareness, straightness, and angles
- Captive boresight harmonization dock to position boresight kits for calibration
- Photo/radiometer to measure light intensity from ultraviolet to infrared
- WWVB comparator for synchronized time/frequency measurements
- A123 calibration system used for the automated calibration of oscilloscopes and multimeters
- Coordinate analyzing theodolite CAT 2000 system is used for coordinate determination for measuring objects such as aircraft, tools, etc.

The following pictures show some of the laboratories' working areas.

I would like to thank Wade Keith, the manager of Quality Engineering at the Mesa facility for this tour. I would also like to thank the McDonnell Douglas management for their work in helping to assure quality in the nation through their support of the NCSL and the metrology field. The labs I have toured have shown such dedication for improving things it is marvelous and inspiring. Truly, there is dedication by the laboratory staffs, and by their management, to the fact that quality is important and necessary.

CAT 2000 optical coordinate measurement system
TOWARD AN INTERNATIONAL STANDARD FOR CALIBRATION SYSTEMS

Rolf B. F. Schumacher

INTRODUCTION

Since 1987, a working group (WGI) of the International Organization for Standardization (ISO), Technical Committee (TC) 176, Quality Management and Quality Assurance, has been working on an international standard for calibration systems recently designated as 10012, Quality Assurance Requirements for Measuring Equipment. This standard is intended to cover the area covered in the US by MIL-STD-45662 and by ANSI/ASQC M1 and Q4. The importance of this and other ISO standards for the US is that they are expected to set the stage for international trade and commerce in the years to come. Especially the European (Economic) Community (EC) is striving hard to have uniform standards in place come 1992. The expected establishment of free trade within the EC then are feared in some quarters to become potential barriers to free trade. Hence, these standards will determine products, production methods, quality, safety, and general acceptability of products sold to or by Western Europe and much of the rest of the world and thus will have a direct influence on the balance of trade of all.

The ISO Mandate

The original mandate to WGI by ISO was to develop an international standard that could replace the NATO documents AQA P (Allied Quality Assurance Publication) 6 and 7. This WGI is a group of the Technical Committee (TC) 176, Quality Management and Quality Assurance. AQA P-6 and 7 were closely fashioned after MIL-C-45662A and MIL-HDBK-52 respectively; they are the only such international documents in existence.

The US and ISO

The US member of ISO is ANSI, the American National Standards Institute. The US position in international standards forums is determined (1) by existing ANSI standards such as ANSI/ASQC M1-1987 and ANSI/ASQC and (2) by the US Technical Advisory Group (TAG) which advises the US delegate. The US delegate is designated by the TAG and appointed by ANSI. The TAG consists of experts in the specific field of the task of the Working Group.

Because all US involvement in these efforts is voluntary and organized and operated with few exceptions by private organizations such as ANSI, the ASQC, and many others, US involvement in the task of writing this standard was slow in developing; it owes much to Dr. McCoubrey's of NIST untiring efforts in getting organized and finally becoming operational. Dr. McCoubrey formed the original US TAG to WGI.

Conflicts

A fundamental difference exists between ANSI/ASQC M1 and AQA P 6 (or MIL-C-45662A). The ANSI standard acknowledges measurement assurance methods for quantifying and controlling measurement and calibration uncertainties, MIL-C-45662A (as well as its successors) does not. Hence, the US position to accommodate measurement assurance methods in the new international standard erected a hurdle most difficult to surmount. Measurement assurance has been slowly gaining recognition in the US and Canada but only in isolated cases elsewhere. Some help for the US position comes from ISO 9004, a quality assurance guidance document which calls for measurement and calibration processes to be under statistical control. That's measurement assurance with its emphasis on the process rather than on individual measurements.

Our briefing on measurement assurance methods to WGI in London in 1987 was met with apparent interest and agreement. Our proposal to introduce the concept in the standard, however, collided with the reality that the vast majority of the potential standards users would be totally unfamiliar with this concept. To the extent that some international members of WGI knew about measurement assurance, the concept was equated with MAPs conducted by NBS and thought of more as a glorified round-robin test than of a statistical measurement process control. Thus WGI, as a group, also lacked the experience with actual measurement assurance to write a standard which addresses itself to that concept even if it had been deemed practical to do so.

To solve the problem, some members in this most cooperative and receptive group mentioned the possibility of generating a guidance document which explains the measurement assurance concept.

A first draft of the standard, hence, bypassed the issue. This draft was distributed to the US TAG which had produced an ad-hoc delegate to the London meeting as it had to its first meeting in Oslo (Les Huntley, John Fluke Mfg. Co.) but was still lacking a permanent delegate and chairman. Hence, most of the US comments and change proposals to that first draft did not go into the appropriate channels on time and could, thus, not be considered at the next meeting in Crystal City, VA in 1988. By the time of that meeting, a US Delegate had been appointed, but it was too late for most of the comments.

Excellent and extensive comments and change proposals had been developed by the DoD with the aim to make the standard suitable to be invoked as a contractual document,
clearly spell out responsibilities, and streamline the wording. These were among those which could unfortunately not be considered. The proposals aimed at weaving the measurement assurance concept into the standard met the same problems as before and deemed by the group still not suitable for inclusion in the standard.

At the end of the meeting, the convener (chairman) of WG1, Peter Clifford of the United Kingdom, requested me to initiate the writing of a Measurement Assurance Guidance document to serve as a companion document to the standard. TC 176 then formally approved this task. It is headed now by Karl Speitel of Eastman Kodak.

The First Draft Proposal

The first Draft Proposal, DP 10012, resulting from that meeting was submitted to ISO as an international ballot earlier in 1989. Since it did not meet any of the remaining US concerns, the US voted against it. So did France and Japan but for different reasons.

A new set of comments and change proposals was generated by the US and contained everything that was not considered earlier, including the DoD comments and change proposals and new proposals for making allowance for measurement assurance.

Vilamoura Meeting, September 1989

The full Technical Comittee met in Faro-Vilamoura, Portugal, September 11 through 16, 1989. Twenty-three countries were represented by 132 delegates and observers in addition to the Chairman and the Secretary. The US was represented by fourteen delegates. (All figures are latest official revisions.) Of the topics of negotiations which are of immediate interest to NCSC was the continued work of WG1 on the draft of the International Standard 10012.

In order to facilitate understanding of the US position on measurement assurance and the importance of uncertainty in traceability, I had prepared written statements which the chairman requested the representatives to read before these issues were to be discussed.

The main objections of the USA to the Draft Proposal were:

1. Reference to measurement assurance or statistical measurement process controls methods were too weak to be effective and included only in the Guidance but not in the Requirements.

2. Traceability was defined without regard to uncertainty and to "national or international" standards, ignoring the sovereignty of nations over their trade and commerce and providing for ambiguity.

3. Unclear responsibilities of the parties in a procurement situation invoking the standard.

Language

The third point constituted the main objection by the DoD whose intentions of the change recommendations were readily accepted. DoD change proposals to tighten the wording of the requirements were not accepted. The majority of the delegates believed that most users of the standard need considerable explanations. Our concern is that redundant wordings and explanations and repetition of requirements, especially when phrased differently, may be interpreted as modifying or adding to the requirements. This concern was, however, deemed less important than the concern of explaining to the user the basics of the standard.

Traceability

The importance of linking traceability to uncertainty was accepted based on the detailed explanation contained in my written statement. For lack of time, our other points of disagreement could not be fully discussed. The convener indicated that our viewpoint will be noted in the standard if we will be unable to resolve our disagreement. I shall attempt to resolve the remaining problem by personal contacts before the next meeting.

Measurement Assurance

I explained that our main concern is to anchor the concept firmly in the standard's requirements and that we are willing to compromise recognizing the lack of familiarity of the other countries with measurement assurance. The exact wording is of secondary importance in recognition of the fact that the concept is so widely unknown. That concern was met to what I believe to be the fullest extent possible at the moment.

Splitting the standard in two parts was proposed by the convener to accommodate more fully the measurement assurance concept in the second part. The first part of the standard should be for standards and calibration laboratories and the second part for the application of measuring instruments – a separation just like our ANSI/ASQC M1 and Q4.

An important part of bringing the measurement assurance concept into the ISO standards will be the guidance document now being written. I submitted to the delegates in writing the envisioned outline of the document and the planned approach prepared by Karl Speitel as discussion basis for this meeting.

Upon my request, another half day of discussions was agreed upon which permitted me to present Karl Speitel's plan regarding the writing of the measurement assurance guidance handbook and to obtain comments regarding the proposed
plan. The main part of the time, however, was used to explain and discuss in detail measurement assurance or the practical implementation of the requirements of ISO 9004 for the statistical control of measurement processes. From the questions and comments posed by the attendees it appeared that they understood well the principles of measurement assurance and agreed as to its value for quantifying and controlling measurement uncertainties.

Interval Adjustment

We had recommended omission of the Appendix which details several methods of adjusting calibration intervals because we believe the methods given are dated and should be contained in a separate document. Probably the best available document on interval adjustment is the Recommended Practice #1 of the National Conference of Standards Laboratories (NCSL), and arrangements could possibly be made with NCSL to use it as is when completed or as a basis for an ISO document with proper recognition of NCSL.

The original Appendix of the draft standard was based on OIML Document No 10. Howard Castrup, previous chairman of the NCSL committee on calibration intervals, had sent me a rough copy of the draft of RP #1, dated 7/89, which I submitted to WG1 after discussing my plan with Howard and Gary Davidson. Peter Clifford recommended to the participants consideration of this document for possible adoption as an ISO guidance document. I believe RP#1 would have to be modified and include terms such as "validation", "verification", "calibration", and others as they are defined by ISO and used in ISO standards.

Summary

A considerable rapprochement between the positions of the US and the other countries has been achieved. The most difficult issue, the introduction of the concept of measurement assurance or statistical measurement process control, appears to be nearing a solution satisfactory to the US. Most significant was the spirit of cooperation which seemed to have developed and which expresses the intent of all participants to resolve all issues in a spirit of true professionalism.

Postscript

As noted by the convenor, all delegates were most knowledgeable in the field of metrology. And the convenor acknowledged: "We have learned a lot during the last three years (during which we worked on the standard)".

The revisions agreed upon at this meeting are now being circulated for proofing. The resulting document will be published early in 1990 as Draft International Standard (DIS) 10012 to obtain international comments as soon as possible, although some issues still remain to be resolved. Members of the US Technical Advisory Group will obtain copies of DIS 10012 as soon as it is issued to comment on it. The comments received will provide the material for the next full meeting of ISO/TC 176 in October 1990 in Switzerland.

Anyone wishing to participate actively in the work of the US Technical Advisory Group is invited to contact me.

Rolf B. F. Schumacher
Rockwell International
US Delegate to ISO/TC 176/WG 1,
Chair of US TAG to ISO/TC 176 Task Group 1 (WG1)

December 1989

* * * * * *

STATEMENT OF THE U.S.A. DELEGATE TO TC 176/WG 1 REGARDING 'TRACEABILITY'

The following statement is provided to facilitate reaching agreement on some unresolved issues in ISO DP 10012 regarding traceability.

Traceability

The purpose of traceability of measurements to accepted standards is to establish agreement of the unit of measurement used to report the measurement. Traceability, then, is about demonstrating by measurements that two things are the same or represent the same measurand.

If a stable measurand Q of an artifact is reported to represent A units of measurement (e.g. 3 meters), traceability of the measurement to the accepted standard is needed to ensure that the unit of meter in the measurement has the same length as the unit of the meter embodied by the standard which the parties to a measurement have agreed upon. Hence, traceability involves deciding whether or not one measurement is the same as another or a specified multiple of another.

If the same Q is measured again by the same process, a new value B is obtained. And B is most likely to be different from A provided the measurement is performed with sufficient resolution. For an artifact believed to be stable, such difference is generally attributed to the variability of the measurement process. It is not generally concluded that the measurand has changed from A to B. Rather, the difference is explained by a number of influences on the measurement process which cannot be held absolutely stable, such as the ambient temperature, the method of measurement, and many other influences, some known and some possibly unknown, including some likely temporary excursion of the value of the measurand about some assumed mean value.
The difference between A and B is used to describe the variability of the measurement process. And repeated measurements of Q, yielding values of C, D, E . . . , etc. are expected to fall within some upper limit U and a lower limit L, with a given probability determined from the experienced variability of the process. Then, any value of Q which falls between U and L with the expected probability confirms that, based on available knowledge, there is no reason to believe that Q has changed. Hence, A is taken as representing the same Q as B or as any other value within the limits U and L with a given probability.

If measurements of a different artifact with similar characteristic, P, also fall within the same limits, it can be said that there is no reason to believe that (the measurand of) P differs (that of) Q. It cannot be positively stated that P and Q are alike. In that case, P and Q are taken as embodying the same measurand. P may in fact be different from Q, but available knowledge of the measurement process does not permit to ascertain that fact. Only if measurements of P fall outside the limits of U and L with the previously expected probability can it be positively stated that P and Q are different.

Hence, it is not possible to demonstrate by measurements that two measurands are alike. It is only possible to demonstrate that one does not differ from the other within given limits of uncertainty. Therefore, traceability is only meaningful within given limits of uncertainty. It is meaningless without a statement of uncertainty.

Example: A stick 1.00m long may be claimed to have the same length as one 0.99m long within plus or minus 0.11m. It must be declared of different length when the stated uncertainty is 0.01m.

Rolf B. F. Schumacher
5 September 1989

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STATEMENT OF THE U.S.A. DELEGATE TO ISO TC 176/WG 1 REGARDING STATISTICAL CONTROL OF MEASUREMENTS

The following statement is provided to facilitate reaching agreement on some unresolved issues in ISO DP 10012 regarding the proposed requirement for measurement processes to be in statistical control.

Introducing Control of Measurement Processes

The concept of maintaining measurement processes in statistical control is undoubtedly new to many metrologists. The U.S. is aware of the difficulties confronting TC 176/WG 1 in drafting a standard with requirements with which little experience is available. We are also aware of the likelihood that a large part of the potential users of a DP 10012 are uninformed of the concept which is also known as measurement assurance. We wish to work with WG 1 in finding suitable language which presents the concept in a readily understandable and acceptable form, and we appeal to the group for their cooperation in reaching that end.

Our proposed changes to DP 10012 intend to convey the ideas we believe should be addressed. The proposed wording itself is unimportant; we are confident it can be improved upon. We recognize the importance of keeping the wording of the standard easy to understand and non-threatening.

Nevertheless, we believe that the concept of measurements as processes in statistical control should be upheld in ISO 10012 because . . .

1. . . . it reflects the present state of measurement technology. The U.S. believes our responsibility is to write a standard which reflects the present state of measurement technology all the while allowing for the many cases where state-of-the-art methods are not needed. ISO 10012 should encourage rather than ignore or discourage the use of more advanced approaches to measurement control. It should not become a barrier towards better metrology.

2. . . . numerous parts of the concept are already widely accepted. Some parts of the concept of measurement processes in statistical control are not more than common sense or good metrological practices and are recognized by metrologists the world over. Examples of this are reflected by the existing draft of ISO DP 10012 where it makes the reader aware of the fact that measurement uncertainties do not only originate from measuring instruments alone, but that other factors, such as the environment, operator, and procedures also contribute to measurement uncertainties. Measurements as processes under control emphasize the importance of the uncertainty contributions by all sources of uncertainties.

3. . . . the concepts of measurements as processes in statistical control are probably already more widely known than may be realized by many in WG 1.

A first indication of that fact may be obtained by considering that the concept of measurements as processes which should be controlled statistically has been accepted without difficulties by our quality control peers representing our countries in other TC 176 forums before it was recommended by ISO 9004. Metrologists the world over, from Canada and the U.S.A. to Saudi Arabia and Taiwan, are increasingly embracing measurement assurance concepts in their work.

4. . . . maintaining measurement processes in statistical control enables the metrologist to link measurements to the economics of measurements and the purpose for which
measurements are made. For more on this topic, please refer to "CONSIDERING THE PURPOSE OF MEASUREMENTS" below.

5. . . . metrologists have already demonstrated their acceptance of measurement assurance concepts. WG 1 would be gravely underestimating the professionalism of their peers by fearing their rejection of measurement assurance. Not long ago, measurement assurance was entirely new in Canada and the U.S.A. (By measurement assurance we do not mean the M.A.P. programs conducted by the U.S. National Bureau of Standards, now designated as National Institute of Standards and Technology or NIST.) Although a majority of metrologists there are still only vaguely familiar with measurement assurance methods, the concepts were immediately accepted. No resistance to such methods or the concept have ever come to our attention. We believe that metrologists elsewhere will accept measurement assurance in the same spirit of professionalism.

Still, we agree with the concern of an apparent majority in WG 1 to keep the language of ISO 10012 so as to make the standard readily understandable and acceptable. This principle has guided the requirements and guidance provisions recommended by the U.S.A. And the U.S.A. would welcome any changes which would further that principle without sacrificing the intent of the recommendations.

Simple Controls for Most Measurements

In general, the calibration uncertainty of a measuring instrument is part of the total uncertainty of the measurement. It is not the total uncertainty. Other variables also contribute to the total measurement uncertainty. Realizing the truth of that statement forms a basis for controlling measurements as processes. If, however, the uncertainty contributions of the other variables are shown or estimated to be negligible with respect to the calibration uncertainty, the measurement uncertainty is a constant. Then the measurement process using that instrument is, or is believed to be, in statistical control.

At the bottom of the hierarchy of measurements and for the vast majority of them are those whose state of statistical control may conceivably be established summarily, e.g. by some initial tests for repeatability and the influence of environment, operators, application, etc.

For such less important measurements, the U.S. proposes, therefore, the following wording to be contained in requirement 3.6:

"Other processes may be summarily controlled and monitored by type tests establishing limits of random and systematic errors obtained in the Supplier's operating environment under adverse conditions of normal use. The uncertainties achieved by processes which are summarily controlled and monitored shall include allowances for process drift and other possible uncertainty elements in the form of additional estimated uncertainties to ensure that measurements and calibrations include the accepted values of the measured characteristics within the stated limits of uncertainty."

This could satisfy the requirement for assurance that measurement processes are maintained in a state of statistical control. At close examination, it will be found that it does not go beyond what DP 10012 requires now.

Requirement 3.6 already specifies "All measurements shall take into account all the errors and uncertainties in the measurement process that are attributable to the measurement standards or measuring equipment and, as appropriate, those contributed by personnel, procedures, and environment." We believe that the proposed wording is only somewhat more specific than the existing wording.

Considering the Purpose of Measurements

An important aspect of measurements is the purpose for which they are made. Following the precedent set by most existing standards, this aspect has received scant mention in DP without guidance of how it can be accomplished by those who may wish to do so.

Statistical controls of measurement processes intimately tie measurement uncertainty or accuracy to risks and, therefore, ultimately to the purpose and the economics of the measurement.

The control of any one measurement process (e.g. the measurement of a 1,000-ohm resistor) may be rather simple. Or it may be complex, depending on the required limits of uncertainty. Such limits are determined with a given probability of including the accepted value of a measurement. Since probability is closely related to risks, and risks eventually are taken on the basis of economic considerations, such risks will vary widely from one measurement process to the other, depending on the importance of the measurement.

It follows then that controls appropriate for the measurement will take a wide variety of forms. The most rigorous controls would normally be established for measuring reference standards or for measurements on which considerable costs or the safety and health of people depend. The U.S. believes we have a responsibility of requiring all metrologists to become aware of the tools available to them for taking such risks into consideration by mentioning them in the standard.

Less important measurements require less rigorous controls all the way down to the method described above under "SIMPLE CONTROLS FOR MOST MEASUREMENTS'.

How to Implement Measurement Assurance

The "Guidance Handbook on Measurement Assurance" will give directions to anyone who wants them on how to go about

(Con't on page 55)
Meet Bard Dunkelberger, ESL Instrument Services Manager, and the NCSL Region 7 Coordinator. Bard has been with ESL nearly a year with previous experience of eight years at Leasemetric, Inc., and 19 years at Kaiser Electronics.

Bard's military experience, with a ten year stint in the U.S. Navy, well prepared him to work with DOD type companies, such as Kaiser and now ESL.

Bard says he is very aggressive with better ideas in supporting Metrology and Quality Control. He believes that Metrology should be the leader in standards for quality measurements and calibration testing technology. He firmly advocates that Metrology must be a part of any electronic test equipment design to fulfill a quality and economic test goal. Further, he supports the service department control for all company rentals, service contracts, measurements standards, capital equipment movement, service for company test equipment and data products.

Bard's current major project is the new ESL ATE program in Metrology using the Apple Mac II as the controller. This is not an easy function, but Bard thinks the friendly flexibility of the Mac exerts itself into testing while providing networking and a statistical management tool for a paperless Metrology Calibration system. Bard is also a member of National Property Management Association, PMA, ISA, and ASQC.

Bard enjoys traveling and is a professional Numismatist (Coin Collector). Bard and his wife, Judy, have two children. Judy is a CAD Engineering Manager at AMD. Dutch, their son, is an Air Force Captain, training KC135 pilots. Teresa, their daughter, is an administrator at Kaiser Electronics.
TOURING OUR MEMBER LABS

SE Laboratories, 1065 Comstock St., Santa Clara, CA 95054
Host: Karen Germain
by John Milburn

Wine touring is a big talk out in California. Myself, I'd rather spend time touring a Metrology lab. Wouldn't you? You can see all the newest in the state-of-the-art measurement equipment, computer printouts, operating/service manuals, technicians doing precision measurements and all that neat stuff. You might spend part of the time completely reading their Quality Assurance manuals. I like talking to the Quality Assurance managers about adherence to MIL-SPECS. Imagine the excitement of following their traceability to NIST. Gee, doesn't that sound like more fun than a wine tour?

Whatever your answer, I'd like to tell you of just such a tour I recently made. This was just a tour, remember, not an audit. I don't believe audits are much fun. Nothing is perfect, therefore an audit should bring those imperfections out to light. Audits are essential, however, to help us all reach a higher level of perfection.

Here it is, Thursday afternoon, October (post quake). I am about to tour the facility of SE Laboratories. SE Labs is a service organization for the calibration and repair of test equipment. SE Labs also does all kinds of environmental testing such as temperature, humidity, altitude, vibration and shock, and salt spray. Environmental testing is very exciting, but I'm supposed to focus on the metrology lab. However, they do use the shakers to calibrate accelerometers. Ovens are used to verify a units' temperature specifications. The vibration systems look adequate to handle a test for adherence of some device under vibration analysis. Perhaps, the old name of calibration is not really very descriptive of the job we all do. What do you think about Measurement Assurance? Isn't that the name of the game -- assurance that the company measurements -- all of them -- are traceable?

A few years ago I toured SE Labs before they moved to this new facility. They were a lot smaller at the time. Even so, they did meet all the requirements for me to do business with them. The Quality Assurance Manager's position appeared as a fill-in sort of a job. The lab looked small compared to some of the big labs I've toured. BUT LOOK AT THEM NOW! I really didn't know what to expect being in a new building and all. They really look great now. A full fledged operation.

SE Labs occupies a 12,000 sq. foot facility. They offer services with compliance to MIL-STD-45662A, MIL-I-45208A, and MIL-Q-9858A, plus other MIL-Specs that relate mostly to environmental testing. They also have a resident DCASR representative. Looking around the laboratories I find some of the newest in standards equipment. Computer-controlled test systems and an information retrieval system seems to be the theme of SE labs. In reading their corporate philosophy it says ... WOW! ... look over there, it's a Valhalla Ultra Precision System for calibrating Multimeters. Karen Germain, the Quality Assurance Manager, says they have an HP 3458A Multimeter on order for the system. It is due to arrive at SE Labs in December. This new voltmeter will extend the system accuracy to the state-of-the-art. The system uses a Valhalla Model 2734, 1V-10V reference. The Model 2734 is presently sent to Lockheed for recertification. An idea would be for some labs to get together and start up a MAP program for this unit. Anybody out there interested?

Their corporate philosophy: to re-invest in the latest technology and equipment, to optimize through computer automation and information processing. Check out the Quality Assurance Manual. It was written by Karen Germain and it is loaded. It spells out the whole operation as it applies to the quality of product. Their product is the same product that in-house labs have as products ... measurement equipment. I can't publish their Q.A. manual but you should read it if you ever get the chance. It looks like a lot of work went into formulating this document. Some highlights I particularly found great were: paragraph 11.0 on Recall system; paragraph 21.1 on placement of label guidelines, which includes placement that deals with not removing plug-ins to see calibration labels; and paragraph 30.0 on internal audits.

I've only mentioned some of the things I've seen here during my tour. Following are some pictures that show some of the individual bench set-ups. I didn't take pictures of the massive collection of manuals they have. There was also the set-up for the procedures manuals, some using the GIDEP, some in-house, and some are manufacturers procedures. Karen says they are progressing rapidly toward having in-house procedures for all instruments supported. That figure presently consists of about 1500 in-house procedures. With the rapidly changing instrument base it could take a lot more work. They presently have 15 technicians in the metrology section of the facility. On the computer files are about 763 customers using their services. One picture I didn't get was of the calibration set-up for certifying TV stations. I'm glad someone has the capability.
I would like to thank Karen for this fine tour. Karen is SE Labs Member Delegate to the NCSL. I’m looking forward to Karen’s increased involvement with NCSL. I hope she has this in her plans.

Using the Valhalla Ultra Precision System gives SE Labs the capability of calibrating almost every Digital Multimeter on the market. The HP 3458A, soon to be added to this system, will add even higher capabilities.

An area of specialty for SE Labs is their microwave section. Calibration is performed on computer automated systems. Here HP 8400 series power sensors are certified after being re-built.

Bench set-up for calibrating oscilloscopes and sampling systems up to 1 GHz. Shown is a technician calibrating an HP 54100D Digital Scope.

Using the HP 11613B to calibrate an HP 8757A

A technician (on overtime?) calibrating a torque wrench using a Precision Load Cell with the capacity to 400 ft/lbs.
COMMITTEE NEWS
(Cont'd from page 41)

This committee is running well. In addition to their twice yearly forums, they have several products in the works. One of these, and RP to describe a “Utilities Industry Calibration Control System”, is in draft form and should be ready for submission to the board for publication the first part of 1990.

PETROLEUM INDUSTRY METROLOGY COMMITTEE

Sue Griston is working on the charter for the committee and trying to determine just what it is the committee should do. A formation meeting will be planned as soon as practical.

EDUCATION LIAISON COMMITTEE

I was given an action item to do preliminary work to determine what the measurement requirements are for engineering programs. Anecdotal information indicates that measurement knowledge of new engineers is inadequate. In 1983 NASA Lewis’ Instrumentation & Control Technology Division brought in Peter Stein to give an instrumentation course to new engineering personnel for this reason and the Deputy Director of this Division believes the situation has not improved. Conversations with young engineers indicate such information where it exists is being passed on in lab courses and is largely unstructured.

I therefore took a random sample of 20 Institutions granting two or four year degrees in Science, Engineering, Engineering Technology, Physics and Electronics in California.

Only one institution, Alan Hancock Jr. College, had a course labeled metrology. I then tallied courses that seemed, from their description, to have metrology concepts imbedded. The results follow:

<table>
<thead>
<tr>
<th>Total Surveyed</th>
<th>Type of College</th>
<th># Courses w/ Metrology Concepts</th>
<th>#Institutions Having Courses w/Metrology Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>4 yr.</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>17</td>
<td>2 yr.</td>
<td>15</td>
<td>6</td>
</tr>
</tbody>
</table>

Sources: 1983 College Blue Book; 1988-89 College Catalogs.

Since it appears that only one third of all Engineering, Electronics and Technology graduates have any training in metrology concepts and that what training there is may be inadequate, the subject seems worth further investigation.

Kate Webser, Education Liaison Chairperson
Editor's Messages (Con't from page 2)

NEW PHONE NUMBER FOR BULLETIN BOARD

Be aware that the NCSL Bulletin Board no longer resides at TRW. As of February 1, you will want to call the Secretariat for modern connection to the Bulletin Board and FAX number. They are both on the same number with a switch. (303) 440-3385.

ASQC MANUAL IN PREPARATION

Last issue I ran about a page describing the ASQC Measurement Assurance Manual in the works. Karl Spiteil asked for inputs and help, so all of you with that helpful inclination now have an opportunity to supply material to Karl. Look up the story on pages 64-65 of the October newsletter, and give Karl a call at (716) 722-2318. He'd appreciate it.

John L. Minck, Editor

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ASSISTANT EDITOR'S MESSAGE:

EARTHQUAKE: OCTOBER 17, 1989

They say things really got shook up out California way. Well, yes, I was there and it was a shaker. It's no joking matter, but we live with the fear of a shake-up every day. Companies have shake-ups, we have political shake-ups, but earthquakes take the cake for a real taste in shake-ups. Now, like I said, it's no joking matter, and it is very costly. But here in California is not the only place subject to the devastating forces of nature. This planet also offers hurricanes, tornadoes, and crippling cold storms, just to name a few. Through-out the world, we have airplane crashes, train wrecks, nuclear accidents, and on and on. Our lives seem to be on the constant brink of disaster. Does warning really help prevent damage from hurricanes as opposed to earthquakes? Are political or company shake-ups any less drastic than earthquakes or hurricanes? I don't want to play down the devastating effects of the recent disasters, but how do we compare mine with yours? Should we compare events?

What do earthquakes and hurricanes have to do with metrology? Metrology is an organization of quality assurance. We compare events. We compare, we analyze, we study, and we try to keep them in control. It is the art of measurement, the art of measurement assurance. It is the precision of determining when, where, how, what, and so on. By measuring the output of an automobile engine we control the amount of pollution to our atmosphere. The more precise the measurement, the better we can control. Possibly with better measurement techniques, we may find answers for destructive earthquakes or hurricanes. Measuring the tensile strength of steel or concrete, under all types of conditions, could make for better freeways. Maybe someday we can build houses that will better withstand horrendous hurricanes. Measuring the effects of profit and loss should prevent shake-ups in our companies. Measuring the probability of events is only as good as the quality of the input measurements.

The whole way of human life is built upon measurements. Improvements to those measurements is the improvement of the enjoyment, safety, and freedom of life. They may be statistical in nature, actual physical/electrical or what have you, but measurements are measurements. Being able to qualify those measurements and find the exactness of the true meaning is what metrology is all about. At one time we were simply the calibration lab, now we find ourselves to be metrologists, the true meaning of the job we do. But it is the total measurement assurance of the system that is important. It is the traceability to national standards, or global standards, for all measurement processes.

Advances in technology – through measurement advancement. What can be seen by comparing statistics from around the world about major disasters? What can be seen as they relate to advances on technology? It seems to show that through advancement we minimize our losses.

Earthquakes have taken many lives in the past, even as recent as Armenia, Turkey, and Mexico, to name a few. Do we have better technology in Silicon Valley than those other places? Who knows, we could have sustained worse damage if a 8.5 had hit us. But how much worse, comparatively speaking? So, I ask, if technology has improved things, then how much better off are we? If we are better off, then we can improve the measurement technology for the rest of the world and save more lives and dollars. Since we don't know everything, we can improve our measurement techniques to improve our chances of survival.

With our technological advancements the world is getting smaller – the community is getting bigger. It is heart warming to feel the community spirit, shown around the world, where everyone pitches in during a disaster. I wish it were that way even without a major disaster

John Milburn, Assistant Editor
THE CALIBRATION SYSTEMS MANAGEMENT COMMITTEES

A 1989 Year End Summary Report

The Calibration Systems Management Committees have been hard at work in 1989 trying to provide products and services that are of benefit to the NCSL member organizations as well as advancing the state of measurement science both nationally and internationally.

Below is a brief summary of the activities of these committees as well as a list of the people that have been involved with them. I want this report to also be a personal THANKS to each and everyone who has provided time and effort to the NCSL activities this year. If you know any of these people and have a chance to see them, please take time to express your gratitude for their efforts. If I have missed anyone I apologize and would like to hear from you.

Laboratory Evaluation:

Jerry Nielsen, Honeywell Inc., was appointed chair of the committee replacing Carl Quinn, Simco, who served as chair for many years. Jerry began to form a committee and had a good meeting at the conference in Denver in order to form the specific plans required to meet goals and objectives of promoting laboratory evaluation, audits, accreditation and self evaluation. Shortly after the meeting Jerry lost his job with Honeywell and has had to resign. I would ask that those involved with the committee hang in there until we are back on track. The following are the committee members:

Jerry Nielsen, Chair
Fred Hopkins
Don Larson
W.G. Turk Levy
Tony Martinich
John McClelland
Clyde Orrison
Carl Quinn
Mike Spinka
resigned Honeywell Inc.
Honeywell Inc.
Eldec Corp.
Sandia National Labs
Honeywell Inc.
Electro Mechanics Co.
Texas Instruments
Simco
Honeywell Inc.

Laboratory Facilities:

The Laboratory Facilities Committee is new and is just beginning its activities directed toward upgrading RF#7, Laboratory Design, to cover issues not addressed in the current issue such as ESD and hazardous material handling. The committee members are:

Ray Perham, Chair
Hank Daneman
Michelin Tire Corp.
HLD Associates

Daniel Dinkins
Walter Fitzgerald
Ian King
Ray Lindsey
Charles McMurry
SWFLANT
Navy Weapons Station
Guidline Instrument Inc.
Duke Power Co.
U.S. Army PMDE Support Group

Calibration Procedures:

Bob Willett, Rockwell International, has continued to act as chair of the committee in order to keep momentum going. His efforts are very much appreciated. Following the issue of RP#3-1988, Calibration Procedures, the committee has been concentrating on developing the input for an RP which describes the content and format for Application and Maintenance Manuals for test equipment.

The committee has also developed a Measurement & Test Equipment (M&TE) manufacturers data base and has distributed RP#3-1988 to about 500 of these manufacturers.

A special workshop session at the 1989 Conference was held by the committee on RP#3-1988 and was well received and helped to fill a need among the NCSL membership. The committee members are:

Bob Willett, Acting Chair
Greg Burnett
Frank Capell
John England
Hugh Feiger
Steve Frei
Tara Harper
Dave Hopping
Jack Huntington
Mike Hutchins
M.B. Lee
Bonam McKinley
Richard Mugg
Clyde Orrison
Cecil Peitz
Mike Riley
Paul Roberts
Keith Scoggins
Mack Van Wyk
Wes Vincent
Paul Wright
Steve Stahley
Rockwell International
Hewlett-Packard Co.
John Fluke Mfg. Co.
Grumman Aerospace Corp.
Anritsu America Inc.
Wiltron Co.
Tektronix, Inc.
Hewlett-Packard Co.
Prema Precision Electronics
Hewlett-Packard Co.
General Dynamics
General Dynamics
Rhode & Schwarz
Texas Instruments
Boeing Military Airplane Co.
Avantest America
Daytron Instruments/Wavetek
Houston Lighting & Power
Boeing Aerospace Co.
ElectroRent Corp.
Rockwell International
Wavetek/Datron

Calibration Systems:

The culmination of several years work was completed with the approval and release of RP#9, Calibration Laboratory Capability Documentation Guideline. The committee is
Committee News

working on a salary survey to be conducted among the NCSL members. They are also developing an RP for the preparation of Calibration Reports. The committee members are:

Dennis Pinnecker, Chair Rockwell International
John Buck Unisys Corp.
Lewis Fong Lockheed Missiles & Space Co.
Max Green Technical Applications, Inc.
Howard Hopkins Air Force Logistics Command
Ken Lund Rockwell International
Bob Judish NIST
Phil McRury Battelle Memorial Institute
Bernie Rand Navy Primary Standards Lab
Jim Ryan McDonnell Aircraft Co.
Bud Scott John Fluke Mfg. Co.

Calibration Intervals:

Work has continued on updating RP#1, Calibration Intervals. This RP revision, which is a major re-write to the original RP has been approved and will be distributed early in 1990. The committee members are:

Howard Castrup, Chair Integrated Sciences
Anthony Adams General Dynamics
Frank Butz General Electric Co.
John Ferling Claremont McKenna College
John Larson U.S. Navy
Ray Kletke John Fluke Mfg. Co.
Alex Macareovich General Electric Co.
Gerry Riesenbeck General Electric Co.
Jim Ryan McDonnell Douglas Aircraft Co.
Rolf Schumacher Rockwell International
Mack Van Wyk Boeing Aerospace Co.

To get a more in-depth look at these committees please review the annual Lang Range Plan, which is available from the NCSL business office in Boulder, Colorado.

If you would like to be involved with the work of any of these committees and thus have an impact on the products and services that NCSL provides, please feel free to contact the committee chairs or myself.

Robert R. Smith, Vice President
Calibration Systems Management -- 1989
Ford Aerospace Corp.
714/720-4820

REQUEST FOR INFORMATION
INTRINSIC/DERIVED STANDARDS COMMITTEE

The Intrinsic/Derived Standards Committee is charged with (1) identifying appropriate standards that can be established as intrinsic or derived standards; (2) establishing procedures and specifying systems to realize, maintain, and operate such standards; and (3) obtaining acceptance of these standards as valid sources of traceability by appropriate agencies and organizations. At the present time, the committee is requesting information on the following topics:

1. Recommendations for intrinsic/derived standards which should be considered for developing into a recommended standards practice. Current intrinsic/derived standards under development include: (1) Josephson Voltage Standard; and (2) Triple Point of Water.

2. Information on any standards that have been developed or are currently being developed by other national organizations, such as ASTM, IEEE, ANSI, or ASQC.

Any information on either or both of these topics will be appreciated. Please contact either:

Dr. Richard B. Pettit
Division 7243
P. O. Box 5800
Sandia National Laboratories
Albuquerque, NM 87185-5800

or

Dr. Klaus B. Jaeger
Division Manager, Metrology
Lockheed Missiles & Space Co.
P.O. Box 3504
Building 195A, O/48-70
Sunnyvale, CA 94088-3504

CALIBRATION SYSTEMS COMMITTEE

Since the last board meeting in Denver, the committee has completed the work on RP-9 Laboratory Capability. It has been published and distributed by the business office in Boulder.

The committee is presently working on a salary survey to be mailed to the membership. We will probably have it ready for Board approval in February, 1990. We have completed a rough draft and are in the process of refining it.
The work on the Calibration Report RP is progressing and we have added another member to the subcommittee, Bud Stott of the John Fluke Mfg. Co.

The remaining goals for this committee for 1989 are:

a. Salary Survey
b. Proposed RP on Calibration Reports.
c. Request capability documents per the RP from the membership for publication of the initial NCSL Calibration Laboratory Capability Guide.

Dennis Pinecker, Chairman

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AUTOMATIC TEST & CALIBRATION COMMITTEE

1. The last meeting was held on 10 July 1989 in conjunction with the NCSL conference. The meeting was attended by 15 people.

2. The primary action items were: (1) to distribute instructions to the interested attendees regarding use of the NCSL BBS bulletin board and to start using the board actively for committee work, and (2) to continue collecting software control and generation practices from member companies.

3. Action item #1 is started, we are logged on to the NCSL BBS. Instructions for using the NCSL BBS for committee work are being assembled for distribution.

4. Action item #2 is started. I am changing jobs on 22 September. I'm quitting Hughes Aircraft and starting at Electro Scientific Industries, Inc. Things are a bit hectic at the moment, but I feel that the committee work will start gaining momentum after I settle into my new job.

5. Our next meeting will be held at the upcoming MSC conference.

Ken S. Landis, Chairman

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MEASUREMENT ASSURANCE PROGRAM COMMITTEE

1. Last meeting was held at the NCSL Conference in Denver on the 12 July. There were 13 attendees. Discussions on current and future round robins took place. Coordinators are needed for a northern and southern California voltage round robin (both DC & AC), nation-wide resistance and mass.

Results from the survey on the interest in round robins are as follows: a) 12 are interested in EMF, b) 11 are interested in resistance, and c) 6 are interested in mass. Six laboratories had various interests such as pressure, volume, temperature, force, microwave, humidity, angle gage blocks and spherical diameters.

2. Status on current round robin efforts:

a. Thread Gage: In progress and going well, gages are currently at McDonald-Douglas. Eleven labs involved. Coordinator: Mr. Jack Edison (Beckman).

b. Gage Blocks: Purchased sets with NCSL funds. Sent to NIST for calibration, NIST has not acknowledged receipt of the standards, follow-up action in progress. RR is in place to continue. Thirteen labs involved. Coordinator: Mr. Jack Edison (Beckman).

Note: Mr. Bob Tobias (TRW) has software for data reduction for the above round robins.

c. 10 Volt (FLA 732): Round robin has been completed and preliminary data has been sent to the participating laboratories. Fluke has acted as the pivot lab. Eleven labs involved. Coordinator: Mr. John Riley (NASA:KSC).

Note: Mr. Riley has software available for data reduction/analysis.

d. Fiber Optic Power: Everything is going smoothly, two labs have completed measurements, standards are back at NIST being calibrated and another five labs are waiting to continue this effort. Calibrations are being done at one power level only. Seven labs involved. NIST is providing the source and sensor, as well as being the central data bank and performing the analysis. Coordinator: Dr. I. K. Rangan (Lockheed).

(Note by K. B. Jaeger: Lockheed, Sunnyvale is exploring the possibility of a RR for capacitance in regard to three versus four terminals. This is in response to a request by HP personnel in Japan to attack the international traceability issue of the HP 16380A Capacitance Standard Set.)

Mike Cruz, Chairman

* * * * * *

NATIONAL MEASUREMENTS REQUIREMENTS COMMITTEE

The search is continuing for two chairpersons to fill the vacancies of the Pressure-Temperature and Flow subcommit-
tees. It is anticipated that these two positions be filled in the near future.

Mr. Laurie Baker, Committee

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INTRINSIC/DERIVED STANDARDS COMMITTEE

The Intrinsic/Derived Standards Committee met at the NCSL meeting in Denver, CO on 12 July 1989. The committee approved the Guidance Document and Committee Handbook, both with only minor revisions. With the approval of these documents, the first working groups could be set up. Two working groups were discussed and approved: WG1, Josephson Voltage Standard; WG2, Triple Point of Water. There were no other suggested working groups for consideration by the committee. However, a questionnaire soliciting suggestions for other intrinsic/derived standards to be considered by the committee will be prepared for publication in the NCSL newsletter. In addition, the questionnaire will solicit information on other standard practices being developed by other organizations, such as ASTM, IEEE, ANSI, ASOC, etc. Finally the question of traceability of intrinsic/derived standards was discussed by the committee. For some standards, the realization by NIST is the legal unit as directed by Congress. This fact may modify the thrust of the committee’s efforts and definitely will have to be incorporated into the definition of traceability associated with each developed standard. The next meeting of the committee is scheduled for the Measurement Science Conference in February 1990.

Dr. Richard Pettit, Chairman

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CALIBRATION PROCEDURES COMMITTEE

From requests made during and after the Conference, we have distributed somewhere between 50-100 packages of the information presented at the calibration procedures Workshop (with exception of that presented by Dave Hopping of H-P). He plans to provide the information in an improved format for reading and it will be combined with Fluharty’s, Van Wyk’s, and my documentation. The total package is available upon request to me.

The Committee membership has changed very slightly since last report and the current listing is attached. I am still working on establishing a vice chairman to eventually become chairman.

I am continuing to add a few M&TE manufacturer companies to the RP3 Committee database and see that they are sent a copy of RP3, supporting documents, a membership brochure, and a Newsletter when I have an extra. I am concerned about the effectiveness of the past spring mailing of the RP3 document to the manufacturers. Approximately 150 of the total 450 were addressed to a name at the company as recommended by local representatives. Others had only the address or a general department name. A very small sample indicates that they didn’t make it to the person’s responsible for calibration procedures, performance specifications, or manuals.

I have drafted the purchase order provision guide which could be an addendum to RP3. I’m looking for suggestions to better get the word out to the manufacturers, etc.

The attached update to the initial July 10th Committee meeting at the Conference should tell you where we are. The manual section leaders have been designated and writing should begin now to result in a rough draft by the next BOD meeting.

Bob Willett, Chairman

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JULY 10, 1989 MEETING NOTES AND UPDATE

The Committee members exchanged introductions and the meeting roughly followed the Agenda of June 15. Seven of the nineteen members were either not at the Conference or had a conflict with our meeting. One guest attending agreed to join and participate in the Committee work.

Towards the task of developing an RP for contents and format for Application and Maintenance Manuals for Test Equipment, the "Manual" was partitioned into six sections. The Committee was then divided into section Subgroups (by preference when possible) to then work on developing those sections as follows:

I. General – Binding type, configuration control, revision control, index, table of contents, style, etc.

Wes Vincent, Electro-Rents, Dallas (Group Leader)
Bonham McKinley, GD/Ft. Worth
Frank Capell, Fluke

II. Installation, Operation, Application (including programming info).

Mack Van Wyk, Boeing, Seattle (Group Leader)
Mike Hutchins, HP, UK
M. B. Lee, GD, Ft. Worth
Richard Mugg, Rohde & Schwarz-Lanham

III. Specifications (overall), Theory of Operation

Steve Stahley, Wavetek (Group Leader)
Dave Hopping, HP, Santa Rosa
Paul Roberts, Datron/Wavetek, UK
John England, Grumman, Bethpage
IV. Calibration - RP3-1988 (completed)

V. Maintenance - Diagnostics/troubleshooting, repair, adjustment, cleaning, etc.

Clyde Orrison, TI, Dallas (Group Leader)  
Tara Harper, Tektronix, Beaverton  
Paul Wright, RJ, Cedar Rapids  
Steve Frei, Wiltron, Morgan Hill  
Jack Huntington, Prema/Montclair

VI. References - Electrical and mechanical Layout Diagrams, PCB/Part Locators, Schematics, Material/parts Listings, software codes and formats, etc.

Keith Scoggins, Houston L&P, Houston (Group Leader)  
Greg Burnett, HP, Englewood  
Hugh Felger, Anritsu America, Oakland

TRAINED AIDS COMMITTEE

Sixteen tapes that cover flowmeters and flowmeter maintenance and calibration have been added to the training aids library. These are now available in 3/4-inch U-matic and 1/2-inch VHS formats. We have some tapes coming that relate to microwave measurements. These will probably be duplicated next year; budget for this purpose should be established; however, the precise number and length of these tapes are not known.

TRAINED INFORMATION DIRECTORY COMMITTEE

Dave Lorenteen will not be at the meeting. The directory has been mailed and should be in the hands of the members. Dave had fourteen hundred copies made. More than a thousand were mailed to current members leaving about three hundred fifty for new members, document sales, and any promotional use approved.

PERSONNEL QUALIFICATIONS COMMITTEE

Richard Hymen reports that because of a heavy work schedule there has been limited committee activity this quarter.

The response to the questionaire used at the Conference was very limited; he received about three reports at the conference, however indicated it was well received there. Rich has accepted an assignment to write an article for the Newsletter that will outline his information needs and attempt to gather some of that information from the reader. The article will be ready by deadline for the next issue.

GLOSSARY COMMITTEE

Stan Crandon reports that he does not have facilities required to complete the goals of this committee. He states that the offer by the Navy to assist in computer needs has been withdrawn and no alternate has been found. He has quite a lot of material but feels it would reduce to only two-three hundred measurement-related terms with two to ten entries per term for actual consideration. Since he feels that he will be unable to continue he has verbally submitted his resignation. I will accept recommendations at anytime during the meeting.

COMPENDIUM COMMITTEE

There has been no committee activity this past quarter. Luckie would like to receive material from members that could be directly entered into list. The preferred format is Title, Author, statement about content - where available and cost, if any.

BIOMEDICAL & PHARMACEUTICAL METROLOGY COMMITTEE

Ralph Bertermann continues as the Acting Chairman of this committee. They have a Forum set up for October 27, 1989 at MKS in Boston, MA. I've reviewed their agenda and it looks like a good one. With their larger mailing list, we hope for a good turnout.

The committee is planning to put on a workshop and present several papers at the 1990 Annual Conference in Washington, DC.

MEDICAL INSTRUMENTATION COMMITTEE

The new Chairman of this committee, Marc Nachman of EIL, is working on the charter and making contacts to get things rolling. He has a very large database of people working in this field and should be able to draw a good crowd at meetings scheduled for the future. He plans to try and put on a one-day forum during the first half of 1990. The objective will be to work up a series of goals and objectives for the committee.

UTILITIES COMMITTEE

The Utilities Committee held a meeting during the 1989 NCSL annual conference. Their next forum will be held at Consumers Power Company of Michigan on October 5-6, 1989 in Jackson, Michigan. A Spring 1990 meeting will be held in the Northwest U.S. hosted by Washington Public Power Supply.

(Cont'd on page 35)
TWO U.S. COMPANIES RECEIVE TOP QUALITY AWARD

Milliken & Company and Xerox Corporation's Business Products and Systems, two U.S. manufacturing companies, received the 1989 Malcolm Baldrige National Quality Award on November 2 for superior quality in their management systems. President Bush, who presented the awards, praised the two companies for "leading the resurgence in American business leadership." Improvements in quality and service by American companies are "national priorities as never before." Bush said. The award, named after former Commerce Secretary Malcolm Baldrige, was established by legislation passed in August 1987. It promotes national awareness about the importance of improving total quality management and recognizes quality achievements of U.S. companies. The 1988 winners were Motorola Inc., the Commercial Nuclear Fuel Division of Westinghouse Electric Corp., and Globe Metallurgical Inc. The award is managed by NIST, with the active involvement of the private sector. For information on applying for the award, contact the Malcolm Baldrige National Quality Award Office, NIST, A1123 Administration Bldg., Gaithersburg, Md. 20899.

CONTACT: John S. Makulowich, 301/975-2036

WWV: A MOST POPULAR RADIO STATION

One of the nation's least known yet popular radio stations is located on prairie land near Fort Collins, Colo. WWV, a short-wave station operated by NIST, broadcasts time and frequency information traceable to the NIST atomic time standard in Boulder, Colo. More than 2 million people get their time directly from NIST each year by dialing 303/499-7111 (a toll call outside the Denver/Boulder area) and hearing the WWV broadcast format; thousands of others use short-wave radios or special WWV receivers to get the time directly. But each day millions of Americans get their time checks indirectly from WWV. Time-of-day services provided by local telephone companies, banks, and other sponsors usually can be traced to WWV Audichron, an Atlanta, Ga., based company that distributes time information traceable to WWV, estimates 10 million people a day use its services. Weatherchron, another Atlanta company that uses WWV as its time source, estimates 70 million Americans have access to its time messages.

CONTACT: Fred McGehan (Boulder) 303/497-3246

NIST WORK CITED BY NOBEL COMMITTEE

When the Royal Swedish Academy of Sciences awarded the Nobel Prize in Physics on Oct. 12, 1989, for research related to atomic clocks, they cited work at NIST's Boulder, Colo., laboratories. Norman F. Ramsey of Harvard University received the prize for discovering the theoretical basis for current cesium atomic clocks; Hans G. Dehmelt of the University of Washington and Wolfgang Paul of the University of Bonn shared the Nobel for developing the ion trap technique which makes it possible to study a single electron or a single ion with extreme precision. In referring to the latter work, the Nobel committee said "this opened the way to a new kind of spectroscopy, which has been further refined and applied particularly at the National Institute of Standards and Technology ... in Boulder, Colorado.

Researchers in NIST's Time and Frequency Division are doing research based on this technique which could someday result in atomic clocks that will neither gain nor lose a second in 10 billion years, or roughly the age of the universe. Professor Ramsey also has close ties with NIST. He has been a member of the NIST statutory Visiting Committee and in the 1986-87 academic year he was a visiting fellow at the Joint Institute for Laboratory Astrophysics (JILA) and is currently a Fellow-Adjunct at JILA. JILA is a cooperative research effort between NIST and the University of Colorado.

CONTACT: Fred McGehan (Boulder), 303/497-3246

EFFECTIVELY DESIGNING COMPUTERIZED WORK STATIONS

The computerized work station often is considered the key to increased office productivity. Yet, work station furnishings and layout seldom are given the same attention and resources as the technology. Instead, space and furniture decisions too often are based on "status" and tradition. To help managers make intelligent choices, researchers in the NIST Center for Building Technology have developed a process for designing work stations based on office activities including reading and writing, talking on the telephone, drafting and drawing, or using a video display terminal. Work station dimensions and configurations then are developed depending on the importance of the activity and the time spent on it. A publication describing this process, "Guideline for Work Station Design" (NISTIR 89-413), is available by sending a self-addressed mailing label to Arthur Rubin, NIST, A309 Building Research Bldg., Gaithersburg, Md 20899. This report is the latest in a series prepared by NIST for the U.S. General Services Administration.

CONTACT: Jan Kosko, 301/975-2762

REDUCING THE RISKS OF COMPUTER VIRUS ATTACKS

To reduce the risk of damage from potentially serious computer viruses, NIST has issued guidelines for controlling
ASTM/NIST/SEMI JOINT WORKSHOP ON MICRO-PATTERNING METROLOGY FOR THE 1990'S

NIST, ASTM, and SEMI (Semiconductor Equipment Manufacturers Institute) jointly sponsored a workshop at NIST on June 27-28, 1989, to discuss and evaluate the current and projected state-of-the-art metrological techniques relating to micropatterning as practiced in the semiconductor industry. The purpose of this workshop was to bring together representatives from all aspects of the microelectronic patterning community to discuss the present and anticipated future metrological problems related to micropatterning and, where appropriate, initiate action to solve them. The main topics of interest included overlay/registration measurements and submicrometer linewidth measurements by use of the optical microscope, scanning electron microscope, and by electrical methods. A follow-up workshop on micropatterning metrology is being planned for the fall of 1990.

CONTACT: Robert D. Larrabee, 301/975-2298

SURFACE METROLOGY CONFERENCE PROCEEDINGS PUBLISHED; CME STAFFER CO-EDITOR

In April 1988, NIST hosted the Fourth International Conference on the Metrology and Properties of Engineering Surfaces and provided a forum on this active branch of engineering for delegates from eight countries and the United States. Kogan Page Ltd. (London) has published the proceedings of the conference in four separate issues of its new journal, Surface Topography, and most recently has produced a single hardbound volume of the proceedings, thus making the information exchanged at NIST available to a wide audience of engineers, designers, and metrologists. The editors of the proceedings are Professor Ken Stout of the University of Birmingham and Theodore Vorbucher of CME.

OIML MEETING ON MASS FLOW METERS

The United States was represented by Otto K. Warnlog, NIST; Michael J. Keilty, Micro Motion, Inc.; Eric Kappelt, Smith Meter, and M.C. Hankel and R. Folkers, Liquid Controls Corp. at a meeting of the International Working Group for the International Organization of Legal Metrology (OIML) FSSD/RS10 on "Direct Mass Flow of Measurement of Quantities of Liquids," held April 5-6, 1989, at the National Weights and Measures Laboratory, Teddington, England. Representatives of 11 other OIML member nations, the European Pump and Meter Manufacturers (CECOD) and the International Bureau of Legal Metrology (BML) also attended the meeting. A draft OIML recommendation on "Mass Flow Instruments for Measuring Quantities of Liquids," developed by the U.S. National Working Group (USNWG) was discussed. The basic principles of this draft recommendation introduced by the USNWG were retained with only minor amendments. The USNWG met June 1, 1989, at NIST to review the results of the meeting and to prepare another draft incorporating the appropriate requirements and test applicable to electronic mass flow meters according to the draft OIML recommendation on "Electronic Measuring Assemblies for Liquids Other Than Water Fitted With Volume Meters." The final recommendation is expected to be adopted as international requirements for testing and verifying the performance of these instruments and will likely serve as a basis for any related EC directive and requirements.

CONTACT: Otto Warnlog, 301/975-4026

NEW AUTOMATED GAGE BLOCK CALIBRATION SYSTEM AT NIST

A new calibration system has been successfully implemented by the NIST gage block laboratory. The new system allows NIST laboratory personnel to implement routinely a measurement assurance program for all NIST reference standard master gage blocks. With the new measurement design, typical estimates for the uncertainty of the calibrations by mechanical intercomparison have already been substantially reduced from between 2.0 and 4.0 microinches (0.05 to 0.10 micrometer) to between 1.0 and 2.0 microinches (0.02 to 0.05 micrometer) or less for gage blocks under 2 inches (50 millimeters). Although uncertainty estimates for the longer gage block sizes have remained unchanged, improved and frequency surveillance of NIST gage block calibration history are expected to reduce presently reported uncertainty estimates for these sizes in the future. The new system includes a database and analysis software to record and monitor the measurement history of customers' gage blocks and, thereby, reduce risks of reporting inaccurate measurements and improving overall measurement confidence.

CONTACTS: Theodore D. Doiron, 301/975-3468 and Jay H. Zimmerman, 301/975-3468.

INTERNATIONAL DIRECTORY OF STANDARDS GROUPS UPDATED

The newly revised Directory of International and Regional Organizations Conducting Standards-Related Activities (NIST SP-767) provides information on 338 groups that conduct standardization, certification, and laboratory accreditation activities. The directory is designed to serve the federal agencies, standards writers, manufacturers, exporters, and others concerned with U.S. participation in international standards. With more than 60 new listings, the volume is one in a series to provide information on multinational standards-related endeavors. International and regional organizations are listed in alphabetical order. Information includes acronyms, national affiliations, U.S. participants, membership restrictions, scope of interest, and availability of standards in English. Copies of NIST SP-767 are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Order by stock no. 003-003-
02937-8 for $22 prepaid. For a list of other NIST standards-related and certification directories contact: Office of Standards Code and Information, NIST, A629 Administration Bldg., Gaithersburg, Md. 20899; telephone: 301/975-4031.

CONTACT: Roger Rensberger, 301/975-2762

EVALUATION OF HIGH-FREQUENCY POWER METERS

Accurate power measurements are fundamental to assessing the performance of almost all radiofrequency, microwave, and millimeter wave equipment. Power considerations are also crucial for the design of efficient, cost-effective, and safe systems. Measurements at these higher frequencies are affected by many factors. Impedance mismatch, interference, leakage, nonlinear effects, and other sources of error must be assessed and minimized. A NIST publication, Performance Evaluation of Radiofrequency, Microwave, and Millimeter Wave Power Meters (NIST TN 1310), describes measurement techniques for evaluating the electrical performance of certain commercially available power meters that use bolometric sensors and operate typically from 10 MHz to 26.5 GHz. TN 1310 is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Order by stock number 003-003-02931-9 for $8.50 prepaid.

CONTACT: Fred McGahan (Boulder), 303/497-3246

FIRST OSI/ISDN TRIAL SUCCESSFUL

A recent trial combining two major communications technologies was pronounced "successful" by NIST. NIST initiated the trial, held the week of June 18th at Mather Air Force Base in California, to determine whether integrated Services Digital Network (ISDN) technology should be included in version two of the Government Open Systems Interconnection (OSI) Profile (GOSIP). Products from five different vendors were included. After August 1990, federal agencies must use the GOSIP specifications in procuring certain networking or telecommunications products. NIST is proposing to revise GOSIP to include ISDN functions as well as several new applications. Before doing so, the institute wanted to be sure that ISDN can support OSI applications. The five vendors participating with NIST in the trial were AT&T Federal Systems, DGM&S, ICL Inc. Retix, and Teleos Communications Inc. The General Motors Technical Center participated as a user.

CONTACT: Jan Kosko, 301/975-2762

NEW TEST CHAMBER DEVELOPED

Electromagnetic interference (EMI) has caused a range of problems in military electronic systems – from the inability of pilots to communicate with air-traffic controllers to catastrophic crashes. Researchers at NIST are developing a new type of electromagnetic test chamber to evaluate the ability of operational systems to withstand the effects of radiated EMI. The new chamber combines features of a transverse electromagnetic cell and a broadband reverberating chamber to provide an electromagnetic compatibility test capability for the frequency range 10 kHz to 40 GHz, a frequency range not offered previously by any single facility. A small prototype chamber, which measures 1.3 by 2.4 by 3.9 meters, has been constructed by NIST and delivered to the U.S. Army, which is interested in constructing a facility 10 times larger and capable of testing full-size helicopters and other aircraft. Initial tests with the chamber have shown the potential for significant cost and time savings. A paper, no. 52-89, describing the chamber is available from Jo Emery, NIST, Div. 104, Boulder, Colo. 80303; telephone 303/497-3237.

CONTACT: Fred McGahan (Boulder), 303/497-3246

IMPROVING PURITY OF DIODE LASERS

Using optical feedback and electronic techniques, NIST scientists have achieved a 10,000-fold improvement on the color purity of commercial diode lasers. Typical diode lasers have spectral linewidths – the range of colors emitted – that are tens of megahertz wide; NIST scientists obtained linewidths of less than 1 kilohertz. The techniques also automatically stabilize the laser’s oscillation frequency. The narrow linewidths and frequency stabilization make the diode lasers, which have low cost and high efficiency, attractive for applications in high-resolution spectroscopy and precision measurements. Narrow laser linewidth will also be a key feature in the next generation of lightwave communication technologies. Additional studies involving modification of the diode lasers – such as changes in the antireflective coatings – will be undertaken. Two papers outlining some of the techniques are available from Jo Emery, NIST, Division 104, Boulder, Colo. 80303; telephone: 303/497-3246.

CONTACT: Fred McGahan (Boulder) 303/497-3246

TWO-WAY TIME TRANSFERS BY SATELLITE

The use of geostationary, commercial communication satellites is a cost-effective way of comparing or synchronizing distant clocks at the highest levels of precision and accuracy. Equipment costs are low, satellite space is abundant, and data reduction is simple. For about $100 per week in satellite lease charges, a precision of 0.5 nanosecond is obtainable. Three recent technical papers authored or coauthored by NIST scientists discuss the fundamentals of two-way time transfers, time transfers between North America and Europe, and NIST-U.S. Naval Observatory experience in two-way time transfer over approximately 2 years. For copies of these papers, contact Jo Emery, NIST, Division 104, Boulder, Colo. 80303; telephone: 303/497-3237.

CONTACT: Fred McGahan (Boulder), 303/497-3246
NASA REVISES SHUTTLE-BOOSTER O-RING SEALS QUALITY BASED ON TYLER ESTLER'S WORK

As a result of the work of Tyler Estler of NIST Center for Manufacturing Engineering, NASA has substantially modified the procedures it requires for the measure-based quality control on the O-ring seals which failed in the fatal Challenger accident. Contacted successively by Morton-Thiokol, producer of the solid rocket booster motor that failed, and NASA itself, Estler worked with the agency and contractor to evaluate both the measuring machines used for inspection of the seals and the procedures by which those machines were being used. Together Estler and NASA found substantial variations in the dimensions of the O-ring seal grooves and weaknesses in the measurement procedures intended to detect such variations from design. Based on that assessment and his analysis of the absolute accuracy of a new type of measuring machine subsequently qualified for use, NASA has implemented a major revision of the formal procedures it uses for assessing the conformity to specification of those critical components.

CONTACT: Tyler Estler, (301) 975-3483

STANDARDS FOR FREQUENCY AND TIME METROLOGY

NIST has played a major role in the development of the newly released IEEE standard definitions of physical quantities for fundamental frequency and time metrology. David Allan of the NIST Time and Frequency Division in Boulder was a key member of the international IEEE committee, chaired by NIST Associate Director Helmut Hellwig, that proposed IEEE Standard Number 1139-1988. Allan was the originator of many of the concepts adopted in the standard. He developed the concept of the two-sample variance, now referred to as the Allan Variance, which provides for convergent specification of time domain performance, even in the presence of nonwhite noise processes such as 1/f noise. These concepts, which form the basis for worldwide specification of high-performance systems, are taught in an annual NIST seminar as well as at key universities in Canada, Europe, and Japan. At least two U.S. manufacturers now offer instruments that directly calculate the Allan variance from time series data. The IEEE standard formalizes use of these widely accepted practices.

CONTACT: David W. Allan, (303) 497-5637

NIST INITIATES "DESIGN FOR QUALITY" COURSE

Jim Filliben, Raghu Kacker, and Eric Lagergren of NIST's Statistical Engineering Division have developed and initiated a course for engineers on design for quality. The importance of designed experimentation — a systematic and rigorous plan for conducting an empirical investigation — is gaining increasing appreciation in the scientific and engineering communities. NIST has a unique vantage point, founded in measurement science, for disseminating the technology of designed experiments to engineers. Widespread development and use of this technology are dominant reasons for Japanese breakthroughs in quality engineering. The course runs over several days and covers specific designs for three classes of engineering problems: 1) how to determine if a scientific/engineering modification has significantly improved the response; 2) how to ferret out systematically the most important factors from a large number of potential factors; and 3) how to converge to an optimal operating condition starting from a "best guess" setting. The course is being given in the fall of 1989 for NIST staff and in the spring of 1990 for engineers from local industry. The course is a feature of NIST's effort to support industry in its pursuit of quality and productivity goals.

CONTACT: Robert Lundegard, (301) 975-2839

NIST TEST SYSTEM PROVIDES NEW CAPABILITIES FOR NONDESTRUCTIVE EVALUATION OF POWER TRANSISTORS

A new NIST nondestructive test system for power transistors that can accommodate up to 100 As and switch up to 2000 V has been applied to two major NASA programs, the space shuttle transportation system and the Hubble space telescope. David W. Berning of the NIST Semiconductor Electronics Division designed and implemented the system, which responds to needs for evaluating new power transistor capabilities that have come into being since Berning's first system was developed a decade ago. The NASA applications are for the gyroscope controller of the space telescope and for the main engine controller of the space shuttle. The Division offers documentation sufficient to build the system, including photographs, a complete circuit description, and a circuit diagram (produced on a computer-aided design system by Robert H. Palm of the NIST Electricity Division). In the system's normal mode of operation, the transistor under test is placed in series with an inductive load and turned on for a period of time needed to obtain a selected collector or drain current. When the transistor is turned off, its collector voltage increases abruptly. As this voltage increases, the system senses the onset of breakdown and quickly shuts the transistor to prevent its destruction. In addition to providing voltage breakdown points, the system has provision for viewing current and voltage waveforms on an oscilloscope or capturing them in a transient digitizer.

CONTACT: Herbert S. Bennett, (301) 975-2053

HEARING ON THE U.S. STANDARDS SYSTEM

On April 3, 1990, NIST will conduct a hearing on U.S. standardization. The purpose is to solicit information on the current effectiveness of U.S. participation in standardization activities, and to obtain suggestions for possible improvements in mechanisms and procedures. The Federal Register notice reproduced below provides more detail.
The following representative subjects may be discussed by participants in the hearing. They are offered as general guidelines to stimulate contributions from interested parties, but are not intended as limitations on subject matter or documented points of view.

Overview

Does the U.S. standards systems, as presently constituted, adequately serve the Nation's trading needs in today's international climate? Identify any weaknesses that require strengthening.

Is there adequate participation by representatives of the public and private sectors? In other countries, governments play a more formal role in standards. Are their systems more effective than ours? What should be the U.S. Government's role? If more coordination is needed among the many U.S. interests concerned with standards and trade, what changes might be beneficial? Is the Standards Council of Canada a model which the United States should consider?

Standards Participation

Does your organization send representatives to participate in international standards committees meetings? On a regular and continuing basis? Cite mechanisms which permit such participation and describe deterrents and possible techniques for improvement.

Who in your organization has responsibility for international standards activities? Describe the degree to which committee organization and procedures facilitate or hinder adequate participation and compare with efforts from other countries. Is the current U.S. standards infrastructure sufficiently supportive of and adequate for your organization's interests? Suggest any mechanisms that might improve the situation for your organization.

Are you an active participant in one or more technical advisory groups (TAGs)? Is there broad and adequate representation from the various U.S. interests? Describe your success or failure of the TAG in providing the needed forum for developing the U.S. position, and the ability of U.S. delegates to gain international acceptance of a U.S. TAG position. What factors contribute to success and/or failure?

How can we best ensure appropriate technical and financial support for international standardization activities? Should the Government help finance participation, especially by small and medium-sized companies?

Standards Usage

What is the relative utility of domestic and international standards for your operations? What standards do you use for trading in foreign markets? Describe any problems you encounter with language, units of measure, obsolescence, etc.

Have you encountered any standards-related trade barriers? Document experiences.

Testing and Certification

Describe any problems associated with acceptance of your products in foreign markets, including any burdensome testing or testing that you have experienced. Do you rely on any existing agreements for acceptance of U.S. test data? Do you use the services of domestic testing and certification bodies, and have you relied on self-certification for either domestic or foreign sales?

Describe any barriers to the acceptance of your product in foreign markets, including the role of testing. What is the impact of the cost of testing and/or certification on your gain or produce acceptance? What strategies do you recommend for improving export potential?

The information and comments obtained from the public hearing will be used to make recommendations to the Secretary of Commerce to improve the effectiveness of U.S. participation in international standards-related activities, coordination with the private sector, and delegation of any appropriate responsibilities to achieve these objectives.

The hearing will be held at 9:30 a.m. on April 3, 1990, in the Auditorium at the U.S. Department of Commerce, 14th Street and Constitution Avenue, N.W., Washington, DC 20230. Persons who wish to participate in the hearing must submit a written request to Dr. Stanley L. Warshaw, Director, Office of Standards Services, National Institute of Standards and Technology, Administrative Building, Room A–603, Gaithersburg, MD 20899. Requests should contain: (1) The person's name, address, telephone and facsimile numbers, and affiliations; (2) the number of participants; (3) the reason for attending; and (4) a list of points to be discussed. Oral presentations will be limited to topics specified in the written requests. Individuals who are unable to attend the hearing may submit written comments.
FEDERAL REGISTER (cont’d)

to Dr. Stanley Warnshaw at the above
address. Both requests and comments
must be received by March 22, 1986.
Those persons wishing to appear at the
hearing will be notified of the time
allotted for their presentations.

Dated: November 21, 1986.

Raymond G. Kammer,
Acting Director,
[FR Doc. 86-2789 Filed 11-24-86; 8:45 am]
BILLING CODE 2510-12-M

U.S. NAVY/NIST COOPERATIVE PROGRAM TO
ADVANCE THE STATE-OF-THE-ART OF LIQUID
FLOWRATE MEASUREMENTS

The fluid flow group of the Chemical Process Metrology
Division has initiated a cooperative flow metrology program
with the U.S. Navy Metrology Engineering Center (NMEC) to
advance the accuracy of the Navy’s liquid flowrate
measurement facilities. The Navy needs to advance flow
measurement accuracy to improve fuel accountability and
improve engine performance testing for sea and air vehicles.
The NMEC objective is to attain flowrate accuracy levels of
+ 0.025 percent, several times better than the current national
standards in the U.S. and abroad. The cooperative program
will improve the traceability for, and the precision of, the
component instrumentation systems that comprise the Flow
Calibration Test Stand (FCTS), which is being designed and
assembled commercially. The FCTS will involve both
volumetric and gravimetric flow measurement techniques
operated to maximize accuracy. In addition, NIST will devise
and implement improved techniques to characterize the
complete performance of the FCTS and assess and quantify
the pertinent systematic errors for such a facility.

CONTACT: George E. Mattingly, (301) 975-5939

EISENHOWER SPEAKS AT DEDICATION OF ORNL
CALIBRATION LABORATORY

Elmer Eisenhower of NIST was invited to speak at the
dedication of the Radiation Calibration Laboratory at the
Oak Ridge National Laboratory (ORNL). The primary focus
of the Laboratory is a set of reference gamma ray sources,
that will be used for tertiary radiation protection instrument
calibration. ORNL will apply for accreditation through the
National Voluntary Laboratory Accreditation Program
(NVLAP) under a new program for secondary calibration
laboratories for ionizing radiation. Eisenhower served as the
chairman of the wiring committee that developed the
evaluation criteria for the NVLAP program.

CONTACT: Tom Heaton, (301)-5528

NIST’S QUALITY-IN-AUTOMATION PROJECT
FEATURED IN MAGAZINE COVER STORY

Quality, a manufacturing trade-press magazine devoted to
product assurance and reliability, has devoted the cover story
of its October 1989 issue to the quality-in-automation (QIA)
project being carried out in NIST’s Automated Manufacturing
Research Facility (AMRF). The article, based on last year’s
QIA progress report, highlights the quality architecture
developed during the first year of the ongoing project. Under
that architecture, the dimensional quality of parts machined
within automated systems is assured by measurement-based
control loops that deal successively with pre-process
characterization, real-time control, process-intermittent
gauging, and post-process gauging. For the latter loop, in
which coordinate measuring machines (CCM’s) form the
principal element, the photo on the issue’s cover shows
laboratory work on characterization of a CMM loaned to
CME by the machine’s manufacturer.

CONTACT: Theodore Vorburger, (301) 975-3493

WORKSHOP ON QUALITY TECHNOLOGIES AND
STATISTICAL METHODS FOR DEFENSE SYSTEMS

A Workshop on Quality Technologies and Statistical Methods
for Defense Systems was organized and cosponsored by the
NIST’s CCAM on behalf of the Secretary of Defense. The
workshop developed an agenda for industrial quality
improvement through the more effective use of statistical
methods in engineering design and development. Leading
quality technology experts, design engineers, and statisticians
from U.S. industry, government, and academia participated in
the workshop. A draft of the written workshop report will be
available for distribution to the participants and submission to
the Office of the Secretary of Defense.

CONTACT: Robert Lundegard, (301) 975-2840

TWO NEW NIST PRECISION MEASUREMENT GRANTS
AWARDED FOR FY 90

Two new $30,000 NIST Precision Measurement Grants have
been awarded for fiscal year 1990. Since 1970, NIST has
awarded Precision Measurement Grants to scientists in
academic institutions, primarily for experimental work in
precision measurement and fundamental constants areas
important to the science of measurement. NIST sponsors
these grants to promote and encourage fundamental research
in the field of measurement science in U.S. colleges and
universities, and to foster contacts between NIST scientists and
those researchers in the academic community who are actively
engaged in such work. The recipients for 1990 are Steven Chu
of Stanford University whose project is titled "Precision
Optical Spectroscopy of Positronium", and Edward E. Eyler of
the University of Delaware whose project is titled "Far
Ultraviolet Spectroscopy with Single-Frequency Lasers." The recipients were selected from among an initial group of 20 candidates by both an outside advisory committee composed of 4 university professors and a NIST committee composed of John L. Hall, Richard D. Deslattes, Barry N. Taylor, and David J. Wineland. The selection process for FY 1991 awards will begin in early fall 1989 with a general call for the submission of preproposal summaries by February 1, 1990.

CONTACT: Barry N. Taylor, (301) 975-4220

VIDEO ON NIST-BOULDER RELEASED

A new videotape, "Science at the Summit: NIST Boulder, Colorado," recently released, describes research activities at Boulder. The 54:34-minute program includes special meters developed to monitor the flow of liquefied natural gas through pipelines, optical fiber technology, broadcast time signals from NBS-6, contributions in the field of metallurgy, high-temperature superconductivity research, work with the railroad industry on testing wheels for cracks, an indoor antenna testing facility, advances in biotechnology, and collaboration between NIST and the Joint Institute for Laboratory Astrophysics. Copies are available on loan from the NIST Information Resources and Services Division.

CONTACT: Fred McGehan, (303) 497-2146 and Ron Meiningher, (301) 975-2761

WEIGHTS AND MEASURES HANDBOOKS REVISED

Two handbooks have been revised by NIST to reflect changes adopted at the 74th Annual Meeting of the National Conference on Weights and Measures (NCWM) held in Seattle, Wash., July 1989. NCWM is an organization of state, county, and city weights and measures enforcement officials, which was established in 1905. NIST, which is a non-regulatory agency, provides technical support to NCWM through its Office of Weights and Measures.

NIST Handbook 44-1990. The major changes to NIST Handbook 44-1990, Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices, include a revised section on liquid measuring devices that establishes a requirement for equipment capable of computing the cash/credit pricing of retail motor fuel. NCWM also adopted a specification permitting the use of electronic data audit trails as security seals for electronic devices that are to be considered the equivalent to the physical sealing of other devices with lead and wire seals or pressure-sensitive seals.

NIST Handbook 130-1990. A new regulation was adopted for the maximum allowable variation (MAV) for polyethylene sheeting. Individual packages of poly sheeting cannot be short weight or short in thickness by more than an MAV of 4 percent of the labeled weight or thickness. NIST Handbook 130-1990, Uniform Laws and Regulations, also has a revision to the Uniform Regulation for the Method of Sale of Commodities that covers stuffed items such as meat, fish, seafood and poultry as combination foods. The quantity representation may be in terms of the total weight of the product or combination, and a quantity representation need not be made for each element provided that a statement listing the ingredients in order of their predominance by weight is shown on the label. This handbook also contains a new method of sale requirement for home liquid oxygen used for respiration. A ticket must be provided showing the weight of the cylinder before filling, after filling, and the net weight of the oxygen delivered.


CONTACT: Roger Rensbruger, 301/975-2762

NIST ANNOUNCES MILLIMETER-WAVE SERVICES

In response to industry needs, NIST has expanded the theory and practice of its antenna near-field scanning method by establishing antenna measurement services at millimeter-wave frequencies (above 30 GHz). Services are now offered for antenna gain and polarization to 65 GHz and for antenna pattern to 50 GHz. The new services use planar scanning, in which a well-characterized measurement probe scans across a plane at a fixed distance from the plane of the antenna. At higher operational frequencies, the errors in the computed far-field pattern introduced by errors in probe position become more significant. NIST has developed special software programs to correct the final results, once the positional error has been determined over the scanning plane. To arrange for a calibration, contact Allen Newell, telephone 303/497-3743 or Kathy Hillen, NIST, Div. 723.10, Boulder, Colo. 80303; telephone 303/497-3753. Copies of paper 46-89, which describes these services, can be obtained from Jo Emery, NIST, Div. 104, Boulder, Colo. 80303; telephone 303/497-3237.

CONTACT: Fred McGehan (Boulder), 303/497-3246

OPTIMUM FLOW CONDITIONING FOR ORIFICE METERS

A common way to measure flow rates of gases and liquids is to insert an orifice plate flowmeter into a length of pipe and measure the pressure drop across the plate. The accuracy of the measurement, however, is dependent on the condition of the flow, which is adjusted using flow conditioners upstream from the meter. European and U.S. specifications for the location of these conditioners differ, and the location has a substantial impact on measurement accuracy. In work spon-

(Cont’d on page 55)
HISTORIC MEETING CELEBRATES THE MKS SYSTEM

Giovanni Giorgi and His Contribution to Electrical Metrology Fifty Years After the Confirmation of the Giorgi (MKS System)

1938 - Torquay - England – 1988 - Torino - Italy
21 and 22 September 1988

A successful historical meeting to celebrate the 50th Anniversary of the confirmation of the Giorgi System was held in Turino, Italy on 21st and 22nd September 1988.

Renowned American and European scientists took part in the meeting, with lectures covering the various historical aspects and the development of the System.

The Proceedings of the Meeting are now in progress of printing. A copy, free of charge, will be sent by surface mail to any applicant. (If an overseas air mail parcel is requested, a contribution of $20 USA $ is required).

Please, write as soon as possible.

Address for orders:
   Prof. Claudio EGIDI
   Dept. Elettronica
   Politecnico di Torino
   C.so Duca degli Abruzzi 24
   10129 Torino, Italy

Editor's Note: Sounds like a deal for all you Technical History buffs.

ASTM STANDARD GUIDE FOR THE DEVELOPMENT AND OPERATION OF LABORATORY PROFICIENCY TESTING PROGRAMS WILL SOON BE AVAILABLE

ASTM's Standard Guide E 1301 for the Development and Operation of Laboratory Proficiency Testing Programs will soon be available. This standard was developed by ASTM Committee E-36 on Laboratory and Inspection Agency Evaluation and Accreditation.

In announcing this new standard at the committee meeting on June 28, 1989 in St. Louis, Missouri, Chairman John W. Locke said, "Now users of laboratories who want to review interlaboratory testing results will have a standard by which to judge those organizations which operate the interlaboratory testing programs. Laboratory accreditation bodies will have guidance when relying on these programs to check the performance of laboratories they accredit."

This standard guide will be the first of its kind to focus on the use of interlaboratory tests to evaluate the performance of the testing laboratory. It will be of significant use to purchasers of laboratory services who want to see the demonstration of laboratory performance when they buy testing services. For more information contact Steve Mawn, ASTM, 1916 Race Street, Philadelphia, PA 19103-1187, 215/299-5521.

The next meeting of Committee E-36 is December 5-6, 1989 in Orlando, Florida. All interested parties are welcome to participate.

Committee E-36 is one of 135 ASTM technical standards-writing committees. Organized in 1898, ASTM (American Society for Testing and Materials) is one of the largest voluntary standards development systems in the world.

RETIRING IN BEANTOWN

L. Kenneth Armstrong
94 Hastings Road
Spencer MA 01562

Sept. 20, 1989

Editor:

I was delighted to hear from you in one of the first mail deliveries to my diggings in this strange environment of Dukakis country. You are right, I did get away in a hurry, and after 43 years of Colorado's bright sunshine, low humidity, and open skies, this is -- well-h- - different! It isn't just the natural environment. Can you imagine not being able to buy picante sauce? They haven't even heard of it!

Then, there is the language: they seem to use the English alphabet, but in strange combinations, e.g., Tatnuck, Qaboag, and Quinsigamond. These are some of the more pronounceable combinations of letters that they call words.

But -- no matter -- local pronunciation has little to do with spelling anyway. Take "Worcester" (the name of the second largest city in Massachusetts). Comparatively, it is one of the most straight-forward spellings in the territory, but how do they pronounce it? "Wuh'stuh!" I do not know if they teach phonics in school here. If so, it probably just confuses the kids. That is not all, but it is probably enough of that. Anyhow, it is probably just what a 66-year-old NCSL retiree needs to keep him from getting set in his ways.
It is nice to have Barbara’s adult children close enough to visit often. They love “Mom’s” cooking and vice versa. This had everything to do with our moving here.

The people outside the family are friendly and helpful to pilgrims such as I — not what I expected of “New Englanders.” So I have already discovered some important positives. I will learn to love this place.

It has already started with the charm of 200-year-old stone walls that still serve as boundary markers; picturesque ponds; tranquil landscapes transversed by winding, tree-arched roads where 30-35 MPH speed limits are strictly enforced; the luxuriant growth of plants and trees; the beauty of abundant flowers — and soon, the incomparable splendor of oceans of oak, hickory, maple, and sumac leaves dappling the hills and valleys with a collage of color — every possible shade of red, orange and yellow. Here and there giant conifers, individually or in clumps, claim their place in the painting with vivid greens. The low-growing plants — the “weeds,” if you will, moderate and blend the scene with mottled browns and grays.

“FALL IN NEW ENGLAND!” YOU MUST SEE IT! IF YOU HAVE SEEN IT, YOU MUST SEE IT AGAIN! And when you do, let me know, maybe we can see each other.

In our "typical" New England "Cape Cod" style home, I am warmed by memorabilia of my great NCCL relationships. With the cash award, I have purchased a desk, chair, office supply-and-files cabinet, and an exercise bike that permits me to exercise without aggravating my artificial knee joint. On my desk is an NCCL telephone-number index (that dates back to 1976), the telephone and answering machine given me by the current NCCL Board, and the Cross pen- and pencil desk set given me at the ’89 conference. On the wall are NCCL plaques of appreciation. Thankfully, NCCL is still a very significant part of my life, and I am glad to know that I will continue to get the Newsletter.

My new business, Advertising Specialties, is getting off the ground. In connection with that, I’ll mail a pen with my name and telephone number on it to anyone in NCSL who mails me a request (two pens and a gold tee if they place an order).

Many thanks for your support and friendship over the years.

Sincerely

Ken

* * * * * * *

NCCL PUBLICATIONS CLUB

If your company* is a member of NCCL, then you may subscribe to the NCCL Publications Club for $100 the first year and $50 each subsequent year.

*Note: The NCCL Publications Club is only available to individuals of a member organization at a specific geographic or city location. A publications subscription is not available to non-members.

The idea of an NCCL Publications Club and a subscription to it is to allow more people in an organization, which is already a member of NCCL, to have their own copies of the many publications available through NCCL. This will be particularly useful to large organizations.

As a subscriber, an individual would receive all the mailings of the Newsletter, new RP’s, new Directories and other general membership publications that become available during the year.

NCCL Member Delegates will continue to receive all publications as part of their regular membership, and also Ballots and selected Surveys not part of the publications club.

For the first year’s subscription all existing copies of RP’s and Directories would be included.

The initial subscription package includes the following as a minimum:

- NCCL Directory of Standards Laboratories
- NCCL Training Information Directory
- NCCL Recommended Practices
- NCCL newsletters (issued quarterly)
- Recent newsletters may be included if available

Annual renewal subscriptions will include all new or revised publications and 4 quarterly Newsletters.

First year subscription rate: $100.00 Renewal rate: $50.00

Please include payment with order. Make checks payable to NCCL, and send your order and check to the NCCL Secretariat, at the above address.

METROLOGY ENGINEER/MANAGER AVAILABLE

One of our Member Delegates was recently discharged in a major Reduction-In-Force (RIF). He has over forty years of diversified experience in a broad range of disciplines, including staff and line positions. Specific experience has been in engineering, manufacturing and product management, and most recently has been involved in establishing test equipment and computer-aided equipment requirements for a major Aerospace Defense Company.

His present location is in the Midwest, but he is willing to relocate. If you have interest or a position, please call the Newsletter Editor at (415) 857-2060 and I will put you in contact with him.

Editor
LIAISON NEWS

OIML REPORT

On September 25, 1989, I attended an OIML Symposium in Paris on recommendations for the construction of national and regional standards laboratories for developing nations. I presented an invited paper on standards laboratories for thermometry, with particular emphasis on implementation of the International Temperature Scale of 1990 in primary and secondary laboratories. (1)

Following the Symposium, I attended, as a United States delegate, a meeting of the International Committee of Legal Metrology. The major topic for discussion was a draft of an "OIML Certificate System" dealing with mutual international recognition and acceptance, for the 49 OIML nations, of certificates of pattern approval for measuring instruments.

This initiative can be of major importance for United States manufacturers exporting to foreign markets, and especially to the OIML member nations. At present, a manufacturer must obtain a pattern approval before exporting an affected product into each individual target nation. An EEC initiative for 1992 is to provide for mutual acceptance of pattern approvals within the EC-12 nations; a group which does not include the United States. The OIML initiative would be applicable to all OIML Treaty member nations, which includes the United States.

Broadly, OIML proposes a voluntary system administered for each nation by its designated member of the International Committee for Legal Metrology (CIML). In the U.S. this responsibility resides within the Office of Standards Services of NIST. The CIML member would receive applications for pattern certification, and would designate an officially recognized laboratory or laboratories where pattern testing to the test stipulations of the relevant OIML International Recommendation would be carried out.

The results of this testing would be embodied in an official report, and, if the pattern of the instrument conforms to the requirements of the International Recommendations, the CIML member would issue an OIML Certificate of Conformity and Test Report to the manufacturer, who would then register the Certificate with the International Bureau of Legal Metrology.

When a Certificate is granted to a manufacturer, he may use this Certificate and Test Report in support of any application for pattern approval in any OIML or other nation. While it cannot be required, under the OIML charter, that a nation accept an OIML Certificate and Test Report in lieu of its own pattern testing, there is a strong inference that it will be a major factor in expediting national approval. Certified measuring instruments are of course limited to the range of instruments covered by adopted OIML International Recommendations. (2)

Some nations, including the United States, found deficiencies of a technical nature in the draft presented; for example, it did not provide for an appeals procedure, which we felt to be essential. Consequently, the draft was not adopted, but a working group was established with the membership from France, the Federal Republic of Germany and the United States to prepare the next draft. It is expected that this work will go forward quickly and that the next draft will be ready for review in the Spring of 1990, and could be adopted by the Fall of 1990 if found acceptable by the necessary majority of OIML Member States. NCSL members who would like to review and comment on this draft, when it is ready, are invited to communicate with me or with Dr. Samuel Chappell, U.S. Member of OIML, Building 101, Room A625, NIST, Gaithersburg, Maryland 20950.

Henry E. Sostmann, OIML Liaison

(2) A list of measuring instruments covered by existing OIML International Recommendations was given in the NCSL Newsletter (see pp 13-14, April 1989).

NEW PUBLICATION ANNOUNCED:
ISOTECH JOURNAL OF THERMOMETRY

A new periodic journal devoted to the art and science of temperature measurement in the Standardizing Laboratory, the Quality Assurance facility, and technological workplace. Contents will include papers and articles on:

* Temperature fundamentals, scales, and their realization
* Good practice in practicable measurement
* Invited papers from acknowledged experts in the fields
* Reviews of current literature, new books, new products
* Reprints of historic landmark papers in thermometry
* And much more. Subscribers' wishes will guide our development

(1) This paper will be published in the OIML Bulletin in the Spring of 1990, and in an expanded version in the Isotech Journal of Thermometry, Vol 1., No. 1, February, 1990.
The Journal will be published approximately semi-annually under the editorship of Henry E. Sostmann and John P. Tavener. The first issue is planned for January 1990, and will include the following:

* The International Temperature Scale of 1990; what it is, how to implement it in your facility (Sostmann).

* A Standard Platinum Resistance Thermometer to interpolate the ITS(90) to 961°C (Tavener)

* Part I of a series on the fundamental basis for temperature measurement (Sostmann)

Subscription for One Year (2 Issues) $15.00 Us

Send to: Isothermal Technology, Pine Grove, Southport PR9 9AG, England, att. John P. Pavener, or

Henry E. Sostmann, 2307 Whitley Drive, Durham, NC 27707 USA

CPEM ’90 LIAISON REPORT

Dr. Jacques Vanier, Chairman of CPEM ’90 reports that everything is proceeding smoothly toward the meeting in Ottawa to be held June 11-14, 1990, at the Westin Hotel. At the present time the organizing committee is seeking ways to encourage increased participation by young scientists and engineers; in this connection, arrangements are being made to provide financial assistance to 20 or 25 people who would otherwise not be able to attend. A number of organizations have expressed an interest in contributing to this cause as sponsors; they include: the International Union for Radio Science (URSI), the International Union for Pure and Applied Physics (IUPAP), some private companies and the Executive Committee of CPEM. Additional sponsors are solicited.

Special speakers have been engaged for two occasions. On the first day, Monday, June 11, the keynote address will be delivered by Professor Claude Cohen-Tannoudji of Ecole Normal Superieure in Paris, an international expert in the field of optically activated atomic and molecular frequency standards. On Wednesday, June 13, Professor Klaus von Klitzing of the Max-Plank-Institut in Stuttgart will present a special address. Professor von Klitzing was awarded the Nobel Prize for his discovery of the Quantum Hall Effect that provides the basis for a new absolute standard of electrical resistance.

The technical program will include a special session on the outlook for realizing a quantum kilogram by taking advantage of recent advances in the realization of electrical units of measurement on the basis of quantum science principles. The kilogram is the only unit of the International System (SI) of measurement that, up to the present time, had not been improved by modern advances in science and technology. The technical program will also include a Round Table discussion on the future role of national standards laboratories in view of the remarkable scientific advances in the definition and realization of measurement units by applications of quantum physics.

Art McCoubrey, CPEM Liaison

PMA LIAISON REPORT

The annual meeting of PMA membership was hosted by the San Diego Section on 13 September 1989 in La Jolla Village Inn, La Jolla, California.

PMA National Officers for the 1989-1990 year are as follows:

Kevin Clark, President
David Workman, Past President
Michael Schmalzl, President-Elect
Terrell J. Wilson, Vice-President
Brent Kirkpatrick, Secretary
Rita Kirchgraber, Treasurer
Bob Myers, Executive Director
Howard R. Adams, Director-at-Large
Michael S. Franczowki, Director-at-Large
Donald Hayes, Director-at-Large

The second edition of the Directory of Metrologists is being prepared for publication and distribution early in 1990.

The Orange Section of PMA won the John Quincy Adams award for having earned the most points in the competition between Sections.

The electronic bulletin board is being installed and debugged.

Glenn E. Rasmussen
NCSL/PMA Liaison Delegate

LIAISON REPORT – PDA

A parenteral drug is injected directly into tissue or the bloodstream rather than using it orally, anally, or topically. There are small volume parenterals (vaccines, antibiotics, and insulin) and large volume parenterals (IV solutions). I'm sure
the organization also includes companies making tablets, capsules, and medical devices.

About the Parenteral Drug Association = PDA = it:

* Was organized in 1946.

* Has 200 corporate and 2000 individual members.

* Costs = corporate (#360 for 6+), & individual ($60).


* Spends $476K of their $964K expense for admin.

* Has, in addition to the eleven paid positions, five officers and twelve directors elected from industry.

* Does not hold local meetings, but holds two regional and one three-day national meeting each year.

* Receives $446K of their $1M income from these meetings.

* Is working on a 9-step five year plan with specific implementation strategies.

* Offers 23+ educational courses: income = $213K; expenses = $106K.

PDA's objectives within the pharmaceutical community are similar to NCSL's within the metrological community. By the end of the year, I will spend some time by phone with my contact, Mr. Frederick Simon in order to discover more of the common ground between the two organizations.

L. David Duff
PDA, Liaison

NIST NEWS
(Cont'd from page 50)

sored by the Gas Research Institute, NIST analyzed the effect of varying the distance from conditioner to orifice meter. The results showed that, in general, the conditioner should be located 17 pipe diameters upstream from the orifice plate for tube bundle conditioners. More details are presented in Optimum Location of Flow Conditioners in a 4-inch Orifice Meter (TN 1330), available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402-9325. Order by stock no. 003-003-02961-1 for $4.25 prepaid.

CONTACT: Collier Smith (Boulder), 303/497-3198

INTERNATIONAL STANDARDS
(Cont'd from page 31)

setting up a rigorous measurement assurance program. It will, therefore, be a valuable addition to ISO 10012. But we do not have to wait for the completion of that handbook to introduce measurement assurance to those many who are not yet familiar with it. We believe the sooner the concept becomes a requirement, the greater will be the benefit for all.

Without ISO 10012 mandating how to comply with it, the requirements will be interpreted and implemented as best as people see fit. This process of evolution will bring about an eventual consensus of the full meaning of the requirements in each case. We shall learn from experience what the requirements can and should mean in each instance. In a field as new as measurement assurance, a useful motto may be "Do it, and you establish a precedent." A mature standard document evolves from some initial position and subsequent revisions based on knowledge and experience.

Rolf B. F. Schumacher
5 September 1989
1990
TRAINING INFORMATION DIRECTORY

National Conference of Standards Laboratories

This directory contains listings of training courses, educational materials and comparing slide in the fields of metrology and calibration. It is distributed as a service to NCSL members and does not serve as an endorsement by NCSL. or to completeness or adequacy of listed courses and materials. Readers should contact training sponsors directly for more information or to inquire about future offering dates.

TRAINING INFORMATION AND DIRECTORY COMMITTEE
David A. Loomis, Chairman
Honeywell Vacuum Systems

Gary A. Adams
Anderson Aerospace

John Biedensiek
Heller Industries

Critical-care devices

NCSL ITEMS FOR SALE

In response to popular demand, the following items are available from the NCSL Secretariat, postpaid, at the prices indicated. Please include payment with order.

<table>
<thead>
<tr>
<th>Item</th>
<th>Price</th>
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<tbody>
<tr>
<td>* Training &amp; Information Directory (annual)</td>
<td>$10.00</td>
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<tr>
<td>* NCSL Directory of Standards Labs (biennial)</td>
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<tr>
<td>Members</td>
<td>25.00</td>
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<td>Non-members</td>
<td>100.00</td>
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<tr>
<td>* NCSL Newsletter (single copy)</td>
<td>5.00</td>
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<td>* One-year Newsletter Subscription</td>
<td>15.00</td>
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<tr>
<td>* Duplicate or Replacement Plaques</td>
<td>50.00</td>
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<tr>
<td>* NCSL Lapel Pins (sterling silver)</td>
<td>15.00</td>
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<tr>
<td>* NCLS 2&quot; 3-ring Binder (info manual) includes Tabbed Index Dividers for Binder (set of 6)</td>
<td>10.00</td>
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<tr>
<td>* Information Manual Fillers (without Recommended Practices)</td>
<td>10.00</td>
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<tr>
<td>* 1985 NCSL Workshop &amp; Symposium Proceedings</td>
<td>25.00</td>
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<tr>
<td>* 1986 NCSL Workshop &amp; Symposium Proceedings</td>
<td>25.00</td>
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<td>* 1987 NCSL Workshop &amp; Symposium Proceedings</td>
<td>N/A</td>
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<tr>
<td>* 1988 NCSL Workshop &amp; Symposium Proceedings</td>
<td>25.00</td>
</tr>
<tr>
<td>* NCSL Recommended Practice: Establishment and Adjustment of Calibration Intervals</td>
<td>$25.00</td>
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RP-1 * Evaluation of Measurement Control Systems and Calibration Laboratories Evaluation Worksheet Attachment 1 | 10.00 |
RP-2 * Calibration Procedures | 10.00 |
RP-3 * Calibration System Specification | 10.00 |
RP-4 * Preparation of Specifications | 10.00 |
RP-5 * Medical Products and Pharmaceutical Industry Calibration System Guide | 10.00 |
RP-6 * Laboratory Design | 20.00 |
RP-7 * An Individual Equipment Evaluation Guide | 10.00 |
RP-8 * Calibration Laboratory Capabilities | 10.00 |
RP-9 All RP's 1-9 inclusive | 80.00 |

Delegates of new members receive all except the NCSL Lapel Pin as part of the new-member information package. Updated material, e.g., Training Information Directory and Directory of Standards Labs are automatically forwarded to member delegates as they are published. Additional items are available at prices indicated. Conference Proceedings orders are accepted as long as limited supply lasts. Make checks payable to NCSL, and send your order and check to the NCSL Secretariat, 1800 30th Street, Suite 305B, Boulder, Colorado 80301.
The meeting was opened by Mike Maxwell. He explained the changes in personnel in the Section and Region Coordinators, and the Region Director. They were then introduced so that new members and attendees could identify the NCSL contacts in the area. Since several new faces were identified, each attendee introduced themselves to the group.

The opening presentation was given by Mike Shaw of Guildline Instruments addressing changes in the US Volt and Ohm. Copies of NIST Technical Note 1263 reprinted by Guildline were handed out to each attendee, as well as several related articles and overhead slides. Mike brought us up to date on changes in the temperature scale and samples of the SI90 label were made available.

Woody Tramel gave the group an update from the Board of Directors information as well as requesting feedback on the proposed location for the 1991 NCSL annual workshop in Albuquerque, N.M. Bill Wightman provided NCSL pins to the member delegates with five or more years of consecutive service.

25 Years
R. Meischeid, Computer Sciences/Raytheon

15 Years
D. Bowen, Harris
E. Nemeroff, Datron
J. Riley, NASA

10 Years
H. Challis, GE
W. Tramel, EG&G

5 Years
G. R. Alkire, Westinghouse
A. Anderson, Guildline
F. Brooks, Delta Electronics Labs
M. Duren, Northern Telecom
J. George, McDonnel Douglas
D. Ingram, Racal Milgo
G. Kriner, Honeywell
R. Lamb, Certified Measurements
C. Reid, Ametek
F. Shemmel, U.S. Navy Lab
B. Wightman, John Fluke

John Riley of NASA presented the preliminary results of the section's ten volt round robin. Since the final measurements have not been completed, only preliminary results were available, however, John pointed out that overall the results looked better than the previous round robin.

The next presentation, given by Blaine Bryan of EG&E, provided an update on the progress of development of a portable alternating voltage check standard that he and some people at Guildline have been working on.

After a break for lunch, Tom Brown of EG&G reviewed two relatively new Measurement Assurance Programs from NIST, Radiometry and Fiber Optics, that he has been working with. Tom explained some of the basics of measurements within these disciplines and the scope of the MAP programs offered. He also identified some problems that users might have to deal with while these programs are in their infancy.

After a short break, the group held a round table discussion on Metrication and the effects and impacts from the amendment to the Metric Conversion Act of 1975 requiring federal agencies to establish the metric system as the preferred system of measurement. Copies of Federal Standard 376A, Preferred Metric Units for General Use by the Federal Government were distributed.

Mike Maxwell began the discussion with a brief background on the laws enacted in the United States back to 1866. The round table soon turned into a lively discussion on a variety of aspects of metrication and its impacts. Tony Anderson and Ian King of Guildline gave the group a contrasting look at changes resulting from the metrication program in England.

The meeting was wrapped up with a schedule for our section meeting for 1990 as follows: 22 March, 1990 and 1 November, 1990.

Twenty-eight attended the Region 4 Florida Section meeting on Oct. 4. (left hand side of the picture)
The Northern Ohio section of Region 5 met on October 17, 1989 at the regional sales office of Hewlett-Packard with Tim Brennan as our host. We had 37 members and guests in attendance.

After registration at 8:30 a.m. the meeting began at 9:10 with a short series of announcements regarding the local NCSL section activities and an overview of the day's meeting.

The heart of the meeting was a panel presentation by four equipment manufacturers' representatives on the topic "How to Live Through the January 1, 1990 Changes in the Volt and Ohm." Panelists were Clark Crain from John Fluke Mfg., Ed Kifer from Keithley Instruments, Hank Schmaj from Hewlett-Packard, and Steve Stahley from Datron Instruments.

Each presenter gave a 15 to 30 minute explanation of how his company is going to handle the changes in the calibration of in-house standards, newly produced equipment for sale, and items returned for repair/calibration. Each company has a cut-off date after which the new volt and ohm values will be used. For a short period of time, dual calibration data using the old and new values can be requested.

Specific model numbers were listed for equipment which must be adjusted to the new values as well as models which probably should be adjusted. Handouts were available from some of the panelists listing equipment affected by the changes and giving recommended procedures for making these adjustments.

Much of the morning was taken up by the panel presentations and having our group picture taken by Max Green, Region 5 Coordinator. Shortly before lunch, a question and answer session began during which the panelists fielded questions from the attendees. Among the many ideas discussed was the question of physically adjusting solid-state 10 volt standards. In view of the extensive data most owners of these units have collected over the past few years showing the behavior of the units, adjusting the standards is not recommended. This discussion with the panelists continued through lunch.

The NCSL had made copies of the NIST Technical Note #1263 available for all those who attended, and additional copies had been reprinted and were provided through the courtesy of Guildline and WKM Associates. Also, on hand for sale were sheets of the official logo stickers from NCSL.

In the afternoon after the formal meeting, the people from the ten Cleveland-area companies which had participated in the local Voltage MAP for the 10-volt solid-state standard during the past summer stayed on. We discussed the results of the data which had been obtained by Jim Crane of Keithley Instruments. This group will meet again at the Spring, 1990 NCSL Section meeting to consider repeating the VMAP in 1990.
The Fall meeting of the Region 6 West section was well attended. Of the twenty-five attendees, seventeen represented NCSL member companies, four were manufacturers and four were support/educational staff.

ACTIVITIES/SUBJECTS

- Bob Willett (Rockwell International, Richardson, TX, 214-996-7070) briefly discussed the July 1989 NCSL Board of Directors meeting and copies of the highlights were available.

- Bill Jump (Eastman Kodak Co., 303-686-0632) discussed the ASQC Measurement Handbook and MET/CAL Division Initiatives. Multiple copies of the Am. Society of Quality Control (ASQC) petition for attendees to sign requesting formation of a Metrology Division were available.

- Gary Carr (StorageTek), NCSL West Section Education/Training Facilitator, asked for input for training required in the near future. Gary will be coordinating all local training sessions and will be a source of information on the programs available from manufacturers. He can be reached at Storage Technology Corp., 2270 S. 88th St., M/S 5116, Louisville, CO 80028, 303/673-3829.

- Deirdre Lavallee (MKS Instruments, Inc.) presented five, ten and fifteen year service pins awards to:
  
  Bill Bruce (10 years)  Paul Trimbach (5 years)
  Bill Jump (10 years)  Chet Wells (5 years)
  Carl Gola (5 years)

- Bob Willett (Rockwell International) presented the Q-Screen/Equipment Tolerancing Software program (available from the U.S. Navy) contact Howard Castrup, Applications International, at 714/394-1104.

- Greg Burnett (Hewlett-Packard Co., Englewood, CO) described the planned activities and asked for input for the Calibration Procedures Committee. Contact Greg at Hewlett-Packard Co., 24 Inverness Place East, Englewood, CO 80112 303/5460.

- Paul Trimbach (Ball Aerospace, Boulder, 303/939-5080) and Bill Jump (Eastman Kodak, Windsor) are starting a West Section Diary to keep the local metrology community updated on the "1990 Volt, Ohm and Temperature Scale Changes". The first issue will be ready by the next West section meeting.

- Chet Wells (SERI, Golden) announced George Washington University's short program on the 1990 Temperature, Volt and Ohm Changes, to be held Friday, September 15, 1989 in Denver.

- After the meeting was adjourned, Scott Hastings (HPS Division of MKS Instruments, Inc.) conducted a tour of the HPS Division facilities.

- Paul Trimbach thanked MKS Instruments for providing the host facilities and also Carol C. Bulik for her assistance. Our hosts provided the grand door prize (microcassette recorder) won by Chet Wells (SERI).

- Appreciation is also extended to our topic discussion leaders and guest presenters.

MEETING DISCUSSION TOPICS

Implementation of the 1990 Changes in the Volt, Ohm and Temperature Scale in Metrology Laboratories

Paul Trimbach (Ball Aerospace, Boulder, 303/939-5080) discussed the 1990 Volt and Ohm changes and Bill Jump (Eastman Kodak Co.) spoke on the 1990 temperature changes. Both addressed the questions of how to implement these changes within a facility. Wilbur Anson, NCSL, advised attendees that he had labels available for sale for those who have equipment that has been calibrated to the new standard. Bill and Paul will discuss this topic again at the next meeting, since the attendees felt that there will be more questions as the changes come into effect.

TOTAL QUALITY ASSURANCE IN THE LABORATORY

Carl Bozeman, Manufacturing Manager for Granville-Phillips Co., Boulder, (303/443-7660), discussed alternative methods of quality assurance based on total employee responsibility. Concepts followed at Granville-Phillips are based on Japanese production methods by involving complete employee participation, thus eliminating the need for a separate quality department functions. Granville-Phillips Co. is a privately held company which manufactures vacuum gauging.

ELECTRIC-STATIC DISCHARGE (ESD)

Willard McFarland is presently the Senior Component Engineer and ESD Coordinator for AT&T Information System's Denver Works. His paper entitled The Economic Benefits of an Effective ESD Awareness and Control Program was instrumental in establishing the need for and implementing the ESD program at AT&T.
Willard presented an excellent explanation of the causes of ESD and the cost savings/economic benefits of having a program in place throughout an entire facility.

**TENTATIVE TOPICS FOR MARCH MEETING: (3/22/90)**

* Continuation of "Implementation of the 1990 Changes in the Volt, Ohm and Temperature Scale in Metrology Laboratories", a continued discussion by Paul Trimbach (Ball Aerospace) and Bill Jump (Eastman Kodak Co.)

* "Fiber Optics": NIST.


* "Bar Coding of Equipment As a Tracking System": Patrick Fedorowicz, Raytheon Support Services Co., Aurora.

The Fall of 1989 D/FW Section of Region 6 met at the Hewlett-Packard Co. offices in Las Colinas (Irving TX) on November 8, 1989. Fifty Seven were registered as attendees, with 35 of those NCSL members and 22 non-members. Thirty two users of M&TE were present, with 18 representing M&TE manufacturers or manufacturer's representatives, and one representing an instrument rental company.

**MEETING ACTIVITIES:**

Bob Willett, Region 6/8 Director, presented "Gracious Host" awards to our regular hosts: H-P, John Fluke, and Tektronix. Representatives from each company received the plaques with our appreciation for their hospitality over the past years. We sincerely appreciate their bearing the burden (read $$$) for hosting the twice annual meetings.

Ronnie Eubanks, Region 6 Coordinator, presented service pins (5, 10 and 15 Yrs.) to a number of long time supporters of NCSL in this area. They were:

- Burt Scammel, Airep Electronics 5 yrs
- Joe Brown, Data Marketing Assoc. 5 yrs
- Luke Smith, E Systems Greenville 10 yrs
- George Brush (Hewlett-Packard Co.) 5 yrs
- John Winters, John Fluke Mfg. Co. 5 yrs
- Ken Horne, KS Specialties 5 yrs
- Jim Bailey, Metrology Specialists 15 yrs
- Terry Mitchell, Motorola Inc. FW 5 yrs
- Ronnie Eubanks, Otis Engineering 5 yrs
- Bob Roberts, Roberts Instruments 5 yrs
- Bob Willett, Rockwell Int'l. NTSD 15 yrs
- Harvey Evans, Scientific Devices 5 yrs
- Don McKenzie, Tektronix Inc. 5 yrs
- Clyde Orrison, Texas Instr. Inc. 5 yrs
- Cliff Snellings, Texas Instr. Inc. 5 yrs
- Earl Murphy, General Dynamics FW 5 yrs
- Bob Pfister, John Fluke Mfg. Co. 5 yrs
SCHEDULED MEETING TOPICS

* "Total Quality Management and Measurement Integrity" (MIL STD from the Factory Floor). Mr. Dave Hopping (Hewlett-Packard Co., Santa Rosa CA) 707/577-4029

* "A Report on Bio-Medical Metrology in Region 6", Mr. Ken Moon (Siemens Medical Systems Grand Prairie TX) 214/660-2700

* "A New Approach to Quality Management", Mr. Jim Hirning (John Fluke Co. Inc. Everett WA) 206/356-6093

* "Advances in Measurement Metrology Techniques in Modern Instrumentation", Mr. Rex Bourg (Hewlett-Packard Co. Loveland CO).

Note: Mr. Ron Swerlein (HP Loveland CO) replaced Rex Bourg, and presented an update on the effectiveness and accuracy of the "autocal" methodology as employed in the HP-3458A DMM.

Mr. Bill Eddy (Continental Electronics, Dallas) addressed the meeting, raising the subject of multiple auditing and its attendant costs to both parties. Discussion from the floor revealed wide diversity of opinion on this matter, and it will be a topic of discussion at a future meeting.

THANKS OUR HP HOSTS!

Region 6 of NCSL expresses its appreciation to the Dallas HP folks for their gracious hospitality and excellent lunch. We greatly appreciate our local hosts and what they do to make these area meetings a success.

DOOR PRIZE WINNERS

At the conclusion of the November meeting, our hosts provided two HP hand-held multimeters and a professional business calculator as door prizes. Three lucky attendees came home "better equipped" than they arrived!

TENTATIVE TOPICS FOR APRIL 1990 MEETING

* Calculation of uncertainty ratios of measuring and test equipment.

* Calibration methodology for medical scanning equipment.

* Auditing practices and philosophies.

* Precision time-base measurements.

* Implementing the 1990 Changes in the Volt, Ohm, and Temperature Scale.

OPEN FORUM FOR METROLOGY/QUALITY TOPICS (ask, you never know who may have the answer to your most nagging problem).

Group Picture of Attendees South Section 6 MTG at Mensor Corp. San Marcos TX, July 19, 1989

Service Award Presentation Recipients in Attendance. Others were absent from meeting. Far left, Bob Willett who Presented Awards

On September 20, 1989, Forty-five people attended the Orange County Section of Region 8 workshop. Ken Landis called the meeting to order at 9:00 AM. Each attendee introduced himself or herself. It was announced that the October meeting of the Equipment Management Forum will be held in Manhattan Beach. Anyone interested in attending should contact Paul Chong, TRW. Copies of MIL-HDBK-52B and the NIST publication concerning the 1990 volt/resistance changes were distributed to all attendees.
The first speaker, Frank Legare, of Hughes Aircraft Co., was introduced. Frank discussed the history of Total Quality Management at Hughes Aircraft Co. He used this format to describe the basics of Total Quality, Centers of Excellence, TQM, World Class Management, or whatever your company calls it. The name doesn’t matter, the implementation and follow through are what counts.

Hughes calls it Continuous Measurable Improvement. This effort has led to the development of customized methods that have contributed significantly toward the achievement of 30% to 90% improvements in most manufacturing and some administrative and engineering activities. The calibration lab, using these techniques, has reduced its equipment turnaround times from 15 to 5 days. The goal is an average 2 day turnaround for all M&TE, with a maximum of 5 days for any one item.

The process is monitored using PQI’s (Process Quality Indicators). Some of the goals of this approach are:

- Make improvement a team effort
- Understand your process thoroughly.
- Recognize what might go wrong.
- Know who your customers & suppliers are.
- Locate where discrepancies could occur.
- Detect whether discrepancies do occur.
- Be aware of the magnitude of problems.
- Organize your information
- Keep track of trends.
- Find root causes of discrepancies.
- Remedy undesirable conditions.
- Make improvements permanent.

These tasks can be reduced to five fundamental steps:

1. Process examination.
2. Data collection, recording, and analysis.
3. Identification of the most important discrepancy.
4. Establishment of the root cause.
5. Improvement action.

* STEPS 2 THROUGH 5 ARE REPEATED CONTINUOUSLY!

After Frank completed his presentation, Ken Landis, of Hughes Aircraft Co., described how these techniques were applied to the Calibration Laboratory at Hughes. The first step was training. This was a very extensive process which included everyone from technicians, to clerks, to management. Each step was completed until, finally, improvements were measured. After the first two years turnaround time was down 60%, the backlog of work was down from 1200 to 300 items, supervision was reduced (through attrition) by 50%, and the technicians had started working together as a team.

A very lively roundtable discussion ensured. Team building was a hot issue, and the evolution of a typical team was described. Highlighting your most important discrepancies using Pareto charts and cause-and-effect diagrams was touched upon.

Two Roadblocks (to TQM) to watch out for were:

1. People who say “We’ve always seen it this way.”

2. Supervisors, managers, etc., who will not give up their "authority" by giving the teams a moderate amount of freedom to solve problems.

The discussion ended on the note that this process is an ongoing one. When you finish and show measurable improvement, then you start over again.

The next discussion leader was Jim Hirning, from John Fluke Instruments, Inc. Jim discussed Fluke’s approach to Quality Management. Historically, key quality tools such as designing for quality, random vibration testing, and temperature cycling have been essential to assuring defect-free products. However, “newer” tools are becoming just as important; these include statistical process control (SPC), just-in-time (JIT), and process metrology. SPC uses control charts and statistical methods to continually improve process, quality, and reliability. Then JIT can be implemented to improve product flow and increase flexibility. Process metrology helps assure that the instruments which calibrate the newly manufactured products remain within specification without removing the product from the floor.

After lunch, Phil Painchaud took the obligatory group picture. Following this, Rolf Schumacher, Region 8 Coordinator, announced that the Orange County Section was half way through its second year. He asked Ken Landis, the OC coordinator, to say a few words. Ken thanked the attendees for the section’s success. He then announced that he was leaving Hughes Aircraft and kicking off a sales career at Electro Scientific Industries. He will represent both ESI and their “Partner in Precision”, Ballantine.

Bob Smith, of Ford Aerospace, followed with the Report from the Board of Directors. He described the recent meeting between NIST and the Executive Directors of NCSL, and the Government Affairs Committee report to Congress. He alerted everyone to the new Letterhead, and the recent changes in our business office. Finally, Bob announced that our membership has exceeded 1000 members.

The final discussion was concerning what you do when you cannot get 4:1 ratios between the unit under test and the standards. Ken Landis described Hughes Aircraft’s approach to the new requirement. Basically, a work sheet is attached to each calibration procedure. When a technician picks up a
procedure with a work sheet that has not been completed, he completes it as part of the calibration. This cover sheet describes the measurement to be taken, the standards used, and the accuracy ratio achieved.

Rolf Schumacher described Rockwell International's methods for handling items with less than a 4:1 ratio. Rockwell has practices which require 4:1 A.R.. When this cannot be achieved, they compensate for a lower A.R. by subtracting the standard's uncertainty from the specified UUT tolerance. The cost of this approach is that a number of in tolerance M&TE will be rejected as bad.

The next two meetings of the Chicago Section of NCSL will be at G.D. Searle Company in April of 1990 and Baxter Health Care in October of 1990.

John Buck, the Region 11 Coordinator was unable to attend. Service award pins were presented to Ralph Bertermann, Ron Dettling, Art Vogt and Dave Walters. Copies of the NIST Technical Note 1263 entitled "Guidelines for Implementing the New Representations of the Volt and OHM Effective January 1, 1990" were distributed and a discussion followed regarding how the various people in attendance would handle these very important changes. Ralph Bertermann then gave us some insight concerning the latest happening of the Board of Directors meeting. John Buck will arrange a joint Region 11 meeting for sometime between the middle of March and the middle of April in 1990. All sections will be invited. He expects to have speakers from NIST and committee chairman from NCSL and other experts in the areas of interest. John thinks that the distances for the various section members to travel is too great for a one day meeting, so he is thinking about a video teleconference. This would be a 4-way hook up between the Twin Cities, Chicago, St. Louis and Kansas City. Each video site could have its own tour if time permits.

Mel Johnson of Wavetek/Datron gave the first presentation on their new 4910 DC Voltage Reference Standard. The 4910 is a very precise Zener diode 10 volt reference source. It is unique in that it has four independent 10 volt outputs that can be averaged providing 1 ppm/year stability. It also has a remote sending buffer that can provide precise voltages for driving voltage dividers. The 4910 provides a 7-day internal battery backup in case of power outages or for transporting to other locations.

The second presentation of the day was given by Glen Berry of John Fluke Company who discussed their new MET/track metrology property management software. MET/track is a powerful MS DOS based Data base system for PC compatible computers. It provides significant benefits over existing systems such as card and large computer systems in data entry, data base Management and report generation. Because MET/track is assigned specifically for metrology property management, it offers significant advantages over commercially available general purpose data management software.

Our last speaker was Dan Tingley of Hewlett-Packard who described HP's new 35660A Dynamic Signal Analyzer. This type of an analyzer provides one with a wide variety of electrical, acoustical and mechanical measurements. A few of the applications are: Acoustic tests such as sound pressure level and room response; resonances in mechanical structures; machine vibration and response of electronic filters and networks. The 35660A is a very cost effective instrument that performs spectrum and network analysis using high speed FFT routines.

During the afternoon a very interesting video was shown by Glen Schultz about the Amoco Research Center and the very diverse research that is done there.

I would like to thank everyone who was involved in this meeting. It was our largest attendance and was one of our most interesting. I would especially like to thank Glen Schultz and Amoco for their outstanding hospitality.
Regional Reports

Mel Johnson of Wavelet/Datron describing their new 4910 Zener Reference Standard.

Glenn Beny of John Fluke describing their MET/TRACK software.

Dan Tingley of Hewlett-Packard describing the HP 35660A Analyzer.

The attendees checking out some of the features of the Hewlett-Packard 35660A Analyzer.

October 17, 1989
Hutchinson Technical College
Hutchinson, Minnesota
Georgia Harris
Twin City Section Coordinator

Fifty eight attendees were at the October 17, 1989 meeting at Hutchinson Technical College, including students in the programs.

John Buck, Unisys, NCSL Regional Coordinator, awarded some five year pins to members. Dick Weber, 3M, Walt Peterson, Medtronic, and John Buck of Unisys, received 5 year service pins. John also discussed the following NCSL/General information items:

* 1988 Omnibus Trade ... Act, and the apparent omission of the term "voluntary" with regard to metrication:

* Regional boundary/office "electron", input was requested from the group.

* Round Robin for thread gauges. A group is starting to get together, additional interested parties were asked to sign up.

* Region 11 meeting jointly with the Twin City, Chicago, and St. Louis sections. John discussed the problems he's had trying to get teleconferencing arranged as well as the considerable amount of driving which would be necessary to have a meeting centrally amongst all three sites.

Rich Barnes, Rosemount, Inc., introduced information about the Precision Measurement Association and discussed the possibility of forming a local chapter with regular monthly meetings.
Several "metrology" and NCSL related door prizes were given away.

The October 17, NCSL Twin City section meeting was developed and focused around the theme of metrology training and education. It included the following speakers and topics.

EDUCATIONAL PANEL

General Information Regarding Metrology Education, NCSL Role in Metrology Training and Education, Kate Webster, Cortez III, Ohio, NCSL Education Liaison.

Industry Survey of the Need For A Metrology Program, Herb O'Neil, Hutchinson Technical College.

Hutchinson Artificial Intelligence Program, Gary C. Meyer, Hutchinson Technical College.

New Program Development in Minnesota, Craig Oliver, MN State Board of Education.

SUMMARY OF DISCUSSION AND EDUCATION INFORMATION

"Oh, sure, you evaluate and test metals right?" "No I said metrology, not metallurgy." "Oh, you mean you forecast the weather?" "No. Metrology, not meteorology."

So it goes. What is "metrology" anyway. People working as metrologists are continually asked what it is they do. It would be a rare day when someone says, "Oh yeah, precision measurement, my sister-in-law is a metrologist too!" The word metrology comes from the Greek root meteron meaning measure. The dictionary defines it as the science of measurement. It is the same root as that of meter (or metre if you prefer.)

Identification and recognition seems to be one of the biggest problems facing the field of metrology. Another of the problems is that there are so many position titles that actually reflect the work of metrologists, or metrology technicians. Calibration specialist. Electrical calibration technician. Precision measurement specialist. Laboratory technician. Measurement engineer. Quality engineer. And it isn't only the position titles that create confusion. It is also the varied background, experience, and fields of employment that add additional chaos. Aerospace, Nuclear, Medical, Military, Government, Manufacturing. Not only different fields, but different levels within an organization require these specialists. Research and Development. Production. Incoming orders.

The training and education of metrology technicians and metrologists is just as varied as the positions and industries. One recurrent problem identified during the group discussion was that of recognition. How can young students look at the potential of going into a career in metrology when they have no idea that such a thing even exists?

Some of the problems of educators include: Curriculum and Textbook development; Job Placement; Funding; Theory vs Application, Hands On Experience; and as mentioned previously, Name Recognition.

Kate Webster, the NCSL Education Liaison Chairperson, spoke at the meeting at Hutchinson, and discussed some of these problems. Job placement is a problem because metrology is a national market. It is harder to find students when they are told that it is likely they will have to move to get a job. Areas around the schools tend to saturate quickly with graduates. And recruitment of new students is even harder when there are unemployed graduates looking for work. Ms. Webster also discussed some other common problems of hands on experience, theoretical vs practical education and the problem of name recognition.

Ms. Webster briefly discussed some of the details of education available other than that at Hutchinson. She told what the focus of the programs were and about how many students are graduated in the programs.

There are currently only five schools in the entire country that have "Metrology" programs. The schools are:

Butler Community College, Pennsylvania
Lowery Air Force Base, Colorado (military)
Yuba College, California
Macomb County Community College Michigan
Hutchinson Technical College, Minnesota

There are several educational institutions which cover metrology concepts, or offer courses in metrology. Some of which are advanced training courses. Equipment manufacturers many times will also provide training for specific type of equipment. NCSL publishes a Training Information Directory of available programs and courses. The directory also identifies some of the other educational institutions. NCSL also is planning a survey of the metrology field.

Theory, application, hands-on experience, and funding all seem to be tied together. Equipment used is expensive. If available equipment is old or outdated, is it then valuable experience? When donation of equipment or grants from industry to schools was tax deductible it was easier to get up-to-date equipment. But with the changes in the tax codes, it is back to other types of funding to provide needed equipment.
Craig Oliver of the Minnesota Board of Vocational Education also spoke at the NCSL meeting. He noted that new programs are continuously being suggested and placement opportunities must exist for a new program to be approved. New ideas are evaluated, he said, based on availability of existing curriculum, staff, facilities, and equipment, and the placement market. He recognized the non-destructive testing program at Hutchinson as having a national and international market. According to staff at the school, they have trouble recruiting and keeping up with the demand for students skilled in non-destructive testing. It is the largest program at the school.

Herb O'Neil, Hutchinson staff member, discussed the original survey which was done to evaluate the need for a Metrology program at Hutchinson. He recognized Glenn Haigh and Ken Sangren of Unisys for being instrumental on the advisory board for getting the program rolling. He also noted that the Metrology program status has changed this year from being a "new" program to one of "continuous" status. Mr. O'Neil also discussed the problem of educators carrying with them a "snapshot" of what industry was like when they went into education (or management). He said that this is a problem similar to available equipment, in that the snapshot must be kept up to date. He also discussed industry changes and an unsettled job market as affecting student recruitment and placement.

Richard Van Gilder, another HTC staff member, talked about the Metrology program at Hutchinson. He discussed some of the details of the course programs and requirements, and stressed the importance of having internships with industry for benefit of students and industry, for hands on experience as well as a chance to evaluate the educational program. He discussed a grant that was received last year to expand their physical and dimensional section of the metrology program, which started out mostly in the electrical area of metrology.

Gary Meyer, recently joined the staff at Hutchinson Technical College, and is responsible for the Artificial Intelligence (AI) program, which is still in "new" status. He discussed AI as it relates to the science of measurement, and describes it as part of the "art" of measurement. He explained that a central goal of AI is in finding ways to use computers and make computers more useful in metrology, as well as among other areas. One example given is that of automated calibration, which is increasingly being used, and requires individuals to be trained in metrology as well as trained to understand the concepts and interfaces in automated procedures.

Job placement isn't always in a "metrology" position, which leads to poor records for the schools when evaluated. This is one of the problems Hutchinson had in a recent survey done of the Technical Colleges (then Vocational Institutes). How many of the graduates are working in the field of "metrology" with their metrology technician certificates? Many are working in metrology, but job titles don't fit. The acceptable titles list had to be expanded for Hutchinson to get a fair shake with the Metrology program.

During group discussions and questions, many of the problems were again stressed. It was pointed out that in a two year program there is only so much time to cover basic material, and that the graduates will be entry level technicians and will understand concepts more than they will have had a chance to do actual calibrations. But with only five schools in the country offering metrology programs, and none of them four year institutions, there is a lot of room to grow.

The day concluded with a tour of the Hutchinson Technical College facilities. Special emphasis was placed on the non-destructive testing section in addition to the Metrology and Artificial Intelligence programs. Staff members requested that if anything is emphasized that it be: "tell students we are here... and then hire them when we're done."

Special thanks go to the Hutchinson staff members Herb O'Neil, Richard Van Gilder, and Gary Meyer, for their assistance with hosting the meeting and for arranging for lunch for the group. Special thanks also to Kate Webster, Cortez III, NCSL Education Liaison, and Craig Oliver, MN Board of Vocational Education for attending and speaking on the topics.
The Region 11, St. Louis Section, fall meeting was held at AT&T Microelectronics in Lee's Summit, Missouri on October 27th. The meeting was attended by approximately twenty metrology professionals from the Kansas City and St. Louis areas.

Leo Morton, Plant Manager at AT&T Microelectronics, gave the opening address. In the address, Mr. Morton described the changes that have taken place in the structure of AT&T since the divestiture of the Bell system in 1984. One fascinating point that he made is that the management charts at AT&T are drawn “upside down”, reflecting the real function of management in his organization. That function is support of the department the manager is responsible for (as opposed to the directing of the department activities).

Following Mr. Morton’s opening address was an update on some of the current activities of the NCSL. I filled in for John Buck, Region 11 Coordinator, for this part of the meeting, as John was unable to attend.

One unscheduled NCSL activity update was provided by Leon Barnes of Allied Signal Aerospace. Leon briefed us on the recent meeting of the Equipment Management Forum (EMF), held in Manhattan Beach, California, and announced that the 1990 EMF meeting will be held in the Kansas City area in October. Tentative co-hosts will be Allied Signal Aerospace and Bendix/King General Aviation Avionics Division.

I passed on a solicitation, from the Twin Cities Section, for companies interested in participating in a thread plug Round Robin. Bendix/King and Allied Signal Aerospace accepted. (If there are other companies in the St. Louis Section that are interested, please call me at (913) 782-0400 x2652).

Next Norm Belecki, NIST Electricity Division, spoke on making the change to the new representations of the Volt and Ohm. Mr. Belecki offered us some excellent guidelines and tips to help us make the change as smoothly (and painlessly) as possible. While no quiz on the contents of Tech Note 1263 was passed out at the meeting, we are all much more confident, now, that we’ll pass the real “test” on January 1st.

Jack Nally, Hewlett-Packard’s Area Quality Manager for the Great Lakes Region, came all the way from Detroit to tell us about HP’s successes with Total Quality Control. His presentation sparked a lot of discussion on implementing this valuable methodology. Continually monitoring the organization’s processes, with emphasis on the customer’s
needs, is a fundamental part of TQe. That Jack filled in, on short notice, for the originally scheduled speaker from HP's Rolling Meadows office is an indication that the folks at HP try to "practice what they preach".

After a well planned buffet luncheon, provided courtesy of AT&T, we held a photo session and a door prize drawing.

Next, Scott Dunbar, a metrologist at Bendix/King, provided us with some very useful tips on selecting software development packages for automated calibration systems. He also presented many of the advantages of automating calibrations, as well as some of the problems that could crop up and how to avoid them. To illustrate some of the points Scott made during his discussion, a demonstration of the software development package that AT&T uses was given during the plant tour.

The last item on the agenda was a tour of AT&T's impressive facilities. Highlights of the tour (besides the software development demo I just mentioned) were:

- Single In-line Package (SIP) IC test and handling robot
- Tool and gage laboratory
- Meters and standards laboratory
- Automatic connector assembly and test machine
- High speed diode tester (35,000 diodes tested and sorted per hour!)

All in all, the meeting was a very successful one, thanks to the considerable efforts of the folks at AT&T. Special thanks to Lowell Snapp, our host, for the wonderful job he did coordinating the resources at AT&T.

Our next meeting is tentatively scheduled to be a Region 11 meeting, via teleconference, between all three Region 11 sections. This meeting is expected to be held in March or April of next year.
Dick Steiner of NIST detailed the various aspects of the Volt/Ohm changes in 1990.

NIST Technical Note 1263 was made available to all attendees. All attendees received a lot of information and became much better informed as a result of this session.

A sincere thank you to all session/workshop leaders.

Thank you to Scientific Devices, West for morning coffee and pastry donation and Electro-Rent for door prize donation.

I especially would like to thank all attendees and supporting companies for your continued interest and support. I encourage you to contact me with ideas for future meeting and suggestions for improvements.

Attendees of the San Diego Section Meeting, Oct. 25, 1989

Region 3 Coordinator

Region 3 of the NCSL held a semi annual meeting on October 12, 1989. The meeting was held at the Johns Hopkins University, Applied Physics Laboratory. Twenty-two attendees were present. The proceedings of the meeting were as follows:

8:45
Meeting called to order by Wayne Zimmerman. Welcomes and thanks were extended.

8:50
Marlin Johnson welcomes attendees to APL and promises a facility tour upon completion of current renovations.

8:55
John Coleman, APL Metrology Head, spoke of his support to Metrology and NCSL and extended his facility to NCSL for future meetings.

9:00
Dr. Joseph Simmons of NIST gave a NCSL board business update including topics of:

- New Secretary Appointment
- 1989 Conference Meeting
- Future 1990 NCSL Meeting
- Cancellation of Board Meeting due to Hurricane Hugo
- 1990 Call for Papers
- Need for Management Assistance in NCSL
- Announcement of International Measurement Traceability Meeting at NIST on November 17, 1989

9:10
Dr. Bruce Field - "Power Quality at NIST", Dr. Field discussed findings of power quality at NIST, identifying problems and its effects on NIST staff. Tabulating problems and how NIST handles their power quality issues. Dr. Field presented an 8-page brochure explaining the NIST findings to this point.

10:25
Dr. Naresh Dao, Vice President of Millitech discussed Millimeter Wave Technology and its application in military and commercial. A brief history of millimeter developments in the 1980's and near term developments. NIST's millimeter standards were questioned. Source Technologies and Josephson Junction Array Technologies were also discussed.

11:45
Norm Belecki of NIST - 1990 Volt and Ohm Change - NIST Note 1263. A discussion of voltage, ohm, watt, and farad value changes. When to adjust and when not to adjust an instrument to the new standards. How to identify and track newly adjusted instruments. Logistics of the 1990 changes.

12:30
Lunch at APL's cafeteria.

1:30

2:30
Wayne Zimmerman asked for future meeting topics and suggestions. Topic suggestions include, a) Statistics and statistical analysis of measurements, b) Discussion on available professional continuing education tailored to the metrology community, and c) a suggestion was made to host our next NCSL meeting in the Virginia area to promote NCSL participation in this area.
The group broke for a catered lunch, hosted by Apple Computer, Bill Maurer.

After lunch, Glen Berry, Marketing Representative for John Fluke gave a presentation. His topic was "The contribution of software to Audit Survival". Glen showed how a good software could assist the Metrology operations for historical, and real time tracking to meet MIL-STD-45662A. He especially addressed OOT, forward/reverse traceability, reports for management and the cost effective justification of such a system.

Bard thanked all participants and closed the meeting at 1:45 pm.

Bard Dunkelberger, ESL, gave the welcome and introduced Bill Maurer, the host, for general information.

He then made a few announcements, reminding everyone of the August NCSL conference, membership dues are now due, requested meeting place for next year and announcing February as the next tentative meeting.

He then introduced Dr. Klaus Jaeger, Lockheed MSC, manager of Metrology to present the Volt/Ohm change. Dr. Jaeger discussed the history and why/how the changes are taking place. The NIST application booklet was handed out. Dr. Jaeger strongly emphasized the point that changes must be coordinated, planned, and implemented. This change cannot be ignored in the Metrology world.

Afterwards, the group took a break for a group picture, then refreshments.

Bard reconvened the meeting and introduced Gary Davidson, TRW, Metrology Services Manager, and post president of NCSL to lead a discussion on MIL-HNBK-52B.

Gary discussed the NCSL participation in the reviews of MIL-STD-45662A and MIL-HNKB-52B. He then polled the group: "How do you rate the adequacy of MIL-STD?" (1-10). All rated the standard 8-9, except one 3. "How many from DCAS?" 2. "How many are in compliance to MIL-STD-45662?" Approximately 40%. "How many in compliance to MIL-STD-45662?" Approximately 40%. "How many in compliance to MIL-STD-45662A?" None. "How many have contracts that require MIL-STD-45662A?" None.

Gary then made a few observations, which the attendees agreed with and were seeking guidance from the group. 4:1 ratio, review of procedure, OOT, and review of vendors.

Handouts were available, MIL-HNKB-52B, NCSL comments on MIL-HNKB-52B, and a statistical sheet on recommendations.
WELCOME TO OUR NEW NCSL MEMBERS

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