... And in Conclusion ...

Dr. Joe Simmons, NBS Representative....

I would like to formally congratulate Dr. Joe Simmons of the National Bureau of Standards on his appointment to the position of NBS Representative to NCSL. Joe has been a member delegate of NCSL since 1985. Over the years, Joe has served the Organization in the capacity of Regional Coordinator, and in 1987, was elected a Vice President. He served in this capacity until his appointment to the position of NBS Representative. Joe has also had a recent promotion at NBS. He is now the Chief of the Office of Physical Measurement Services. On behalf of the entire NCSL Organization, I would like to congratulate Joe on these appointments.

John Minck, Wildhack Award Recipient...

Each year, the William A. Wildhack award, which is the highest award of the NCSL, is given to an individual or group for outstanding contribution to the field of metrology. This year's well-deserving recipient is Mr. John Minck of the Hewlett-Packard Company.

John, is currently the editor of our quarterly NCSL Newsletter. He has performed in this capacity for the past many years, and to that we are all grateful.

The NCSL Newsletter is more than just another organization's house-organ, it is the vehicle by which we inform and promote the Organization's activities. When done in the professional manner which we have grown accustomed to, the Newsletter is by far one of our most powerful tools.

Again, our congratulations to John Minck and a special thanks to the Hewlett-Packard Company for their many years of support.

1987 Conference...

Another item which I cannot overlook is our spectacular 1987 Conference. I have been receiving numerous compliments on the conference and exhibits, and it makes me proud to have the opportunity to represent the Organization as President. To all the people who put hard work and long hours into arranging the conference and exhibits, we all thank you for a job very well done. With the 1988 Conference arrangements already underway, 1987 will be a tough act to follow, but then again, we have a lot of super people on the 1988 Committee.

In Conclusion...

As I wind down my term, I want to take this opportunity to thank all the people in NCSL who made me look good; the Board, Committee Chairpersons, the tireless Regional organizers, special project and support people. And finally I want to recognize Suzie Mas, my Administrative Assistant who really kept things together in this hectic 1-1/2 years. To all of you, my most heartfelt thanks & best wishes.

Ed Nemeroff, President
EDITOR'S MESSAGE

THE WILDHACK AWARD, WHAT A GREAT SURPRISE!!

Other than total disbelief, my first reaction to Pete England’s announcing my name as 1987 Wildhack recipient was that he somehow had read the wrong name. I have always considered myself one of the cheerleaders, and not one of you members who has labored long and hard in the Metrology trenches. And much as I nag and bluster about it, I really like editing this Newsletter.

There is some poetic justice in all this however. It was just about 2 weeks before the Conference, on a hot summer afternoon, I found myself unloading 1000 pounds of Newsletter mail sacks out of the company station wagon at the Palo Alto Post Office. I remember saying to myself, “Why am I doing this? I’m too old for this”. Well, of course I do know why I do it, and the reason is that it is important for our measurements community.

So it is a very humble editor that thanks NCSL for this award. I want to be sure that every member of NCSL knows that I consider this honor one of the top events of my life. I know that you have put me into pretty rarified company, that of John Fluke Sr. and Dr. Ambler and Dr. Andy Dunn. I promise to keep up the nagging of Industry and Congress to make our National Measurement System the best it can be.

NEWSLETTER QUESTIONNAIRE REPORT

Thanks to about 100 of you, we have a nice sampling of feedback for the survey to rank various sections of the Newsletter. This is all reported on page 36, along with a lot of verbatim and suggestions. The Board and I will be taking all of these comments to heart and trying to meet your expectations for the Newsletter. Actually, the rankings seem fairly good, and I appreciate your good words.

John L. Minck, Editor
Mr. John L. Minck of Hewlett-Packard Company in Palo Alto, Ca, has received the 1987 William A. Wildhack Award from the National Conference of Standards Laboratories (NCSL). The award was presented by Pete England, Chairman of the Wildhack Award Committee on July 12, 1987 during the organization's annual conference in Denver, Colo. The award is presented annually to recognize outstanding contributions to the field of metrology and measurement science, consistent with the goals and programs of the NCSL.

The NCSL is a non-profit international trade association of almost 800 companies and organizations that maintain or have an interest related to measurement standards and calibration facilities. Measurements range from the legal weights and measures required by national and international commerce to the support of research and development of the highest technology systems now being engineered, as typified by the national space efforts.

The award was established in 1970 in honor and recognition of Bill Wildhack, a long-time employee of the U.S. National Bureau of Standards. Mr. Wildhack was not only very instrumental in the founding of the NCSL, but also, through his wisdom, his leadership, his dedication and foresight, he helped shape the organization during its early formative years.

Minck was recognized for over 15 years of volunteer membership in NCSL, starting as Regional Coordinator for the San Francisco Area in 1972, through Director and Vice-President. He was National President for 1977, and for the last 10 years has been Editor of the NCSL Newsletter. The award carries an inscribed plaque, an embossed emblem and a $1000 honorarium.

John Minck has been Marketing Communications Manager for HP's Stanford Park Division in Palo Alto, CA since 1974. He received a BSEE from the University of Notre Dame in 1952 and an MSEE from Stanford University in 1957. After 3 years with the U.S. Atomic Energy Commission and 2 years with the U.S. Air Force, he joined Hewlett-Packard in 1958. Since then, he has held mostly assignments in microwave marketing, including Division Marketing Manager. He also led a product team which developed early light-emitting-diode displays.

Minck is active in the NCSL, the Armed Forces Communications and Electronics Association and a Defense Electronics Association. He has been a resident and lived in Palo Alto with his wife Jane since 1958. He has three adult children. He is a regular contributor to microwave industry magazines and has written numerous articles and papers on measurement technology. He is co-author of a laboratory manual for microwave measurements.

Previous winners of the NCSL Wildhack Award have included John M. Fluke, Chairman, John Fluke Company (now deceased); Dr. Ernest Ambler, Director of the U.S. National Bureau of Standards; Dr. Andrew Dunn, Head of Electrical Standards of the National Research Council of Canada; Doug Strain, President of ESL, Inc; Dr. Bruno Weinschel, Founder of Weinschel Engineering Co. and Dean Brungart, Metrology Manager, Teledyne Systems Co.
Cooling off the Conference power beside the fancy ice carving, Ed Nemeroff, Daron, NCSL President, Bob Weber, Lockheed, Conference Co-Chairman, and Dean Brungart, Teledyne, Exhibits Chairman.

Keynote Astronaut Jim Lovell reminded us of the enthusiastic times of the U.S. Apollo program and specifically of the near-disastrous flight of Apollo 13 which he commanded.

Thank God for those volunteers who help with the local arrangements and registrations; Dorries Schaffner, Helen Valdez, Joan Willshire, Roland Vavken.

Spouses program registration. Denver is a great place to visit and the social program was well received.

The welcoming reception featured a strolling musical group, along with exhibit viewing and cocktails.

This conference probably set the standard for a world-class buffet, Sunday evening.
The future Wildhack winner, blissfully unaware that Pete England was ready to announce his name.

Many of the papers went on with standing-room-only crowds, and had active participation of the listeners. Incidentally, extra copies of the paper proceedings are available from the Business Office.

We had a fine representation of international attendees this year.

The Annual Banquet featured the Colorado Mormon Chorale, who entertained us with a program of patriotic and religious songs.
BGen Ering Royer, Dean of Faculty of the USAF Air Force Academy, told us how the Air Force is integrating computer training into the cadets' life.

Here are two well-deserved awards for unsung heroines; Jo Emery and Dorries Schaffner of the NBS Directors Office who helped with NCSL matters for all the years that the Secretariat resided at the Bureau.

Many of the workshops were handled informally, getting right down to the nitty-gritty details of doing the job.

The wrap-up session rewarded those who persevered to the end with an assortment of door prizes, awarded by Arrangements Chairwoman Suzie Mas and Chairman Jim Ingram. For such demanding jobs, they are both pretty bright and alert as the week winds down. Great job, Suzie and Jim.

Speakers like Lynn Thompson of Butler Community College stayed after their presentation answering questions.

Best Paper Winner, Jim Ingram (c), Lockheed, Runners-up Papers, B.W. Mangum (l), NBS, and Dave Workman (r), Marietta, Denver.
THANKS TO OUR NCSL EXHIBITORS FOR THEIR SUPPORT
AN INDIVIDUAL INSTRUMENT EVALUATION GUIDE

by

James M. Ingram Jr.
Lockheed Missiles and Space Company
0/48-70, B/195A
Sunnyvale, California 94089

ABSTRACT:

Tight budgets and a multitude of products make the selection of test equipment a demanding task for today's metrology organization. If it were only necessary to look for the least expensive instrument, the task would be fairly simple. However this is not the case; technical specifications, training, repair services, parts support, reliability, company policy, warranty, and documentation are some of the myriad considerations in making the selection. Therefore, it is necessary to approach the selection process in a methodical manner.

This paper describes an evaluation system designed as an objective measure of an instrument. Also included are the design requirements of the system as well as methods of application.

THE NEED EXISTS

Buying new test equipment is like trying to buy a new car. There are many manufacturers, models, and options to complicate the choice. But many of us spend more time selecting a new car than we do test instruments. This seems foolish when the test instrument may cost several times as much. When we do take the time to evaluate instruments properly, we've found it is an expensive proposition. The list of possibilities seems endless.

Further complicating the situation is the fact that the same model may be evaluated by different organizations, creating a duplication of effort. Comparing these multiple evaluations reveals yet another problem with the typical system. Everyone has his own ideas on evaluating, and even with an evaluation checklist one winds up with completely different ratings. These ratings may be given in ambiguous terms so that comparisons are difficult, or subjective evaluations are made based on prejudice and the rater's perception of the need for the instrument.

Whether due to inflation, instrument complexity, or technological advances, it is a fact that the cost of instruments is going up. It costs more to evaluate them because of the high price of technician time and the longer evaluation times dictated by increased instrument complexity. The high cost of the hardware required to perform the evaluation adds to an already very expensive process. Any mistakes can be very costly.

How then do we make an intelligent, informed decision on what to buy? We need an objective evaluation system with sufficient detail to guarantee that the proper instrument is selected. The procedure should be easy to perform and should ideally produce the same results regardless of the organization or individual making the evaluation.

WHAT DO WE WANT

Before we can write a procedure we must first define our requirements for a test instrument evaluation system. These requirements can be broken down into several areas.

Objective – The evaluation process should utilize a strictly defined numerical rating system to standardize the way instrument features and capabilities are graded. The scoring system should be easily followed by the rater. Rating questions should be designed to require a definite response with each possible answer assigned a specific score. The process should result in the same ratings regardless of the individual doing the evaluation. This is the true test of the systems objectivity.

Stand-alone – It is very important that the evaluation be based only on the instrument in question. There should be no requirement for a comparison with competing instruments. Comparisons may be made later by equating raw scores or ratings weighted by priorities. The individual evaluation may then be used for other comparisons or even by another organization.

It is very important that the evaluation be based only on the instrument in question. There should be no requirement for a comparison with competing instruments. Comparisons may be made later by equating raw scores or ratings weighted by priorities. The individual evaluation may then be used for other comparisons or even by another organization.

Comprehensive – The evaluation procedure should establish a rating system for every area possible. Unneeded areas may then be skipped for certain projects or types of equipment. The objective is to make the procedure applicable to as wide a range of test instruments as possible.

Evaluate for system compatibility, documentation, ergonomics, technical support, training and parts availability as well as the normal technical evaluation.
Flexible – The format of the evaluation system should lend itself to modification. It should be easy to delete or add sections as required by the needs of the users. The scoring sheets should allow for fast computation of the raw score. The system should be simple to understand and easy to apply the necessary weights dictated by an instrument’s projected use.

Current – Include the latest capabilities possible while still being general in nature. Rate the ability to interface with today’s computers as well as operate in the automated systems becoming so necessary for top productivity. Try to forecast future trends and uses and incorporate the necessary questions to evaluate how well the instrument will meet the need.

Policies – It is necessary that the evaluation system conform to company policies and procedures. There may be policies that set methods of acquisition, standardize instrument groups by manufacturer, or even impose pricing constraints. These rules should be considered in setting up the evaluation system. This is not to say existing policies or procedures may not be changed, but that an easier transition may be made to the new evaluation system if other changes aren’t required at the same time.

THE RESULT

A complete procedure (Appendix A) was written utilizing the requirements listed above. The evaluation was broken down into several sections for ease of use. The overall process is based upon:

A. a review of the manufacturer’s specifications and publications including operation, calibration, and maintenance manuals for the instruments;

B. evaluation of a “Candidate Quality Information Questionnaire” completed by the manufacturer;

C. laboratory testing of the instrument to ensure it meets manufacturer’s stated specifications, including the verification of environmental stress parameters.

Testing is normally done in a calibration laboratory under controlled conditions.

Detailed instructions are provided in Section IV of Appendix A to lead the evaluator through the testing process. These instructions are designed to make the evaluation scheme more objective. Several different persons performing the evaluation should arrive at essentially the same result.

The process was designed to evaluate the following:

A. Instrument design

B. Manufacturer’s support

C. Operator and computer interfaces

D. Documentation

E. Instrument performance

F. Reliability

G. Safety

The scoring method used depended on the specs being evaluated. Initially, there are several Go/No-Go requirements relating to safety and the manufacturer’s QA program. The process may be halted here or continued with special notes made on the reason for the exception. Another method of scoring is to list a series of questions and award one or more points for each question answered with a ‘yes’. Specific points may be assigned in areas where a numeric answer is possible. Using this method, a specific number or range of numbers will translate to a specific score. Also, specific points may be assigned by choosing one of several descriptions or categories. For the laboratory evaluation of the instrument, a score is assigned based on the percent of the parameters tested that pass.

In addition to the evaluation procedure, a “Candidate Quality Information Questionnaire” (Appendix A, Section VIII) was established to provide some input from the manufacturer. Information is requested on the manufacturer’s quality system, reliability data, design techniques, instrument maintainability, and procurement details. This information is then used to fill out part of the evaluation.

A summary sheet (Appendix A, Section VII) is then provided to combine the scores. The summary lists the categories and points that may be earned. There is also room for the evaluator’s comments on the areas checked.

HOW ARE THE RESULTS USED?

Now that we have this in-depth evaluation of the instrument, what do we do with it?

As-is: The raw score may be compared to scores of like instruments evaluated under the same system. This comparison can assist in the final selection of the instrument to be acquired.

Weighted scoring: If some features or criteria, such as training or service availability, are considered more important than usual, you may weight the scores. This is done by multiplying the raw score for those points by a weighting factor greater than one. Each instrument’s raw scores are weighted the same way and a new total score calculated. The
total weighted scores are then compared for the decision process. There are many variations of this method. As another example, each of the scores on the evaluation report may be weighted differently to stress its relative importance. As long as each instrument's scores are weighted the same you can still make an effective comparison.

Added or deleted criteria: Even though the system was designed to be complete, there may come a time when you wish to add to the criteria being evaluated. Simply add the new criteria utilizing the same format as the rest of the evaluation. The scores may be weighted so that the total possible score remains 200 points.

Reducing the criteria is even easier: simply delete those not needed. Again, you may adjust scores by weighting. The comparisons are still valid as long as all instruments are evaluated on the same criteria. Reducing the criteria is an obvious step when a less expensive evaluation process is needed or less stringent requirements are used.

Sharing: One big advantage of having an objective evaluation procedure is the ability to share the results. This may be between divisions or organizations of the same company or even between companies, and can result in savings of time and money for all parties involved.

CONCLUSION
An objective, repeatable evaluation system is needed to save on the increasing cost of the test equipment selection process. It must be flexible enough to be used in any situation requiring a methodical approach to instrument evaluation. Savings will be limited only by the user's ability to adapt this general guide to their specific needs.

APPENDIX A

I. INTRODUCTION
The purpose of this document is to provide an objective rating system to use in the evaluation of General Purpose Test Instruments. The procedure is designed so ratings performed on different instruments by various metrology organizations may be compared for selection purposes.

II. TYPE OF INSTRUMENTS COVERED
The guide is to be used to evaluate commercially produced and catalogued "Off-the-shelf" General Purpose Test Instruments. Such instruments will usually be fully documented by the manufacturer as to their overall construction and operational abilities under both normal and adverse conditions.

III. EVALUATION PROCESS
The evaluation process utilizes a strictly defined numerical rating system to standardize the way instrument features and capabilities are graded. The resulting evaluation may be compared with others performed on like instruments to select the best instrument. As long as the same rating system is used there should be no requirement to retest. The comparison may be accomplished using the raw score. Additional considerations may be added for specific projects or requirements. Evaluation is based upon:

A. a review of manufacturer's specifications and publications including operation, calibration and maintenance manuals for the instrument;
B. an evaluation of the "Candidate Quality Information Questionnaire" (Section VIII);
C. testing of the instrument to ensure it meets manufacturer's stated specifications including verifying environmental stress parameters. Testing is normally done in a calibration laboratory where controlled conditions are maintained.

IV. STANDARD EVALUATION CRITERIA
Use the Instrument Evaluation Report (Section VII) at the end of this procedure and the detailed instructions and rating criteria below to survey the instrument. Have the manufacturer fill out and submit a "Candidate Quality Information Questionnaire" (Section III).

A. Immediate Rejection Criteria
The following areas should be considered first since they are of the Go/No-Go type. A failure here should be the basis for stopping the evaluation. Document the reasons for not continuing on the evaluation report.

1. Manufacturer's QA Program – Does the manufacturer have an established QA program performing inspections on the production line or after product completion? This is a GO/NO-GO requirement. If the manufacturer has no QA program the evaluation should stop here and the model should be rejected. No points assigned.
2. Grounding – Has the manufacturer designed the instrument for proper grounding including case and circuit grounds? This is a GO/NO-GO requirement. If the grounding is not correct the instrument should be dropped from consideration as not safe for use. No points assigned.

B. Design Characteristics

1. Programmability – Does the instrument have the capability to be computer controlled via an IEEE-488 interface? Does the instrument have a built-in self test program? The actual testing of these capabilities is done later in the evaluation. Assign the following points:
0 points – does not have any capability for either self test or IEEE-488 control

2 points – has either self test capability or IEEE-488 capability but not both

4 points – has both self test and IEEE-488 capability

6 points – has extensive IEEE-488 control, self test and fault diagnostic capabilities.

2. Component selection – Evaluate the selection of the components used in the production of the instrument. Each question below answered YES is worth 1 point. There is a possible total of 3 points.
   a. Has the instrument been built with no proprietary parts?
   b. Was the instrument built with few nonstandard or difficult-to-obtain parts?
   c. Were high quality parts used in the construction of the instrument to insure reliability?

C. Service Support Features

1. Service training – Evaluate the training programs offered. Considered schedules, location, cost and depth of training. Each question below answered YES is worth 2 points. There is a possible total of 6 points.
   a. In-depth training is available.
   b. Training is available and is scheduled 3 or more times per year.
   c. The total cost (travel plus tuition) is less than $3000 for each student to attend the course.

2. Factory service centers – Evaluate the time required by the manufacturer’s service center to repair an instrument sent to them. Do not include shipping time as this will vary and may be controlled through the use of certain carriers necessary for the situation. If no previous work with the vendor, check the experience of references against the vendors promised turnaround time. Assign the following points:
   0 points – no manufacturer service centers
   1 point – greater than ten working days for repair
   2 points – 6 to 10 working days for repair
   3 points – 5 or less working days for repair.

3. MTBF – Evaluate the manufacturer’s reported Mean Time Between Failures. This data is part of the Quality Questionnaire (Section VIII)

4. Manufacturers warranty – Evaluate the warranty offered for length and coverage such as parts, labor, shipping costs, and any special considerations. Assign the following points:
   a. Warranty coverage
      0 points – no warranty offered
      1 point – parts OR labor covered but not both
      2 points – full warranty for parts and labor
      3 points – full warranty plus one or more of the following:
         (1) extended warranty available
         (2) loaner unit available during repair time.
         (3) free shipping to and from the repair center is included in the warranty.
   b. Length of warranty
      0 points – no warranty offered
      1 point – less than 1 year
      2 points – 1 year to 3 years.

5. On site service – Assign one point if the service is available and zero points if not available.

6. Replacement parts – Evaluate the manufacturer’s commitment to maintain readily available stocks of replacement parts at the component, printed circuit board or module level. How long will the manufacturer maintain support of the model? Request a certificate from the manufacturer stating how long support will be provided. Assign the following points.
   0 points – manufacturer will not provide a guarantee of support for any period of time
   1 point – manufacturer will guarantee up to 3 years of support
   2 points – manufacturer will guarantee 3 to 5 years of support
   3 points – manufacturer will guarantee over 5 years of support.

7. Notification of design changes – Evaluate the arrangements of the manufacturer to notify users of any changes in the design or production of the model which may affect it’s form or function. Assign the following points:
0 point – only available as a one time request and user must pay for the service.
1 points – only available as on one time request but user in NOT required to pay for the service.
2 points – provided as an ongoing service for a price usually only paying after the warranty runs out.
3 points – provide all design change notifications at NO cost to the user for the life of the model.

D. Instrument – Operator Interface

1. Bus control implementation – Evaluate the degree of conformance of the manufacturer's specifications with the interface and technical specifications of the ideal IEEE-488 control bus. Assign the following points:

- 0 points – not compatible without major adaptations to the software, firmware or hardware.
- 4 points – compatible with only minor changes.
- 6 points – fully compatible implementation of the IEEE-488 specifications.

2. Instrument operation – Evaluate the extent to which the manufacturer has attempted to make the instrument safe and easy to operate. Each question below answered YES is worth 2 points. There is a possible total of 12 points.

a. Can the front panel controls be programmed through the IEEE-488 interface?
b. Have the front panel controls been located in a manner to promote ease of operation?
c. Has the manufacturer used displays that are flexible and easy to understand?
d. Are there indicators to warn of dangerous conditions?
e. Has the manufacturer built in safeguards to prevent an operator from sustaining injury through use of the instrument?
f. Has the manufacturer built in safeguards to prevent damage to the instrument through misuse by the operator?

c. Have adequate protection schemes been employed to guard against hazardous conditions during repair or adjustment?
d. Are all components, subassemblies and electrical connections securely supported to provide suitable protection against environmental conditions existing during normal handling and operation of the unit?
e. Have adequate provisions been made for heat dissipation and protection from the effects of moisture, contamination and ESD?
f. Are interconnecting wires wrapped in bundles and routed to avoid interference with service and repair operations?

2. Servicing capabilities – Evaluate how well the manufacturer has designed the instrument from a service standpoint. Each question below answered YES is worth 2 points. There is a possible total of 18 points.

a. Are the built in fault diagnostics effective in determining the cause of a failure to the subassembly, printed circuit board or component level?
b. Are test points provided that are clearly marked and readily accessible with minimum disturbance of other parts?
c. Are preventive maintenance procedures provided by the manufacturer?
d. Can the instrument be serviced or calibrated without the use of special test fixtures?
e. Is the mean time to repair less than 4 hours? Do not assign any points if there is no figure available.
f. Are the internal calibration references accurate, stable and protected from the effects of the operating environment?
g. Are calibration procedures provided for calibration of all functions and parameters?
h. Do programmed calibration procedures check 90% or more of the functions and parameters?
i. Are the calibration procedures valid and do they call for adequate calibration standards?

E. Instrument Design

1. Instrument construction – Evaluate how well the manufacturer has designed the instrument from a mechanical standpoint. Each question below answered YES is worth 3 points. There is a possible total of 18 points.

a. Has the instrument been designed using easily removed subassemblies to facilitate repair?
b. Are necessary adjustments easily accessible without disassembly

c. Have adequate protection schemes been employed to guard against hazardous conditions during repair or adjustment?

F. Documentation

Manuals and documentation – Evaluate how well the manufacturer has documented the instrument. Each question below answered YES is worth 1 point. There is a possible total of 12 points.

a. Are the manuals provided clearly written and illustrated for ease of understanding and use?
b. Are separate sections provided for alignment?
c. Are cautionary notes and warnings clearly defined?
d. Does the instrument specification sheet fully describe the capabilities and limitations of the instrument?

e. Are instructions provided for installation, operation, programming and calibration of the instrument?

f. Does the manual provide sufficient theory of operation necessary to analyze and isolate problems within each subassembly? Adequate references should be made to block or schematic diagrams to correlate the text with the instrument components.

g. Are fault isolation procedures and servicing instructions complete and easy to understand? The procedures should provide a list of necessary tools, special test fixtures and test instruments. Software fault isolation procedures should be well documented.

h. Do calibration procedures fully describe calibration steps and adjustments and provide a list of necessary tools, special test fixtures and test instruments?

i. Are all parts, components and subassemblies properly identified in a parts list containing the component reference designation, description, part number and manufacturer?

j. Are schematic and interconnect diagrams provided for all electrical parts of the instrument?

k. Does the manufacturer provide a description of the operation of internal software programs?

l. Are mechanical drawings provided to assist in the installation, repair, identification and location of all parts, including printed circuit board components and traces?

G. Performance Verification

The performance verification is performed to verify the manufacturer's stated operating specifications under user conditions and environmental stress. Evaluate each of the following areas and assign the points as indicated. This section has a total possible score of 100 points.

1. Conformance to specifications – Verify that the unit is capable of meeting the requirements for each parameter specified by the manufacturer over extremes of the operating range. Count the total number of parameters checked and divide this into the number of parameters that met specifications. This is the fraction of parameters that meet specifications. Multiply this number times 60 to determine the number of points to assign. Round the answer to the next whole point. The maximum score is 60 points if all parameters are met. Document in detail any parameters not met.

2. System interfaces – Verify that connecting the instrument in a system or through interfaces does not cause degradation of performance of other instruments under operating conditions. This is a very important consideration. If degradation results then seriously consider terminating the test and documenting the reason for failure in the comment section of this evaluation. Assign 20 points for a pass condition and zero points for a failure.

3. Environmental stress – Verify the instrument meets manufacturer's stated parameters for temperature and humidity environmental changes. Count the total number of parameters checked and divide this into the number of parameters that met specifications under environmental stress. This is the fraction of parameters that meet specifications. Multiply this number times 20 to determine the number of points to assign. Round the answer to the next whole point. The maximum score is 20 points if all parameters are met. Document in detail any parameters not met.

V. USING THE RESULTS

Adding all of the points together will give a possible score of 200 points. This may now be compared directly to another instrument rated under the same system.

VI. CONCLUSION

This procedure may not provide the full evaluation necessary for selection of an instrument for a particular project. It will establish a method for a general rating of an instrument usable by others applying the same system of standard scoring.
VII. INSTRUMENT EVALUATION REPORTS

Manufacturer: ________________________________     Engr.: ____________
Model Number: ________________________________    Tech.: ____________
Nomenclature: __________________________________ Date: ____________

Maximum points possible noted for each section in ( ).

A. Immediate Reflection Criteria
   (Go/No-Go)
   1. Manufacturer's QA program
   2. Grounding
      Comments:

B. Design Characteristics
   POINTS
   1. Programmability (6)
   2. Component selection (3)
      Comments: Subtotal (B): ____________

C. Service Support Features
   POINTS
   1. Service training (6)
   2. Factory service centers (3)
   3. MTBF (3)
   4. Manufacturer's warranty
      a. Warranty coverage (3)
      b. Length of warranty (3)
   5. On site service (1)
   6. Replacement parts (3)
   7. Notification of design changes (3)
      Comments: Subtotal (C): ____________

D. Instrument – Operator Interface
   POINTS
   1. Bus control implementation (6)
   2. Instrument operation (12)
      Comments: Subtotal (D): ____________

E. Instrument Design
   POINTS
   1. Instrument construction (18)
   2. Servicing capabilities (18)
      Comments: Subtotal (E): ____________

F. Documentation
   POINTS
   Manuals and documentation (12)
      Comments: Subtotal (F): ____________
G. Performance Verification

1. Conformance to specifications (60)

\[
\left(\frac{\text{# parameters met spec.}}{\text{total parameters checked}}\right) \times (60) = \left(\frac{\_}{\_}\right) \times (60) = \_ \\
\]

2. System interfaces (20)

Subtotal (G): 

3. Environmental stress (20)

\[
\left(\frac{\text{# parameters met spec.}}{\text{total parameters checked}}\right) \times (20) = \left(\frac{\_}{\_}\right) \times (20) = \_ \\
\]

Comments:

CONSOLIDATED SCORE

Subtotal (A) 

Subtotal (B) 

Subtotal (C) 

Subtotal (D) 

Subtotal (E) 

Subtotal (F) 

Subtotal (G) 

Final Total: 

POINTS

(VGo/No-Go)

(9)

(25)

(18)

(36)

(12)

(100)

(200)

General Comments:

VIII. SUPPLIER CANDIDATE QUALITY INFORMATION

Please answer as clearly and concisely as possible, ALL questions on this questionnaire. Failure to answer ALL of these questions could automatically disqualify potential supplier participants. This information will be handled confidentially.

Supplier Company Name: 

Candidate instrument Name: 

Model Number *:

* If a newer model is available please so indicate.

I. QUALITY

A. A copy of the Company’s quality control policies and procedures for this instrument candidate is enclosed.

YES ; Comments:

B. A copy of a simplified quality production flowchart for this instrument is enclosed.

YES ; Comments:

II. RELIABILITY

A. Mean-Time-Between-Failures (MTBF)

MTBF: ___ hours.

Note: MTBF calculations shall be performed in accordance with Mil-Hdbk-217D Notice 1, section 5.2, using Ground Fixed (G.F.) environment. Documentation providing the details of the calculations shall be included with this questionnaire.

B. Environmental tests performed on this instrument. Please include test levels and specifications during development and for production.

1. Temperature

   (a) Burn-in:
   
   (b) Cycling
   
   (c) Other

2. Vibration

   (a) Random:
   
   (b) Sinewave:
   
   (c) Other:

3. Other environments

   Comments:
Note: If selected, will you authorize a loaner (for about 1 month) for evaluation tests with temperature and humidity cycling.
YES/NO Comments/Concerns:

C. Design Techniques
1. Thermal
   (a) Heat sinks. Comments:
   (b) Airflow direction. Comments:
   (c) Other methods. Comments:
   (d) Thermo survey performed (hot spot detection etc.) Comments:

2. Electrical
   (a) Stress relating criteria. Comments:
   (b) Component quality (Mil-spec., commercial, hermetic and non-hermetic). Comments:
   (c) Was design independently evaluated by Q.A.? Comments:

3. Mechanical
   (a) Type of card/module design (edge cards etc.) Comments:
   (b) Type of Plating (gold, silver etc.) Comments:
   (c) IC mounting technique (soldered, sockets etc.) Comments:

D. Type of parts utilized (custom or standard) in your instrument.
1. What percentage of parts and their names are proprietary/custom versus design standard? Comments:
2. How long have these parts been in service? Comments:

E. Safety
Does the instrument meet safety standards? Which standards? (OSHA, UL etc.)
Comments:

III. MAINTAINABILITY

A. Mean-time-To Repair (MTTR)
   1. MTTR Min./hours.
   2. Predicted or operational?
   3. Where and how was data established? Comments:
   4. What environmental conditions? Comments:

B. Service manuals (describing theory of operation, schematics, parts list, servicing, and calibration)
   1. Two copies of service manual must be submitted with this questionnaire. Comments:

C. Training
   1. Training locations:
   2. Type of training available:
   3. What conditions (cost, scheduling, prerequisites etc.) Comments:
STANDARD REFERENCE MATERIALS FOR USE IN PRECISION THERMOMETRY

by

B.W. Mangum
Temperature and Pressure Division
Center for Basic Standards
National Bureau of Standards
Gaithersburg, MD 20899

ABSTRACT

Several Standard Reference Materials (SRMs) have been developed at the NBS in recent years for use in precision thermometry. They are either fixed-point materials or devices with fixed-point temperatures in the range from 0.015 K to 2053°C. This article reviews the use and importance of thermometric fixed points in precision thermometry and of SRMs that are providing some of those fixed points.

INTRODUCTION

International temperature scales (ITS) are defined by means of temperature fixed points, standard thermometers for interpolating between their defining fixed points, and specified equations that describe the behavior of the standard thermometers at temperatures between the fixed points. Generally, a thermometer other than one of the standard types is required for a given application, however, and its operating range may be over such a limited range of temperatures or the temperature dependence of its thermometric property requires so many calibration points that its calibration at any of the temperature fixed points defining the scale or at only those fixed points of the scale may be precluded or insufficient in number. Consequently, the working thermometer must be calibrated either by comparison against a standard thermometer (or another thermometer for which the accuracy of its calibration is considerably greater than that required of the working thermometer) or by the use of secondary fixed points, if a sufficient number of them exist in the region of interest.

If the number of temperature fixed points in the region of interest is sufficient, then calibration by the fixed-point method is the easiest and most accurate method to use. Devices providing fixed-point temperatures not only provide a uniform environment for calibration of thermometers but also they may provide reference points for various biomedical tests and a convenient way of checking the calibration of a thermometer prior to and after its use. Temperature fixed points thus play a major role in precision thermometry. In recent years, several temperature fixed-point materials and devices have been established at the National Bureau of Standards (NBS) as Standard Reference Materials (SRMs). Their fixed-point temperatures extend over the range from 0.015 K to 2326 K and they may easily be precisely and accurately realized. A description of these SRMs and some of their applications will be presented. Fixed-point devices currently under investigation for feasibility to be SRMs will be discussed briefly also.

FIXED POINTS AND TEMPERATURE SCALES

Although the first thermometer was invented only in about 1592 (by Galileo [1]), people from prehistoric times have been interested in heat and temperature. It was only in the eighteenth century, however, that the concept of temperature began to be developed. In the latter part of the seventeenth century, temperature scales began to be devised but their dependence on the properties of the thermometric fluids was not recognized. For example, in 1665, Robert Boyle, Robert Hooke, and Christian Huygens suggested independently that thermometers could be calibrated effectively from a single fixed point, but there was no consideration of what fluid to use.

The first efforts to construct a scale based on two fixed points came in 1669 when Fabri suggested the melting point of snow as the lower temperature and the “greatest summer heat” as the upper. In 1694, Renaldini proposed the freezing and boiling points have been included as defining points of almost all temperature scales, either explicitly or in practice, ever since. The Celsius scale, previously called the Centigrade scale, that is in use today was based originally on the freezing and boiling points of water, at 0°C and 100°C, respectively, as the two fixed points. The centigrade scale may have been suggested as early as 1710 by Elvius but between 1740 and 1745, it was proposed again, apparently independently, by Linnaeus and by Anders Celsius, after whom the scale is named.

In the nineteenth century, temperature began to take a fundamental position in thermodynamics that was being developed at that time. The kinetic theory of gases developed by Maxwell and Boltzmann in the middle of the nineteenth century aided in an understanding of the relationship of temperature to other basic physical quantities. The final link between the thermodynamical definition of temperature and the rest of physics came with the statistical mechanics of Boltzmann and Gibbs in 1902.

In 1848, William Thomson (Lord Kelvin) proposed a scale of temperature based on the efficiency of an ideal reversible heat engine [2], which is dependent only on the limits of temperature between which it works. Sadi Carnot had characterized
the ideal heat engine in 1824 ("the Carnot cycle"). This thermodynamic temperature scale (known as the Kelvin Scale) can be made identical to the ideal-gas or absolute temperature scale developed by Amontons, Charles, Dalton, Gay-Lussac and Regnault if the values are selected to be identical at one finite temperature. Both scales have an absolute zero of temperature; the size of the temperature unit (the kelvin) is determined by specifying the triple point of water to be 273.16 K.

Gas thermometry has been the most widely used technique for measuring thermodynamic temperatures. Thermodynamic temperatures, however, are very difficult to measure accurately and for this reason internationally agreed-upon practical scales have been developed and promulgated, beginning with the ITS-27. Such scales are based (1) on temperature fixed points (equilibrium states of pure substances to which temperatures as close to thermodynamic temperatures as possible have been assigned), (2) on standard thermometers that are calibrated at those points and used for interpolating between them, measured physical (thermometric) property of the standard thermometers. These scales, essential for science, technology, and commerce, yielded temperatures as close to thermodynamic temperatures as possible at the time of their adoption. The latest internationally accepted scale is the International Practical Temperature Scale of 1968, amended edition of 1975 (IPTS-68 (75) [3]. This scale extends upward without bound from 13.81 K. The fixed points of this scale are listed in Table 1. The standard thermometer for the range 13.81 K to 903.89 K is the platinum resistance thermometer (SPRT); for the range 903.89 K to 1337.58 K, the standard thermometer is the thermocouple. The optical pyrometer is used above 1337.58 K, using Planck's radiation law, and the freezing point of gold (1337.58 K) as the reference point.

From this brief discussion of thermometry and temperature scales, we see that thermometric fixed points have been and still are extremely important in thermometry, both for definition of a scale and as the basis for calibration of thermometers, one of the means by which scales are promulgated. Materials suitable for use in producing some of the defining fixed points of the IPTS-68 (75) are available from the NBS as SRMs. Some SRMs (actually, thermometric devices) that are suitable for use in accurate calibration of thermometers other than the standard thermometers are available also. These latter SRMs probably have greater general utility than those for the defining fixed points since the thermometers for which these SRMs are designed are much more widely used than the SRTs.

REQUIREMENTS FOR PRECISE AND ACCURATE THERMOMETRY

A. General Considerations

If one is to perform accurate and precise thermometry, care must be taken (1) in selecting the appropriate thermometer for the application, (2) in calibrating that thermometer, and (3) in the appropriate use of that thermometer. In many cases, the irreproducibility of the thermometer is the major contributor to the total uncertainty of temperature measurements. The error from this source can be determined by checking the thermometer at one or more well-defined and reproducible fixed points. Such checks can determine both the irreproducibility upon thermal cycling over the temperature range of the application and the irreproducibility upon routine handling. Fixed points used for this purpose, for calibration, and/or for checking the calibration drift of a thermometer must be well characterized, stable with time, accurately and precisely reproducible, and accurately and precisely realizable. Of course, uncertainties originating with instrumentation used in the measurements must be known also.

The reproducibility of a thermometer used in a given application, the accuracy and precision with which fixed-point temperatures are realized during their use in calibration of that thermometer, and the accuracy and precision with which the thermometer is calibrated determine the overall accuracy attainable with that thermometer if it is properly used. Some SRMs that meet the requirements of fixed points for use in precise and accurate thermometry have been developed by and are available from the NBS. Work on additional fixed-point devices as SRMs is currently in progress at the NBS.

B. Thermometers

There are numerous kinds of thermometers but the types used in precision thermometry are rather limited. Other than the standard thermometers specified by the IPTS-68(75), there are industrial platinum resistance thermometers (IPRTs), liquid-in-glass thermometers, thermistors, germanium resistance thermometers and rhodium-iron resistance thermometers. The last two named are used primarily below 30 K and require many calibration points for an accurate calibration; consequently, their calibration by the fixed-point method (in which only fixed points are used) is not possible. In the moderate temperature range, i.e., from −50 °C to 200 °C, thermistors are the most precise thermometers available for general, routine use. Since the SPRT, the standard thermometer in this region, is large, fragile, sensitive to vibrations, expensive, requires deep immersion, and requires elaborate equipment for its use, it is not suitable for routine laboratory use. At temperatures above about 200 °C, the IPRT is probably the most precise, stable and reproducible thermometer for routine use. Liquid-in-glass thermometers are large, require deep immersion, are slow to respond, are fragile, and are not easily adapted to automation. Total immersion mercury-in-glass thermometers can have uncertainties as small as ± 0.03 °C, however, in the region from 0 °C to 100 °C, partial immersion thermometers have uncertainties no smaller than ± 0.3 °C and, thus, are not classified as precision thermometers. There are special...
thermometers, SRM 934, which are of the partial immersion type and, yet, because of their limited temperature range, have uncertainties no greater than $\pm 0.03$ °C. Their range is from 24 °C to 38 °C, with a scale at 0 °C also. They are used primarily in enzymology applications.

C. Temperature Fixed or Reference Points and Those Provided by SRMs

Table 1 lists the temperature fixed points used in the definition of the IPTS-68 [75]. As can be seen, thirteen fixed points cover the range from 13.81 K to 1337.58 K. Although there are no SRM devices available for realizing any of these points, the SRMs listed in table 2 are the pure metals with which to prepare tin and zinc fixed-point cells. The total uncertainty (systematic and random) associated with realizing each of these points can be as small as $\pm 1$ mK. This is the value realized in the NBS Platinum Resistance thermometer Calibration Laboratory in routine calibrations of SPRTs. Using just the freezing points of tin and zinc and the triple point of water, SPRTs can be calibrated for use from $-50$ °C to 631 °C. This range includes most of the industrial applications requiring precision thermometry. Consequently, SRMs 740 and 741 are extremely valuable. Errors propagated from the $\pm 1$ mK calibration errors at each of the tin and zinc freezing points sum to approximately $\pm 1$ mK for all temperatures below 420 °C. At temperatures above 420 °C, however, each of the errors increases monotonically to an amplification of about 3.5 at 631 °C, resulting in a total uncertainty from calibration of $\pm 7$ mK at 631 °C.

Table 3 lists SRMs which can be used to prepare some secondary fixed-point devices. The tin and zinc SRMs, numbers 42g and 43h, listed in Table 3 are less pure than SRMs 741 and 740, resulting in lower freezing-point temperatures, although not significantly so for many applications. Aluminum, copper, lead and mercury freezing points currently are only secondary reference points but some of them will probably become defining fixed points of the next ITS. Temperature fixed-point cells prepared from the SRMs of Table 3, with the possible exception of copper, yield freezing-point temperatures reproducible to $\pm 1$ mK.

In addition to SRMs consisting of materials to be used in preparing temperature fixed-point cells (see Tables 2 and 3), there are some SRMs consisting of fixed-point devices, ready to be used in the realization of internationally accepted secondary fixed points. These SRM devices are listed in Table 4. The temperatures realized with the gallium melting-point cells [4], the succinonitrile triple-point cells [5,6], and the indium freezing/melting-point cells are reproducible to $\pm 0.1$ mK, $\pm 0.5$ mK and $\pm 0.1$ mK, respectively, with a total uncertainty of $\pm 0.6$ mK, $\pm 1.5$ mK and $\pm 2.0$ mK, respectively. The rubidium used for SRM 1969 is less pure than the gallium, succinonitrile and indium in SRMs 1968, 1970 and 1971, respectively, and, consequently, the temperature realized with SRM 1969 is less reproducible [7]. The uncertainty associated with the realization of the rubidium freezing point is $\pm 5$ mK.

The gallium melting-point standard, SRM 1968, consists of about 26 grams of 99.9999% pure gallium in an all-plastic cell. It is widely used (1) in clinical chemistry laboratories where the temperature realized with it is the reference temperature for enzyme reactions, (2) in calibrations of thermistors and SPRTs, and (3) as a reference point for checking the calibration of thermometers.

The succinonitrile triple-point standard, SRM 1970, is a fairly new SRM which became available in December 1984. It consists of about 60 grams of 99.999% pure succinonitrile in an all-glass cell. The succinonitrile was provided by zone refining, generally, with 3 cells being prepared from each zone-refined lot. Due to the possibility of differing amounts of impurities in the cells, each cell was tested for suitability to serve as SRM 1970. All cells with triple-point temperatures below $58.0785$ °C were rejected as too impure. We started with 115 cells. One of the cells broke during tests and of the remaining 114 cells tested, 109 met the requirements for suitability. SRM 1970 has been found to provide an excellent point for the calibration of thermistors [8]. In fact, it was found that if thermistors were calibrated at the succinonitrile triple-point temperature (provided by SRM 1970), at the gallium melting-point temperature (provided by SRM 1968), and at the triple-point temperature of water, temperatures determined by the thermistors agreed with those determined with SPRTs to within 1 or 2 mK over the range from 0 °C to 70 °C.

The rubidium freezing-point temperature provided by SRM 1969 is sufficiently reproducible to serve as a good-quality point for calibration and as a reference or check point for analyses conducted at or near body temperature. Each of the all-stainless-steel cells of SRM 1969 contains about 154 grams of 99.9% pure rubidium.

The indium freezing/melting point standard, SRM 1971, with a fixed-point temperature of $156.635 \pm 0.002$ °C, is a new SRM that was developed to meet the needs of the biomedical and clinical laboratory communities at the high temperature end of their precision thermometry range and of industrial laboratories in the moderate temperature range. SRM 1971 consists of 100 grams of 99.99999% pure indium in an all-plastic cell sealed with an organic epoxy under a dry argon atmosphere. The stated uncertainty of $\pm 2$ mK is the estimated total uncertainty in the freezing-point temperature of indium as realized in SRM 1971. SRM 1971 can be used to calibrate thermometers that have diameters less than 4.4 mm and that require an immersion in the uniform environment of the indium at its liquid-solid transition temperature of no more than 7.0 cm. A high-temperature silicone fluid should be placed in the well of the cell to promote good thermal
contact between the thermometer and the liquid-solid interface of the freezing indium.

The temperature fixed points discussed here so far have been in the region of the IPTS-68(75). Although the low temperature end of this scale is 13.81 K, there is a need of a scale at lower temperatures. There have been several national low-temperature scales in existence for a number of years and in an effort to unify those scales, the 1976 provisional 0.5 K to 30 K Temperature Scale (EPT-76) was adopted [9]. The fixed points defining that scale are given in Table 5. Note that some of those fixed point are superconductive points, i.e., temperatures of transitions from the normal to the superconductive state. These are second-order transitions and, thus, do not themselves provide a uniform temperature environment for calibration as do first-order transitions (such as the liquid-solid transition). Those superconducting points may be realized through the use of SRM 767a, listed in Table 6. Also listed in Table 6 are the five components of SRM 786, covering the range from 0.015 K to 0.2 K. Although industrial applications at temperatures in the range of these SRMs are very limited, these SRMs are useful to those who wish to determine the temperature reproducibility of physical phenomena or of cryogenic equipment in this temperature range.

SRMs THAT ARE BEING DEVELOPED CURRENTLY AT NBS

The oncology community involved in cancer therapy by hyperthermia needs two temperature fixed points, in the form of fixed-point devices, bracketing the hyperthermia region, with one providing a reference point near 41-42 °C and the other having a reference point in the vicinity of 44-45 °C. These are needed in order to be able to accurately check, at the time of use, the calibration of thermometers used during the hyperthermia treatment. Several materials are candidates for use at these temperatures. Some of these are phenol at about 41 °C and n-lauric acid or n-docosane at about 44 °C. Investigation of these three materials is in progress, and from preliminary measurements on them, it appears that the development of these points as fixed points is feasible. The triple-point temperatures are at the right values, and if we can purify the materials sufficiently and if they are stable and have reproducible triple-point temperatures, they should make excellent fixed points for hyperthermia applications. This would then lead to one or two SRMs (devices) which could significantly improve the current state of the thermometry involved in these applications.

SUMMARY AND CONCLUSIONS

There are several SRMs consisting of devices which are intended for use in preparing temperature fixed-point cells, some to be used for realizing the IPTS-68(75) and some to be used for realizing secondary fixed points. In addition, there are several SRMs consisting of devices which may be used directly in the realization of fixed-point temperatures, either very important secondary fixed points in the moderate temperature range or as defining points of the EPT-76. Materials with fixed-point temperatures suitable for use as calibration check points for thermometers used in cancer therapy by hyperthermia are currently being investigated and, when that work is completed, devices containing those materials will be established as SRMs. It is anticipated that these will be available in 1988 or 1989.

REFERENCES


9. 1979, The 1976 Provisional 0.5 K to 30 K Temperature Scale, Metrologia, Vol. 15, pp. 65-68.
<table>
<thead>
<tr>
<th>Equilibrium State</th>
<th>$T_{68}(K)$</th>
<th>$t_{68}^{(C)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triple point of equilibrium hydrogen</td>
<td>13.81</td>
<td>-259.34</td>
</tr>
<tr>
<td>Boiling point of equilibrium hydrogen</td>
<td>17.042</td>
<td>-256.108</td>
</tr>
<tr>
<td>Boiling point of equilibrium hydrogen at 25/76 standard atmosphere</td>
<td>20.28</td>
<td>-252.87</td>
</tr>
<tr>
<td>Boiling point of neon</td>
<td>27.102</td>
<td>-246.048</td>
</tr>
<tr>
<td>Oxygen triple point</td>
<td>54.361</td>
<td>-218.789</td>
</tr>
<tr>
<td>Argon triple point</td>
<td>83.789</td>
<td>-189.352</td>
</tr>
<tr>
<td>Condensation point of oxygen</td>
<td>90.188</td>
<td>-182.962</td>
</tr>
<tr>
<td>Triple point of water</td>
<td>237.16</td>
<td>0.01</td>
</tr>
<tr>
<td>Boiling point of water</td>
<td>373.15</td>
<td>100</td>
</tr>
<tr>
<td>Freezing point of tin</td>
<td>505.1181</td>
<td>231.9681</td>
</tr>
<tr>
<td>Freezing point of zinc</td>
<td>692.73</td>
<td>419.58</td>
</tr>
<tr>
<td>Freezing point of silver</td>
<td>1235.08</td>
<td>961.93</td>
</tr>
<tr>
<td>Freezing point of gold</td>
<td>1337.58</td>
<td>1064.43</td>
</tr>
</tbody>
</table>

Table 2. SRMs of such purity that they are suitable for use in realizing fixed points of the IPTS-68(75).

<table>
<thead>
<tr>
<th>SRM</th>
<th>Type</th>
<th>$t_{68}^{(C)}$ (grams)</th>
<th>Wt./Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>740</td>
<td>Zinc, 99.9999%</td>
<td>419.58</td>
<td>350</td>
</tr>
<tr>
<td>741</td>
<td>Tin, 99.9999%</td>
<td>231.9681</td>
<td>350</td>
</tr>
</tbody>
</table>

Table 3. SRMs (materials) intended for use in preparing secondary reference-point cell.

<table>
<thead>
<tr>
<th>SRM</th>
<th>Type</th>
<th>$t_{68}^{(C)}$ (grams)</th>
<th>Wt./Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>42g</td>
<td>Tin</td>
<td>231.967</td>
<td>350</td>
</tr>
<tr>
<td>43h</td>
<td>Zinc</td>
<td>*419.58</td>
<td>350</td>
</tr>
<tr>
<td>44f</td>
<td>Aluminum</td>
<td>660.3</td>
<td>200</td>
</tr>
<tr>
<td>45d</td>
<td>Copper</td>
<td>1084.8</td>
<td>450</td>
</tr>
<tr>
<td>49e</td>
<td>Lead</td>
<td>327.493</td>
<td>600</td>
</tr>
<tr>
<td>743</td>
<td>Mercury</td>
<td>-38.841</td>
<td>680</td>
</tr>
<tr>
<td>742</td>
<td>Alumina, 99.9 + %</td>
<td>2053</td>
<td>10</td>
</tr>
</tbody>
</table>

*SRM 43h is less pure than SRM 740 and has a freezing point 0.001 °C lower.
### Table 4. SRM devices for realizing some secondary reference points.

<table>
<thead>
<tr>
<th>SRM</th>
<th>Type</th>
<th>( t_{68}(^\circ C) )</th>
<th>Wt./Unit (grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1968</td>
<td>Gallium, 99.9999 + %</td>
<td>29.7723</td>
<td>25</td>
</tr>
<tr>
<td>1969</td>
<td>Rubinum, 99.9 + %</td>
<td>39.30</td>
<td>150</td>
</tr>
<tr>
<td>1970</td>
<td>Succinonitrile, 99.999 + %</td>
<td>58.0796</td>
<td>60</td>
</tr>
<tr>
<td>1971</td>
<td>Indium, 99.9999%</td>
<td>156.635</td>
<td>100</td>
</tr>
<tr>
<td>934</td>
<td>Termometers for enzymology</td>
<td>24-38</td>
<td></td>
</tr>
</tbody>
</table>

### Table 5. Reference points of the EPT-76.

<table>
<thead>
<tr>
<th>Reference Point</th>
<th>( T_{76}(K) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superconducting transition point of cadmium</td>
<td>0.519</td>
</tr>
<tr>
<td>Superconducting transition point of zinc</td>
<td>0.851</td>
</tr>
<tr>
<td>Superconducting transition point of aluminum</td>
<td>1.179 6</td>
</tr>
<tr>
<td>Superconducting transition point of indium</td>
<td>3.414 5</td>
</tr>
<tr>
<td>Boiling point of ^4He</td>
<td>4.22 1</td>
</tr>
<tr>
<td>Triple point of equilibrium hydrogen</td>
<td>13.804 4</td>
</tr>
<tr>
<td>Boiling point of equilibrium hydrogen at 25/76 standard atmosphere</td>
<td>17.037 3</td>
</tr>
<tr>
<td>Boiling point of equilibrium hydrogen</td>
<td>20.273 4</td>
</tr>
<tr>
<td>Triple point of neon</td>
<td>24.559 1</td>
</tr>
<tr>
<td>Boiling point of neon</td>
<td>27.102</td>
</tr>
</tbody>
</table>

### Table 6. SRM devices for use at low temperatures and for realizing some temperature of the EPT-76.

<table>
<thead>
<tr>
<th>SRM</th>
<th>Type</th>
<th>Material</th>
<th>Nominal T (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>767a</td>
<td>Superconductive Thermometric</td>
<td>Niobium</td>
<td>9.3</td>
</tr>
<tr>
<td></td>
<td>Fixed Point Device</td>
<td>Lead</td>
<td>7.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Indium</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aluminum</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zinc</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cadmium</td>
<td>0.5</td>
</tr>
<tr>
<td>786</td>
<td>Superconductive Thermometric</td>
<td>Gold-Indium</td>
<td>0.205</td>
</tr>
<tr>
<td></td>
<td>Fixed Point Device (Low)</td>
<td>Gold-Aluminum</td>
<td>0.157</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Iridium</td>
<td>0.098</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beryllium</td>
<td>0.024</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tungsten</td>
<td>0.015</td>
</tr>
</tbody>
</table>
METHODS FOR CALIBRATION OF VIBRATION MEASUREMENT REFERENCE STANDARDS

by

David R. Workman
Engineering Group Leader
Martin Marietta – Denver Aerospace Metrology
Denver Colorado

ABSTRACT

This Paper will discuss the methodologies which can be used by a Metrology Laboratory to calibrate Vibration Reference Systems and maintain a capability with legitimate traceability based on dimensional, physical, electrical and/or defined physical constant units.

INTRODUCTION

A common industry misconception is that legitimate traceability is only obtained by having "Artifact Standards" calibrated by the National Bureau of Standards (NBS). Less recognized is the fact that many standards can be legitimately derived from other traceable measurement units. Given adequate capability in the fundamental areas of traceability, legitimate standards can be determined and maintained locally with certainties as good as, and in some cases better, than by using the services of NBS.

A prime example of this situation relates to the field of shock and vibration measurement where all performance characteristics are derived from physical constants, ratio measurements and other measurement disciplines. This report will describe methodology which may be employed by competent calibration facilities to maintain Vibration Reference Systems.

Because the finite detail required to explain methodology related in this report would represent a textbook in itself, discussion will be limited to general capabilities. References given at the conclusion of this paper may be consulted where further information is required.

ROUTINE CALIBRATION OF VIBRATION MEASUREMENT INSTRUMENTATION

While there are many types of vibration measurement transducers, to simplify the following discussions, such will be referred to only "Accelerometers". As seen in Figure 1, a typical measurement system consists of an Accelerometer, Signal Conditioning Unit (Amplifier and/or Power Supply) and Meter or Recorder type of Readout. The Accelerometer converts the Physical stimulus of shock or vibration into an electrical analog which has a defined proportionality to the physical stimulation. Referring to the Piezoelectric Accelerometer, the most commonly encountered type of device, the transducer is charge generating with its output expressed in pico-Coulombs (pCb)/Acceleration unit (G). As related to the output of the signal conditioning unit, the output is normally expressed in milliVolts (mV)/G.

Unless required by significant workload, most organizations choose to send accelerometers to outside facilities for calibration. Even where capability is required, the calibration laboratory usually is involved with accelerometer calibration only to the extent illustrated in Figure 2, the "Back-to-Back" type of calibration comparison system. In simplification, the item being tested (Test) is compared to another similar device with known characteristics (Standard) while both are undergoing the same or presumed same vibration stimulus. The sensitivity (mV or pCb/G) of the Test instrument is determined by calculating the ratio between the Test and Standard outputs (Ex/Es) and multiplying the resultant by the known sensitivity of the Standard (mV/G) or:

\[ \text{Test mV/G} = \text{Standard mV/G} \times \left( \frac{\text{Ex}}{\text{Es}} \right) \]

Calibration of the Standard is normally obtained from a higher capability Metrology Laboratory or by determining its characteristics from comparisons against an Accelerometer/Amplifier Reference System which has been tested by NBS or other suitable agencies. This paper will concentrate on methodology for calibration of the Reference Standard Systems which are used to establish the sensitivity values of a routine Accelerometer Calibration System.

FUNDAMENTAL REQUIREMENTS FOR CALIBRATION OF REFERENCE STANDARDS

Referring back to Figure 1, it is evident that in basics, calibration of Vibration Reference System, consisting of an Accelerometer and Amplifier, requires knowledge of both the applied acceleration and an ability to accurately measure the resultant output voltage over the required frequency and dynamic (G) range.

VOLTAGE MEASUREMENT

Typically, vibration measurements are made over the frequency range of 10 Hz to 10 kHz, with the majority of sinusoidal tests being concentrated in the 20 Hz to 2 kHz range.
range. The technology of Modal Testing has resulted in having additional frequency requirements in the 0.1 to 10 Hz region. Typical signal conditioning equipment has a maximum output in the region of 10 V rms.

Voltage measurement instrumentation in the range of 0.5 to 10 V rms can be supported, relative to traceability and accuracy, by NBS calibrated AC/DC transfer standards. While traceability is not as clearly defined for frequencies below 10 Hz and under 0.5 V, accepted technology exists. While many instruments can measure voltages in this frequency/level span, their operation is justified more by theory of operation than traditional traceability. Examples of these types of instrumentation include sampling voltmeters, oscilloscopes and oscillographic recorders.

While some may question the traceability of very low frequency measurements, a competent facility can normally justify its capabilities, even in this voltage/frequency range.

ABSOLUTE ACCELERATION STANDARDS

It follows that if the ability exists to measure the output voltage of a Vibration Reference System, the remaining requirement for calibration relies on the ability to apply known levels of acceleration to the system. Measurement unit sources of traceability for acceleration standards are given by the accepted Displacement, Velocity and Acceleration Relationships:

\[ G = 0.511 \ D \ F \ 2 \]
\[ V = 3.14 \ D \ F \]
\[ D = G/(0.511 \ F \ 2) \]

Where: \( G = \) Acceleration in g (386.09 in/sec 2) units or Metric equivalent.
\( D = \) Displacement in inches pk to pk or Metric equivalent.
\( V = \) Velocity in inches per sec or Metric equivalent.

In other words, methods for establishment of absolute vibration levels can be related to the supported traceability requirements of linear measurement and frequency. It can also be related through the relationship of Force and Mass and by the lesser used technology of referencing to the earth’s gravitational constant. In general, the traceable or defined parameters which can be used to determine absolute vibration levels include:

a. Earth’s Gravitational Constant
b. Mass
c. Displacement
d. Frequency
e. Force

CALIBRATION METHODS

The main problem to be faced by the organization attempting to establish capability for absolute calibration of Vibration Reference systems is that numerous methods exist for determination of vibration levels but none, by themselves, cover the entire range of requirements, and all have their limitations. Among the many methods which can be supported by indirect unit traceability or acceptance of defined physical constants are the following:

a. Servo Accelerometer (Transfer of Earth’s Gravity
    Constant of Vibration)
b. Displacement Measurement of Optical Persistence
c. Reciprocity Calibration
d. Interferometer Systems (Laser, Michelson and
    Fizeau)

While all of the above can be established by any competent facility, points of both technical and economic concern relate to whether or not the workload can justify the expenditures of both manhours, to establish the required capabilities, procurement of specialized equipment and time to sustain such.

SERVO ACCELEROMETER TRANSFER AGAINST THE
GRAVITATIONAL CONSTANT

This methodology requires the use of a servo (Force Balance) Accelerometer with a built-in test coil. This technique (Figure 3), which was first proposed by Walter Kistler, can achieve an accuracy of \( \pm 0.2\% \) over the frequency range of DC to 100 Hz, when employed with an appropriate vibration transducer and signal conditioning system. While this technique is probably the most accurate and easiest to accomplish at the accepted 100 Hz reference frequency and below, it has not yet received widespread acceptance or common use; although original research in this area dates back to the 60’s. Where results have been compared against both manufacturers’ and NBS calibration data, over the limited range of lower frequencies, deviations have always been less than the expressed confidence levels of the calibration agencies. Such technology was employed at MMDA in 1982 as a normal part of the automatic calibration system [1] and has been used successfully since that time.

Because the system responds to static acceleration, the DC sensitivity (AS) can be measured by determining the absolute
average of outputs when subjected to both + and – orientation against the earth’s gravity. This methodology is readily understood and accepted.

The conversion of a known static acceleration sensitivity to vibration requires the use of an integral test coil. With the Accelerometer mounted on what approximates an infinite mass relative to that of the moving element, both + and – polarity DC currents are applied to the test coil and resultant system outputs are measured. An absolute transfer function of DC in versus system output can then be calculated by the equation:

\[ S_{dc} = \frac{E_{out}}{D_{in}} \]

Where: \( S_{dc} \) = DC transfer function

\[ E_{out} = \text{System Average Output Signal} \]

\[ D_{in} = \text{Input Forcing Signal} \]

The process is then repeated over the frequency range of interest with AC transfer functions (SF) determined at each desired frequency. The sensitivity at each frequency is then easily calculated by the following equation.

\[ E_{s} = A_{s} \times \left( \frac{S_{f}}{S_{dc}} \right) \]

Where: \( E_{s} \) = System Sensitivity in mV/G at (f) Hz

Results of many years of experience with the original Kistler 305T and its Sunstrand replacement indicate an almost systematic – 0.2% response over the range of DC to 100 Hz.

The main limitation of this methodology is, because of the high damping ratio and relatively low resonant frequency of Servo Accelerometers, use of this technique is not recommended beyond the normal basic sensitivity frequency of 100 Hz. Another limitation is that, while the original Kistler system had a special fixed gain amplifier, one must currently use a multi-function amplifier which has sacrificed stability for multi-purpose usage. Also, the original 305T had a 1/4-28 mounting hole which made it convenient to mount either a Reference Piezoelectric Accelerometer directly on the Servo Accelerometer for comparison purposes or to mount same directly on a "Back-Back" calibration system. The mounting hole is not available on current models and this necessitates the use of adaptors which increased the likelihood of relative motion errors.

**DISPLACEMENT MEASUREMENT BY OPTICAL PERSISTENCE**

The most commonly encountered methods for establishment of absolute vibration levels at using areas are parallel line or "V" type displacement gages. Based on the assumption that such devices exhibit a known displacement, the vibration level is adjusted until a closure is indicated. Given a known vibration level and frequency, the applied acceleration can then be calculated.

Such methodology is useful over the range of approximately 40 to 100 Hz. Below 40 Hz, a clear closure is difficult to ascertain and above 100 Hz, it requires a high G level to achieve a useful displacement. Where the parallel line method is used, the uncertainty relates to one line width, which can easily be as much as \( \pm 10\% \) of indication. Most "V" gages are printed on a paper background and have little dimensional stability. In practice, such devices are good, at best, for only an approximation of vibration amplitude. Of interest is the fact that while such are in common use, where viewed by the writer, very few have indicated evidence that they have been calibrated or verified for obtainable accuracy. Unless evidence to the contrary is available, such methods can not be seriously considered as a legitimate source of traceability.

In the 60's, the writer developed a type of displacement calibrator which came to be known as a Beveled Plane Displacement (BPD) calibrator [2]. The primary feature of this device was the undercut plane construction which gave a sharp closure, eliminated parallax errors and was easily certified by any competent gage laboratory. With a microscope for increased resolution, overall uncertainties as low as \( \pm 0.2\% \) were achievable for fixed point standardization over the previously referenced 40 to 100 Hz range at levels in the region of 10 G's.

The bottom line is that if a properly designed gage is available and used, the optical persistence method can achieve a high level of accuracy for standardization at the lower frequencies, with traceability to both dimensional and frequency standards. On the negative side, the achievement of high accuracy results with this method is normally very operator dependent.

**RECIPROCITY CALIBRATION**

The most commonly used method for standardization of a Reference Systems is the technique referred to as reciprocity Calibration. In layman’s language, reciprocity calibration is simply the process of comparing two transducers, one of which must have the capability of being used as both a mechanical to electrical (Velocity) and electrical to mechanical (Shaker) transducer. The other is normally an Accelerometer/Amplifier system which provides an output in mV/G. Two configurations are commonly used. The first is where the Velocity Coil is an integral part of a vibration shaker [3] and the second requires the application of vibration from an external source to verify mechanical to electrical properties of the reciprocal Transducer/Shaker [4]. Simplified test diagrams of the test setups required for the two shaker method are shown in Figure 4.

When both transducers are operated in their linear range, a reciprocal relationship exists for the ratio of driver coil current to force produced at the mounting point of the Accelerometer which equals the ratio of the velocity of the mounting point to the voltage produced across the coil when vibration is caused.
by another source. Bypassing the derivation given in the references, the sensitivity of the Accelerometer System (Sa) in mV/G for the two shaker system is determined by the equation:

$$ Sa = 2635 \left( \frac{J}{f} \right) \frac{1}{2} $$

Where: $j = (-1)^{1/2}$, the 90 degree vector
$J = $ intercept of plot to weight transfer admittance ratio, lb/mho
$R = $ voltage ratio, volt/volt
$f = $ frequency, Hz

In general, the reciprocity calibration method is capable of high accuracy over the range of 50 to 1000 Hz with an uncertainty in the region of $\pm 0.5\%$. When performed, the traceable elements are mass, frequency and the AC resistance used to determine drive current. The other element of the process, which is AC voltage ratio, by definition does not require traceability to NBS so long as the process is verified by accepted technology.

INTERFEROMETER SYSTEMS (LASER, MICHELON AND FIZEAU)

Detailed discussion of vibration measurement with interferometry could easily require a textbook by itself [5]. All systems perform the function of measuring displacement and when related to frequency give knowledge of the applied acceleration in g's. The fundamental traceability element of displacement relates to a defined physical constant, the wavelength of light. The other element, frequency, is traceable through accepted methodology.

In general, interferometer measurements are applicable in the frequency range of 1 to 10 kHz with capabilities in the region of $\pm 1$ to 3%. The major limitations of this methodology is that it works best on small displacements, which dictates the use of higher frequencies to obtain usable G levels, and motion is usually sensed by a mirror attached adjacent to the Accelerometer being tested. Because such systems cannot sense the actual movement at the Accelerometer mounting point, unless the structure is infinitely rigid, a relative motion error will exist between the mirror and mounting point; which will become progressively worse as frequency increases.

FUNCTION SEPARATION

In the 60's, a considerable amount of research time was spent by the writer in analyzing the characteristics of Accelerometer systems (6,7). The theory which evolved from this study was that the calibration of a properly designed Accelerometer Reference System could be determined as well or better than by absolute vibration testing over the normal use range by combining absolute sensitivity determination at a low frequency with electrical system performance and mounted resonance tests to determine overall response. The general theory is that over a normal sinusoidal vibration range of 10 Hz to 10 kHz the overall system performance is the combination of:

a. Absolute System Sensitivity determination (mV/G) at a reference frequency (100 Hz typical) where Resonance, Electrical and Strain Effects are negligible.

b. Electrical system performance as verified by injection of a signal through the transducer/amplifier system to account for impedance changes of the transducer and amplifier as a function of frequency and simulated vibration level (Figure 6).

c. Determination of mounted resonance and the anticipated increase in sensitivity as such is approached (Figure 5).

The normal concern relative to this methodology is that such does not indicate real deviations resulting from "local resonances" that are caused by cable connections, mounting and the like and provides no dynamic verification at low frequencies where strain effects are evident. Experience of the writer has proven that such concerns can be eliminated by the selection of an appropriate accelerometer and simple performance evaluations.

Concerns relative to "local resonances" can be eliminated by evaluating the transducer selected for use as a standard to determine that it has a "smooth" response curve as determined by comparison against a high integrity comparison standard over the intended use range. If no unusual deviations are noted, the theoretical high frequency performance is, for all practical purposes, assured.

The first step towards eliminating concern regarding low frequency strain effects is to select an Accelerometer which is specified to have low strain sensitivity. The second step is to evaluate the unit at the lowest test frequency by re-positioning the cable while being vibrated and observing the change in output. An appropriate Accelerometer, for use as a Reference Standard, should not indicate any significant deviations. Likewise, a soft rubber/low noise cable should be used for the connection between the Accelerometer and system amplifier.

Basic sensitivity determination at 100 Hz can be made by:

a. Transfer against a Servo Accelerometer which has a sensitivity determined by the earth's gravitational constant.

b. Reciprocity calibration.

c. High accuracy optical vibration measurement technique.
The electrical performance tests can verify both system frequency response and dynamic linearity. In general, Piezoelectric Accelerometers have a systematic sensitivity increase of approximately 1% per 500 g's. As such, because reference systems are rarely used over 100 g's, the linearity error of the accelerometer will be no more than +0.2% at this level, which can for practical purposes be ignored. Evidenced linearity deviations are more the result of electrical system deviations resulting from noise at low g levels and system saturation at higher levels.

The primary factor affecting high frequency performance is the mounted resonance of the Accelerometer. The primary question is "mounted on what?". The most practical configuration known for determination of mounted resonance is that referenced by ISA - RP 37.2 (1964) (8) which specifies mounted resonance as "that which is obtained with the Accelerometer mounted on an anvil constructed of machinable tungsten alloy with the approximate dimensions of a one inch cube". Using the configuration shown in Figure 5, experience has proven that the mounted resonant frequency can be determined repeatable with a precision of a few tenths of a kHz, so long as consistent mounting methods and torque are used. With a typical Accelerometer having a resonance in the region of 30 kHz, such variations will account for less than ± 0.5% deviations at 10 kHz. The advantage of this technique and resultant traceability constant is that high frequency performance resulting from mounted resonance is then determined by a defined physical constant, the one inch cube of machinable tungsten alloy.

On an overall basis, the Reference System performance can then be related as the combined mathematical function of Absolute Sensitivity, Electrical Performance and Mounted Resonance.

CONCLUSION

As indicated by this report, if economically feasible, any competent laboratory can establish capability for calibration of Accelerometer Reference Systems; so long as proper traceability, control and documentation are maintained on the elements from which the vibration constants are derived. The argument that such are not traceable because the accelerometers are not calibrated at NBS is, to say the least, ridiculous.

Whether or not the technology used is appropriate and adequate is another question. Even with computer analysis of data, all of the described methods are highly operator dependent. If the methodology is not properly documented, upon change of personnel, it may be discovered that the capability left with the engineer an/or skilled system operator. Attempts to use individuals from the "technician labor pool" without proper indoctrination and surveillance, usually results in what can only be described as "interesting results".

Attempting to perform the described higher levels of calibration with lesser trained individuals can be a disaster.

Likewise, it is cautioned that establishing such capabilities in theory is not the same as having proven performance. It is strongly suggested that to gain confidence in self-calibration capabilities, upon activation, comparisons should be made against the results obtained from recognized calibration authorities like NBS. Experience has proven that competent calibration system should produce results which differ from those of a recognized calibration authority less than half of the outside calibration agencies tolerances over the range of 10 Hz to 10 kHz, regardless of what accuracy is claimed or which methodology or combination of methodologies is employed.

REFERENCES


3. ANSI, "Calibration of Shock and Vibration Pickups".


Figure 1. Typical Vibration Measurement System

Figure 2. Simplified "Back to Back" Accelerometer Calibration System

Figure 3. Servo Reference Accelerometer System Test Arrangements

Figure 4. Reciprocity Calibration Test Setsups

Figure 5. Piezoelectric Reference Accelerometer Resonance Test Arrangement

Figure 6. Piezoelectric Accelerometer/Amplifier Reference System Electrical Insert Response Test Arrangement
HIGHLIGHTS OF THE NCSL BOARD MEETING

DENVER REGENCY
JULY 12-17, 1987

PRESIDENT'S REPORT – ED NEMEROFF

Ed reported that he met with Don Johnson and Kurt Reimer in April regarding the appointment of an NBS Representative. The Representative has been identified as Joe Simmons. He also met with Ron Colle and others regarding NBS guidance documents.

EXECUTIVE VICE PRESIDENT'S REPORT – GARY DAVIDSON

The following liaison appointments were made:
Chet Crane as MSC Liaison, Don Cox as GIDEP Liaison,
Peter Under as AALA Liaison.

Gary reported that Form 990 for 1986 was filed with the IRS, and that the CPA audit of all the 1986 books was completed.

Board Meetings for 1988 will be held as follows:

February 1-3, 1988, Lake Tahoe
April 25-27, 1988, Georgia/South Carolina (tentative)
August 14, 18-19, 1988, Grand Hyatt Hotel, Washington DC
October 24-26, 1988, TBD

In addition the 1988 NCSL Conference will be at the Grand Hyatt Hotel, Washington, DC, August 14-18, 1988.

Gary presented the Financial Statement and letter from the CPA.

PAST PRESIDENT'S REPORT – PETE ENGLAND

1988 NCSL Nominations Committee has a preliminary slate of candidates for office for the 1988 year. These will be mailed to the general membership by the end of the month.

A motion was made by Pete England, seconded by Roland Vavken that the date in the By-laws for the 1988 nominations be delayed 45 days. The motion passed.

TREASURER'S REPORT – ROLAND VAVKEN

A motion was made by Roland Vavken, seconded by Pete England, to raise the Secretarial Checking Account from $2500 per month to $3000 per month. The motion passed.

A motion was made by Roland Vavken, and seconded, to raise the Secretariat Expense account from $7000 to $9000. The motion passed.

NBS REPRESENTATIVES REPORT – JOE SIMMONS

Joe was welcomed as the new NBS Representative, and received further well wishes for his appointment as Chief of the Office of Physical Measurement.

Joe announced that in FY 88 there would be an OMB imposed 8% surcharge on all calibrations.

SECRETARIAT'S REPORT – KEN ARMSTRONG

Ken reported that thirty new members were approved this month.

GOVERNMENT AFFAIRS COMMITTEE – JOHN LEE

Action by the DOD on the proposed revision to Mil-Std-45662 has been somewhat delayed. The DOD is tentatively scheduled to have their first internal meeting in mid July. The DOD will have an industry meeting with NCSL invited to attend in late July or August. It is anticipated that the final new document will be out late in the fourth quarter or early in the first quarter of 1988.

Joe Simmons reported that the FY 1988 budget at NBS is expected to be between $142M and $166M, as compared to the FY budget of $122M. It is believed that the testimony of NCSL and others was responsible for this planned increase.

Joe Lee has been asked to serve as a member of the National Academy of Science's Bureau of Oversight for a term of two years commencing October 1987.

OPERATIONS V.P. REPORT – BOB WEBER

Business Systems – Roland Vavken

Meetings and Programs Committee – Moe Corrigan

In response to the problem concerning publishing meeting notices on time, Moe sent out questionnaires to each Director and Coordinator to provide direct input. There was only one response and that was from someone who had already provided the information.
Board Meeting

Publications Committee – Tom Knowles

During the past quarter the Committee has supported the publication of the "National Measurement Requirements Committee" and the "1987 Workshop and Symposium Technical Presentations" documents.

Administrative Guidelines & By-laws – Dean Brungart

The following Guidelines were developed or revised:

<table>
<thead>
<tr>
<th>T/C</th>
<th>Table of Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.0</td>
<td>Past President’s Job Description</td>
</tr>
<tr>
<td>10.2</td>
<td>Operation of Secretariat Checking Account</td>
</tr>
<tr>
<td>10.3</td>
<td>Asset Accountability</td>
</tr>
<tr>
<td>22.1</td>
<td>Communication of Meetings Scheduled</td>
</tr>
<tr>
<td>50.0</td>
<td>Industrial Technology Vice Pres. Job Des.</td>
</tr>
</tbody>
</table>

MARKETING V.P. REPORT – BILL SIMMONS

Newsletter Report Committee – John Minck

John reports that the response from the Newsletter quality survey was very positive. A discussion was held on the effect of page count and contents vs. the quality of the publication. It was generally agreed that the quality should not suffer.

Membership Committee – John Curtin

John reports that he analyzed the NCSL membership and broke it down into 14 industry sectors. He was asked by the Board to break down the Aerospace and Government segment into a more definitive analysis.

Publicity Committee – Al Herman

Al has been busy working several publicity projects this quarter, and has been working hard to complete a new NCSL display for the conference.

Honors and Awards Committee – Jeff Taylor

Calibration Systems Management Committee – Selden McKnight

Selden reported that their primary activity was the workshops for the conference. An effort was made to have the members of NCSL to participate more in the sessions.

A discussion was held on the need of Salary Surveys and their usefulness and how to get the most information out of them. It was agreed that the next one should be more sectional.

Measurement Assurance Committee – Arno Ehman

Arno reported that the Gage Block and Volt MAP’s in region 8 are doing well. (See Committee News)

NMRC Committee Report – K. Jaeger

The NMRC report of 1986 has been printed and copies of it will be distributed to member delegates.

Chairman of the NMRC subcommittees are all in place. The latest change was the replacement of Frank Koida by Bahman Radjabi for the RF-Microwave sub-committee.

Klaus proposed a new Intrinsic Standards Committee be formed. The Board then created an Ad Hoc Committee on Intrinsic Standards and placed it under the Vice President of Industrial Technology. The Committee will be chaired by Klaus Jaeger.

Laboratory Evaluation Committee – Carl Quinn


Calibration Intervals Committee – Howard Castrup

(see Committee News)

Equipment Management Forum – Charles Sides

An executive level review of the EMF activities and future plans was held in San Antonio, Texas. A review of the 1987 Draft EMF Administrative Guideline Manual to resolve any conflict with the NCSL By-Laws.

INDUSTRIAL TECHNOLOGY VP REPORT – JOE SIMMONS

Joe reported that due to a change in his position at NBS to Acting Chief of the NBS Office of Physical Measurement Services, he has submitted his resignation as Vice President of Industrial Technology. Joe thanked all of his Committee Chairman and members for their work. He is now the NBS
Representative. Chet Crane has been appointed the new Vice-President.

**Biomedical & Pharmaceutical Metrology – Doug Smith**

Doug reports that the Committee has been inactive for the past two quarters. He also reports that there are two projects pending: firstly, a MAP program on Pressure for ranges needed by the pharmaceutical industry and, secondly, a feasibility study for an awareness program in Puerto Rico. Various pharmaceutical companies are being polled for interest.

**Automatic Test & Calibration Systems – Ken Carrington**

The Committee has been inactive except for the tape exchange program. The tape exchange program is under the direction of Robert Smith.

**Product Design and Specifications – James Hartley**

A discussion was held on RP3 and the differences between, calibration, pre-calibration, adjusting, and various other terminologies.

John Lee suggested that the Committee look into Jim Ingram’s Paper as a possible RP.

**Utilities Committee – Raymond DeSandra**

Had good attendance at the Utilities Committee meeting. They propose some new additions to the Glossary.

**EDUCATION & TRAINING VP REPORT – JOHN MARTIN**

John reported that he attended the May 6th, Region One meeting in Bedford, Mass, and presented highlights of the April 1987 Board Meeting.

**Training Aids – Joan Wingo**

Thirty additional master tapes have been received and reviewed. The tape entitled “Zap, Static Awareness” has been edited to exclude potential offensive comments.

**Training Information & Directory – David Lorenzen**

David reported that the Training Information and Directory Committee met in May, 1987 to plan the 1988 Training Information Directory. Action assignments were made to committee members and a schedule was established. Plan for the actions at their next meeting were also presented in the report.

**Adjunct Training – Bill Doyle**

John Martin announced the appointment of Bill Doyle, USIR, as Chairman of the Adjunct Training Committee.

**Education Liaison – Kate Webster**

Kate reported that both Butler Community College and Hutchison Vo. Tech. Institute are experiencing a high demand for their metrology technician graduates.

Herb O’Neil reported that Hutchison Vocational was becoming the Hutchison Technical School. He expressed a need to have correspondence from companies on their letterheads voicing support of Metrology. This would aid in support of Hutchison’s programs in Metrology.

**Metrology Compendium – Cliff Koop**

Cliff Koop has indicated that he wished to continue to chair the Metrology Compendium Committee and that he would chair the Ad Hoc Committee on the Glossary of Terms.

**LIAISON DELEGATES REPORT – GARY DAVIDSON**

**PMA – Glenn Rasmussen**

A questionnaire for gathering information to compile a Directory of Metrologist has been prepared of distribution.

PMA is requesting assistance of NCRL in distributing this questionnaire to NCRL members by including copies in future mailings.

The ISO committee is working to develop a uniform way of reporting uncertainty of measurements.

The administrative functions of the PMA have transferred to the office of Myers/Smith, Los Angeles, California.

An action item was given to Glenn Rasmussen to obtain a copy of the PMA questionnaire concerning a Directory of Metrology and forward the same to Bill Simmons.

An action item was given to Bill Simmons to have the PMA questionnaire concerning a Directory of Metrology published in the NCRL NEWSLETTER as a tearout.

**GIDEP – DON COX**

**MSC –**

**OIML –**

**NVLAP/AALA – Peter Unger**

Gary Davidson welcomed Peter Unger as Liaison from AALA.

Peter presented an overview of what AALA was doing and what they supported. He spoke of the actions, documents and committees that NCRL and other organization had that could support AALA in their endeavors.

**ANSI – Rolf Schumacher**

The Board of Standard Review of ANSI has approved the standard for "Calibration Systems" under the designation "ANSI/ASQC M1-1987, Calibration Systems"
Rolf reports that although the effort of writing the standard conducted under the auspices of the American Society for Quality Control Metrology Technical Committee, most of the writing group members were recruited through NCSL. In fact, NCSL has provided the vehicle of informing the U.S. metrology community of the efforts and progress in writing the standard and has provided the forum in which some of the more difficult questions could be debated with a large number of metrologists. This standard could not have been written without NCSL.

The subject standard covers only the calibration phase of measuring instruments. A second standard covering other standards as Mil-Std-45662 is being written.

ASQC – Karl Speitel

The annual Quality Congress of the ASQC was held on May 4 – 6, 1987 in Minneapolis. The Metrology Session was well attended.

ISA – Mike Suraci

Mike reported that he has contacted several at the ISA Headquarters regarding the appointment of a Member Delegate from the ISA. A Member Delegate from the ISA is expected to be forthcoming in the next 90 days.

WECC – Graham Cameron

Following the appointment letter to WECC, Graham wrote to the President of WECC suggesting that the exchange of information between organizations would be mutually valuable. Graham reported that he has provided WECC with information on the NCSL 87 and 88 Conference plans.

IEEE – Jerry Hayes –

Jerry reported that the IEEE is composed of some 229,000 members in several societies.

The IEEE has invited NCSL to advertise at their conference and affairs.

Jerry stated that a liaison has been established through mutual interest and testimony before the U.S Senate Sub-Committees, both parties advocating support for precision measurement and metrology.

ASTM – George Uriano

CORM – Bill Simmons

JLC/CCG – Fred Seeley

IMEKO – Mike Suraci

No new information has been forthcoming on the IMEKO Conference at this report.

A+ A – Bob Willett

ATTENDEES:

Ed Nemeroff
Gary Davidson
Chet Crane
Bill Simmons
Bob Weber
John Martin
Del Caldwell
Roland Vavken
Selwyn Smith
Joe Simmons
Pete England
Jim Ingram
Ralph Bertermann
Robert Smith
Tony Anderson
Graham Cameron
John Riley
Bob Willett
David Duff
Graham Cameron
Rolf Schumacher
John Lee
Jeff Taylor
Dean Brungart
Howard Castrup
Selden McKnight
Klaus Jaeger
Charles Sides
Jim Hartley
John Curtin
Douglas Smith
John Minck
Carl Quinn
Jerry Hayes
Glenn Rasmussen
Karl Speitel
Mike Suraci
Pete Unger
Ken Armstrong
Bill Doyle
Randi Wear
Herb O'Neil
Suzie Mas
Norman Belecki
Val Gersbach

Datron Instruments
TRW
Teledyne Micro
Sverdrup Technology
Lockheed MSC
Westinghouse
Navy, MEC
Rockwell INTL
GE Solid State
NBS
General Dynamics
LMSI
G.D. Searle & Co.
Ford Aerospace & Comm.
Guilin
Canadian DND
NASA, KSC
Rockwell INTL
Eli Lilly & Co
DNO/
Rockwell International
Telogy Inc.
Lockheed-Georgia
Teledyne Systems
SAIC
Hughes Aircraft
Lockheed MSC
Boeing
TVA
Anritsu
Abbott Labs
Hewlett-Packard Co.
Simco Electronics
Science Applications Intl.
Northrup Corp.
Eastman Kodak
Lockheed MSC
AALA
Speedwell INTL
USIR
John Fluke Mfg. Co.
HAVTI
Datron Mfg. Co.
NBS, Electricity
John Fluke Co.
MEASUREMENT SYSTEM COURSES OFFERED

Phoenix, Arizona – Two Short Courses: Measurement Systems Engineering, March 7-11, 1988, and Measurement Systems Dynamics, March 14-18, 1988, are being offered for the 27th year. The latest developments in electrical measurements of mechanical and thermal quantities will be presented by a lecturing staff of extensive industrial experience and academic background.

The ability to design measuring systems to perform a predictable and controllable way is the result of the new Unified Approach to the Engineering of Measuring Systems on which the lectures are based.

Featured speakers include Peter K. Stein, President, Stein Engineering Services, Inc., Phoenix, Arizona, developer of the Unified Approach of the Engineering of Measuring Systems; Dr. Robert J. Moffat, Professor of Mechanical Engineering, Stanford University, and Director of its Thermosciences Division; L. Spencer Wirt, Senior Research Scientist, Lockheed California Company, developer of a new family of acoustic materials and of the Dam-Atoll ocean-wave energy extraction method; F. Michael Tovey, Consultant, Tovey Engineering, Scottsdale, Arizona, material scientist and transducer designer; Dr. Patrick L. Walter, Supervisor, Test Measurements and Precision Centrifuge Division, Sandia National Laboratories, Albuquerque, New Mexico, expert in the acquisition of high-speed, transient data, and of its validation and processing.

The program is intended for engineers, scientists and managers of industrial, governmental and educational organizations who are concerned with planning, executing, or interpreting experimental data and measurements.


These programs, started 27 years ago, have been given to over 10,000 engineers, scientists and managers in over 250 programs all over the U.S., Canada, Europe, New Zealand, Australia and China. The Unified Approach to the Engineering of Measuring Systems on which these lectures are based, has won acclaim and praise, and its developer has been awarded Fellow status in ISA and SEM, and received the Outstanding Educator Awards from both societies.

TROUBLESHOOTING MICROPROCESSOR-BASED EQUIPMENT AND DIGITAL DEVICES

Micro Systems Institute, 73 Institute Rd., Garnett, KS 66032
800-247-5239

DATES AND LOCATIONS FOR 1987 FALL/WINTER SESSIONS

Chicago, IL – Sept 29–Oct 1
Holiday Inn/Wheeling – Northbrook
2875 N. Milwaukee Ave
Northbrook, IL 60062
(312)298-2525

Minneapolis, NM – Oct 6–9
Airport Rodeway Inn
1321 East 78th St.
Bloomington, MN 55420
(612) 854-3400

Cincinnati, OH – Oct 27–30
Radisson Inn
11440 Chester Road
Cincinnati, OH 45246
(513) 771-3400

Atlanta, GA – Nov 10–13
Amberley Suite Hotel
5885 Oakbrook Parkway
Nocross, GA 30093
(404) 263-0515

Norfolk, VA – Nov 17–20
Waterfront Holiday Inn
8 Crawford Parkway
Portsmouth, VA 23704
(804) 393-2573

Oklahoma City, OK – Dec 1–4
Holiday Inn – West Holidome
I-40 at Meridian
Oklahoma City, OK 73108
(405) 942-8511

Course Description

This four-day training workshop is structured to provide the technical knowledge required to diagnose and repair microprocessor-based devices at system, board, and
component levels. Working on individual microprocessor trainers, attendees will master the essential elements of microprocessor servicing-knowledge of the hardware, machine-level software, specialized test equipment, and appropriate troubleshooting techniques. They will return to their jobs prepared to maintain all types of microprocessor-based equipment.

The first part of the course examines microprocessor/microcomputer systems, including micro devices, machine-language programming, memory, buses, I/O ports, clocking, support devices, instructions and programs. The second part of the course explores troubleshooting procedures and the use of specialized instrumentation available for microprocessor systems maintenance.

This course is designed to provide real solutions to problems encountered in troubleshooting microprocessor-based equipment. Emphasis is given to new techniques and approaches unique to the microprocessor systems. Procedures for adapting systems and/or designing new systems to take advantage of these techniques is examined.

Each participant is furnished with a single-board trainer to use throughout the course. Experiments demonstrating both fundamental concepts and specific techniques for diagnosing failures are performed on these boards. Other special trainers for troubleshooting faults and a wide variety of state-of-the-art test instrument designed for microprocessor servicing are also provided. These hands-on experiments will be performed:

* Single Board Systems
* Oscilloscope Use
* Probe Use
* Signature Analysis
* Self-Test
* Emulation
* Logic Analysis
* Micro Lab Troubleshooting
* Process Control
* Interfacing

**Course Instructor:** Duane Eyman has over thirty years of experience in the computer and electronics industry. He is a graduate of the University of Kansas and a former member of the faculty of Pittsburg State University. Mr. Eyman’s background includes work on space and aeronautical electronics systems while associated with the Army and Air Force as an engineer and technician.

**CONTACT:** Janet McHenry 800-247-5239

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**TEKTRONIX SERVICE TRAINING SCHEDULE ANNOUNCED**

A wall-chart-sized training schedule is available from Tektronix for class schedules for a full year. In addition, a page-full of training video tapes are listed and priced.

**CONTACT:**
Tektronix Service Training
PO Box 4600, MS 94-925
Beaverton, OR 97076
1-800-835-9433, Ext WR1407

**MEASUREMENT ASSURANCE – MEASUREMENT UNCERTAINTY COURSE DATES ADDED**

The Measurement Uncertainties course described in the July, 87 NCSL Newsletter (p. 10) and taught by our own Rolf Schumacher has added several course dates.

Oct. 19-23, 1987 Anaheim, CA
Jan./Feb., 1988 Location to be determined
June 6-10, 1988 Ottawa, Canada

**CONTACT:**
Marlene Chandler
Coast Quality Metrology Systems
35 Vista Del Ponto, San Clemente, CA 92672
(714) 492-6321
Gary Davidson, the new Executive Vice President of NCSL, is the manager of Equipment Control at TRW in Redondo Beach, California. Gary has either been in or around metrology for nearly 25 years, starting out as a metrology technician. Gary says that coming up through the ranks has been very challenging and rewarding, and has provided constant change in the work environment. Gary went from technician to metrology engineering, specializing in the DC and Low Frequency Standards, to a staff role where he was responsible for calibration intervals. That led into data processing and on into management. Gary has particularly enjoyed his work in statistical controls and uncertainties for standards, involvement in starting the first group Measurement Assurance Program, direction of development of a sophisticated interval analysis system, project manager for the Equipment Quality Utilization Analysis Traceability Evaluation System (EQUATES), and implementation of Bar Code technology for inventory control and asset management.

In Gary's current assignment, he is primarily responsible for the management of 46,000 item of test equipment with a replacement value of $146,000,000. The test equipment is in an equipment pool that is rented, much like a rental company, to internal customers within TRW. He is also responsible for recall for calibration, parts and vendor service procurement, spare parts, transportation service, and EQUATES, which he is proud to say received special recognition during TRW's Air Force CORE.

Gary's involvement in NCSL began in 1978 when he was appointed Chairman of the Measurement Assurance Committee. In 1980, he became Treasurer of NCSL, and in 1987 he was elected to the position of Executive Vice President. He also co-chaired the 1983 NCSL Conference in Boulder, Colorado, and chaired the Ad-Hoc Secretariat Transition Committee, which established the World Wide Headquarters for NCSL in Boulder, Colorado. Gary also was responsible for starting the Equipment Management Forum Committee which was chartered in 1986.

Gary credits NCSL for providing much of his professional and personal growth. Participation in regional meetings, conferences, committees, and the boards of directors provides no better source of exposure to your peers. A little knowledge gained from each one adds up to a wealth of knowledge that may be used professionally and personally.

What is Gary's philosophy in 12 words or less. "There's no such word as can't, and there's always a better way."
We’d like to thank everyone who took the time to send in comments on the Newsletter style and content. The results are fairly Gaussian, like the rest of human nature, and are summarized below. Interestingly, the total count ran just at 100, so calculating the percentages is pretty easy. It looks like most folks want more technical and management articles.

That’s easy for me, but it means all of you are going to have to start writing.

The way I read it, we need a few tweaks in emphasis, but generally people seem fairly happy with things as they are. Editor

<table>
<thead>
<tr>
<th></th>
<th>Mean (not inc. N.O.)</th>
<th>Highly Useful</th>
<th>Not very Useful</th>
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<td>20</td>
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<td>28</td>
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<td>Management Articles</td>
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<td></td>
<td>NBS Updates</td>
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SOME VERBATIM COMMENTS

Editorial Style

1) Just hitting the highlights are fine. (2 votes)
2) New format excellent for my needs, good overall quality.
3) New typestyle and size is perfect.
4) OK as is. (5 votes)
5) Could be more brief (4 votes)
6) Don’t read every detail, but scan areas of interest.
7) Nice font.
8) Presented papers could be further shortened.
9) Board meeting could be outlined and full-length made available elsewhere. (2 votes)

10) Just a summary and conclusions of the Board.
11) Continue with NBS as is now.
12) Editor has done remarkable job (amended by others to outstanding). (Editor’s note: this is getting embarrassing)
13) Try to get better quality pictures.
14) Less brief, want to know where we’re going and why.

Content

1) Consider a section "Concerns of the Board", i.e., poor voter response or companies dropping membership.
2) Region reports should be brief and always have attendees list.
3) Board meeting information should be brief. (5)
4) More technical articles. (3)
5) More articles on operation of smaller in-house calibration laboratories.
6) Status on what is being done by NBS, NCSL, and other organizations about NBS services not yet available. Costs and turnaround time of services.
7) Liked the exposure of Butler College grads; encouraging to young metrologists.
8) More info on NBS capability.
9) Considerable detail is missing from SP 250, such as price, range, limits of errors. Newsletter could regularly include such info.
11) Calibration and Stds Lab environmental requirements.
12) Would like an index for technical and management info.
13) Seems to be a lack of familiarity of member delegates; more profiles needed.
14) As an individual, I am mostly interested in operational data such as training, interval adjustments, ratio for OOT, average salary, equipment mgmt. and 45662.
15) Well-balanced.
16) Prime interests are mgmt., electronics metrology, lab environment, standards and accuracies.

17) Would like an article or two each issue from a committee chair, on projects, goals and objectives.
18) Want terms and definitions – interpretations. Practical criteria, practices, solutions.
19) Would like an article on evolution of a measurement, e.g., "evolution of capacitance measurement".
20) Other desirable subjects: Factual information on office candidates, a "help-wanted" column, a "swap-column", interim Directory updates, a publication or book review section, significant interactions between NBS and other National Standards Labs.
21) More detail on substantive and contentious material.
22) Concentrate on attendee input and worthy information relative to all.
23) Add vendor expos to calendar.
24) More participation from foreign members. How do they satisfy their government specs, etc.
25) Updated processes of calibration from other company’s systems have been useful.

Other
1) Keep up the good work (4) (Ed. Note: Plugging for a raise)
2) Would like to see it evolve along lines of IEEE Spectrum.

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**NCSL NEWSLETTER EDITORIAL SCHEDULE FOR 1988**

<table>
<thead>
<tr>
<th>Issue Date</th>
<th>In Mail</th>
<th>To Printer</th>
<th>Last Editorial to Editor</th>
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<tr>
<td>Jan. 88</td>
<td>1 Jan. 88</td>
<td>15 Dec. 87</td>
<td>25 Nov. 87</td>
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<tr>
<td>Apr. 88</td>
<td>1 Apr. 88</td>
<td>15 Mar. 88</td>
<td>25 Feb. 88</td>
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<td>July 88</td>
<td>1 Jul. 88</td>
<td>15 Jun. 88</td>
<td>25 May 88</td>
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<td>Oct. 88</td>
<td>1 Oct. 88</td>
<td>20 Sept. 88</td>
<td>1 Sept. 88</td>
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**EDITOR'S NOTE**

This schedule is of guidance for anyone who needs to submit material for publication in the Newsletter. You can understand that in a purely voluntary function like this, the Newsletter must be secondary to my regular job. I try to stay on schedule, but there is zero backup, so if I must travel on company business or other, nothing gets done.

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**NCSL ITEMS FOR SALE**

In response to popular demand, the following items are available from the NCSL Secretariat, postpaid, at the prices indicated.

<table>
<thead>
<tr>
<th>Item</th>
<th>Price</th>
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<tr>
<td>Training &amp; Information Directory</td>
<td>$10.00</td>
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<tr>
<td>NCSL Directory of Standards Labs (biennial)</td>
<td>$25.00</td>
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<tr>
<td>Calibration Lab Managers' Guidebook</td>
<td>$5.00</td>
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<tr>
<td>NCSL Newsletter (single copy)</td>
<td>$5.00</td>
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<tr>
<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)</td>
<td>$5.00</td>
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<tr>
<td>Tabbed Index Dividers for Binder (set of 6)</td>
<td>$1.00</td>
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<tr>
<td>Additional Information Manual Fillers</td>
<td>$10.00</td>
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</tbody>
</table>

Delegates of new member companies receive all the asterisk items as part of the new-member information package. Updated material, e.g., Training Information Directory and Directory of Standards Labs are automatically forwarded to all member delegates as they are published. Additional items are available at prices indicated. Mail orders, prepaid in U.S. funds, to the NCSL Secretariat, Suite 305 B, 1800 30th St., Boulder, CO 80301.
PRESIDENTS'S INITIATIVE CITIES NBS RESEARCH PROGRAMS

In his keynote address to the Federal Conference on Commercial Applications of Superconductivity (Washington, D.C., July 28-29), President Reagan announced an 11-point initiative to promote further work in the field of superconductivity and ensure U.S. readiness in commercializing these technologies. The president’s proposal includes the creation of a "superconductivity center" at the NBS Boulder Laboratories which would coordinate the bureau's current and planned research across a broad, interdisciplinary range of theoretical and technical issues concerning high-temperature superconductivity with a particular emphasis on electronics applications. The initiative also supports accelerated programs at NBS in measurement standards and technologies, in the development and commercialization of these materials.

CONTACT: Michael Baum, 301/975-2762

NBS ANALYSIS OF DUPONT PLAZA HOTEL FIRE AVAILABLE

On Dec. 31, 1986, a fire in the Dupont Plaza Hotel in San Juan, Puerto Rico, killed 98 people. As part of the federal team investigating the fire, scientists and engineers from the NBS Center for Fire Research used tools developed through a decade of research to calculate the course of the fire. The results showed that once set, the fire spread from the ballroom through the first two floors of the hotel killing most of the victims in 10 to 15 minutes. Had this fire growth analysis been done to test the building design, say the researchers, it would have shown that the glass partitions separating the ballroom from the hotel lobby were insufficient to resist this fire. Also, it would have shown that both of the exits from the casino, where most of the victims died, could be quickly blocked by the fire. The NBS researchers also calculated what would have happened if sprinklers or smoke detectors had been present. The NBS investigation represents a new approach to fire analysis, say the researchers, and demonstrates how these tools can be used to both investigate and prevent fires. A report, *An Engineering Analysis of the Early Stages of Fire Development – The Fire At the Dupont Plaza Hotel and Casino, December, 1986* (NBSIR 87-357760), is available from, the National Technical Information Service, Springfield, VA. 22161 for $18.95 prepaid. Order by PB #87-201828.

CONTACT Jan Kosko, 301/975-2762

NBS PUBLICATIONS CATALOG ISSUED FOR 1986

Researchers and librarians in industry, academia, and government will be interested in a new catalog, *Publications of the National Bureau of Standards, 1986 Catalog*, (SP 305, Supplement 18). It lists approximately 1,600 reports and journal articles published by NBS and those appearing elsewhere during 1986. Papers published prior to 1986 but not reported previously also are included. Full bibliographic citations with keywords and abstracts for papers published and entered in the National Technical Information Service (NTIS) collection are cited in "NBS Publications Announcements." Entries are arranged by NTIS subject classification and listed alphanumerically by order number. Four indexes are included for identifying papers by author, keywords, title, and NTIS order/report number. Each entry lists appropriate title, order, and abstract number. The catalog also contains ordering information, availability, and a list of depository libraries. Copies of SP 305, Supplement 18, are available for $18 prepaid from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Order by stock no. 003-003-02798-7.

CONTACT: Roger Rensberger, 301/975-2762

UPDATE TO STANDARD REFERENCE DATA DIRECTORY ISSUED

Scientists and engineers who have a need for reliable evaluated data on the chemical and physical properties of substances will find the latest supplement to the 20-year directory of publications and computerized databases useful. Prepared through the National Standard Reference Data System (NSRDS), *Standard Reference Data Publications, 1985-1986*, (SP 708, Supplement 1), updates the 1964-1984 directory with new information on reprints and supplements from the *Journal of Physical and Chemical Reference Data*, other NSRDS data compilations and critical bibliographies, computer programs for handling technical data, and magnetic tapes in the National Standard Reference Database series. Author, materials, and properties indexes, as well as ordering information and price lists, are included. For information on the directory, or to obtain a copy of SP 708, Supplement 1, send a self-addressed label to: Office of Standard Reference Data, A233 Physics Building, National Bureau of Standards, Gaithersburg, Md. 20899, telephone: 301/975-2208.

CONTACT: Roger Rensberger, 301/975-2762
AT&T, DEC HELPING NBS DEVELOP TEST METHODS FOR POSIX

Researchers from AT&T and Digital Equipment Corporation are working with NBS to develop test methods for the Standard for Portable Operating System Environments, commonly known as "POSIX" (a trademark of the Institute of Electrical and Electronics Engineers). Test methods are needed by industry and users to ensure that the operating system environments being developed conform to the proposed POSIX standard. POSIX was developed by IEEE with participation from industry and NBS. In addition, NBS is developing a Federal Information Processing Standard based on POSIX. (FIPS are developed by NBS for use by the federal government.) Anthony Ingoglia from AT&T and Robert Bagwill from DEC will work with the NBS Institute for Computer Sciences and Technology.

CONTACT: Jan Kosko, 301/975-2762

NEW STANDARDS FOR CONNECTING STORAGE DEVICES TO COMPUTERS

The Secretary of Commerce has approved two new Federal Information Processing Standards (FIPS) which should reduce the governments's costs of mass storage equipment such as magnetic disk and tape devices. Adopting voluntary industry standards that were developed with NBS assistance, the new standards define the functional, electrical, and mechanical specifications for an intelligent peripheral interface and a small computer system interface. These standard interfaces should improve the ability to interchange storage equipment and broaden sources of supply, thus reducing costs for initial acquisitions as well as replacement. Both standards become effective Dec. 16, 1987. For information on ordering, contact the National Technical Information Service, Springfield, VA 22161. Refer to FIPS 130, Intelligent Peripheral Interface (IPI), or FIPS 131, Small Computer System Interface (SCSI). FIPS 130 adopts ANSI X3.129-1986; X3.147-1986; X3.132-1986; and X3.130-1986. FIPS 131 adopts ANSI X3.131-1986.

CONTACT: Jan Kosko, 301/975-2762

NBS RECOMMENDS 400TH ENERGY-RELATED INVENTION

A new process for continuous casting of steel cylinders used in manufacturing seamless pipe and tubing recently became the 400th invention to be recommended by NBS to the Department of Energy (DoE) for possible assistance in development and marketing. Through the Energy-Related Inventions Program, conducted jointly by NBS and DoE, inventors can receive help in getting their ideas from the workshop to the marketplace. NBS provides, at no cost to the inventor, evaluations of energy-related inventions and recommends those it considers promising to DoE. In turn, DoE can provide financial support or help in marketing an inventor's idea. The one-time DoE grants typically have ranged between $50,000 and $200,000, with an average of $80,000 per invention. Those with ideas that will help save energy or who would like more information on the program should write to Office of Energy-Related Inventions, Rm. 209 Engineering Mechanics Building, National Bureau of Standards, Gaithersburg, Md. 20899.

CONTACT: Jan Kosko, 301/975-2762

NBS ESTABLISHES ULTRA-CLEAN CERAMIC PROCESSING LAB

One of the barriers to the widespread use of advance ceramics is the inability of manufacturers to produce materials with consistent performance. Impurities in ceramic powders during compaction, calcination, and sintering can affect the microstructures and other properties of advanced materials used for high-temperature engines and turbines, semiconductors, superconductors, and other aerospace and electronic products. To study the effects of contamination on the processing and composition of advanced ceramics, NBS has established a clean room facility for producing powders and sample materials with controlled levels of impurities and dopants. The laboratory, which has special work areas where several different projects can be conducted simultaneously without cross contamination of materials, includes a laminar flow work area with "class 10" clean room conditions, and such laboratory equipment as a rotary evaporator, drying oven, a press for making pellets, and controlled atmosphere furnaces. For information on the multi-user facility, which is available for cooperative programs with scientists from industry and universities, contact: Dr. John E. Blendell, A258 Materials Building, National Bureau of Standards, Gaithersburg, Md. 20889, telephone: 301/975-5796.

CONTACT: Roger Rensberger, 301/975-2762

INTRODUCTION TO STANDARD ACTIVITIES PUBLISHED

The ABC’s of Standards-Related Activities in the United States (NBSIR 87-3576) is an introduction to voluntary standardization, product certification and laboratory accreditation programs in the United States. The report is designed to provide information for users who may not be familiar with various areas of standardization and the relationships between groups. Information is provided on the history of standardization, types of standards, private standards groups in the U.S., and procedures, and the benefits and problems of standardization such as participation in the standards process by qualified consumer representatives. For copies of NBSIR 87-3576, send a self-addressed mailing label to: Maureen A. Breitenberg, A629 Administration building, National Bureau of Standards, Gaithersburg, Md. 20899, telephone: 301/975-2762.

CONTACT: Roger Rensberger, 301/975-2762
NBS PUBLISHES REPORT ON STANDARDS AND TRADE CONFERENCE

Manufacturers, marketing representatives, product developers, regulatory officials, exporters and others concerned with international trade will be interested in *Proceedings of Conference on Standards and Trade* (NBSIR 87-3573). The conference, held on May 5, 1987, was sponsored by the bureau and the Department of Commerce's International Trade Administration. It provided a forum for representatives from business, standards communities, and government to identify possible standards-related actions to be undertaken by government or jointly with the private sector to improve the country's trade balance. The conference proceedings include recommendations by participants that might be taken in specific national markets and in various international standards arenas to ensure adequate U.S. representation in organizations that develop international standards. For copies of NBSIR 87-3573, send a self-addressed mailing label to: Judy Baker, Office of Product Standards Policy, A603 Administration Building, National Bureau of Standards, Gaithersburg, Md.

CONTACT: Roger Rensberger, 301/975-2762

NBS MAKES HIGH-TEMPERATURE SUPERCONDUCTING DEVICE

Scientists at the NBS Boulder Laboratories have demonstrated what may be the first superconducting electronic device to operate at 81 kelvin – above the liquid nitrogen temperature of 77K. The superconducting quantum interference device, or SQUID, is a high-temperature version of the most sensitive existing device for measuring magnetic fields. In the future these high-temperature devices may replace important elements of the common electrocardiogram, and be used for prospecting and in computers. Dr. James E. Zimmerman, a recently retired NBS physicist now working in the bureau's Boulder laboratories as a guest researcher, designed and constructed the SQUID. The yttrium-barium-copper oxide material, which permitted the device to operate up to 81 K, was made at NBS by Dr. Ronald Ono and Mr. James Beall of the bureau's Center for Electronics and Electrical engineering. In another development at NBS, Drs. John Moreland and Alan Clark observed the ac Josephson effect above 77K, confirming that electrons in these new materials are paired as they are in conventional superconductors. Devices based on this effect may become future microwave detectors and sources and voltage standards.

CONTACT: Collier Smith, 303/497-3198

FIRST ENERGY GAP MEASUREMENTS ON SUPERCONDUCTOR MATERIALS

Using a recently developed break junction technique, NBS researchers have made the first electron tunneling measurements of the energy gap in one of the new superconductor materials with relatively high critical temperatures ($T_C$). The material was lanthanum-strontium-copper oxide, which becomes superconducting at 36 K, and is similar to other materials recently discovered with $T_C$ as high as 98 K. The energy gap in La-Sr-Cu-O$_2$ was found to be $7.0 \pm 0.1$ meV. This measurement provided the first glimpse at the microscopic quantum nature of the superconductivity in these high-$T_C$ materials. Until recently superconductivity was a phenomenon observed only at temperatures below about 20 K, where refrigeration costs are very high. Several materials have now been discovered with $T_C$ up to five times as high, allowing the substitution of liquid nitrogen (at 77 K) for helium as a refrigerant, lowering costs by a huge factor. An article by J.M. Moreland and A.F. Clark of NBS appears in the May 1987 issue of *Cryogenics*.

CONTACT: Collier Smith, 303/497-3198

MEASUREMENT ASSURANCE FOR THE NUCLEAR POWER INDUSTRY

NBS and the Atomic Industrial Forum (AIF) have begun a new measurement assurance program to aid nuclear power facilities in making accurate measurements of radioactivity. The program, conducted by AIF with assistance from NBS, concentrates on operational and environmental radioactivity measurements (not personnel dosimetry), and includes the distribution of blind standard samples for measurement by participants, analysis of the consulting, and direct traceability to NBS standards. Utilities representing approximately 40 operating power stations and four commercial laboratories which provide radioactivity standards and calibration services for the nuclear industry already participate in the program. The cost of participating in the program is approximately $10,000 for the first year. For further information or to enroll in the program, contact David Harward, Atomic Industrial Forum, 301/654-9260. For technical details about the program, contact Daniel Golas, an AIF research associate at NBS, 301/975-5540.

CONTACT: Michael Baum, 301/975-2762

BUREAU SUCCESSFULLY OPERATES 10-VOLT JOSEPHSON ARRAY

Researchers at the NBS Boulder Laboratories have achieved an extremely precise 10-volt output from an array of superconducting Josephson junctions. The array may eventually serve as a new standard for the U.S. legal volt at an unprecedented level of accuracy for this voltage. The researchers believe the array has more active elements than any previous fully operational superconducting integrated circuit. Development of the array was driven by increasing demands for calibration of popular 10-volt Zener diode standards. Such standards are gradually replacing 1-volt Weston-type cells as secondary standards in industrial and
military laboratories around the country. Each Josephson junction can generate only a few millivolts (thousandths of a volt). Previous 1- or 2-junction Josephson standards required a complicated resistance bridge to compare the tiny standard voltage with that of devices being calibrated. However, increased accuracy is possible when many Josephson junctions in series can be fabricated on a single chip, eliminating the need for the resistance bridge. NBS researchers have now succeeded in operating an array of 14,184 Josephson junctions to provide a 10-volt output, realizing a voltage standard at an even more useful level. These long arrays of superconducting junctions are constructed using technology borrowed from the semiconductor integrated circuit industry, substituting thin films of superconducting metals such as lead and niobium for the semiconductors.

CONTACT: Collier Smith, 303/497-3198

ANTENNA MEASUREMENT ERRORS DESCRIBED, EVALUATED

When antennas are measured or calibrated in anechoic chambers, a misalignment of the receiving and source antennas will lead to errors. In the case of near-field measurements, uncertainty about the location of the probe with respect of the antenna will cause relatively large errors. Two recently published reports from NBS rigorously examine these errors to quantify their effects on measurement accuracy. Evaluation of Off-Axis Measurements Performed in an Anechoic Chamber (TN 1305) and Displacement Errors in Antenna Near-Field Measurements and Their Effect on the Far Field (TN 1306) are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. TN 1305 may be ordered for $2.25 prepaid; order by stock no. 003-003-02779-1. TN 1306 costs $2 prepaid; order by stock no 003-003-02776-6.

CONTACT: Collier Smith, 303/497-3198

BUREAU SIMPLIFIES CIRCUIT CHECKS FOR DATA CONVERTERS

NBS has developed a method that reduces the number of tests needed to ensure reliable operation of digital-to-analog converter (DAC) circuits from 1,024 to as low as 13. These circuits are at the heart of computer-based systems, modern test measurement and diagnostic equipment, and even new home stereo components. The NBS method combines analytical computer modeling information with actual measured errors obtained from bench testing a number of data converters of the same type. From these two sources, researchers pinpoint which individual clusters of circuit components require attention in order for the overall data conversion device to operate acceptably. NBS identified 13 calibration points, representing the complex effects of many circuit components, but this number could vary depending on the type of converter circuit. DAC manufacturers will likely find the NBS method useful because it can save manufacturing time. These companies also can include generic information needed to apply the NBS technique in a converter's basic specifications without jeopardizing proprietary information. Customers then can confirm the manufacturer's test results.

CONTACT: John Henkel, 301/975-2762

PROBLEMS IN MEASUREMENT OF SUBMICROMETER STRUCTURE

Two papers in the current Journal of Research of the National Bureau of Standards examine measurement problems that will be encountered as the integrated circuit (IC) industry moves to circuits with submicrometer features. The size of features on ICs has been reduced to the point where measurement of their dimensions presents serious problems. However, their dimensions must be accurately measured to be controlled. Parallel papers "Submicrometer Linewidth Metrology In the Optical Microscope" (Nyssonen, Diana and Larrabee, Robert D., J. Res. Natl. Bur. Stand. 92 Dimensional Metrology: Scanning Electron Microscopy" (Postek, Michael T. and Joy, David C., J. Res. Natl. Bur. Stand. 92 3 (1987), pp. 205–228) examine potential problems in making accurate measurements of these features at such small dimensions using either optical or scanning electron microscopes. Sources of measurement error, possible solutions, and NBS plans for standard reference materials to aid industry in making accurate submicrometer feature measurements are discussed. Copies of the papers are available from the Microelectronics Dimensional Metrology Group, A347 Technology Building, National Bureau of Standards, Gaithersburg, Md. 20899, telephone: 301/975-2064.

CONTACT: Michael Baum, 301/975-2762
Randy Wear, NCSL South Texas Section Leader and San Antonio Account Manager for John Fluke Manufacturing Company, Inc. has been involved in the calibration and precision instrument field for over 11 years. Born in Birmingham, Alabama in 1956, Randy traded in the small town life to join the United States Navy in 1975. Randy served as a Second Class Petty Officer in the field of interior communications electronics.

Following an honorable discharge, Randy's experience as a technician and Petty Officer in charge of a Precision Measurement Equipment Laboratory lead him to pursue a career in the field of electronic measurement equipment with John Fluke Manufacturing Company.

In December of 1979 Randy relocated his family from Charleston, South Carolina to The Silicon Rain Forest in Everett, Washington where he began work as an electronics technician in the General Test and Systems Group at John Fluke Manufacturing Company Inc. While working in Everett, Randy attended Everett Community College to pursue his interests in Mathematics.

In March 1984 Randy again relocated his family to Atlanta, Georgia to pursue his new career goals in the field of marketing and sales. He served as Staff Engineer for Fluke's Atlanta District Sales Office.

Randy and his family once again pulled up stakes in October of 1985 moving from Atlanta to Sugar Land, Texas where they presently reside. Randy is the San Antonio Account Manager responsible for the sales of Fluke products to Major Commercial Accounts in the South Texas area. Along with Randy's responsibilities as an Account Manager, he has volunteered to serve the National Conference of Standards Laboratories as South Texas Section Leader.

On the personal side, Randy has two sons, Shawn and Andy who are 8 and 5. Shawn will begin the third grade next fall and is involved in karate (recently receiving his yellow belt) and baseball. Andy will begin kindergarten this year and also plans to begin karate and baseball. The woman in Randy's life is a pretty, red-headed Irish girl named Dottie. She does an excellent job of running and managing the household, keeping Randy's life in order and raising two energetic boys, along with pursuing her hobbies and staying active in aerobics classes. The newest member of the Wear family is an apricot poodle named Dusty.

Randy's hobbies consist of golf, hunting, fishing and aerobics.
Our host, Bob McFarland, General Manager of the National Distribution Center in Garland, Texas, begins with a brief introduction. "U.S. Instrument Rentals, the leading automated design and test instrumentation rental company, is a subsidiary of the San Francisco based U.S. Leasing International, Inc. U.S. Instrument Rentals was established in 1974 to serve the electronic marketplace. Headquartered in San Mateo, California, the company rents, leases, and sells electronic design and test instruments, data-processing equipment, telecommunications products, and analytical instrumentation primarily to the business community. Our customers include corporations of all sizes, government agencies, government contractors, non-profit institutions, and pharmaceutical, chemical, and environmental industries."

Lab technicians check and calibrate all equipment in the Distribution Center. A total of 36 different workstations are available for lab use, some of which are dedicated to specialized procedures.

The business of renting electronic test equipment places several unique demands upon U.S. Instrument Rentals' metrology operation. First is the need to warehouse a large inventory of many different kinds of test equipment, ranging from meters and oscilloscopes to sophisticated microprocessor development systems. This in turn requires that the laboratory be prepared to calibrate, maintain, and repair this broad spectrum of equipment.

U.S. Instrument Rentals' main thrust is the rental, lease, and sale of electronic test and measurement equipment. The National Distribution Center for automated design and test instruments is located near Dallas, Texas. It occupies 100,000 square feet and carries one of the largest inventories of test equipment in the industry. It also includes a 20,000 square foot calibration facility which contains over $2 million of laboratory standards for use in routine calibrations and repairs.

A view of the large warehouse shelf storage area at NDC. U.S. Instrument Rentals carries over 5,000 different manufacturer models in its inventory of electronic test equipment.
USIR provides same day shipment of any piece of equipment in inventory, so it is important that the lab and warehouse functions be integrated in the most efficient way possible. The Distribution Center was designed with this criterion in mind. This allows USIR to fully support all of its customers' needs while providing a calibration system that is in full compliance with MIL-STD-45662.

At the Dallas facility a complete staff of 45 skilled technicians working two shifts a day, five days-a-week and one shift on Saturday and Sunday, are grouped by product specialty. The technicians are responsible for checking and calibrating all equipment before it goes to the customer. This is no small task since there are some 5,000 different models in 15 separate product categories, representing tens of thousands of individual pieces of equipment. Among the types of products stocked are analyzers, CAE/CAD equipment, microprocessor development systems, counters, desktop controllers, generators, meters, oscilloscopes, recorders, signal modifiers, and telecommunication test devices.

To accomplish the complex calibration process, the company groups the calibration technicians into teams that specialize in generic groups of equipment. The laboratory quality program is managed by certified quality engineer.

A complete conveyor system implements a modern approach to inventory control and warehousing. Incoming rental returns are unboxed, examined for physical damage, and checked to ensure that all accessories are present. The equipment then goes to the conveyor belt for the trip to the lab. At the end of the ride the equipment is loaded onto shelved carts for processing through the lab.

Incoming rental equipment passes on a conveyor belt from the receiving area to the storage area. Along the way, it is unboxed, checked for damage, then sent to the lab for thorough inspection and recalibration.

Next, all units are checked and calibrated by lab technicians, and any missing accessories are replaced at that time, if available. The recalibrated equipment is then returned to carts for its ride to the inventory shelves. Those pieces of equipment that are unable to be calibrated, whether due to electrical failure, damage, or unreplaceable accessories, are sent to the repair area for further investigation and refurbishing. This calibration procedure is repeated before any piece of equipment is shipped out again, resulting in every device being actually double checked before it goes to the customer.

Of particular interest to the user is USIR's fully automated on-line computer system that provides immediate answers to the availability of any piece of equipment in stock. With the use of remote computer terminals located in each of our network of nationwide sales offices, a salesperson can confirm the availability of a piece of equipment and reserve it immediately. With the aid of the computer, the centralized Distribution Center can quickly process and package equipment in foam packing or for placement in our customized, rugged, two-way shipping containers. Either way, the equipment arrives at your door in good condition. And if a customer has any problems, a twenty-four hour, seven days-a-week service hotline is available for customers in the field. In the event of equipment failure, the Distribution Center can usually get a replacement to the customer within 24 hours.
U.S. Instrument Rentals' customized two-way shipping containers are designed to provide maximum protection against shock/vibration and protect some 400 different types of uniquely shaped instruments.

In the last few months, U.S. Instrument Rentals has successfully passed numerous audits of its quality program by such prestigious corporations as TRW, NORTHROP, WESTINGHOUSE, ITT, ROCKWELL INTERNATIONAL, FORD AEROSPACE, and UNIVERSAL TESTING LABS for compliance with the following Department of Defense directives.

- MIL-Q-9858A Quality Program Requirements
- MIL-I-45208A Inspection System Requirements
- MIL-STD-45662 Calibration System Requirements
- MIL-MDBK-52A Contractors Calibration System
- MIL-STD-105D Inspection By Attributes Plan

Moreover, the calibration system requirements at U.S. Instrument Rentals are in full compliance with the U.S. Air Force Technical Order – TO33K-1-100, TMDE calibration interval, which establishes time intervals between calibration.

U.S. Instrument Rentals has been configuring systems, advising customers, and providing application assistance since 1974. Because of the breadth of its product line and in-house technical expertise, the company has been exposed to most difficulties encountered in configuring systems.
1987 REVISION TO NATIONAL MEASUREMENT REQUIREMENTS REPORT

Anyone working on projects requiring measurement services from the U.S. NBS, and worried about the setting of national priorities for them may wish to get this major report which presents all those requirements. The NMRC has revised their 1986 report to include the latest concerns and parameters. Contact the NCSL Secretariat if you didn’t get one.

Anyone who has been frustrated trying to find technical papers or reports dealing with calibration intervals, accuracy ratios, error modeling or the like will be gratified to know that the CIC has taken as a task for 1987 the start-up of a centralized library to bring together analytical work done in the metrology arena. To date, no established repository of this sort is known to us. Such a library will help to standardize terminology, disseminate knowledge, and minimize duplication of effort in analytical metrology research and development work. It may also provide a sounding board for workers within the field, and could improve visibility to those in technical or scientific disciplines currently outside the metrology community. Potentially, the library could stimulate a broader base of talent for dealing with metrology problems.

We are asking each NCSL member organization to participate in setting up the library by providing information on relevant technical and scientific papers, letters, circulars, newsletters, books, articles, etc. Please let us know if you or your colleagues have documents that can be shared by completing the enclosed forms and sending them to:

Howard Castrup
C/o SAIC
300 South Park Ave. Suite 950
Pomona, CA 91766

We are aiming at producing a document catalogue by late 1987 containing a list of contributors and short descriptions of material based on the information provided.

Howard T. Castrup
Chairman

Ed Note: Howard asked for questionnaires to be submitted by August 15, but I’ll bet he’ll be happy to hear from you anytime if you have information for him.

* * * * * *

EQUIPMENT MANAGEMENT FORUM
MESA, AZ, 2-19-87

This report assumes no editorial license; questions and comments are as much as possible verbatim. Some grouping for commonality of subject has been attempted where useful.

Reviewing the questions and discussions of the workshop leaves one with several distinct impressions:

1) There appears to be a great void in the Equipment Management Community in regard to "How To". The
questions, enthusiasm and the general air of expectance certainly attest to the need on the part of the EMF to continue, not merely probing for where it hurts, but also providing some needed Rx for as many of the ills as can be dealt with in a timely manner.

2) The call is almost universal from every quarter for a "handbook" of some nature: Recommended practices, definitions, terms, examples of working systems and how they came to be. Not just the highly sophisticated systems with procurement, utilization, chargeback, and disposal sub-systems, but just bare-bones inventory-control/custodian-tracking systems as well.

3) The diversity of questions, equal only to the diverse mix of the attendees, rings loud and clear that the Equipment Management Forum not only has a place in the sun but also has its work cut out for it.

Raymond Barrett,
Tektronix, Inc.
I & T Equipment Management

Problems/Solutions Workshop

PROBLEM/CONCERN
* convincing upper management of the value of the Pool concept
* how to get upper level management involved
* how to justify and set-up an equipment management system
* how do I implement Equipment Management
* how to sell management system to company and users

SOLUTIONS
* documented financial analysis showing clearly the advantages and disadvantages of the proposition
* use contacts from EMF or all of NCSL to find out how other companies have done it

POINTS TO CONSIDER
* cost avoidance
* higher rate of redeployment
* minimize redundant acquisitions
* improved utilization
* improved return on assets/investments
* better visibility of total equipment acquisitions
* standardization of equipment
* standardized production operating procedures
* standardized/minimized parts inventory

RECOMMENDED ACTIONS
* identify and set-up a recommend data record format for an equipment management record
* need of Equipment Manager's Handbook – many need to know how to set up a system
* provide suggestion on how to implement an Equipment Management system

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PROBLEM/CONCERN
* chargeback System
* how do you develop and what are some examples of a pool chargeback system
* incentive for returning equipment to the pool

SOLUTIONS
* secure commitment to centralize function from top management is first step
* establish a central owner for all test equipment under full concept
* provide fiscal justification for such a centralized function
* some combination of the above as appropriate for your organization

RECOMMENDED ACTION
* forum should prepare a handbook of guidelines detailing the necessary steps to establish an effective chargeback system
* recommend approaches to overcome common obstacles
* also techniques and methods to generate fiscal justification for implementing such a system, in a phase-by-phase manner
* incentive programs which have been proven to be effective, maximizing system compliance

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PROBLEM/CONCERN
* how do you calculate utilization
* define utilization
* pool equipment turn-over (DCAA proof)

SOLUTIONS
* no solutions elaborated on, however, one of the rental companies has offered to the EMF a model of how they calculate utilization
* set a separate P.C. control system

RECOMMENDED ACTION
* possible subject matter for future EMF workshop
* recommend EMF include definition(s) and yardstick(s) for monitoring in Equipment Manager's handbook
PROBLEM/CONCERN
* how do some companies screen inventories for possible redeployable equipment

SOLUTIONS
* central acquisition facility

PROBLEM/CONCERN
* management of personal tools/equipment on the job
* how to control if tools are taken home
* who pays for recalibration/repair

SOLUTIONS
* identify and control same as company owned
* don’t allow personal tools
* company pays for repair/recalibration
* rely on personal integrity of employee
* allow them but control if used for product acceptance

PROBLEM/CONCERN
* defining common terms/definitions
* ensure discussions and charts clearly define content of inventory under analysis, e.g., electrical, electronic, physical – if mixed, what ratio

SOLUTIONS
* need glossary of terms that industry can use

NOTES
* EMF steering committee is attempting to put together definition of terms

PROBLEM/CONCERN
* equipment over spec’d by for actual need requestor

SOLUTION
* greater involvement by equipment management or technical review board in specification phase of procurement activity

NOTE
* need to weigh cost effectiveness of such involvement

PROBLEM/CONCERN
* tracking equipment: issued, but to whom
* incomplete record due to human error

SOLUTION
* bar coding
* real-time system operated by central group

RECOMMENDED ACTION
* could be a future forum subject

PROBLEM/CONCERN
* what is most effective method of tracking the where-abouts of all categories of equipment

SOLUTION
* open

RECOMMENDED ACTION
* could be future forum subject

PROBLEM/CONCERN
* what’s the criterion for setting up repair parts for equipment servicing

SOLUTION
* open

RECOMMENDED ACTION
* could be future forum subject

PROBLEM/CONCERN
* on initial start-up of pool system – should all pool equipment be recalled for issue

SOLUTION
* in most cases this is not practical
* do a wall-to-wall inventory over the weekend
* use recall list for initial inventory
* what type of equipment should be in the pool
* collect inactive equipment

RECOMMENDED ACTION
* could be subject for future forum

PROBLEM/CONCERN
* should the pool have full or partial control of it’s equipment

SOLUTION
* full control on paper
* complete control gives more clout in operation of pool
PROBLEM/CONCERN
* what should be pool equipment
  GPTE
  SPE
* how should the pool control the movement of equipment
* how does the pool make the user take the pool seriously
* how does the pool obtain a total (complete) inventory

SOLUTION
* open

RECOMMENDED ACTION
* could be subject for future forum

PROBLEM/CONCERN
* should pool equipment in the crib be in cal

SOLUTION
* identify and keep active equipment in cal
  * cal when requested
  * don't have an equipment pool

PROBLEM/CONCERN
* when does calibration begin

SOLUTION
* when equipment comes off the shelf
  * when calibrated
  * when put into use
  * user is responsible for adhering to recall notice

PROBLEM/CONCERN
* what do we expect from EMF
  * solutions needed
    chargeback system – what works
    how to present to management real needs in a convincing way
    should there be portable standards for mobile calibration
    better management tools/methods for good equipment management
    committee for studying recommended practices: barcodes
    chargeback
    rent/lease/buy
  * demonstration of active management system – good things and pitfalls

PROBLEM/CONCERN
* where can you get license for barcode readers

SOLUTION
* buy package from reader supplier, if available
  * get licensed and do it yourself

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PROBLEM/CONCERN
* manufacturers do not have the capability to certify calibration to MIL-STD-45662 after performing repairs on returns

SOLUTION
* perform source surveys to establish calibration capability status for manufacture and for calibration service only organizations

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PROBLEM/CONCERN
* how do I get equipment which is not used, returned to the pool

SOLUTION
* get industrial engineering to implement work sampling plan

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MEASUREMENT ASSURANCE COMMITTEE REPORT

I. Region 8 Group 1 and 2 Volt MAP repeats:

Both groups had successful repeats, with the NBS transport standard being hand-carried both ways. This appears to have become a necessity, at least from the West Coast, but no one knows why.

II. Region 8 Gage Block "Round-Robin":

The Southern California Gage Block Round-Robin Group is ready to start round three.

The two sets of blocks used in the exchange and supplied by McDonnell Douglas have been sent to NBS for measurement. Assuming a timely return from NBS, round three should be under way by August or September of this year. Completion is estimated to take six or seven months.

III. Region 4 Volt MAP plans

In preparation for their first Volt MAP, the three-lab Florida group of Guildline, Datron, and EGG has completed the first
Committee News

phase of a three-way round-robin, so far with very good results.

Arno Ehman

EDUCATION COMMITTEE REPORT

Butler Community College and Hutchinson Vo. Tech. Institute continue to be the academic institutions producing metrology technicians. Both are experiencing a high demand for their graduates. Hutchinson is graduating 40 students who have numerous job offers. They have received funding to write a proposal on artificial intelligence curriculum. The metrology proposal for Allen Hancock Junior College is temporarily on hold.

Kate Webster
Education Liaison Committee

CALIBRATION INTERVAL COMMITTEE REPORT

An impromptu meeting was held on May 5-6, in Claremont, CA. John Ferling hosted the event, which was attended by John, Frank Butz, Jerry Hayes, Ray Kletke, John Larsen, Jim Ryan and me. A summary of the presentations is as follows:

May 5

Jim Ryan – Jim discussed McDonnell Douglas Electric Company’s study to determine the calibration interval system best suited to company needs. A great deal of planning and implementation effort went into the study and I’m sure the results will be of interest to all CIC members. Also presented were some very interesting data on cal standard-to-test equipment and test equipment-to-end item accuracy ratios encountered in typical test and validation scenarios at the MDEC facility.

Frank Butz – Frank took us into the unfamiliar (to most of us) world of mechanical standards and test equipment with a detailed discussion of the General Electric Company’s system at Evendale, Ohio. The presentation was particularly illuminating with regard to the baseline assumptions appropriate for managing mechanical equipment. Also presented was a comprehensive scheme for grouping such equipment into generic categories for purposes of interval assignment.

May 6

John Larsen – John presented the wide variety of topics encompassed by the U.S. Navy systems and provided insight into the logistic and management environment in which the system operates. A number of statistical/analytical techniques and methods were described for determining and adjusting intervals, identifying dogs and gems, and grouping equipment by similarity of design and performance. A short discussion was also given which challenged certain assumptions concerning multiparameter instrument tolerancing.

Howard Castrup – I summarized the various special studies, empirical findings and thought processes that went into developing the TRW OSG system. The basic methodology and approach was outlined and the system design and operating environment baseline was described. In addition to interval determination and adjustment, dog/gem identification, equipment grouping, suspect user identification, and system selfevaluation features were discussed. Also covered was the variety of mathematical functions employed to model a broad spectrum of standards and test equipment.

Prior to the presentations, the meeting opened with a brief review of NCSL RP#1. This review concluded with some discussion of assigning updating specific parts of the RP to specific Committee members. It was decided to postpone test assignments until after the presentations were completed to provide the best match between RP topic and member expertise. This will be taken up at our next regularly scheduled meeting in July.

Howard T. Castrup
Chairman
NATIONAL MEASUREMENT REQUIREMENTS COMMITTEE
(Input for Calibration Requirements)

Name: __________________________ Title: __________________________

Company: __________________________ Phone: __________________________

Address: __________________________ __________________________

Principal Products/Service at this Location: __________________________

Measurement Requirement Category (please check one and mail this form to appropriate subcommittee chairperson listed):

DC-Low Frequency: ________ RF-Microwave: ________ Electro-Optics: ________

Mr. Donald Dalton
P.O. Box C9090
MS: 271G
Everett, Wa. 98206

Mr. Frank Koide
Koide International Consultants
5757 Caminito Empresa
La Jolla, CA. 93037

Mr. Gary Mathers
Naval Weapons Station
Seal Beach Detachment
(Code: 3123)
Corona Annex
Corona, CA 91720-5000

Temperature-Pressure: ________ Physical-Dimensional: ________ Other: ________

Mr. Laurie Baker
Rockwell International
AMSD Metrology
MS: HC02
3370 Miraloma Ame.
Anaheim, CA. 92803

Mr. Robert Tobias
TRW
One Space Park
Mail Code: S-2470
Redondo Beach
CA. 90278

Description of Requirement for which Adequate Calibration Support is not Available:

1.) __________________________

2.) __________________________

Estimate of Financial, Schedule, Manufacturing Impact if Requirement is not Supported:

________________________________________

________________________________________

________________________________________

Other Comments:

________________________________________

________________________________________

________________________________________

Ed Note: The board of Directors has asked that this NMRC questionnaire be included in each issue of the NCISL Newsletter.
TWO POSITIONS ON INTERNATIONAL WORKING GROUP ON UNCERTAINTIES

Editor's Note: These things happen a lot. A strong difference of opinion on technical matters or direction. Dr. Ron Collé of NBS submitted his meeting report of the Advisory Group on Uncertainties, and, soon after, Rolf Schumacher submitted a report in conjunction with Ron Dieck and Mike Englund which differed considerably from the first one.

So I'm doing what many editors would do in this spot - printing both of them, so you the reader can get the flavor of both sides. Finally, the third report is from Mr. Collé on the May 6-8, 1987 meeting in Paris. And incidentally, in the January 1988 issue, I hope to print the paper by Dr. Colclough which also bears on the subject.

MINUTES OF THE MEETING ON MEASUREMENT UNCERTAINTIES
April 24, 1987
NBS, Gaithersburg, Maryland

1. Attendees

Mr. Albert
D. Braudaway
M. Brossmen
R. Collé
C. Croarkin
W. Crummett
L. Currie
R. Dieck
D. Edgerly
M. Englund
D. Flynn
A. Goldman
A. Greedone
B. Horwitz
K. Jaeger
R. Judish
R. Kamper
H. Ku
R. Loevinger
A. McCoubrey
M. Natrelia
E. Nemeroff
A. Painter
D. Sharp
E. Schonthal
R. Schumacher

FDA
Sandia Laboratories
EPA
NBS
NBS
Dow Chemical
NBS
Pratt & Whitney
NBS
Garrett Turbine Engine Co.
NBS
Los Alamos National Laboratory
National Standards Testing Lab.
FDA
Lockheed Missiles and Space
NBS
NBS
NBS
NBS
Boeing Aerospace
IBM
Bruel & Kjaer
Rockwell International

Meeting of the ISO/TAG-4/WG-3 on Uncertainties. The meeting was co-chaired by David Edgerly and Ron Collé of NBS.

3. Discussion Summary

Mr. Edgerly opened the meeting, welcoming meeting attendees and stating that the purpose of the meeting was to discuss an international effort to develop a guidance document for the treatment and reporting of measurement uncertainties.

Mr. Edgerly provided background on the international effort to develop the guidance document. The meeting attendees recommended that the background information be included in the minutes. Accordingly, it is summarized below.

Background

The need for a guidance document on uncertainties has been longfelt throughout the international measurement community.

International measurement community includes:

* national measurement laboratories (NBS, NPL/NEL, PTB, BNM, VanSwiden, etc.) together with the organizations of the Treaty of the Meter
* international standards organizations (OIML/ISO/ IUPAC)
* multinational/national corporations involved in international trade who rely on national calibration certificates as evidence of traceability to national standards.

In the late 1970's, the International Committee of Weights and Measures (CIPM) began to explore the problem by doing a survey of 32 national measurement laboratories to determine their practices in assigning measurement uncertainties. The results of the survey indicated a need to try and find some common ground rules that the national labs could follow that might lead to some measure of agreement on how to assign uncertainties.

In 1980, BIPM convened a meeting of experts from 11 national labs to try and arrive at uniform guidelines on uncertainties. Ron Collé participated in that effort. It resulted in a report (1981) which essentially provided five guidelines which are more or less in the nature of an approach which indicates the goal to be achieved rather than an explicit specification of algorithms and methods. Most of the BIPM working group members felt that many further details would have to be addressed and resolved before the recommended approach could be routinely, uniformly, and widely used. In any event, the CIPM recommended in 1981 that national labs
try and implement the guidelines and report back on their results and experience.

Between 1982 and 1986, Dr. Ambler, NBS Director, asked the CIPM to consider if work should be undertaken to further develop the BIPM guidelines. NBS knew, for example, that a number of European National Labs had incorporated the Guidelines into their calibration services. However, the CIPM decided not to take further action, but instead, to refer the matter to ISO Technical Advisory Group 4 on Metrology with the feeling that it might be interested in extending the original work done by BIPM and also in developing guidance on uncertainties that would be of practical benefit to national calibration services and to private industry.

Why ISO TAG-4? TAG-4 is a horizontal committee within ISO that is responsible for coordinating measurement related questions within the 160 or so TCs within ISO and for cooperating with BIPM, OIML, and the IEC on common measurement problems. Recently, TAG-4 was successful in producing an International Measurement Vocabulary which has gained recognition among all four organizations.

At its last meeting in April, 1986, TAG-4 agreed to establish a new Working Group 3 to develop a guidance document on uncertainties. It was also agreed that Ron Collé would chair the new WG-3 and that it would be made up of 11 members nominated from within the four international organizations. TAG-4 also established the terms of reference for WG-3 which are as follows:

"To develop a document based upon the recommendations of the BIPM Working Group on Uncertainty which provides guidance on the expression of measurement uncertainty for use within standardization, calibration, laboratory accreditation and metrology services. The purpose of such guidance is to promote full information on how uncertainty statements are arrived at and to provide a basis for the international comparisons of measurement results."

WG-3, under Ron Collé’s leadership, held its first meeting this past October to decide upon a course of action and a schedule for developing the draft Guidance Document. The second meeting is scheduled for May 6-8 in Paris.

One final point of background and this concerns how the final TAG-4 Guidance Document on Uncertainties will probably be handled by the four international organizations involved and what its status may be as regards its use in the U.S. or by NBS for that matter. Given that Collé can achieve agreement on a draft within WG-3, it will be circulated to the four international organizations involved (BIPM, OIML, ISO, and IEC) for further circulation and comment within the members of such organizations. Comments received as a result of that circulation will be sent to WG-3 to consider and resolve. Once this is done to the satisfaction of WG-3 and the leadership of the four organizations, the document would be published by ISO with the imprint of the four organizations on the cover.

It is not likely that there would be any attempt to require use of the guidance document by the four organizations involved. If the product is good, it will be used in national labs, as for example, in issuance of calibration certificates and perhaps by secondary standards labs. Its use by industrial labs will depend upon its perceived utility.

Presentations by Ron Collé

A major purpose of the meeting was to have a general discussion of the BIPM/CIPM Recommendation and of the proposed contents of the Guidance Document. In order to provide a suitable focus for these discussions, Ron Collé gave three brief presentations.

The first presentation was a historical survey of uncertainty treatments, primarily from an NBS perspective. These treatments ranged from over 30-year-old practices in which estimates of different error types could not be combined; to the current use of the BIPM/CIPM Recommendation. It was pointed out that the treatment of measurement uncertainties is often based on and strongly tied to a mathematical theory of errors. Despite this supposed theoretical basis, there is no unequivocal one-to-one correspondence between uncertainties and different error types. Uncertainties are not errors! Random errors arising from the inherent stochastic variability of a measurement process may indeed manifest as computed statistics (e.g., a standard deviation) which may be taken to be an estimate of random uncertainty. But, any physical realization of a systematic error manifests as an observable offset or correction that must be applied to the measurement results. Hence, only estimates of offsets having unknown magnitude are available.

As a result, no currently used definition of systematic uncertainties is entirely self consistent with the distinction between random and systematic errors. These systematic uncertainties include estimates of underlying random error components for which computed statistics are not available, as well as estimates of offsets of unknown magnitude. There would seem to be very little difference in any underlying nature of these two kinds of estimates. As a result of the ambiguities in relating different types of errors to corresponding uncertainties and even the absence of a theoretical basis for combining the different error types, a large number of incomplete and inconsistent practices emerged.

Collé summarized the two main philosophical approaches that are presently dominant. The “classical” approach is based on
Uncertainties

a central distinction between so-called random and systematic uncertainties. The uncertainties are presumably classified by the underlying physical error type (although in practice this is never achieved), and the approach demands that the different uncertainty types be combined by different methods. Causing even further confusion, the uncertainties in these classical treatments are said to depend on one's "perspective" and they possess chameleon-like properties, and may change from one type to another. In contrast, the "romantic" approach dispenses with the underlying error distinction, and classifies the uncertainties only on the basis of how the uncertainty estimates were made. All uncertainty components in this approach are treated similarly and can be combined by the same general propagation formulae. The romantic approach underlies the BIPM/CIPM Recommendation.

Collé's second presentation consisted of a review of the BIPM Recommendation. The contents of the Recommendation should by now be very familiar to the Advisory Group, and will not be summarized here. A few points, however, are perhaps worth reemphasis:

(1) The distinction between type-A and type-B uncertainties is very logical (being based on what is actually done by the metrologist) and is practical. It is based on an approach given by Eisenhart and Collé in the NBS Communications Manual.

(2) The distinction between errors and uncertainties is an important one that must be maintained in order to have a clear understanding of uncertainty treatments.

(3) Because of all the past confusion over the terms "random" and "systematic", their use is strongly deprecated.

(4) One of the most important and principal achievements of the Recommendation was that it provided (or for the first time) a consistent way for reporting all uncertainty components - in terms of a variance for type-A uncertainties and "B-var" for type-B (of related quantities like standard deviation, covariance, correlation coefficient, "B-covar", etc). A major impact, of course, is that some metrologists may have to change the basis upon which their type-B uncertainties are reported (but perhaps not necessarily change how they are initially estimated provided they make a conversion).

(5) The use of quantities like a variance and "B-var" were chosen since they are or represent distribution-free parameters which are not as dependent on underlying assumptions. Quantities like the square root of B-var are in general more reliable than extreme maximum limits.

(6) A combined uncertainty obtained by applying appropriate propagation formulae using all uncertainty components is not to be interpreted as possessing some "error confidence." This can only be done by invoking additional assumptions.

(7) The complete specification of all uncertainty components which are reported on a comparable basis is the only way to achieve a meaningful comparison between two uncertainty statements.

The third presentation consisted of an overview of the proposed contents of the Guidance Document. For the most part, it follows the outline provided in the Report of the First Meeting of ISO TAG-4/WG-3 (October 1986). For additional information, copies of the overhead viewgraphs used in the presentation are available. It was emphasized that no one should be needlessly offended by the use of any vocabulary or terms within these documents since none of these semantic decisions have been made. Collé specifically requested Industry input on suggestions for additional items to be covered in the Guidance Document, as well as information that might be incorporated into examples of uncertainty treatments and help on developing a suitable glossary of terms and vocabulary, particularly for the type-B components, have not been selected and assurances were made that none will be chosen that violate any well-known statistical definitions.

Following Collé's presentations there was general discussion among the attendees. Several important points were made. First, several attendees expressed concern about abandoning the "classical" approach to uncertainties in favor of the BIPM guidelines, indicating that the classical (random/systematic) treatment of errors was incorporated into a number of existing American standards (ASME, ISA) and would be difficult to change. Edgerly responded that there would be no pressure on such groups to change. The international effort was to achieve uniform methods for assigning uncertainty statements to calibration certificates from national labs and the like. Whether or not industry found it necessary to embrace the BIPM guidelines would be up to industry and the various voluntary standards bodies involved. Others indicated that they felt that there were not significant differences between the two approaches and that perhaps too much was being made of the differences between the two. Collé responded that time and experience in applying the two approaches would determine if such were the case.

A question was posed as to whether it would be possible for the U.S., as a member of the ISO/TAG-4/WG-3, to propose acceptance of an international guidance document based upon the "classical" approach rather than the BIPM approach. Edgerly indicated that the terms of reference of the TAG-4/WG-3 were clear on basing the guidance document on the BIPM work and that it was unlikely that the European members would want to do otherwise since many of them had already adopted the BIPM guidelines in their calibration services. He indicated that the U.S. should not lose this chance to work towards international uniformity and that it
was important for trade. The majority of meeting attendees agreed.

Edgerly indicated that the next meeting of ISO/TAG-4/WG-3 would be May 6-8, in Paris from which a first draft of the guidance document would emerge. Once ready for circulation, it will be sent for review to the U.S. individuals invited to participate with NBS in developing inputs to the TAG-4 effort. A meeting of the U.S. group would be scheduled several months after circulation of the draft.

Ron Collé
Convener, ISO/TAG-4/WG-3

A DISSENTING POSITION ON UNCERTAINTIES

In 1980, the International Bureau of Weights and Measures (BIPM) had held a meeting of representatives from eleven national standards laboratories to "try and arrive at uniform guidelines on uncertainties. Ron Collé participated in that effort." It resulted in a report with five guidelines on the goals to be achieved for reporting measurement uncertainties.

"Most of the BIPM working group members felt that many further details would have to be addressed and resolved before the recommended approach could be ....used"

"Between 1982 and 1986, Dr. Ambler, NBS Director, asked the CIPM (the International Committee on Weights and Measures) to consider if work should be undertaken to further develop the BIPM guidelines". Several ":...European National Labs had incorporated the guidelines into their calibration services. However, the CIPM decided... to refer the matter to ISO Technical Advisory Group 4 on Metrology with the feeling that it might be interested in existing the original work done by BIPM and also in developing guidance on uncertainties that would be of practical benefit to national calibration services and to...industry." The Technical Advisory Group (TAG) 4 then established a new Working Group (WG-3) chaired by Ron Collé and consisting of eleven members nominated from within the four international standards organizations, OIML, ISO, IEC, and IUPAC.

The objective of WG-3 is:

"To develop a document based upon the recommendations of the BIPM Working Group on Uncertainty which provides guidance on the expression of measurement uncertainty for use within standardization, calibration, laboratory accreditation, and metrology services. The purpose of such guidance is to promote full information on how uncertainty statements are arrived at and to provide a basis for the international comparisons of measurement results."

"WG-3, under Ron Collé's leadership, held its first meeting this past October to decide upon a course of action and a schedule for developing the draft Guidance Document. The second meeting is scheduled for May 6-8 in Paris."

"It is not likely that there would be any attempt to require use of the guidance document by the four organizations involved. If the product is good, it will be used in national labs, as for example, in issuance of calibration certificates and perhaps by secondary standards labs. Its use by industrial labs will depend upon its perceived utility... It is not being written in the format of a voluntary standard."

Ron Collé emphasized that "uncertainties are not errors". He explained that the reasons for "all the past confusion" in assessing measurement uncertainties is in part that systematic uncertainties have their origin at times in part in pure estimates and in part in scholastic derivations (from random errors). This give systematic errors or uncertainties a "chameleon-like" property which changes from case to case.

The BIPM recommendations can be summarized as follows:

1. Uncertainties are expressed by components belonging to either Category A (evaluated by statistical methods) or Category B (evaluated by methods other than statistical). These are to replace "random" and "systematic" uncertainty components.

2. Category A components are to be characterized by estimated variances, $\sigma^2$, or standard deviations, $\sigma$, giving covariances where appropriate.

3. Category B components are to be characterized by quantities $1$, considered approximations to the corresponding variances or standard deviations, "...the existence of which is assumed", and by their covariances.

4. The resulting "...combined uncertainty should be characterized by the numerical value obtained by applying the usual method for the combination of variances...(and)...expressed in the form of 'standard deviations'".

5. If multiplying factors are needed to obtain an overall uncertainty, they"...must always be stated".

Several meeting ":...attendees expressed concern about abandoning" the terms "random" and "systematic" uncertainties"...in favor of the BIPM (recommendations), indicating that the ...random/systematic...treatment of errors was incorporated into a number of existing American standards...and would be difficult to change. Edgerly responded that there would be no pressure on such groups to change. The international effort was to achieve uniform..."
methods for assigning uncertainty statements to calibration certificates from national labs and the like."

"A question was posed as to whether it would be possible for the U.S. ...to propose acceptance of an international guidance document based upon the "classical" approach rather the the BIPM approach. Edgierly indicated that the terms of reference to the TAG-4/WG-3 were clear on basing the guidance document on the BIPM work and that it was unlikely that the European members would want to do otherwise...The U.S. should not lose this chance to work towards international uniformity and that it was important for trade. The majority of the meeting attendees agreed."

Another meeting of the U.S. group will be scheduled several months after circulation of a first draft of the guidance document.

Some Personal Observations

Advice sought to be strictly limited

I attended the meeting believing that the "advisory Group" would be requested to offer advice and recommendations, perhaps develop some consensus, regarding the subject matter which already had become rather controversial in the U.S. This expectation was shared by other attendees and voiced during the meeting by Carroll Croarkin. But we were soon to learn that this was not the case, except perhaps for some narrowly defined topics to be given later. The meeting chairman, who admitted to some co-authorship of these recommendations, indicated his resistance to any attempt to change them.

Despite some very lively debates initiated by some attendees, there was very little genuine discussion and no attempt whatsoever to come to a mutual understanding or at least to an understanding of the reasons for the divergent views of the BIPM from the established approach dubbed by Dr. Colle as the "classical" one.

What is the Problem?

As I have learned from a renowned researcher and scientist of NBS who supports the BIPM recommendations, it has been exceedingly difficult to compare results of scientific investigations, primarily in the determination of natural physical constants, because of widely differing practices in assessing the uncertainties of their measurements, especially between countries. Thus, different countries have come up with differing "best" values for numerous physical constants which, in the end, have resulted in different values for the units of measurements in terms of the SI base units, the meter, the kilogram, the second, the Kelvin, and the mole, for example. The upcoming changes in the U.S. volt and ohm are testimony of this problem and are intended to remove the international differences in the interest of science and commerce. The BIPM recommendation would, for the future, provide a common reference for uncertainty statements and facilitate better comparisons of values and uncertainties of physical constants determined by various researchers.

Probably only a minority of these scientists and researchers, affiliated with various national standardizing laboratories, have either much interest in, or familiarity with, the problems associated with disseminating the units of measurements as required for trade and commerce. Dr. Eisenhart of NBS, renowned father of today's statistical approach to determining measurement uncertainties, says of one of the prominent proponents of the BIPM recommendations (with whom he disagrees): "I doubt whether he's ever seen a standard laboratory from the inside."

So, the question appears to be whether the solutions to the problems of small group of researchers should become the problems of industry and commerce at large. Industry and commerce need measurement accuracy primarily as a universally agreed upon means of communications regardless of the agreement and consistency of the magnitudes of the units among themselves. That's why we can change the unit of the volt and the ohm by a few parts per million without making any difference to most. In comparison, those who need internal consistency of the units are a small minority who could solve their problems also in concert with the needs of industry and commerce. Some attendees of this meeting, myself included, believe that all would be better served by reaching an agreement in the determination and reporting of measurements uncertainties which is based on the concepts of random and systematic uncertainties as they are widely being used in the U.S. now.

A Chance for International Agreement?

The role of the "Europeans" and the "international" community in the questions at hand was repeatedly emphasized. But exactly how strong is their claimed support of the BIPM recommendations, how much weight do they carry and what do "they" who supposedly support the BIPM recommendations know that seemed to elude those attendees who cared to debate the issues at the meeting? Unfortunately, no answers to these questions were attempted at that meeting.

For instance, Ron Dieck, Mike Englund, and myself repeatedly raised and tried to debate the concept sometimes described as "fossilized" or "frozen" random error. For instance the random error of a standards laboratory calibrating a ("test") instrument would cease to be a random error when the test instrument is used to make measurements. The uncertainty of the standard, including the uncertainty due to the random error incurred during its calibration, would be "fossilized". The meeting chairman only expressed his
dissatisfaction with the concept that a random error under one set of circumstances should become something else under a different set of circumstances, but did not offer any arguments why the concept may be faulty. Recognizing that measurement uncertainties are complex and often inconvenient to handle, the BIPM itself asserted that "...it would be naive to think that nature acts merely in accord with human wishes." Mike Englund said: "The confusion is based on a lack of familiarity with the terms and not on any lack of logic. Why shouldn't an error have "chameleon-like" properties? It seems perfectly logical that an error can have different effects on a measurement depending on the frame of reference."

The meeting chairman then explained that it was he who proposed the BIPM recommendation of abolishing the concepts of random and systematic uncertainties and introducing instead Type A and Type B uncertainties while admitting that these have their problems, too.

It should be noted that the report of the BIPM Working Group that had developed the controversial recommendations emphasized"...the new terms...'group A' and 'group B'...should be considered as provisional." According to Dr. Colle, however, they are cast in concrete.

Mike Englund remarked that, in the U.S., we know how to use the existing method and classifications of random and systematic errors but not how to work, treat, and design experiments based on the proposed classifications. Even if the existing methods are misunderstood or perhaps even flawed, we'd be trading one possibly flawed method, that's beginning to become more widely understood in the U.S. and that we know how to work with, for another that's neither understood nor known as to its use. Ron Dieck's impression was that the meeting chairman "...throughout had a condescending almost cynical attitude about error models typical of what we use. His criticism was strongly stated but vague technically."

The concept of the "fossilized" or "frozen" random error was first described by none other than Youden in Uncertainties in Calibrations, IRE Transactions on Instrumentation, Volume I-11. Numbers 3 and 4, December, 1962, although Youden did not use that terminology. The dichotomy of random and systematic error, created to differentiate between repeatable variability and fixed or unknown offset or bias, was attacked by Mueller (Some Second Thoughts on Error Statements, Nuclear Instruments and Methods 163, 1979) who featured prominently in the deliberations of the BIPM leading to the BIPM recommendations. This article was based on such obvious errors as equating random quantities from different populations with a random variable of the same population. My challenges of this article in letters to Dr. Mueller and the BIPM have never been answered.

Dr. Colle stated that he would present a paper at the forthcoming Workshop and Symposium of the National Conference of Standards Laboratories (NCSL) that would explain in detail his disagreement with the existing terms and practices. Although a separate session had been planned for his presentation, eagerly awaited by some, no paper was available, and the session was canceled.

So it seems that, if somebody knows what is wrong, logically untenable, with the concepts of random and systematic uncertainties, it is being kept a guarded secret. The arguments against these concepts that I have read are based on readily demonstrable errors. More likely is that the concepts are not generally well understood. The question then is: "Should these concepts then be replaced by others that are even less well understood and designated by inherently meaningless terms, A and B, that cannot but becloud the concepts even further?"

Dr. Ku obliquely alluded to the lack of understanding of the concepts of random and systematic errors during the meeting when he described his findings of a survey of the international members of the BIPM on their position regarding the terms random and systematic errors. He had described these findings in more detail at an ISA meeting in St. Louis a few years earlier. (That meeting was chaired by Dr. Abernethy from Pratt & Whitney, renowned for his work in measurement uncertainties, who described the BIPM recommendations as "poppycock"). At that occasion, the audience repeatedly broke out in laughter about the misconceptions being held by most of the respondents. It should be noted that this is the same "international" or "European" forum whose majority apparently supports the abolishment of these terms.

As mentioned earlier elsewhere, in 1964, I visited the renowned PTB in Germany where our discussions finally led to the determination of measurement uncertainties and the statistical methods for establishing limits of random error promoted by Dr. Churchill Eisenhart since the turn of the decade. It turned out that they hadn't heard about it yet, but finally one of the PTB engineers smiled, saying: "Those Americans, they do everything with statistics, don't they?" The resulting general amusement indicated that this statement had pretty accurately reflected the sentiments of the participants of that meeting. Twenty years later, the PTB issued guidelines for the statistical determination of measurement uncertainties based on the BIPM recommendations. It is not clear why the U.S. should now change to follow such an "international" leadership whose existence and supposed demand for acceptance of the BIPM recommendations is not at all clear, contrary to the assertions of the meeting chairman.

An article by A.R. Colclough of the British National Physical Laboratory, titled Two Theories of Experimental Error (Journal of Research of the National Bureau of Standards, Vol. 92, No.
3, May-June, 1987) takes issue with these recommendations. A detailed examination of the rationales underlying the BIPM recommendations and what the author calls the "orthodox theory" concludes that the rationale of the BIPM recommendations is "...found to be unrealistic...(and) remains unjustified by objective standards...The concept of systematic error is...indispensable." Regarding the BIPM recommendations, Colclough argues that "...there will be a serious question about the objectivity of uncertainty evaluations calculated from them." It should be noted that the NPL is also a member of the BIPM... a source document, reported to provide "background information" for the course to be taken by the Working Group, as outlined by meeting chairman, is Expression of Uncertainties of Final Measurement Results: Reprints, issued January 1983, contained articles by Eisenhart and Ku with a postscript by Eisenhart and Collé. It is difficult to determine the relevance of this document to the projected course of action. It cannot be taken to defend either the intended radical change of terms or any other of the hotly contended issues of the BIPM recommendations.

The minutes of the meeting contain the statement: "The majority of the meeting attendees agreed" – supposedly with the position taken by the meeting chairman. It is not clear to what "agreement" this sentence refers, but there seemed to be no visible sign of any such majority opinion at the meeting nor of any votes or polls being taken. In fact, most attendees of the meeting were silent and did not express any opinion. Most of those few who did express opinions appeared to have problems with what was presented and apparently argued along the positions also taken by Colclough.

What is Behind the Proclaimed "International" Leadership?

There appears to be no reason to doubt the assertions by the meeting chairman that numerous, and perhaps a majority, of the member delegates of the BIPM support its recommendations. But is that "leadership"? As was remarked during the meeting by one attendee, in most countries, unlike in the U.S., calibration and standardization work is strictly regulated, and sometimes virtually operated, by the government, leaving little room for independent developments or voice in the regulations. Hence, the practices followed in these countries are those mandated more or less by the national government standards laboratories whose expertise in matters of uncertainty determination has not always been established. The question then is whether the arguments should be settled by a majority vote of the members of a small club or by convincing logic.

True to the tradition in a number of European countries that all wisdom emanates from the government, the BIPM also appears to display some disdain for opinions of non-governmental bodies. Although an appendix to the BIPM recommendations (CIPM Draft, 1984) has been distributed only in its French version, it nevertheless makes interesting reading. Among other things it says: "In their majority, the national laboratories well accept these recommendations; there were individual reactions, sometimes agitated, but these were only individual reactions." Science by majority vote?

Still, the degree to which the BIPM recommendations are being adopted by the European members remains questionable at least. "The Expression of Uncertainty in Electrical Measurements", another document published, in April 1986, by the British NPL, retains the terms random and systematic uncertainties (also referred to as "errors" in that document). Whether the U.S. will be isolated from the rest of the world by staying with "random" and "systematic" designations, therefore, remains to be seen.

Conclusion

In view of the firm establishment of the concepts of random and systematic errors in the U.S., and the accompanying methodology of treatments, as exemplified by some ASME and ISA Standards and the recently published ANSI/ASQC Standard on Calibration Systems, it is doubtful whether these concepts will be changed in the near future or at all. Especially in view of the world leadership of the National Bureau of Standard's Statistical Engineering Laboratory in the field of uncertainty determination and with respect to the extensive work in this area performed there and in U.S. industry, which to this day have firmly established these concepts, no convincing arguments have been offered to change the technology of measurement uncertainty determination so far developed in the U.S.

Mike Englund thinks that this well established technology "...needs to continue to evolve... There certainly is room for growth and improvement of (this) approach as it withstands the test of time and professional scrutiny. There is no justification, in my mind, for discarding the methodology just because some groups are having trouble with the application."

Ron Dieck, Mike Englund, and I believe, however, that it is important that we continue to work in the Advisory Group for reasons of damage control. Any work performed by the Advisory Group, for instance in developing practical examples of implementing the BIPM recommendations, could have a significant influence on the degree of compatibility of the Type A and Type B uncertainties with the random and systematic uncertainties used in the U.S. and elsewhere. From this point of view, any future work of the Advisory Group could be of considerable importance in providing a smooth translation of the BIPM recommended designations into the customary designation, if, and to the extent that, the BIPM recommended designations will be used. Otherwise, a great danger could arise from a confusion between the two systems and the meanings of their uncertainty quotations which could throw U.S. technology, undoubtedly a leader in the field of...
uncertainty determination, back by at least a decade of development.

Ron Dieck adds that acceptance of the BIPM recommendations would require costly and confusing conversion. "Most industry representatives at this meeting objected to (the BIPM) model...Many were especially upset by the elimination of the terms "random" and "systematic" error.

"I do not believe we can stand by idly and watch this happen. Only our active, credible, aggressive participation has the potential to reduce or eliminate the conversion costs which may be coming. This BIPM methodology has the potential to alter our whole approach to the subject of measurement uncertainty if it is ever applied to data outside that obtained in the calibration laboratory."

NBS electrical laboratories have already begun to use the Type A and Type B designations without much explanation despite the BIPM consensus "...that many further details would have to be addressed and resolved before the recommended approach could be routinely, uniformly, and widely used". This premature use is already creating confusion and appears, therefore, ill advised. I recommend that such NBS laboratories be approached with the recommendation to delay implementation of the BIPM recommendations until the guidelines are developed.

Postscript

I am indebted particularly to Ron Dieck and Mike Englund for critically reviewing these comments and adding their thoughts to it. The responsibility for the accuracy of the facts reported as such as well as for my personal opinions reported here, however, remains mine.

Rolf B. F. Schumacher

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REPORT OF THE SECOND MEETING OF THE ISO/TAG-4/WG-3 WORKING GROUP "UNCERTAINTIES"

by R. Collé, Convenor

Convened
May 6-8, 1987
at the Bureau International de l'Heure, 11 rue Turgot, 75509 Paris

A. Introduction
B. Opening of the Meeting (Agenda Item 1)
C. Report of the First Meeting (Agenda Item 2)
D. Proposal by Dr. Colelough (Addition to Agenda)
E. Reviews of the Draft – Chapters 1 to 6 (Agenda Item 3)
F. Development of Examples (Agenda Item 4)
G. Notation, Nomenclature and Glossary (Agenda Item 5)

H. Assignments and Future Work Group Activities (Agenda Item 6)
I. Closing of Meeting (Agenda Item 7)
J. Annexes

Report

A. Introduction

The Second Meeting of ISO/TAG-4/WG-3 "Uncertainties" convened at the Bureau International de l'Heure, Paris from May 6 to 8, 1987. The task of the working group is to develop a guidance document based on the BIPM/CIPM Recommendation for the treatment and reporting of uncertainties. The first meeting of the working group (held October 1-3, 1986, Paris) resulted in an overall approach, and an outline and workplan for this guidance document. The purpose of this second meeting was to continue the development of the guidance document, particularly a review and evaluation of a preliminary draft of the first six chapters.

In the time since the first meeting, two changes in the membership of the working group occurred. Dr. Pekka Karp resigned from the Technical Inspection Center (Finland) and could no longer assume the responsibilities of serving on the working group. Mr. J.E. Burns was replaced by Dr. A.R. Colelough as representative from the National Physical laboratory (U.K.). The present working group membership is given in Annex 1.

This report of the second meeting is organized and presented in the same order as that given in the meeting Agenda (Annex 2) since the order of the meeting closely followed the originally proposed agenda. The report, however, does not chronologically detail every discussion of the working group throughout the meeting. Rather, the report summarizes only the major discussion items and conclusions reached by the working group.

In attendance at the second meeting:

Dr. R. Collé NBS (Convenor)
Mr. Peter Clifforde IEC (Member)
Dr. A.R. Colelough NPL (Member)
Mr. J.C. Courtier AFNOR (Member)
Dr. Olev Mathiesen ISO (Member)
Dr. Jorg Muller BIPM (Member)
Dr. Klaus Weise PTB (Member)
Dr. F. Petik BIML (Observer)
Mr. W.H. Emerson BIML (Observer)

Absent:
Mr. J.R. Allesi ISO (Observer/Secy. ISO TAG-4)
Dr. R. Kaars VSL (ISO TC-69 Liaison)
Dr. A. Vishenkov GOST (Member)

B. Opening (Agenda Item 1)

Following welcoming remarks by Mr. B. Athane, Director of BIML, the Convenor, Dr. R. Collé, opened the meeting. The Convenor agreed to also serve as Rapporteur for the Second
Uncertainties

Meeting and indicated that the Report would be considerably less detailed than the Report of the First Meeting which covered many initial organizational matters and decisions on the overall direction of the working group activities. The Agenda (Annex 2) was adopted with one addition. Dr. Colclough requested that he be given an opportunity to present a proposal to the working group for their consideration.

C. Report of the First Meeting (Agenda Item 2)

A final version of the Report of the First Meeting, prepared by Drs. Karp and Colle, was distributed to the working group. This final version incorporated some changes and comments previously submitted by the working group members. In some cases, changes and comments not incorporated were made at the discretion of the Convenor.

D. "Proposal" by Dr. Colclough (Addition to Agenda)

Dr. Colclough, expressing a concern over the adequacy of the BIPM Recommendation in terms of the treatment of different categories of uncertainties, offered and presented a "proposal". This proposal, having two parts, is reproduced in Annex 3. The proposal consisted of a redefinition of type-A and type-B uncertainties, and an alternative treatment for their combination.

The proposal was discussed at great length by the Working Group, but could not be accepted since it violates the underlying principles of the BIPM/CIPM Recommendation (and hence the TAG-4 charge to the Working Group), and it is in serious disagreement with the majority of the working group members' philosophical approach to uncertainties.

E. Review of the Draft – Chapters 1 to 6 (Agenda Item 3)

The working group reviewed the draft in detail. Many minor corrections and modifications in the text were noted. In addition, the working group concluded that the draft requires substantial revision and rewriting. Major structural and organizational changes will be made. These changes include:

* Revise the Basic Concepts in Chapter 2 to include a statistical model approach as well (i.e., without a propagation formula)

* Incorporate a uniform and consistent notation for the symbols used in the models, functions, etc. throughout Chapters 3 to 5

* Revise Chapters 3 and 4 so that they are more parallel in approach and structure

* Add reference to the availability of many other appropriate statistical tools and techniques

* Revise the examples in Chapters 3 and 4, and include a statistical model example (i.e., not requiring a propagation formula)

* Revise the simple examples in Chapter 5

* Delete the references to the BIPM/CIPM Recommendation in Chapter 6 (which will be covered in the earlier overview) and include simple reporting examples

Beyond the required additions and deletions, a substantial polishing of the language to a uniform style will be made for the next draft.

F. Development of Examples (Agenda Item 4)

The word group reviewed, discussed and critiqued all of the examples submitted by the members. These included:

* hardness measurement

* measurement of pressure with a pressure balance

* calibration of end gauges

* masses of radioactive sources

* resistance and reactance of an electrical conductor

* length, width and area of a rectangle

In all cases, the submitted examples required revisions that would either clarify the examples, provide more information, or eliminate needless detail. Various assignments for making these revisions were accepted by the work group members (see Section H). Considerable work is also necessary to assemble the examples into a uniform format and style. Most of the examples, although arising from different areas of metrology, are very similar and illustrate only a few principles. The work group concluded that additional examples covering instrument calibrations; control chart data; calibration curve data (linear adjustment); and time dependent, between-group
variations should be developed. The revised and new examples will be submitted to the convenor.

G. Notation, Nomenclature and Glossary
(Agenda Item 5)

The working group considered the matter of developing notation, nomenclature, and definitions for a Glossary.

The working group agreed to continue the use of the terms "type A" and "type B" in the absence of any suitable and appropriate alternatives. All proposals for alternative descriptive terms were not suitable to a majority of the working group. It was also noted, however, that there is a historical precedent for using symbols rather than words for mathematical concepts (as in errors of Type I and Type II).

The need to not violate well-defined statistical concepts and definitions particularly in regard to the nomenclature for type B uncertainties is a sensitive topic and was reemphasized. The working group considered three nomenclature options.

Option 1: Using a long descriptive label to clearly distinguish in all cases between type-A and type-B entities, as in "type A uncertainty", "type-B uncertainty", "type-A variance or covariance", "type-B uncertainty", "type-A variance or covariance", "type-B variance", etc.

Option 2: Using a prefix such as "quasi" or "pseudo" to distinguish between type A and B entities, as in "variance" for type A and "quasivarriance" for type B; "standard deviation" and "quasistandard deviation"; etc.

Option 3: Using entirely new words such as "Bvar", "Bcovar", etc.

None of the three options appeared to be ideal. The working group choose Option 1 as "the least of all evils." Although the use of the long descriptors (e.g., "type-B standard deviation") was recognized to be cumbersome, the other options appeared to introduce more problems. Option 2 was nearly as cumbersome and appeared to be more awkward. Option 3 was superficially appealing, but it required finding an entire set of new words. Few words were found and even those proposed did not have readily apparent meanings which would make their adoption very difficult.

The need to not use well-known statistical symbols (such as s and $ \hat{s}$ ) for type-B quantities was also recognized. The working group agreed on a compact and consistent notation for individual type A and type B uncertainty components, as well as for a unified set of symbols which could be used for both types and for combined uncertainties. This adopted notation is outlined in Annex 4.

A first, cursory attempt at developing a Glossary of terms was considered by the working group. This Glossary is briefly outlined as it was presented at the meeting in Annex 5. Dr. Mathiesen agreed to work on using the outline to develop a draft of the Glossary.

An important aspect of the Glossary is consideration of the exact wording which will be used to describe the various type B entities. This is also an important consideration in terms of their wording and meaning when used reporting practices. Annex 6 contains a proposal by Dr. Colee for how the type B quantities can be described and several examples of their possible use. This proposal was adopted by the working group and will be used in the next draft of the guidance document text.

H. Assignments and Future Work Group Activities (Agenda Item 6)

A new draft of the first six chapters of the guidance document will be prepared by the Convenor for distribution to be the working group in late summer. Comments on this draft will be made by correspondence during September and October, 1987.

The revised and new examples will be submitted to the Convenor by the end of September for collection and distribution to the working group. These examples include:

- Revision of the hardness measurement incorporating more detail and information on the measurement and its model (Dr. Petik)
- Revision of the end gauge example which requires shortening (Mr. Emerson with assistance by Dr. Mathiesen)
- Revision of the electrical conductor and rectangle examples clarifying that these are constructed, hypothetical examples (Dr. Weise)
- Development of a calibration curve example (Dr. Weise using thermometer data provided by Dr. Colclough)
- Development of a "check standard" example showing an additional time-dependent component of variation (Dr. Cole)

Other working group members were encouraged to collect and develop additional examples for consideration.

Using the outlined glossary developed at the meeting (Annex 5) Dr. Mathiesen will prepare a draft of the glossary and submit it to the Convenor by September 30, 1987. It will be distributed to the working group with the collected Examples at that time.

Inasmuch as the next activities of the working group will occur by correspondence, it is anticipated that the next meeting of
the working group will not convene until early 1988. This meeting will be scheduled in the Autumn after the revised draft is distributed and commented on.

I. Closing of the Meeting (Agenda Item 7)

The Convenor thanked all of the attendees for their cooperative and constructive work. He also thanked Mr. Athane and the BIML staff for their help in organizing and conducting the meeting.

J. Annexes

The following annexes are attached:

1. Membership list for ISO/TAG-4/WG-3

2. Meeting Agenda

3. Dr. Colclough’s “Proposal” (as presented at the meeting)

4. Notation (as presented at the meeting)

5. Glossary outline (as presented at the meeting)

6. Description of type-B quantities (as presented at the meeting)

Ron Coët
Convenor
CALL FOR PAPERS

1988 NCSL Conference Grand Hyatt Washington

_Competitiveness in a World Market_
August 14–18, 1988

TOPICS FOR PAPERS AND WORKSHOPS

- Strategic Planning
- Equipment Management
- Documentary Standards
- Laboratory Accreditation
- Metrology Education & Training
- Laboratory Automation
- Data Networking
- Intrinsic Standards
- New Trends in Instrumentation
- Advances in Measurement Disciplines—
  - Electro-Optics
  - DC/Low Frequency Electrical
  - Microwave/Millimeterwave
  - Time & Frequency
  - Optical & Ionizing Radiation
  - Physical & Dimensional
- Industry—Specific Metrology for Utilities &
  Pharmaceuticals

PAPER REQUIREMENTS

Papers submitted for consideration must not have been published elsewhere. They should be non-commercial and objective.

DUE DATES

Abstract: December 1, 1987
Paper: April 1, 1988
Abstracts of 200 words or less and completed camera-ready manuscripts should be sent to:

Joe D. Simmons
National Bureau of Standards
Rm. B160, Physics Bldg.
Gaithersburg, MD 20899

DOD VALUE ENGINEERING CONTACTS

VALUE ENGINEERING POINTS OF CONTACT
JULY 1987

A 33-page document with names of engineering contacts in a wide variety of commodities from missiles to cold-weather clothing recently crossed my desk. Your company may have a manager who worries about productivity improvements for military contracting.

CONTACT: DOD Industrial Productivity Support Office
c/o Defense Logistics Agency
Cameron Station
Alexandria, VA 22304-6183
There is a quarterly document that every metrology engineering group should get, to keep up the connection with the NBS Center for Electronics and Electrical Engineering. That center is responsible for most of the derived standards and therefore all the RF/Microwave work.

This quarterly bulletin provides abstracts for all their project output. You can get on the mailing list by contacting the CEEE at (301) 975-2220.

Any organization working on ATE that has military end-use or other impact from DOD ATE strategy, ought to be receiving this quarterly ATE Newsletter. It covers everything from software to testability and standards.

CONTACT:

Betty Sponaugle
SEA CEL-DSTA
Naval Sea Systems Command
Washington, DC 20362-5101
(202) 692-0170
MEETINGS AND PROGRAMS ANNOUNCEMENTS

October 8-9, 1987
The Equipment Management Forum (EMF) will be hosted by Ben Brown of McDonnell Aircraft Co., St. Louis, Missouri. The meeting will be held at the Sheraton West Port Inn in St. Louis, MO. The EMF steering committee will meet on the 7th, prior to the Forum. For information call Ben Brown (314) 234-9759 or Charlie Sides (206) 744-9944.

October 12-16, 1987
Measurement Uncertainty given by Dalfi, Inc. in Orlando Florida – call (619) 578-9500.

January 28-29, 1988
1988 Measurement Science Conference, "Total Quality through Measurement Science", will be held at the Hyatt Regency Hotel in Long Beach, Calif. For information, call John Van de Houten, Conference Chairman, at (213) 535-1497.

February 1-3, 1988
NCSL Board of Directors meeting, Incline Village, Nevada.

March 7-11, 1988, March 14-18, 1988
Measurement systems engineering
Measurement systems dynamics. Peter Stein, short courses Phoenix. Contact 602-945-4603

April 25-27, 1988
NCSL Board of Directors meeting, Pine Mountain, GA

May 2-5, 1988
ISA’s Aerospace Industries/Test Measurement Div. 34th International Instrumentation Symposium, at Albuquerque, NM, Call J. Taylor at 818-357-2281.

June 7-10, 1988
CEPM ‘88 - Conference on Precision electromagnetic Measurements to be held at Tsukuba Science City, Japan. Write to: CPEM'88 Secretary, Dr. Toshio Nemoto, c/o Business Center for Academic Societies, Japan Conference Department 40-14, Hongo 2-chome, Bunkyo-ku, Tokyo 113, Japan.

August 14-18, 1988
NCSL 1988 Annual Conference at the Grand Hyatt Hotel, Washington, D.C.

August 14-19, 1988
Board of Directors meeting, Grand Hyatt Hotel, WA, D.C.

October 24-26, 1988
NCSL Board of Directors meeting, Santa Fe, New Mexico

November 14-17, 1988
5th Environmental Stress Screening Electronic Hardware National Conference, Orlando Marriott. Call (312) 255-1561.
Rolf Schumacher - Measurement Uncertainty Course.

Oct. 19-23, 1987 Honolulu, CA
Jan./Feb., 1988 Location to be determined
June 6-10, 1988 Ottawa, Canada
Call Marlene Chandler (714) 492-6321

REGIONAL MEETINGS SCHEDULE

REGION 1. Typically holds two (2) meetings per year, a regional business meeting and a technical session. The next meeting is scheduled for the Fall of 1987.

REGION 2. Three (3) meetings are held each year. The next

REGION 3. Plans to hold three (3) meetings this year. The next meeting will be held on September 24th at Norfolk, Virginia. Call Fred Dern for info at (804) 865-3254

REGION 4. Plans are to hold two (2) meetings each year. The next meeting is scheduled for October 21st in the Atlanta area. They also plan to hold two Section meetings in Central Florida next year, on May 18th and October 26th, 1988.

REGION 5. The meeting schedule is as follows: Oct. 27, Southern Ohio/Kentucky at Monsanto in Miamisburg, Ohio

November 3, Indiana at Detroit Diesel Allison in Indianapolis, Indiana

November 10, Northern Ohio at Gould in Cleveland, Ohio

March 10, Joint Ohio meeting at Battelle in Columbus, Ohio

April 12, Michigan (place to be announced)

April 19, (tentative) Indiana at Delco in Kokomo, Indiana

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

11/4/87 at HP
11/9/88 at Fluke
11/4/89 at HP
11/9/89 at Fluke
11/4/90 at HP
11/9/90 at Fluke

South Austin Section (tree year schedule): The Thursday of the first full week of Jan., May and Sept.. The locations to be determined within a 50 mile radius of Austin. The dates are:


North (Oklahoma City) Section: Tentative new section now in the planning/organizing phase.

West (Denver) Section: Discussion planned to reevaluate the section. (First full week = Sunday through Saturday).

REGION 7. Plans to hold three meeting each year. The next meeting is scheduled for October 29th 1987, so mark your calendars.

REGION 8. Plans to hold six sectional meetings this year. October 8th, Phoenix/Tucson section meeting in Tucson (scheduled to permit returning NCSL board members to attend), November 4th, Los Angeles Section meeting in Los Angeles, December 2nd, San Diego Section meeting in San Diego.

REGION 9. Plans to hold two meeting each year. The next meeting is tentatively scheduled for the Fall of this year.

REGION 10. (INTERNATIONAL) Plan to hold the 7th Annual Canadian Conference on December 2nd & 3rd at the Canada Centre For Inland Waters, 867 Lakeshore Road, Burlington, Ontario, hosted by Les Peer. For more information call Marilyn Ross at 919-997-3411.

REGION 11. Plans to hold a Chicago Section meeting on October 27th, 1987 at the Fermi National Accelerator Laboratories in Batavia, Illinois. The Twin Cities Section plan to meet in October too and Rosemount Engineering will host the meeting.
PMA LIAISON REPORT
A questionnaire for gathering information to compile a Directory of Metrologists has been prepared for distribution. Various organizations are being requested to assist in distributing copies of the questionnaire. The PMA officers are hereby requesting the assistance of the NCSL Board of Directors in distributing this questionnaire to NCSL members by authorizing the NCSL Secretariat to include copies of the questionnaire in a future mailing.

A committee of the International Standards Organization (ISO) is working to develop a standard for the uniform reporting of uncertainty of measurements. DeWayne Sharpe has been appointed PMA representative on the Advisory Group on Uncertainty.

PMA has agreed to be a co-sponsor of the 1988 and 1989 Measurement Science Conferences.

The administrative functions of the PMA have been transferred to the office of Myers/Smith, Los Angeles, California.

REPORT FROM ANSI

Although the effort of writing the standard was conducted under the auspices of the American Society for Quality Control (ASQC) Metrology Technical Committee, most of the Writing Group members were recruited through NCSL. In fact, NCSL has provided the vehicle of informing the U.S. metrology community of the efforts and progress in writing the standard and has provided the forum in which some of the more difficult questions could be debated with a large number of metrologists. This standard could not have been written without NCSL.

This standard covers only the calibration phase of measuring instruments. The second standard which the Writing Group is now working on will, together with this standard, cover the field covered by such other standards as MIL-STD-45662. This standard, however, is the first and so far, to our knowledge, only one making full use of the opportunities offered by measurement assurance methods and thus represents a significant advancement in the field of calibration.

Rolf B.F. Schumacher
ANSI Liaison
June 10, 1987
General Electric Co.
Clearwater, FL
John Riley
Region 4 Coordinator

The workshop was attended by 24 participants representing 14 private and government sector organizations. Meeting arrangements were handled by Hugh Starling, General Electric.

Tony Anderson, Guildline, presented an overview of NCSL activities from the perspective of the Board of Directors. Tony informed us that NCSL was now incorporated. After completing his presentation, Tony opened the session to member feedback on a number of critical issue including:

Voter Apathy: Preference expressed for option to choose directors (more candidates than slots); tend not to vote if otherwise.

Newsletter: Three volunteers for articles: R. Bowen, Harris; H. Starling, GE; and W. Tramel, EG&G. Five newsletter questionnaires were collected and sent to the editor.

Methods of Improving Visibility of Member Delegates: get appointing officers to attend workshops, pick appropriate corporate level for appointing officers, and acknowledge length of service of delegates.

Flow Meter Calibration:

Gary Cohrs, Flow Technology, Phoenix, AZ, gave a technical presentation on the history of mass/time, volume/time flow calibration, and the recent development of a primary standard volume time calibrator, which can use either a liquid or gas as the calibration fluid. Gary also discussed the application of calibration curves plotted for K factor vs Reynolds number, and described a system for the tandem calibration of turbine flow meters.

Regional Planning Session. Tony Anderson and John Riley led a planning session to establish a consensus for scheduling workshops in the Central Florida locale with sufficient lead time to minimize conflict with other NCSL meetings. The dates for the next two Central Florida workshops were set for May 18, 1988 and October 26, 1988. The next regional workshop is set for October 21, 1987, and will initiate sectional activity in the Atlanta area. A questionnaire on regional activities was completed by all attendees, and the responses are to be used in developing and scheduling regional/secional activities.

Calibration of Leak Rate Standings: Tom Mason, General Electric Neutron Devices, gave an interesting and informative talk on the history of leak rate calibration, methods used, the present discussions in the leak measuring community on units (moles/sec vs std cc/sec), the relative advantages of linear and exponential temperature coefficients, and closed vs open end leak standards. Tom went on to describe the calibration system developed at GE for the calibration of diffusion and orifice leak standards over the range 10⁻⁸ to 10⁻⁵ std cc/sec.

Report on Activities of Calibration Systems Management Committee: Woody Tramel/EG&G, gave a thorough review of the activities of this committee. He pointed out the work done in narrowing the 220 measurement parameters identified in the capabilities survey to approximately 40, and described efforts to standardize the quantification and listing of uncertainties associated with the measurements. Woody requested feedback from attendees. The discussion of laboratory accreditation indicated it was not a major issue/concern for participants.

Region Four Measurement Assurance Program Activity: John Riley provided an overview and status on two regional programs. A 10 volt measurement "Round Robin", using a pair of 732A Voltage Reference Standards, provided by the John Fluke Manufacturing Co., is being circulated among six participating laboratories. This program calls for the pair of Voltage References to circulate through each lab twice before the circuit is completed. Vu-graphs for the control charts for difference between the unit, assigned values, standard deviations and Younden plots of the output of the two units, were shown. The round robin was limited to the first six labs responding. The experiment is now in its 4th week. A regional program has been established for maintaining the "Mid Florida Volt". Participants are Datron, Guildline Instruments, Inc., and the Kennedy Space Standards Laboratories/EG&G. The "away" phase of the first circulation of standard cell enclosures is underway. The enclosures will be moved among the participants on a four week cycle until each participant has intercompared its laboratory standard with transport standards of the other participants. Comparison of pivot lab standard and transport standards, with an NBS enclosure, is scheduled for January 1988.

All participants were provided with a copy of Dr. Andy Dunn's paper, "The Uncertainty Budget", which was received from Graham Cameron in time for reproduction and distribution.
Reports from the Regions

An information package was provided to all participants, which included NVLAP notice on NRC's requirements for calibration of dosimeters by accredited labs and NBS announcements of a workshop, new test services for leak rate standards, and recommendations for standardization of leak rate terms.

Region 4 Schedule:
10-21-87 Atlanta, GA
5-18-88 Central Florida
10-26-88 Central Florida

Attendees:
John Riley
Herb Challis
Glen Cochran
John Shumake
Jack R. George
Blaine Bryan
Woody Tramel
LaMonte Rosbrook
Keith Sawayda
Raymond Vivian
Romon Vigo
Hugh Starling
Thomas M. Mason
Vincent Piucci
Jim Roux
Otis Jackson
Frank Manginelli
Tony Anderson
Dick Bowen
Walt Witko
Paul Quinn
Gary Chors
Bob Hanson
Gary Roberts

NASA/KSC
General Electric
Keltec FL
Honeywell
McDonnell Douglas
EG&G Florida
EG&G Florida
Kings Bay Subase, GA
General Electric
General Electric
General Electric
General Electric
General Electric
General Electric
Ametek, Mansfield & Green
Fluke
Honeywell
Guildline
Guildline
Harris Corp. GSS
Fluke
Quinn Associates
Flow Technology
Fluke
Honeywell

The NCSL Region 8 San Diego Section meeting was held on May 20, 1987 at the Stardust Inn in Mission Valley. Twenty-one NCSL delegates and guests were in attendance.

After introductions and some announcements, Chet Crane gave his report from the board of directors meeting held in San Antonio April 12 through 15.

John Lee combined the comments on MIL-STD-45662A and sent them on to the Army for their consideration. He also expressed his thanks to the membership for their input.

Ed Nemeroff gave testimony on behalf of NCSL at Senate hearing which were well received. It seems as though the NBS budget may indeed see a substantial increase in the future. His Congressional testimony, however, was somewhat critical of some of NBS's programs.

Chet Crane gave some good news about NCSL's Treasury which now stands at about $176,000, a rather solid financial footing for an organization this size.

There was some discussion at the board meeting for a new name for NCSL. Someone mentioned that we are truly international in scope and membership and that the new name should reflect this.

There was also talk of a new slogan, even to the point of suggesting a contest with prizes.
Chet also issued a plea for more participation in committees. There are several to choose from and they are listed in the newsletter. If you feel you can contribute, please contact the appropriate person and offer your help.

After the break, Rolf Schumacher polled the members at the meeting on the merits of the different sections of the NCSL Newsletter. The results will be forwarded to John Minck, Newsletter Editor. A suggestion was made to send the Newsletter to the Military PMEL facilities.

The comment was also made that the level of competence of personnel coming out of military calibration schools is definitely lower than it was 10 to 15 years ago. This trend shows that our industry needs to take responsibility for training new technicians in our specialized field of metrology.

Another item mentioned was that if we are the "voice of the standards world" we should try harder to get our message to the PMEL personnel in the armed forces.

Rolf Schumacher led a point by point discussion of NCSL's reply to the Army. The main stumbling block is still the paragraph 5.6.2 "Notification of Out-of-Tolerance Conditions." NCSL strongly suggested that the deletion of the word "significant" would cause a tremendous increase in cost for the entire industry. There are literally hundreds of thousands of out-of-tolerance conditions that do not affect product quality and it is realized that the many definitions of "significant" have created problems in this area. Accordingly, the NCSL has provided a definition of "significant out-of-tolerance condition" as follows:

"The accuracy of the M&TE [Measuring & Test Equipment] is sufficiently degraded to affect product quality. Determination of a "significant out-of-tolerance condition" is dependent on the specific out-of-tolerance parameter, the use requirements of the M&TE, and the degree of out-of-tolerance condition in relation of the parameter being measured."

The local BIOMED companies seem to be unaware of existing BIOMED committees in NCSL, so Dick Ringard will be contacting them and providing them with further information.

The question of Software (QA) control started a lovely discussion that covered many areas concerning this topic.

Attendees

G.T. Nowell, Jr. G.D. Electronics
N.R. Straub G.D./Convair
Al Kohler MA/Com
Ron Sisto Unisys
R. Sebring Unisys

W.R. Fry Retired
R. Schneider Navy
Louis Cretelle Navy Primary Std Lab
Calvin Tong Navy Primary Std Lab
Bob Siegel Dcas Pro Hughes/Fullerton
Dick Lindsey Hewlett Packard/Fullerton
Jim Barger Comtel
Chuck Van Winkle Dalfi, Inc.
Robert Smith Ford Aero Space/Irvine
George Doyle Singer Company
Chet Crane Teledyne Microelectronics/L.A.
Rolf Schumacher Rockwell/Anaheim
Jim Paton Teledyne Ryan Electronics
Julio L. Netto, Jr Ringard Metrology
Richard Ringard Ringard Metrology
Glenda Ringard Ringard Metrology

Reports from the Regions

Group picture at the Stardust Inn in Mission Valley

Chet Crane, right, gives report from the NCSL Board of Directors

- 69 -
International Regional Director's Report

Planning Meeting for 7th Annual Canadian Meeting

Some seventeen persons attended the planning meeting on 15 June, which was hosted in an excellent fashion by Guildline.

The 7th annual meeting will be held at Canadian Centre for Inland Waters, Burlington, Ontario in the Hamilton-Toronto area. At the time of writing the date is not yet finalized but will likely be 1 and 2 or 2 and 3 of December 1987.

We do not plan to have an equipment/services display this year but workshops following identified themes.

Minutes of the planning meeting will be provided to the Board in the near future. The strengthened organizational chart is attached as Annex "A".

Interested parties can contact Marilyn Ross, NCSL Canadian Secretariat, Quality Engineering Test Establishment, Ottawa, Ontario, KIA OK2, (819) 997-4211, for further information.

Educational Committee Meeting

The Canadian educational committee met at Guildline Instruments Ltd., Smiths Falls, Ontario for a full day on 24 June and developed plans for action under chairperson Nancy Jackson.

The committee has developed a core competency model identifying the needs for an electrical/electronic metrologist. A similar model will follow for dimensional metrology.

Through the insight of Dr. Dennis Coffey, Educational Officer, Standards Council of Canada, a high quality slide presentation has prepared covering "Metrology - the Science of Measurement". The presentation, which incorporates many pictures from National Research Council of Canada and the Defense standards laboratories, covers length, mass and pressure, time, electricity, temperature and luminous intensity. The presentation which was reviewed in committee will be modified and rescripted to increase interest in the field for late high school, early community college attendees. It is hoped to make metrology an attractive, exciting (career path) to students. It will be used to influence institutions in modifying their curricula.

The slides will be made available to NCSL members to enhance understanding within their own organizations, make local or meeting presentations or illustrate traceability pathways and illustrate values of measurement through analogies i.e., the ratio of 1 millimth inch to one inch is the same as the diameter of a needle to height of CN tower in Toronto.

Chairperson Nancy Jackson has a strong background in acquiring educational support for various technologies in the province of Ontario. She and I will be developing the rationale for this requirement.

If the committee is to effectively influence post secondary institutes of learning so that metrology related courses can be introduced into curricula, a "needs survey" will be required. The committee will need financial support to achieve this action. After additional work has been done by the chairperson I will be presenting the requirement prior to or at the Fall Directors' meeting.

The committee has benefited from the American experience and does not plan to "re-invent the wheel" in Canada.

At the right stage it may invite persons from NCSL to a selected community college to bring their experience and knowledge to the issue.

Informational Visit of NBS Staff

The writer coordinated an informational visit of two well known NBS staff members to Canada 27-30 April.

Drs. Joe Simmons and Art McCoubrey spent a day at the National Research Council of Canada, a day at the Defense QETE Standards Laboratories including discussions with defence quality assurance staff, our metrologists and Standards Council of Canada accreditation staff.

A visit was paid to two accredited/recognized calibration facilities in the Toronto area and the Centre for advanced Technology Education in Toronto.

The exchange of ideas was extremely valuable to all of us.

Communications

Membership follow up letters were mailed.

Letter mailed to WECC recommending exchange of information with NCSL, following my appointment as liaison person.

Made arrangements for international dinner speaker – Dr. Peter Heydemann.

Various communications with the Secretariat Office, the President and various members throughout the world.
MINUTES OF THE CORPORATE ORGANIZATIONAL MEETING
OF THE BOARD OF DIRECTORS

Ed. Note: NCSL is now a non-profit Colorado Corporation. It seemed appropriate to report on the minutes of the incorporation, just to keep our members informed.

The organizational meeting of the National Conference of Standards Laboratories, a Colorado nonprofit corporation, was held on July 12, 1987. Gary Davidson was chosen temporary Chairman of the meeting and Selwyn P. Smith was appointed temporary Secretary and kept the minutes.

The temporary Chairman reported that the originals of the Articles of Incorporation had been filed with the Secretary of State of the State of Colorado and presented to the meeting a copy thereof. A copy of the Articles and the Certificate of Incorporation were ordered attached to the minutes of this meeting as Exhibit A. (Ed. Note: All exhibits available from NCSL on request).

The Chairman stated that since the Articles of Incorporation had been filed, the Certificate of Incorporation issued and this meeting duly constituted, the incorporator should be discharged. Thereupon, pursuant to motion duly made, seconded and unanimously approved, the following resolution was adopted:

RESOLVED, that the incorporator of the Corporation be and hereby is discharged and indemnified by the Corporation from and against any expense or liability actually incurred by him by reason of having been the incorporator of the Corporation.

The temporary Chairman offered to the meeting a set of Bylaws which he proposed be adopted by the Corporation. He indicated that the Bylaws had been widely circulated among the initial Board of Directors and that he believed the Bylaws as presently drafted incorporated the assorted changes that had been recommended by members of the Board of Directors. After full discussion, on motion duly made and seconded, the following resolution was unanimously adopted:

RESOLVED, that the Bylaws, a copy of which has been presented to this meeting, be and are hereby approved and adopted as the Bylaws of this Corporation and the temporary Secretary of the meeting is hereby directed to attach a copy of the same to the minutes of the meeting as Exhibit B.

The temporary Chairman stated that the next order of business pertained to election of officers. He stated that since the Bylaws provided at paragraph 4.2 that the election of officers and members is done annually by members by secret mail ballot with one exception it would comport with the intention of the Bylaws if those persons who served as officers of NCSL prior to its Incorporation were to continue until the next balloting took place. After full discussion, on motion duly made, seconded and unanimously approved, it was agreed that the individuals serving as officers of the Corporation prior to its incorporation continue in their respective capacities. Those officers are as follows:

Edward Nemeroff, President
Gary Davidson, Executive Vice President
Pete England, Past President
Delbert H. Caldwell, Vice President, Lab Management
William Simmons, Vice President, Marketing
John T. Martin, Vice President, Education
Chester Crane, Vice President, Indust. Technolgy
Robert Weber, Vice President, Operations
Selwyn P. Smith, Secretary
Roland Vavken, Treasurer
Richard Drews, Director, Regions 1 and 2
Anthony Anderson, Director, Regions 3 and 4
Ralph Bertermann, Director, Regions 5 and 11
Robert Smith, Director, Regions 6 and 8
James Ingram, Director, Regions 7 and 9
J. Graham Cameron, International Director

The President then stated that since the Articles of Incorporation had been filed, George Uriano had resigned as the NBS Representative. He stated that pursuant to the provisions of Article 1.3 of the Bylaws the NBS Director nominates an NBS staff member to represent NBS on the Board of Directors. He stated that the nominee must be confirmed by the Corporation's Board of Directors and that the person nominated by the NBS Director was Dr. Joe Simmons. After full discussion, on motion duly made, seconded and unanimously approved, Dr. Joe Simmons was confirmed as a member of the Corporation's Board of Directors.

The President then stated that he had instructed the attorney to notify the Internal Revenue Service that the National Conference of Standards Laboratories had converted from being an unincorporated association to being a Colorado corporation. He stated that the attorney had advised him that the IRS had indicated such a conversion would have no effect on the organization's tax exempt status. He stated that the attorney would forward the Articles of Incorporation and the Bylaws to the IRS together with a letter notifying the IRS of the change to corporate status on NCSL following this meeting.

The President stated that the next order of business pertained to opening a bank account for the Corporation. Accordingly, after full discussion, upon motion duly made and seconded, the following resolution was unanimously adopted:

RESOLVED, that funds of the Corporation be deposited in FIRST NATIONAL BANK OF BOULDER, COLORADO and GREAT WESTERN SAVINGS and LOAN ASSOCIATION and that the printed resolution be attached to the minutes of this meeting as Exhibit C and be deemed a resolution of the Corporation duly adopted by the Board of Directors.

There being no further business to come before the meeting, on motion duly made, seconded and unanimously approved, it was adjourned.

Selwyn Smith, secretary
WELCOME TO OUR NEW NCSL MEMBERS

USAF-5AMS/MAAP
Minot AFB, ND 58705-5000
Delegate: SMSgt Bruce J. Sander

Ford Motor Co.
Tusla, OK 74122
Delegate: Richard Ferrero

Hewlett-Packard Co.
Santa Clara, CA 95051-7299
Delegate: Bob Pitcock

Bell Communications Res. Inc.
Dallas, TX 75247
Delegate: D.W. McCullough

Thomson Components
Mostek Corp.
Carrolton, TX 75016
Delegate: Kenneth D. Moore

Hughes Aircraft
Fuller, CA 92634
Delegate: Kenneth Landis

John Fluke Mfg. Co. Inc.
Sugarland, TX 77479
Delegate: Randal H. Wear

Tech. Sales & Marketing, Inc.
Indianapolis, IN 46250
Delegate: Jack H. Lockhart

Ford Motor Co. of Canada, Ltd.
Niagara Falls, Ont. L2E 6X3 Canada
Delegate: Len Stolik

Tektronix, Inc.
Vancouver, WA 98668
Delegate: Virgil Hanes

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