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Primary Standards Laboratory Report 1st Half 1994

Measurement Standards Department

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550
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Primary Standards Laboratory Report 1st Half 1994

Measurement Standards Department
Sandia National Laboratories
Albuquerque, NM 87185

Abstract

Sandia National Laboratories operates the Primary Standards Laboratory for the Department of Energy, Albuquerque Operations Office (DOE/AL). This report summarizes metrology activities that received emphasis in the first half of 1994 and provides information pertinent to the operation of the DOE/AL system-wide Standards and Calibration Program.

Foreword

This report was compiled and edited by W. G. T. Levy, Sandia National Laboratories. Additional information on the activities covered in this report may be obtained by contacting W. G. T. Levy, Measurements Standards Department 1143, Sandia National Laboratories, PO Box 5800, Albuquerque, New Mexico 87185-0665, telephone (505) 845-8268.

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Primary Standards Laboratory Report

1st Half 1994

1. Introduction

The Primary Standards Laboratory (PSL) operates a system-wide primary standards and calibration program for the U.S. Department of Energy, Albuquerque Field Office (DOE/AL). The PSL mission is as follows: to develop and maintain primary standards; to calibrate electrical, physical, and radiation reference standards for customer laboratories (DOE/AL nuclear weapon contractors); to conduct the technical surveys and measurement audits of these laboratories; and to recommend and implement system-wide improvements.

This report summarizes activities of the PSL for the first half of 1994 and provides information pertinent to the operation of the DOE/AL Standards and Calibration Program. Specific areas covered include development projects, improvement projects, calibration and special measurements, surveys and audits, customer service, and significant events. Appendixes include certifications and reports; a discussion about commercial laboratories used for calibration; PSL memoranda (PSLM); test numbers from the National Institute of Standards and Technology (NIST), formerly the National Bureau of Standards (NBS); and DOE/PSL memoranda on the Standards and Calibration Program with emphasis on traceability of PSL calibrations.

2. Development Projects

Intermediate Range Vacuum Standard

The Intermediate Range Vacuum Standard and Low-Range Flow Generator under development at NIST have been integrated to operate as a single system. The combined system will be used for fundamental state-of-the-art vacuum calibrations in the transition range from the molecular to viscous gas flow regime. The system has undergone bakeout at 100°C using internal quartz infrared heating lamps and an external insulating shroud. The base pressure attained after bakeout was in the low 10^{-9} torr. The

three conductance elements developed for the chamber of the Intermediate Range Vacuum Standard are undergoing in situ testing and calibration by NIST's Primary Leak Standard. After some minor problems, the system was interfaced with a DEC computer and is now "automatable" as requested in the original contract. Total automation will be achieved after a new contract is issued the first part of FY95. The total system will be delivered to Sandia in December 1994.

Digitally Synthesized Source

NIST has developed and is in the process of delivering to the PSL an improved version of the original Digitally Synthesized Source (DSS). The new DSS provides IEEE 488 bus control of the frequency, waveform, and RMS output voltage level and improved resolution, dc offset adjustment, and less harmonics in the output signal. This version of the DSS will provide improved calibrations of low-frequency and low-voltage devices than are presently attainable through the use of thermal voltage converters. The DSS operates over the frequency range from 1 to 5,000 Hz and provides voltages from 0.001 to 7 V. There will be an overlap with thermal voltage converters from 0.5 to 7 V and from 10 to 5,000 Hz. Six DSS units have been delivered to the PSL; the remaining units should be shipped before October 1994. NIST has developed a step calibration process for routinely operating the DSS up to 1,000 Hz, and a step-by-step calibration procedure and any special noncommercial hardware required for calibrating frequency flatness at higher frequencies. The PSL plans to place DSS units in service at the CSL sites to provide improved low-frequency and low-voltage calibration capabilities. This transfer of technology should begin during the first half of FY95.

Representatives of Sandia's Safety Engineering Department reviewed one of the initial DSS units for electrical safety. The DSS design, components used, and construction were approved. A suggestion for improved routing of wiring was implemented in this unit and will be incorporated in the remaining DSS units before they are shipped to other locations.

High Current AC Source

NIST is developing for the PSL a High Current Source (HCS) that will be capable of delivering RMS currents to 100 amperes at frequencies from dc to 100 kHz, decreasing to 25 A at 1 MHz. This system is modeled on the NIST-developed transconductance amplifier that produces 30 amperes from dc to 100 kHz and 8 A at 1 MHz. NIST expects to deliver the complete system before January 1995. This transconductance amplifier will increase the PSL capability to generate ac currents from the present limit of 20 amperes at 50 kHz. A series of high-current, high-frequency current shunts will be needed to effectively use this system.

Inductive Voltage Divider Calibration System

NIST is developing for the PSL an automated system for the calibration of Inductive Voltage Dividers (IVD) or Ratio Transformers. This system is modeled on the system that NIST developed for the NASA ZENO experiment (a paper on this system was presented at CPEM 94, Boulder, Colorado, in June 1994). The PSL system will provide calibration of ratios to 10 parts per billion and is computer controlled. NIST expects to deliver the complete system before October 1994. Training on the system will be at NIST or at the PSL, depending on our mutual schedules.

3. Improvement Projects

UCMM Status

When we relocate, a number of improvements will be made to the UCMM. In particular, the laser electronics will be upgraded and a wavelength tracker installed, allowing real-time velocity-of-light compensation. Also, the laser paths will be enclosed to reduce air turbulence-caused wavelength fluctuations.

A major renovation is being arranged for completion in the 1994-95 time frame. The UCMM's Allen-Bradley 8200 controller and Moore Metrology Software System will be replaced by a Leitz controller and QUINDOS software. More details on the renovation will appear in the next report.

PSL UNCERTAINTY POLICY

An Uncertainty Guidance has been approved for the PSL. This guidance outlines procedures to be followed for obtaining, combining, expressing, and

using measurement uncertainties. Tolerance testing and assignment of tolerances are not addressed.

The guidance notes that to evaluate the certification uncertainty over a specified time interval as required for AL57XA, the time-of-test uncertainty should be combined with any additional uncertainty components, such as those from use conditions, drift, shipping, and safety factors. Combination of the components should be made either by (1) calculating standard deviations and a root-sum-of-squares (RSS) of the result or (2) combining RSS of some components and adding together ranges of the remaining components. In the first case, the uncertainty is to be given by ks , where $k = 3$ is chosen to give a 99% or better level of confidence to the results, and s is the RSS of uncertainty components expressed as standard deviations. In the second case, the uncertainty is given by $ks + R$, where the new term R is the sum of all the semiranges of uncertainty components expressed as ranges. These ranges should bound 99% or more of the distribution of the ranges in question.

After January 1, 1995, all new uncertainty analyses and major revisions of old analyses will follow the above guidance. Also after that date, all PSL certificates will include a level of confidence (recommended as $>99\%$) to be associated with the certification uncertainty. Existing uncertainty analyses are grandfathered. Also grandfathered is existing usage of PSL uncertainties by our customers. However, for proper future use of PSL uncertainties in a customer's uncertainty analysis, it is recommended that customer uncertainties be added to PSL uncertainties when both are expressed at the same level of confidence. It is also proper to combine by RSS or by a combination of RSS and addition when the customer can justify such use. If there is a question about the meaning or use of the certification uncertainty on a PSL certificate, phone the certifying project leader for clarification.

Upgraded Certification of HP8553 VANA Performance

An HP8753C Vector Automatic Network Analyzer (VANA) is used in the PT3644 Tester at Pantex in Amarillo, Texas. The analyzer must be certified every few months according to in-place testing procedures. At the request of Sandia's Antenna Development Department, who is responsible for this tester and its various calibration procedures, the Microwave Project upgraded its HP8753 VANA certification program, CERT8753, to the B2 version. Two principal requirements requested were a convenient method of producing a certificate in the format used by the

Pantex Calibration Laboratory and the capability of using the software on a PC system without the use of a Basic Language Processor (BLP) interface card. The Microwave Project will maintain control over the software in the future.

The first requirement was met by modifying the certification software to produce an ASCII file containing the certification data and certificate cover sheet. Previously, the data and certificate cover sheet were only printed as a hard copy on an attached printer. The user may modify this file using an editor or word processing or other program to produce the certificate in the desired format. The CERT8753 program was ported from the HP Basic system to a system using TransEra Corporation's High Tech Basic (HTBasic). This system runs on a PC without a BLP interface card. However, it requires an IEEE-488 interface card to connect to the Network Analyzer. With the HTBasic system, an executable file (EXE file extension) is produced that runs on the PC. An additional requirement to run this executable file is the TransEra Runtime version software.

In addition to these major changes in the HP8753 certification program, several other changes were implemented, including:

- an option to recalculate the uncertainties at a different confidence level without reading the various standards files
- a new highlighted display allowing the user to quickly see what parameters may be changed
- a check to determine whether the standard airline satisfies the phase shift requirements at the selected frequencies for the reflection coefficient certification
- the addition of code to prevent an I/O lockup of the system when the phase is certified under some unique conditions for the network analyzer.

Time and Frequency

Of the two HP 5071A cesium beam frequency standards units that were placed in service in 1993, one failed in service and was sent back to the manufacturer for repair. It is now back on line and operation seems to be normal. The HP 5071A standards are operating with an uncertainty of approximately 1 part in 10^{12} (as compared to Loran C) through the use of the NIST Frequency Measurement Service.

The design for the frequency distribution system for the new Standards Building has been completed. Amplifiers for distribution of the standard frequencies to all laboratories in the building have been ordered and received but were rejected because the supplier installed wrong connectors. The correct units have been ordered, and the amplifiers should be received by the end of CY1994.

Automated Intermediate DC Voltage Calibration System

DC project personnel devised and carried out preliminary acceptance tests of an automated intermediate voltage calibration system that is being custom built by a Canadian Company. The system passed these preliminary tests. It is designed to permit measurement of voltages up to 1,200 V with an accuracy of 2 ppm. Before shipment to the PSL, the system will be certified to 5 ppm by NRC in Canada. The PSL is responsible for developing the necessary technical data and procedures for certifying the system to 2 ppm.

New Software for Microwave Peak Power Meter Calibrations

HP BASIC 5.0/5.1 program SF1PKHP_A0 was written for the new series of HP Peak Power Analyzers, models 8990A and 8991A. This software facilitates the calibration of these power meters for pulse-top power levels from 10 to 100 mW over a frequency range of 2 to 18 GHz. The software runs on an HP Vectra PC with a Basic Language Processor card for instrument control. This software was placed into service after successfully completing the PSL Calibration System Review process.

4. Calibration and Special Measurements

Mass MAP

A mass MAP with buildup has been done on a set of metric weights (1 mg to 5 kg) belonging to the Los Alamos Yucca Mountain Project (YMP). This was the first calibration work done by the PSL for YMP. The administrative lessons learned will ease the way for future YMP work.

New Solid State DC Voltage Standards Study

The DC project is determining the shipping characteristics and stability of 12 new solid-state voltage standards. Before shipment, the manufacturer calibrated the standards at 10 V and 1.018 V using a Josephson Array standard. They are being tracked at the PSL using our Josephson array standard. Typical differences at 10 V between the manufacturer's values and PSL values were about 0.4 ppm, with the largest difference being 0.62 ppm. These preliminary results are acceptable because they have not yet been corrected for drift (the manufacturer's measurements and the first set of PSL measurements were separated by about a month). At 1.018 V, most of the measured differences were about the same, but a significant portion of these taps (4 out of 12) showed differences of about 1 ppm or more, with the largest difference being 3.8 ppm.

Temperature Bridge vs Electronic Temperature Indicator

DC project personnel compared temperature measurements made by a nine-dial thermometer bridge with those made by an electronic temperature indicator, using the same SPRT, in a precision oil bath. When the bath temperature was a nominal 25°C, the measurements agreed to within 2 milli-degrees. The inherent measurement noise of the temperature indicator was equivalent to about 0.0004°C. The noise of the bridge was unmeasurable, but was at least two orders of magnitude smaller.

5. Surveys and Audits

Technical Surveys

During this period, the PSL conducted two technical surveys of integrated contractors, and a survey report was written for these two surveys plus the one conducted in December 1993.

Measurement Audits

Fourteen measurement audits were initiated with the CSLs during this period. Eleven measurement audit reports were written on audits previously completed.

6. Customer Service

PSL Customer Service Representative – Inquiries

The Customer Service Representative received 9 inquiries during the period, all of which have been resolved.

7. Significant Events

New Weapons Production Primary Standards Laboratory

The occupancy contractor, K. L. House Co., Inc., was awarded the contract on January 3, 1994, and given notice to proceed on January 13, 1994. In accordance with the schedule submitted by House on February 7, 1994, structural work and electrical and plumbing rough-in would be complete and actual move would begin on August 1, 1994, and be complete on October 2, 1994. As of June 30, 1994, work was approximately on schedule. However, completion of move in has been delayed somewhat, but should be completed before the end of November 1994.

Most of the deficiencies of the building shell reported by SNL inspectors have been resolved. The test and balance of the building systems has been completed, and the report has been received from the T&B contractor. The building systems began continuous operation on May 23, 1994. Temperature in the laboratory modules is staying within $\pm 1^\circ\text{C}$.

Relocation of Length-Mass-Force Labs

The length-mass-force labs began relocating to WPPSL in September. It is anticipated that calibration activities will be affected for periods ranging from several weeks to months, depending on specific environmental requirements, etc. The UCMM in particular may not be able to perform calibrations for an extended period of time (refer to UCMM Status in section 3, Improvement Projects).

MMIC Metrology Evaluation Visit by NIST

The PSL, in collaboration with Sandia's Advanced Devices and Applications Department, has joined the NIST Industrial Consortium for Microwave Monolithic Integrated Circuit (MMIC) Metrology. The purposes of this Consortium are:

"to develop improved measurement standards and methods in order to provide increased yields and product performance in the industry"

and

"to encourage the voluntary adoption of such standards by the industry by disseminating information on their use through publication and other means."

As a first benefit of Consortium membership, Sandia hosted a visit by Dr. Dylan Williams of NIST in mid-March. John Cable of Allied Signal Kansas City was also an interested guest. Dr. Williams conducted two seminars regarding on-wafer microwave calibrations and measurements and conducted an evaluation of the accuracy of Advanced Devices and Applications Department on-wafer calibration techniques. The Thru-Reflect-Line on-wafer calibration techniques developed by the Consortium demonstrated much better accuracies than did the commercially available, off-wafer calibrations that are widely used in the industry.

Dr. Williams also gave instruction on the use of the Consortium-developed on-wafer calibration soft-

ware that was delivered to Sandia and the PSL. The Consortium software is proving very useful in Advanced Devices and Applications Department MMIC design work, particularly its ability to measure the characteristic impedance of on-wafer transmission lines.

It is not yet clear what role a metrology laboratory such as the PSL should play in MMIC metrology. Traditionally, in coaxial and waveguide technology, the PSL has disseminated standard values, by artifacts, from NIST to PSL customers. The apparent trend toward on-wafer "standards" as espoused by the Consortium seems to eliminate, or drastically modify, the traditional role played by the PSL. In fact, Dr. Williams said he does not envision NIST in the role of calibrating artifacts to support on-wafer metrology. At this point, the PSL welcomes input from present and potential customers regarding helpful services the PSL might provide in the emerging MMIC metrology field.

Presentation

P. D. Thacher, "Measurement Uncertainty," presented to the EG&G/LV Standards Lab, March 1994.

APPENDIX A

Certificates and Reports Issued

The certificates and reports issued by the PSL are summarized in this appendix.

Reference Standards for

Allied Signal, Inc., Kansas City Division	61
EG&G Energy Measurements Inc., Las Vegas, NV	19
Martin Marietta Specialty Components, Inc.	55
Lawrence Livermore National Laboratory	25
Los Alamos National Laboratory	50
Mason and Hanger-Silas Mason Co.	71
EG&G Mound Applied Technologies, Inc.	57
Martin Marietta Energy System Inc.,	
Oak Ridge Y-12 Plant	0
EG&G Rocky Flats Plant	25
Sandia National Laboratories/New Mexico	84
Sandia National Laboratories/California	37
Westinghouse Savannah River Laboratory	<u>5</u>
Subtotal	489
Other Reference Standards and Delegated Instruments	427
Special Measurements	<u>20</u>
Subtotal	447
Total	<u>936</u>
Total Active Items Currently in Recall System	5,441

APPENDIX B

Commercial Calibration Laboratories (CCLs) and Designated Calibration Sources (DCSs)

The latest revision to AL56XA (Rev. 2, May 28, 1993) reestablished much of the guidance for the approval and oversight of commercial suppliers of calibrations for the Nuclear Weapons Complex. This guidance had been removed from the previous revision (Rev. 1). However, Rev. 2 still left room for additional guidance in the form of a Primary Standards Laboratory Memorandum (PSLM) to be issued with DOE approval. Release of this PSLM (PSLM 28) is expected during the second half of CY 1994.

Rev. 2 of AL57XA provided for two types of commercial suppliers whose standards and calibration programs require approval by the contractors' metrology group. These are:

- **Commercial Calibration Laboratory (CCL).** A commercial subcontractor whose primary business is to perform calibration services and who has been approved by either the PSL or the Contractor Standards Laboratory (CSL) to perform calibrations on measurement standards and M&TE of the DOE Nuclear Weapon (NW) contractor or another subcontractor.
- **Designated Calibration Source (DCS).** A subcontractor whose primary business is to provide products or services and who has been approved by either the PSL or a CSL to perform calibrations on its own measurement standards and M&TE, those of the DOE NW contractor, or another subcontractor.

Since the contractor programs are still currently evolving at various rates and have not yet achieved sufficient commonality between programs (including Revision 2 and proposed PSLM 28 requirements) to permit unrestricted use of CCLs or DCSs between contractors, and because of legal issues that must be resolved, the usual list of commercial sources of calibration services is not included in this issue of the PSL Semiannual Report.

Questions regarding this matter should be addressed to W. G. T. Levy of the PSL Surveys and Audits Project Dept. 1143, MS 0665, (505) 845-8268.

APPENDIX C

Listing of PSL Memoranda (PSLM)

Over the years the PSL has issued various memoranda that provide general technical requirements and standards of good practice for the CSLs. These memoranda are listed here by number. A review for possible update, addition and/or obsolescence of these PSLMs is continually under way at the PSL. A copy of the latest index of the PSLM will appear in each semiannual report. The current issue reflected herein is Rev. 6, which is being issued to reflect the new PSLM 28, dated 9/30/94 and listed below.

PSLM No.*	Date	Title
1A	7/09/80	Exceptions to Recall Requirements
2	1/14/70	(standard leak terminations)**
3B	5/16/88	Laboratory Environments
5E	7/19/89	Calibration Obtained from Other than the Primary Standards Laboratory
11A	3/06/72	Gage Block Materials
13B	11/20/86	Packaging Requirements for Shipment of Standards
14	11/20/74	Designated Commercial Standards Laboratories
20B	1/30/89	Rating and/or Reporting for Technical Surveys and Measurement Audits
23	6/05/80	NBS Calibrated Standards
24A	7/18/86	Weights to be Calibrated by the PSL
26	3/30/83	Checking and Cross-Checking of Standards
27	7/19/89	Reference Materials
28	9/30/94	Oversight of the Calibration Program at Commercial Calibration Laboratories and Designated Calibration Sources

* Missing PSLM numbers were obsoleted in Rev. 5 or earlier revisions.

APPENDIX D

NIST/NBS Test Numbers

Following is a list of some of the presently valid NIST/NBS test numbers assigned to reports of tests performed for the PSL, including some of the more frequently used standards. However, where traceability is questioned by first-tier suppliers and others outside the DOE/AL Weapons Complex, it is the position of both the DOE/AL and PSL that the memorandum on traceability dated November 25, 1991, written with the concurrence of the DOE/AL, be used to answer such questions. A copy of this memorandum along with DOE's cover memorandum and transmittal letter are reprinted herein for ready reference.

Standard	NIST/NBS Test No.
ac Voltage	809920
ac Current	521/240751
High-Frequency Inductance	808351
Capacitance	249663
High-Frequency Capacitance	811439
Self-Inductance	253058
dc Resistance (Thomas 1 Ω)	811/253818
(hi value resistors)	811/250182
High Voltage Resistor	881/253702-94
High-Voltage Pulse	728/250161-92
Gage Blocks, Long English	821/251200-93
Gage Blocks, Long Metric	821/251200-93
Gage Blocks, Angle	821/249554-92
End Standards	821/250779-92
Threadwires (English)	821/249762-92
Threadwires (Metric)	821/252109-93
Master Steel Balls (English)	821/251866-93
Master Steel Balls (Metric)	821/247725-91

Standard	NIST/NBS Test No.
Optical Flats	731/244765-89
Surface Roughness Standards	821/252241-93
Force (Proving Rings)	
5,000 lbf	822.07/248918
10,000 lbf	822.07/248127
20,000 lbf	822.07/252526
60,000 lbf	732.07/245921
100,000 lbf	732.07/244961
Pressure, Air (Ruska-F/N 4174)	P-8388
Pressure, Air (Ruska-F/N 2409)	P-8468
Pressure, Oil (Ruska-F/N 10029)	P-8387
Ion Gages	
(Granville Philips-F/N 6508)	NV 161
Spinning Rotor Gages (SRG)	
MKS-11172H	MR 16A
MKS-8696H	HV 134B
MKS-86854	MR 16B
MKS Capacitance Diaphragm Gages	
F/Ns 8537, 8549, 8547	V195
F/Ns 7889, 7890, 7893, 10618	V183
Accelerometer (Vibration)	
6830	732/246233-90
6829	822/250465-92
11298	
11299	
Lamps Tungsten Strip	
7005	534/242010-88-1
7002	534/242010-88-2
Thermocouple (Type S)	248034

Note: The voltage maintained by the DC Project since December 4, 1991, has been defined by the Sandia National Laboratories Josephson Voltage System, an intrinsic standard. Proper operation of this standard is checked through periodic intercomparison experiments with NIST. The system converts fre-

quency to voltage by means of a superconducting solid-state array of Josephson junctions. The frequency used is traceable to NIST through the AC Project by means of the NIST Frequency Measurement System.

APPENDIX E

DOE/PSL Memoranda on Standards and Calibration Program

United States Government

Department of Energy

memorandum

Albuquerque Operations Office

DATE: DEC 17 1991
REPLY TO
ATTN OF: WQD:QOB:ALF(192)
SUBJECT: AL Standards and Calibration Program

TO: Those on Attached List

There have been some inquiries of the Department of Energy (DOE) Albuquerque Field Office (AL) contractors from other federal offices and contractors concerning how traceability of calibrated items is accomplished at their facilities. For continued and up-to-date response to these questions, the Primary Standards Laboratory has revised a memo (originally prepared on November 12, 1986) describing how traceability is accomplished throughout the AL complex, and this office has prepared a memo identifying each contractor facility participating in the AL calibration system. These memos are attached and should be provided to your contractor(s) for answering future inquiries.

A. E. Whiteman
Director
Weapons Quality Division

Attachments

Addressees - Memorandum dated **DEC 17 1991**

J. LaGrone, Manager, OR
D. J. Bostock, Y-12 Plant Manager & Vice President, MMES, Inc., Y-12
P. M. Hekman, Manager, SR
A. L. Schwallie, Executive Vice President, WSRC, SR
N. C. Aquilina, Manager, NV
R. Grant, EG&G Measurement Inc. Las Vegas, NV
S. Metta, Reynolds Engineering & Electric Co., Mercury, NV
P. M. Ramey, Area Manager, AAO
C. C. Alley, Plant Manager, M&H-SM Co., Inc.
J. A. Morley, Area Manager, DAO
D. E. Michel, President, EG&G-Mound
R. M. Nelson, Jr., Manager, RFO
J. O. Zane, General Manager, EG&G, RF
E. W. Bean, Area Manager, KCAO
L. W. Smith, President & General Manager, AS-KCD
G. W. Johnson, Area Manager, PAO
R. C. Abington, General Manager, GEND
J. L. Bellows, Area Manager, LAAO
R. D. Patterson, Office Leader, QOO, MS-K307, LANL
K. A. Carlson, Area Manager, KAO
C. M. Tapp, Director, Org. 4300, SNL
A. E. Hunt, Project Manager, WIPP
A. L. Trego, General Manager, W

memorandum

Albuquerque Operations Office

DATE: DEC 17 1991

REPLY TO
ATTN OF: WQD:QOB:ALF(201)

SUBJECT: AL Standards and Calibration Program: Traceability

TO:

One of the responsibilities of the Albuquerque Field Office (AL) is to insure the accuracy of test and measurement equipment used for weapons design, development, and production throughout the AL complex. To assist us in meeting this responsibility, AL has tasked the Primary Standards Laboratory (PSL) at Sandia National Laboratories, Albuquerque, to provide calibration traceability for each of the following contractors:

Allied Signal Inc., Kansas City Division
General Electric Neutron Devices Department, Pinellas Plant
Los Alamos National Laboratory
Mason & Hanger Silas-Mason Co., Inc., Pantex Plant
EG&G, Mound
EG&G, Rocky Flats Plant
Sandia National Laboratories, Albuquerque
Sandia National Laboratories, Livermore
EG&G Idaho, Inc.
EG&G Energy Measurements, Inc.
Reynolds Electrical & Engineers Co., Inc.
Martin Marietta Energy Systems, Inc., Y-12 Plant
Westinghouse Hanford
Westinghouse, Savannah River
Lawrence Livermore National Laboratory

Attached is a memo prepared by the PSL which contains excerpts from AL Order 57XA, "Standards and Calibration Program." It describes how traceability is achieved throughout the AL complex. If you have any further questions concerning this matter, please contact this office.

A. E. Whiteman
Director
Weapons Quality Division

Attachment

PRIMARY STANDARDS LABORATORY

Sandia National Laboratories, Albuquerque, New Mexico 87185

November 25, 1991

To Whom It May Concern:

The Department of Energy (DOE) has the overall responsibility for all phases of the design and production of nuclear weapons, and it has placed the specific responsibility for these activities with its Albuquerque Field Office, DOE/AL.

Considering the nature of these nuclear devices, the reliability requirement is extremely high. All aspects of Quality Assurance are given high priority by DOE/AL in carrying out its responsibilities for the nuclear weapons program. One of the particularly important quality elements is the assurance that measuring and test equipment used throughout all phases of the program are providing proper measurements and are properly calibrated.

One of the documents relating to the requirements for the prime contractors engaged in the various phases of the nuclear weapons program is AL Order 57XA, Rev. 1, "Standards and Calibration Program" dated October 22, 1990, which addresses in substantial detail the means for assuring that proper measurement results are being obtained. This Order provides that Sandia National Laboratories (SNL) establish a Primary Standards Laboratory (PSL) and that reference level calibration laboratories be established at each of the prime contractors. These calibration laboratories are termed Contractor Standards Laboratories (CSLs). It also states the requirements for the PSL and CSL, as well as DOE/AL, their Area Offices, and other DOE Field Offices, relative to the implementation of the standards and calibration program which insures the accuracy of measurements made for the nuclear weapons program.

The purpose and scope of AL Order 57XA as stated therein is as follows:

"PURPOSE. This Order assigns responsibilities and sets forth the minimum requirements for the management and operation of the Nuclear Weapons Standards and Calibration Program (NWSCP). This program provides for a system to ensure the accuracy of measurement standards and measuring and test equipment (M&TE) used in nuclear weapons activities."

"SCOPE This order is applicable to the Department of Energy (DOE) and their contractors who are engaged in activities related to the research, design, development, preproduction, production, testing, stockpile evaluation, and retirement of nuclear weapons. Requests for deviation from any part of this Order must be submitted to DOE Albuquerque Operations [Field]* Office (AL)."

*Information enclosed in brackets ([]) does not appear as such in AL57XA but is added here for clarity.

One of the most important aspects of the AL Standards and Calibration Program is "Traceability", which is defined in paragraph 5.s. as follows:

"Traceability. The ability to relate individual measurement results through an unbroken series of calibrations to one or more of the following: 1) U. S. national standards maintained by the National Institute of Standards and Technology; 2) national standards of other countries which are correlated with U. S. national standards; 3) accepted values of fundamental physical constants; 4) values derived by the ratio type of self calibration techniques; 5) values obtained using nationally accepted measurement systems; or 6) comparison with consensus standards."

Paragraph 6.d. of AL Order 57XA establishes Sandia National Laboratories as the location of the Primary Standards Laboratory for the DOE/AL Weapons Complex as follows:

"SNL

"(1) Establishes the highest level metrology organization for the Nuclear Weapons Program, the PSL, by providing facilities, staff, equipment, and management for implementation of the NWSCP.

"(2) Ensures the PSL maintains an effective standards and calibration program in accordance with this Order."

The requirements most closely concerned with traceability for the PSL and CSLs in this regard are covered in paragraphs 6.e. (1) and 6.e. (2), respectively as follows:

"(1) Primary Standards Laboratory

- (a) coordinates the system-wide NWSCP for the DOE and their contractors by providing technical guidance, training, and consultation;
- (b) publishes the PSLM; [Primary Standards Laboratory Memoranda].
- (c) provides a research and development program in the area of measurement technology to enable the timely provision of new measurement standards and M&TE for a properly balanced program and measurement compatibility;
- (d) develops, maintains, or specifies primary standards;

- (e) provides the certification of reference standards, when they are within their capacity and capability, to the contractors; [when neither the PSL or NIST have the capability, the PSL oversees the CSL source of outside calibration].
- (f) provides technical oversight of the contractors by:
 - 1 performing and reporting the results of technical surveys of the contractor's standards and calibration programs;
 - 2 periodically attending contractor surveys of current and potential CCLs; [Commercial Calibration Laboratories]; and
 - 3 conducting and reporting the results of measurement audits of the contractor's metrology organization.
- (g) provides immediate feedback to the appropriate DOE office when any deficiencies are identified during the technical survey; and
- (h) reviews the contractor's procedures for approval and oversight of CCLs."

"(2) Contractors:

- (a) provide facilities, staff, equipment, and management for implementation of the NWSCP and establish the CSL function;
- (b) maintain certified reference standards; and certify and maintain working and transfer standards and M&TE, and any associated instruments used to perform calibrations;
- (c) consult with their CSL organization prior to procurement of M&TE which may require calibration to determine whether the procurement could impact the current calibration capability;
- (d) utilize the other Contractors, when necessary, to obtain calibrations that are not within their current capacity and/or capability;
- (e) consult with the PSL prior to procurement of measurement standards and M&TE which may impact the current PSL capability;

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- (f) maintains and provides to the PSL, documented procedures for the approval and oversight of CCLs to ensure the integrity of procured products and/or services. The extent of the approval and oversight activities for each CCL will be dependent upon the complexity of the product or service provided. CCLs will be approved to perform calibrations within specific measurement fields, ranges, and uncertainties;"

The calibrations certified by the Primary Standards Laboratory and Contractor Standards Laboratories at their respective levels are covered by the above requirements.

In accordance with AL Order 57XA, the Director of DOE/AL's Weapons Quality Division reviews and performs periodic surveys of the operation of the PSL for conformance to these requirements. In addition, the PSL performs periodic technical surveys of the CSL operations and operates a technical measurement audit program for all of the CSLs per AL Order 57XA. The PSL also routinely participates in Measurement Assurance Programs (MAPs) sponsored by the NIST to insure that the continued calibration capabilities are maintained at a high point of proficiency.

Evidence of traceability is maintained on file in the Primary Standards Laboratory along with detailed documentation of each calibration. The Primary Standards Laboratory publishes a semi-annual report of its major activities which includes a section on typical National Institute of Standards and Technology Test Numbers. Each CSL also maintains detailed evidence of traceability in their files for instruments calibrated in their laboratory.

R. T. Johnson, Jr., Manager
Measurement Standards
Department 4340

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