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Sandia WIPP Calibration Traceability

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ABSTRACT

The qualification of existing data (QED) effort undertaken by Sandia National Laboratories has required a detailed assessment of the calibration traceability of the Sandia Waste Isolation Pilot Plant (WIPP) instrumentation. The method used to evaluate the traceability entailed identifying the types of measurements made by Sandia during testing at the WIPP, defining the traceability process for the measurement types used in testing at WIPP, and randomly sampling the traceability to establish confidence that the calibrations used would meet the standards of the National Institute for Standards and Technology (NIST). Ultimately, eight measurement types were defined and twelve actual calibration records for these measurement types, were traced back to NIST or an intrinsic standard recognized by NIST. The results indicate that the calibration of Sandia WIPP instrumentation through the Sandia WIPP Site Calibration Laboratory, the Sandia Secondary Standards Laboratory, and/or the Sandia Primary Standards Laboratory, is traceable to NIST. Additional reviews of the quality assurance used by the applicable calibration laboratories indicate that the certification of WIPP instrumentation adhered to the requirements of American Society of Mechanical Engineers NQA-1-1989 Basic Requirement 12 and Supplemental Requirement 12S-1 as well as the applicable Department of Energy Directive AL57XA for the time period reviewed. Generally this review covered calibrations from 1980 to the present. To substantiate Sandia's confidence in the calibration traceability, copies of external audits of the Secondary and Primary Standards laboratories and audits of key commercial calibration laboratories used by Sandia WIPP have been included in this report. Examination of the calibration traceability process includes the results of a statistical analysis used to develop a confidence level in the traceability process.

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ACRONYMS AND DEFINITIONS

Acronyms

ac - Alternating current
ANSI - American National Standards Institute
dc - Direct current
DRZ - Disturbed rock zone
EDC - Electronic Development Corp.
EP - Engineering procedure
HP - Hewlett Packard
ISBPT - Intermediate-scale borehole test
L&N - Leeds & Northrup
LVDT - Linear variable differential transducer
NCSL - National Conference of Standards Laboratories
NIST - National Institute for Standards and Technology
NVLAP - National Volunteer Laboratory Accreditation Program
PRT - Platinum resistive thermometer
PSL - Primary Standards Laboratory
QA - Quality assurance
QAP - Quality assurance procedure
RH - Relative humidity
RI - Research, Inc.
RTD - Resistive temperature device
SNL - Sandia National Laboratories
SPRT - Special platinum resistive thermometer
SSL - Secondary Standards Laboratory
SSSPT - Small-scale seals performance test
SWCF - Sandia WIPP Central Files
TSI - Thermal-structural interaction
WIPP - Waste Isolation Pilot Plant
YMP - Yucca Mountain Project

Definitions

Traceability - The ability to relate individual measurement results through an unbroken chain of calibrations to one or more of the following: (1) U.S. national standards maintained by NIST: (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) intrinsic standards based on fundamental constants of nature with values assigned or accepted by NIST; or (6) comparison with consensus standards.

Standards - Those devices used to calibrated measurement and test equipment or other measurement standards and provide traceability. Measurement standards may be items that are used to provide basic units of measure, such as standard resistors and gauge blocks, or may be more general-purpose items such as meter calibrators.

NIST - National Institute of Standards and Technology - this is a measurement service organization established to offer the highest order calibration for precision equipment or to transfer standards to national measurement standards. Prior to 1988, NIST was referred to as the National Bureau of Standards (NBS). For this report, the use of the acronym NIST implies the same organization as the acronym NBS.

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1 INTRODUCTION

This report summarizes the work performed to establish calibration traceability for the instrumentation used by Sandia National Laboratories at the Waste Isolation Pilot Plant (WIPP), during testing from 1980 through 1995. Identifying the calibration traceability is an important part of establishing a pedigree for the data and is part of the qualification of existing data (QED) process directed by A. Stevens and V. Harper-Slaboszewicz. The basis for establishing traceability is identified in the American Society of Mechanical Engineers (ASME) NQA-1-1989 Basic Requirement 12, "Control of Measuring and Test Equipment" and Supplementary Requirement 12S-1, "Supplementary Requirements for Control of Measuring and Test Equipment." In general the requirement states that the calibration of measuring and test equipment must have a valid relationship to nationally recognized standards or the basis for the calibration must be documented. Since most of the instrumentation used at WIPP by Sandia has been calibrated by either the Sandia WIPP Site Calibration Laboratory, the Sandia Secondary Standards Laboratory (SSL), or the Sandia Primary Standards Laboratory (PSL), this effort focused on establishing their traceability to a nationally recognized standard. It is important to point out that this effort did not assess calibration traceability for the numerous contractors currently performing work in support of Sandia, nor did it address contractors used by Sandia in the past. The responsibility for establishing current contractor calibration traceability lies with the Sandia WIPP quality assurance (QA) auditors.

On occasion Sandia has used commercial calibration laboratories (CCLs) to support the certification of their instrumentation. The general guideline for selecting CCLs was to use only companies audited and approved by either the SSL/PSL, the WIPP site calibration group, or the Sandia WIPP QA organization. A thorough review of all calibration records indicates that Sandia has utilized approximately 17 CCLs since 1980. Of this total, only two appear to have performed calibrations critical to Sandia test programs directly supporting WIPP compliance. These laboratories are DH Instruments in Tempe, AZ, and MTS, Inc., in Minneapolis MN. Additional discussion on the traceability of the two primary CCLs and a list of all CCLs is contained in Section 5 and Appendix E.

Sandia recognized that just establishing calibration traceability would not necessarily mean that all QA requirements were met during the certification of test instrumentation. To address this concern, the assessment was expanded to include the following activities: (1) Identify the historical involvement of the SSL/PSL at WIPP and determine the guiding documents used by them. (2) Review and summarize external audits performed on the SSL/PSL. (3) Evaluate the SSL/PSL against the requirements of NQA-1-1989 over the time they supported WIPP. (4) Define the calibration traceability for the eight basic measurement types utilized by SNL at WIPP. (5) Demonstrate the use of statistical analysis and random sampling to increase confidence in the traceability process. These were the five areas researched as part of this effort and the results are contained in subsequent sections of this report.

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2 HISTORY OF THE SSL/PSL

Sandia was required by the Department of Energy (DOE) to provide two different but related metrology operations. The first was to provide a Primary Standards Laboratory to administer a Standards and Calibration Program for the entire DOE nuclear weapons complex. The second was to provide a Secondary Standards Laboratory which would operate the Standards and Calibration Program to ensure accurate traceable measurements for all Sandia programs. Until October 1993, these two operations were in different programs areas but now they function together under the Measurement Standards Program in the Materials Programs & Metrology Center of Sandia. When the SSL and PSL started supporting the WIPP site in the early 1980s, they operated according to the requirements identified in DOE Supplemental Directive AL57XA Rev. 1. Starting in May 28, 1993, DOE AL57XA Rev. 2 became the guiding document for both the SSL/PSL. The PSL is the custodian of DOE Directive AL57XA. Based on this DOE Order, the SSL/PSL defined Sandia's Calibration Program as documented in Engineering Procedure EP401560. This procedure is intended to meet the requirements of DOE Order AL57XA and to comply with best industry practices. EP401560 defines the hierarchy of calibration traceability from NIST through the Primary Standards Laboratory to the Secondary Standards Laboratory and finally to the Sandia WIPP Site Calibration Laboratory. Based on the guidelines in EP401560, Sandia's WIPP Site Calibration Laboratory is classified as a calibration station.

Starting in 1995, the SSL/PSL moved away from the use of EP401560 and developed a new set of operating instructions (OI). The first document OI2855-1144-2, pertains to calibration requirements for line organizations and the second, OI2855-1144-1, pertains to the standards and calibration program. The operating instructions are based on the requirements of DOE Order AL57XA Rev. 2, the new American National Standards Institute/National Conference of Standards Laboratories (ANSI/NCSL) Z540-1-1994 standard, and best industry practices. An important note is that the SSL/PSL was involved with the development of this new ANSI/NCSL Z540-1-1994 procedure and the National Volunteer Laboratory Accreditation Program (NVLAP). The SSL/PSL is currently receiving its accreditation from NIST as an NVLAP facility. Once the SSL/PSL has been NVLAP certified, NIST intends to use the SSL/PSL to assist with the auditing of other facilities undergoing NVLAP accreditation. Given the number of guiding procedures used over the years in operating the SSL/PSL and the potential for going to the ANSI procedure, matrix (Table 2.1) was developed showing the basic NQA-1 requirements which apply to the calibration program and identifying the correlation between these NQA-1 requirements and similar requirements in the other calibration procedures referenced in this report. Copies of the above-referenced procedures, DOE Orders, and ANSI documentation have been submitted to the Sandia WIPP Central Files (SWCF). They are listed in Appendix A.

The SSL/PSL started supporting the WIPP site at approximately the same time Sandia started its testing program at the site. Initially both test equipment and instrumentation were calibrated directly by the SSL. In approximately 1984, Sandia WIPP started developing on-site calibration capabilities for certifying some of its instrumentation. The first capability established

was the voltmeter calibration system. Eventually most of the instrumentation installed by Sandia at WIPP was calibrated by the site laboratory. This includes extensometers, closure gauges, most of the pressure gauges, humidity sensors, calipers, micrometers, data acquisition systems, strain gauge stress meters, air velocity meters, thermocouples, etc. There are several reasons Sandia developed a site calibration facility. By developing the ability to calibrate instrumentation in-house (underground), Sandia improved the costs associated with the calibrations by reducing the down time experienced when equipment was shipped to Albuquerque for calibration and Sandia was also able to minimize the corrosion created from transporting equipment between the underground and the surface. An additional advantage to having a calibration facility at the site was the ability to characterize and evaluate the performance of instrumentation. The effects of the gauges could be accounted for when the data were reduced and the maintenance of the gauges could be improved to enhance gauge performance and longevity.

The Sandia WIPP Site Calibration Laboratory operated according to EP401560 until 1994. As defined in EP401560, the laboratory is classified as a calibration station. In May 1994 Sandia issued QAP 12-1, "WIPP Calibration Laboratory Quality Assurance Program," as the directive for operating the site calibration facility. The Sandia WIPP Site Calibration Laboratory has maintained a close working relationship with the SSL/PSL and has always relied on the SSL/PSL to establish and maintain its traceability. Although the SSL/PSL can be viewed as a supplier to the WIPP laboratory, it has also provided the technical oversight for the calibration activities at the WIPP site. In this capacity, the SSL has performed external audits of the Sandia WIPP Site Calibration Laboratory approximately once every 2 years. These audits independently verify that the laboratory was operating according to the applicable engineering procedure or operating instruction. Adherence to the applicable standard is the primary method by which a laboratory ensures that its traceability has been maintained.

Table 2.1. Correlation between NQA-1 requirements and other calibration requirements

Requirement	ASME NQA-1, 1994 Edition	ANSI/NCSL Z540-I-1994	DOE AL 57XA, Rev. 2	Engineering Procedure 401560 Rev. C	SNL WIPP QAP12-1, Revision 1
Quality assurance, audit and review	2S-1 QA Program, 18S-1 audits	Part I, Section 5, quality system, audit and review; Part II, quality assurance requirements	Section 6.a.3, Provides oversight; Appendix A; Section 1.c, surveillance activities	This procedure does not contain an applicable section	Section 5.0, QA requirements; Section 6.0, records
Training of calibration personnel and training records	2S-4, Section 4 training; 12S-1, Section 5, records	Part I, Section 6, personnel	Appendix A; Section 1.b., personnel	This procedure does not contain an applicable section	QAP 2-1, 2-2

Table 2.1. Correlation between NQA-1 requirements and other calibration requirements (cont'd.)

Requirement	ASME NQA-1, 1994 Edition	ANSI/NCSL Z540-I-1994	DOE AL 57XA, Rev. 2	Engineering Procedure 401560 Rev. C	SNL WIPP QAP12-1, Revision 1
Calibration procedures	6S-1, Document control	Part I , Section 10.1, 10.2; Part II, Section 18.5, calibration procedures	Appendix A; Section 3.b., procedures	Section 3.6, calibration procedures	Section 4.3, calibration procedures
Certificates and records	8S-1, Identification and control of items; 12S-1, Section 5, records	Part I, Section 13	Appendix A; Section 3.d., datafiles	Section 3.7, records; Section 2.1.1, 3.9, certifications and labels	Section 4.4, calibration reports; section 6.0, records
Selection of measuring and test equipment	12S-1, Section 2	Part I, Section 7.1; Part I, Section 8.1, 9.1 and 10.2; Part II, Section 18.2, adequacy of measurement standards	Appendix A; Section 1.a, policy	Section 2.1.3, purchase of M&TE	Section 4.1, step 1
Traceability to national recognized standards	12S-1, Section 3.1, calibration	Part I, Section 9, measurement traceability and calibration	Appendix A; Section 3.c., traceability	Section 2.2.1, 3.5, traceability	Section 4.1, traceability
Calibration recall system	12S-1, Section 3.1, calibration; Section 3.2, control	Part II, Section 17.3, recall system	Appendix A; Section 3.g., recall system	Section 3.11, recall system	Section 4.7, step 2
Out-of-tolerance conditions	12S-1, Section 3.2, control	Part II, Section 18.8, out-of-tolerance conditions	Appendix A; Section 4, non-conformance	Section 2.1.2 3.8, out-of-tolerance conditions	Section 4.8, out-of-tolerance condition
Calibration status labels	12S-1, Section 3.2, control; Section 5, records	Part II, Section 18.10, calibration status	Appendix A; Section 3.e., identification	Section 2.1.1, 3.9 calibration labels	Section 4.5, calibration status
Calibration lab environmental conditions	12S-1, Section 3.2, control, Section 4, handling and storage	Part II, Section 18.3, environmental conditions	Appendix A; Section 2.a., metrology laboratory	Section 3.3, laboratory environment	Section 4.2, environmental controls
Handling and storage of calibration equipment.	12S-1, Section 4, handling and storage	Part I, Section 11, Handling of calibration items; Part II, Section 18.12, storage and handling	Appendix A; Section 2.b., storage and transportation	Section 3.4, handling of standards	Section 4.6, storage and handling

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3 AUDITS OF THE SSL/PSL

There are only a limited number of documented external audits and assessments available on the SSL/PSL. The first audit of the SSL occurred in 1989 and the only audit of the PSL occurred in 1993. Prior to these dates, there are no documented audits available on either the SSL or the PSL. All available audits of the SSL/PSL have been summarized in this section of the report. Section 3.1 details the results of the Yucca Mountain Project (YMP) audit of the PSL. Section 3.2 summarizes all SSL audits. This includes the three audits performed by the PSL, one audit performed by the Yucca Mountain Project, and one overview performed by SNL WIPP QA. Section 3.3 details the results of the EM-342 assessment performed by the DOE during 1993/1994. This was a comprehensive review of the Sandia WIPP testing program and included a review of the calibration traceability of SNL WIPP measuring and test equipment (M&TE). The results of the EM342 assessment are summarized in this report. It is important to note that the EM-342 assessment reviewed all areas of the SNL testing program but for this report only the aspects dealing with calibration are discussed.

3.1 PSL Audits

The Yucca Mountain Project audit of the PSL was performed according to the requirements of the Office of Civilian Radioactive Waste Management (OCRWM) YMP quality assurance requirements document (QARD) and included the following elements: organization, QA program, implementing documents, document control, nonconformances, corrective actions, and control of measuring and test equipment. The overall results of the audit indicated that the PSL calibration activities comply with the applicable YMP QARD quality assurance requirements. However, there were three findings (areas for improvement) identified by the audit team and summarized as follows: (1) Out-of-calibration measuring and test equipment in the work area was not being controlled as required. Expired M&TE should be tagged, segregated, or otherwise controlled to prevent use until it has been calibrated. (2) There was no system in place to provide for the prompt identification, control, and correction of items or activities that do not meet established procedures or requirements. (3) Superseded procedures were generally maintained as historical information with current procedures, creating the possibility that obsolete versions might be used. The PSL resolved the three findings as verified by the YMP auditor and subsequently the PSL was placed on the approved vendor list for YMP. Additional details on the findings, the responses to the findings, and the YMP follow-up concurrence/confirmation report are included in Appendix B. No other documented audits exist for the PSL from 1980 through 1993. In January 1995, an audit of the PSL and SSL was initiated by NIST. This audit is part of the new National Volunteer Laboratory Accreditation Program. To date, the results have not been officially released by NIST. Laboratory management indicates that the delay is due to their relocation to a new facility and the desire of NIST to review various aspects of this new facility. When the report is made available, a copy will be submitted to the SWCF.

In the past the PSL has utilized an interlaboratory comparison program to verify the quality of its work. This program involves an exchange of standards among a group of primary standard level calibration facilities. Each laboratory checks the calibration of the selected M&TE and reports the results to NIST. The results are then compared against the values measured by NIST. Although an interlaboratory comparison program does not provide definitive evidence that the PSL is adhering to sound quality assurance practices, it does provide additional evidence that the PSL has maintained traceability and accuracy with NIST. Throughout the years the PSL has participated in this exchange of standards with various primary standards laboratories, but for this paper only two examples of an interlaboratory comparison report have been included in Appendix B. The first report refers to the comparison of 10-kohm and 1-ohm resistance standards. The appendix contains only the first page of this report and specifics regarding serial numbers of the M&TE. The measured values and the procedure used are contained in the full report maintained by that the PSL. The results of this comparison indicate the PSL was well within the accepted tolerance of the NIST measured values. The second report refers to the use of a Fluke 732A dc reference standard for assessing the performance of the PSL's 10-V Josephson array. The Josephson array is an intrinsic standard developed to generate a precise 10 V of direct current using microwave levels and helium. The accuracy of an intrinsic standard is very hard to verify, so the intent was to compare a specific Fluke 732A voltage standard against each participating laboratory's Josephson array. The results of this report were inconclusive with regard to measurement accuracy because a system error was identified in the measurement process used by the participating laboratories. The problem appeared to be thermal EMF voltages that created erroneous readings because the 732A transfer standard was near other 732As. Once again, these reports provide evidence that the PSL works closely with NIST in maintaining their traceability and accuracy by participating in these types of programs.

3.2 SSL Audits

The SSL has been formally audited or surveyed five times from 1989 to the present. No documented audits exist prior to 1989. The PSL has been the primary organization performing the audits of the SSL, starting with the first audit in 1989 and with additional audits in 1991 and 1993. These audits were performed according to the requirements of DOE Order AL57XA and Sandia Engineering Procedure 401560. The SSL was also audited by the Yucca Mountain Project at the same time the PSL was being audited in 1993. A separate audit report was issued by YMP for the SSL and is numbered CSL-SQ93-01. The YMP audit was per the provisions of the OCRWM QA requirements. The final audit of the SSL was performed by SNL WIPP QA department in January 1994. This overview is numbered QAO-94-01 and was performed per the requirements of SNL WIPP QAP 12-1 (draft) and Sandia Engineering Procedure 401560. Copies of all audit reports, as well as all existing follow-up documentation are included in Appendix C of this report.

3.2.1 1989 PSL Audit of the SSL

This audit was performed in April 1989 and the lead auditor was Turk Levy. Mr. Levy is the primary lead auditor for the PSL and was selected for this position based on more than 20 years of experience in metrology. Mr. Levy is not an NQA-1 qualified lead auditor. The general results of the audit indicate that the SSL was implementing a calibration program in accordance with the AL57XA requirements. The following areas needing improvement were noted: (1) Increased effort toward more formal calibration procedures, (2) increased formal documentation of computer software, (3) the need to record temperature and humidity in all calibration facilities; and (4) improved quality assurance training of personnel. Complete details regarding the areas assessed, the specific quality assurance concerns and specific technical concerns are contained in the report in Appendix C. Also included with the initial audit report is the SSL response to the findings. The response was issued by R. B. Pettit, SSL supervisor to R. T. Johnson of the PSL on October 25, 1989. In all cases the SSL identifies appropriate changes they intend to implement or they provide additional detail which clarifies the audit finding such that it is no longer a finding. The PSL did not perform a follow-up assessment to ensure that the SSL implemented the changes identified in the audit response. The 1991 PSL audit would be the only follow-up to the 1989 audit. An area in which the 1989 audit exceeded the basic NQA-1 requirements is the use of measurement audits. The PSL used measurement audits to assess the technical quality of the work being performed by the SSL. These audits entailed the PSL recalibrating M&TE certified by the SSL and comparing the results of the two calibrations. The 1989 audit included seven measurement audits of M&TE which had been calibrated by the SSL. All seven items were successfully verified by the PSL to have met the stated uncertainty values. As it relates to the primary objective of this report, the 1989 SSL audit clearly states that traceability to either the PSL or NIST was present.

3.2.2 1991 PSL Audit of the SSL

This audit was conducted in October 1991. The report was issued in March 1992. The audit was performed to DOE Order AL57XA, good laboratory practices, and the quality plans implemented by the SSL. The lead auditor was Mr. Frank Garcia. His qualifications for this position are based on more than 20 years of experience in metrology. Mr. Garcia was not an NQA-1 qualified lead auditor. This audit did not verify that all findings and corrective actions identified in the 1989 audit report were implemented by the SSL. The process used for determining whether the SSL had addressed the 1989 findings was to infer they were corrected if the same findings were not repeated in the 1991 audit report. In general the results indicate that the SSL was implementing an acceptable standards and calibration program in accordance with DOE AL57XA with no major deficiencies. There were several general comments made by the auditors, some of which would be findings according to NQA-1 requirements. These are as follows: (1) Expired equipment was not properly tagged, segregated, or uniquely identified. (2) Records were not being maintained in storage areas which provided sufficient protection against fire and water damage. (3) M&TE was used beyond its calibration recall interval and no nonconformance-type action was implemented. (4) Procedures for dealing with out-of-tolerance

environmental conditions needed to be developed. (5) No uncertainties were being supplied to the user by some of the SSL organizations. Items 1 and 5 appear to be similar to findings identified in the 1989 audit report, thus they apparently were not corrected by the SSL. Once again, this audit did not point out any concerns with the traceability of SSL calibrations. For this audit only two measurement audits were performed on items calibrated by the SSL and both items successfully passed. For the 1991 audit, the PSL did not request, nor did the SSL provide, a written response to the findings raised in the audit report. The only way to determine if the SSL addressed the items is if the findings were identified again in the 1993 PSL audit report.

3.2.3 1993 PSL Audit of the SSL

The PSL audited the SSL in December 1993. The survey was performed to the requirements of AL57XA, EP401560, and to good laboratory practices. The lead auditor was Mr. Turk Levy, the primary auditor for the PSL. Mr. Levy was not an NQA-1 qualified lead auditor. For this audit the team also included Mr. Eugene Dorneman of DOE/AL Weapons Quality Division, Programs Planning Branch. Mr. Dorneman was invited to participate to provide some independence from Sandia. The general summary states that the SSL was adequately implementing standards and calibration programs in accordance with AL57XA/EP401560. The 1993 audit report by the PSL is the first report to mention that the SSL was checked against the results of the previous audit. The only significant concern identified was with the exploratory batteries test area. (They have a calibration station.) The WIPP has never used the exploratory batteries test area for the calibration of SNL WIPP equipment so the concern will not be addressed in this report. The audit also identifies 56 additional discussion items. This report covers those items identified in calibration areas utilized by WIPP and which would be findings if the audit had been conducted according to NQA-1 requirements. They include the following: (1) Tamper seals were not being uniformly implemented on user-accessible adjustments. (2) Uncertainty analysis needed to be performed for all calibration stations. (3) Implementation of the out-of-tolerance (nonconformance) process was not consistent across the organizations. (4) There was a lack of review and verification when new calibration procedures were implemented. and (5) limitations (failure to meet manufacturer's specifications) identified during the calibration of M&TE were not always noted on the calibration certificate. During the course of this audit the PSL also performed nine measurement audits, which the SSL successfully passed. A follow-up report to this audit was issued by J. M. Simons, manager of the SSL, to K. A. Carlson, DOE KAO on February 1, 1995. The follow-up report indicates the implementation of changes which would address the concerns raised during the audit or that the SSL provided additional input which eliminated the concern. The PSL did not perform any additional follow-up reviews to ensure that the SSL truly implemented the changes identified in the report. Finally, this audit did not identify any concerns with regard to the traceability or accuracy of the calibrations performed by the SSL.

3.2.4 YMP Audit of the SSL

The SSL was audited by the YMP from May 21 through 26, 1993. The audit report issued on the SSL is numbered CSL-SQ93-01. The YMP audit was per the provisions of the OCRWM QA requirements. It contained five general findings: (1) QA element 1: appropriate management responsibilities and organizational functions have not been adequately defined in the quality plan; (2) QA element 2: adequate training and qualification documentation exists, recommend establishing a training database; (3) QA Element 6: specific revision/version of calibration procedures was not available or not recorded on calibration records; (4) QA Elements 15 and 16: deficiencies other than out-of-tolerance conditions were not documented and the use of "do not use" tags (red tags) was not consistently understood and practiced; and (5) QA Element 12: out-of-tolerance conditions still needed to be reported in lieu of negotiating a lesser accuracy with the client. A follow-up report to the YMP audit was issued by D. W. Braudaway, Quality Coordinator of the SSL to R. R. Richards of the YMP Quality Assurance Dept. on November 1, 1994. YMP then verified that the corrective actions had been implemented and the SSL was placed on the OCRWM approved vendors list. It is important to point out that the audit report specifically mentions that traceability of calibrations and records is commendable in the SSL/PSL. Copies of the applicable reports are included in Appendix C.

3.2.5 WIPP QA Review of the SSL

On January 12 and 13, 1994, SNL WIPP QA performed overview QAO-94-01 of the SSL. The overview was performed according to the requirements of SNL WIPP QAP 12-1 (draft version) and EP401560. Seven problems were identified as a result of this overview. Not all of the problems were the responsibility of the SSL; some of them were related to the way the SNL WIPP Site Calibration Laboratory was initiating calibration work requests. The following summarizes the findings: (1) The SNL WIPP Calibration Laboratory was not formally communicating the parameters at which they would like their M&TE certified (example: range, accuracy, temperature). (2) Shipping and handling of M&TE between WIPP and the SSL was not covered by a procedure that included training of individuals transporting equipment. (3) The Sandia WIPP QAPD allowed the use of commercial calibration labs that had not been audited by either the SSL or WIPP QA. (4) Many calibration reports issued by the Sandia WIPP Calibration Laboratory did not contain calibration uncertainty values. (5) WIPP pressure transducers were calibrated by the SSL using standards of insufficient accuracy. (6) SSL calibration records did not contain sufficient information, such as procedure and revision number, calibration temperature, standards used to calibrate the equipment, etc. (7) Calibration reports issued by the SSL did not always state the uncertainty. All findings were addressed and verified, as detailed in a memo of record issued by T. A. Dean on August 21, 1995. With one exception, overview QAO-94-01 identified no finding which would indicate a concern with the accuracy and traceability of the calibrations performed by the SSL. The observation that the accuracy of the SSL pressure calibration was questionable is addressed in nonconformance reports (NCRs) 94-015, 94-016, 94-017, 94-018, 94-019, 94-020, 94-021, 94-022, 94-023, 95-08 and 95-09. The corrective action for these NCRs was based on the observation that the SNL WIPP Calibration

Laboratory had been using a commercial calibration laboratory, DH Instruments, to perform pressure calibrations (see Section 5.3 of this report) prior to and after any calibrations performed by the SSL. All pressure calibrations by DH Instruments indicated that the pressure transducers were still within tolerance; thus the calibrations by the SSL were not utilized. All reports and memos generated as a result of this overview are included in Appendix C.

3.3 DOE 94 EM 342-AS-01 Quality Assessment

The EM 342-AS-01 was a sampling-based assessment of the SNL process for collecting WIPP siting, site characterization, and performance assessment (PA) data. The evaluation of the PA data collection process is the primary area of the EM 342 assessment which is relevant to this report. In evaluating the PA data collection process, the EM342 audit team used the applicable NQA-1 requirements, including those requirements which assess the adequacy of SNL calibration traceability. The assessment was conducted from approximately May 1993 to March 1994 and the assessment team was composed of DOE Headquarters and support contractor personnel, with observers from the Environmental Protection Agency (EPA) and DOE Carlsbad Area Office. In summary, the assessment team found "that SNL PA testing and associated data collection activities were inadequately and inconsistently implemented, particularly in the area of instrument calibration." In making an assessment of the calibration traceability and accuracy, the EM342 team traced four unique M&TE calibration records from the SNL WIPP site back through the SSL and PSL to NIST. The process for tracing the calibrations back to NIST was very similar to the process used during the development of this report. The first traceability involved tracing the calibration of an Ames closure gauge used in the WIPP simulated contact handled (CH) and remotely handled (RH) transuranic (TRU) waste test experiments (Rooms T and J). The closure gauge was calibrated at the WIPP site using a logging multimeter and a unislide fixture. The calibration records reviewed for the logging voltmeter were readily accessible and established traceability to NIST. The calibration records for the unislide fixture were not located during the EM342, nor during the development of this report.

The second sample traced to NIST was a Kulite pressure transducer used in the small-scale seals performance test (SSSPT), Series C and D. Calibration records were considered satisfactory, with the exception of the nonconformances noted during the QA program assessment, and they are restated below for this report. The third item traced to NIST was a closure gauge installed in the heated axisymmetric pillar test (Room H). This item was calibrated using an RI calibration fixture and a logging voltmeter. To the extent these items were reviewed, they appeared to have sufficient traceability to NIST; the only concerns identified were the QA program concerns stated below. The fourth item traced to NIST was a Rosemount pressure transducer used in the permeability testing program. The assessment team was not specific about the concerns but they felt that questions were still unanswered as to the traceability of the standards to NIST. A review of the traceability chart does not reflect the concerns raised in the text, as generally all records appear to have been traceable to NIST. All of the calibration traceability exercises performed by the assessment team are contained in attachments A-4

through A-7 of the EM342 report. The EM342 assessment report has been submitted to the Sandia WIPP Central Files.

In addition to assessing the traceability of calibrations, the EM342 assessment team reviewed the quality assurance program for the SSL/PSL. As mentioned above, the assessment team identified the following nonconforming conditions with the QA program: (1) No formal procedure for calibration of M&TE, reference standards, secondary standards, or SNL standards was available. (2) There was no formal process for imposing WIPP QA or technical requirements for calibration (i.e., required range, accuracy, etc.) on the SSL. (3) There were no training requirements at all levels of the SNL calibration program. (4) Acceptance limits supplied by the SSL and WIPP site calibration labs varied from manufacturer's specifications without a stated rationale. (5) SNL Overview Report QAO-94-01 identified 11 deficient items which needed to be corrected. All of these concerns have been addressed. Item 1 was addressed by the completion of SNL WIPP QAP12-1; item 2 was addressed by the implementation of SNL WIPP technical procedure 497; item 3 was addressed with the development of a formal training program in the SSL/PSL; item 4 has been addressed as all calibration records now contain uncertainty values; and item 5 was addressed as documented in Section 3.2.5 of this report.

In summary, the EM342 report established that three out of four calibrations reviewed appeared to be traceable to NIST. The one item that was not traceable was a length standard (unislide) used to calibrate closure gauges and extensometers for some of the early TSI experiments. The unislide calibration records could not be located for 1983 (time period reviewed by EM342). The calibration records for the unislide were located starting in 1985 and exist throughout the remainder of its use in the WIPP Site Calibration Laboratory. Also starting in 1985, the site laboratory started using calibration fixtures to certify the performance of closure gauges and extensometers. The traceability of the calibration fixtures was assessed in this report as documented in Section 5.1.

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4 GENERAL QUALITY ASSESSMENT OF THE SSL/PSL

As part of the SNL WIPP QA effort to establish the quality and traceability of the SSL/PSL, the SSL/PSL quality assurance program was reviewed. The review was based on the QA criteria identified in NQA-1-1989 Basic Requirements 12 and 12S-1. NQA-1 is the current QA requirement being imposed on the SNL WIPP program. NQA-1 requirements were never passed down to the SSL/PSL by the WIPP program. The SSL/PSL has followed the requirements of DOE AL57XA and, as documented in Section 2 of this report, AL57XA (Rev. 2) contains all applicable elements of NQA-1 requirements 12 and 12S-1. The results of the review are documented in two checklists given in Appendix D. The first checklist applies to the SSL and the second applies to the PSL. The checklists are divided into 5-year time periods starting in 1980. The 5-year periods to establish a time line for when aspects of the current SSL/PSL QA program met the applicable NQA-1 requirement. In a summary, the review points out two primary areas in which the SSL/PSL was not meeting NQA-1 requirements during the 1980s and early 1990s. The first deficiency was the lack of a formal training and qualifications program, with applicable documentation prior to 1993. The second deficiency was the lack of external audits for either the SSL or PSL prior to 1989 and 1993 respectively. This topic has already been discussed in detail in Section 3. Some of the more positive aspects of the review are that the SSL/PSL has had a recall system in place at all times; they have thoroughly documented all calibrations and the documentation is being properly maintained; and procedures or equipment manuals were used when equipment was calibrated.

As part of this quality assessment, a review of the CCLs used by the Sandia testing program was performed. A primary concern identified during this review is, that prior to 1994, the use of CCLs was allowed by the SNL QAPD (Rev. P) without the CCL having to be formally audited by the SNL QA department. The principal investigator (PI) or the designee could use a CCL if they supplied adequate documentation of the procedure used to calibrate the item, personnel qualifications, and traceability of standards used. The use of the term "adequate"' left the assessment of the CCL's records to the PI. In many cases this allowed the use of CCLs even though no subjective evidence of the CCL's qualifications was made available or was reviewed by a qualified person. The requirement to review and audit all CCLs was implemented with the completion of QAP12-1, in May 1994. In an effort to determine the extent of the problem, all calibration records were reviewed to determine the total number of CCLs used. The review indicates that 17 CCLs performed calibrations in support of Sandia WIPP. Table E.1 in Appendix E lists the CCLs and the associated test program. Of these 17 CCLs, only two appear to have performed critical calibrations supporting compliance-related testing. The first CCL was DH Instruments, in Tempe, AZ, and the second was MTS, Inc., in Minneapolis, MN. DH Instruments was identified based on their having certified most of the standards and pressure instrumentation used by Sandia at the WIPP site since 1989. MTS, Inc. was identified based on having performed load (force) cell calibrations in support of the geomechanical laboratory starting in the early 1980s and the WIPP site load cell calibration standards starting in 1985. It appears that traceability for all Sandia WIPP load cell calibrations passes through MTS, Inc. Both DH

Instruments and MTS have been surveyed by the SSL/PSL. DH Instruments was surveyed in 1991 and 1993 by the PSL, with no major concerns noted. In general, the surveys indicate that DH Instruments was implementing adequate QA measures to ensure the traceability and accuracy of their calibrations. MTS, Inc. was surveyed by the SSL on September 12, 1990. The results of the survey indicate that MTS was following adequate QA practices which ensured the traceability and accuracy of their calibrations. Neither survey provides subjective evidence or information regarding the scope of the surveys and the reasons for the survey conclusions. To help provide additional evidence of the traceability and quality of calibrations by DH Instruments, an example of one of their calibration records and a list of organizations who have audited them have been included with the survey reports in Appendix E.

5 TRACEABILITY DEFINITIONS FOR SNL WIPP CALIBRATIONS

In reviewing the calibration records and test data, it was determined that all calibrations at WIPP would correlate to one of eight basic measurement types or to a combination of the eight measurement types. The eight measurement types were identified as length, dc volts, resistance, pressure, weights and balances, temperature, humidity, and force (load). This section develops the traceability of these eight measurement types, thereby defining the general calibration traceability for all internal SNL WIPP calibrations. The process used for defining the traceability involved selecting a specific gauge which represented a measurement type and tracing the calibration of that gauge back to NIST. The results of this effort for the eight measurement types can be viewed in the figures located in Sections 5.1 to 5.8. Although the figures include traceability information, such as serial numbers and calibration dates specific to the gauge used in developing the traceability definition, the process should be consistent for all similar gauges. It is important to point out that many of the calibration standards identified in the flow charts are not necessarily the same pieces of equipment (by serial number and model number) used for all WIPP calibrations of this type. Over the years the SSL/PSL has upgraded their calibration standards and in many cases they own several identical standards which may have been used to calibrate WIPP instrumentation. Although the serial numbers and model numbers of the standards might have changed over the years, the traceability process defined in the charts is relatively consistent. In those cases where the process has changed significantly with time, a separate traceability definition has been developed.

Included with the figures is a short narrative describing the traceability to NIST. For several of the critical measurement types, traceability was defined at two separate time periods to help identify any variability in the traceability path over time. Usually the first time period correlated to the early 1980s and the second period to the early 1990s. A measurement type was considered critical if traceability for a large number of gauge calibrations would need to be established by following the same path and the data measured by the gauges were deemed important for compliance. The four critical measurement types were length (Section 5.1), dc volts (Section 5.2), pressure (Section 5.3), and resistance (Section 5.4). Length calibrations were identified as critical based on the use of length measurement instrumentation in characterizing the repositories' geomechanical behavior. This includes the use of length measurement instrumentation in Room H, the intermediate-scale borehole test, the A-rooms, Room B, Room G, SSSPT, and Room D. The geomechanical data from these tests support the modeling of the repositories as it relates to compliance. The dc voltage measurements are critical for compliance because almost all instrumentation installed by Sandia at WIPP used dc voltage as the output signal. Most of the data acquisition systems (DAS) were then designed to measure a dc voltage signal type. Even when gauges with a 4-20 mA signal output were used in testing, the current was converted to a voltage signal at the DAS by dropping the current across a current viewing resistor. It would be an accurate assessment to state that all tests which utilized a data acquisition system relied on dc voltage as the primary gauge signal type to be measured. Pressure measurements were used in assessing the disturbed rock zone (DRZ) in both the air

intake shaft (AIS) and Room D, far-field permeability testing throughout the repository, SSSPT series A and B brine and gas flow testing, Culebra testing, and geomechanical testing in the ISBT and Room H. Pressure measurements were used to calculate well water levels, determine formation permeabilities, and measure formation stresses and strains. Resistance measurements are not generally associated with specific test data; instead resistance was the primary measurement type used to verify DAS cable configurations, and gauge performance characteristics, and in troubleshooting instrumentation as part of the gauge maintenance program.

5.1 Length Calibrations

Length calibrations support data measured in the intermediate-scale borehole test, the A-rooms, Room B, Room D, Room G, Room H, Room Q, the air intake shaft and the SSSPT series A, B, and D. For length calibrations, traceability was defined for two different time periods. The first time period covers length calibrations prior to 1989 and the second time period covers post-1989 length calibrations. The distinction between the two time periods is based on a change in the working standards used by the SNL WIPP site calibration laboratory. Prior to 1989, length calibrations were performed using step gauges as the standard. The step gauges in this case were fabricated aluminum blocks with fixed reference points. The length of travel between the base of the step gauge and the fixed reference points was measured and certified by the SSL. Step gauges were used to calibrate extensometers, closure gauges, and linear variable differential transducers (LVDTs). By 1989, the SNL WIPP Site Calibration Laboratory began using a Daedal rail table as the standard for calibrating length (displacement) instrumentation. The Daedal rail table relies on counting the revolutions an electrical motor makes as it turns a precision-ground lead screw, which in turn moves a rail table. The number of revolutions corresponds to a specified length. The SNL WIPP Site Laboratory switched to the Daedal rail table because the repeatability, control, and accuracy of this system were several times greater than the old step gauges.

For both the step gauge calibrations and the Daedal rail table calibrations, the primary traceability was achieved using a helium-neon (He-Ne) laser. The performance of the He-Ne laser prior to 1989 was verified by comparing it with a 48-inch standard certified by NIST. In reviewing the calibration records for the this standard, an apparent concern was that the most recent NIST calibration occurred in 1973 (see Figure 5.1). This appears to be a legitimate concern, but in fact, it has very little impact on the performance of the laser. NIST has designated the helium-neon laser as a secondary length standard based on the intrinsic wavelength of He-Ne. If the laser is emitting an He-Ne light source, the accuracy is established as better than $1x10^{-6}$ ppm. The SSL verified the He-Ne laser using the 48-inch length standard to ensure that electronics were operating properly. The SSL did not perform the verification to certify the length measurement capabilities of the laser. Additional details are contained in a memo from NIST to the SSL in Appendix G.

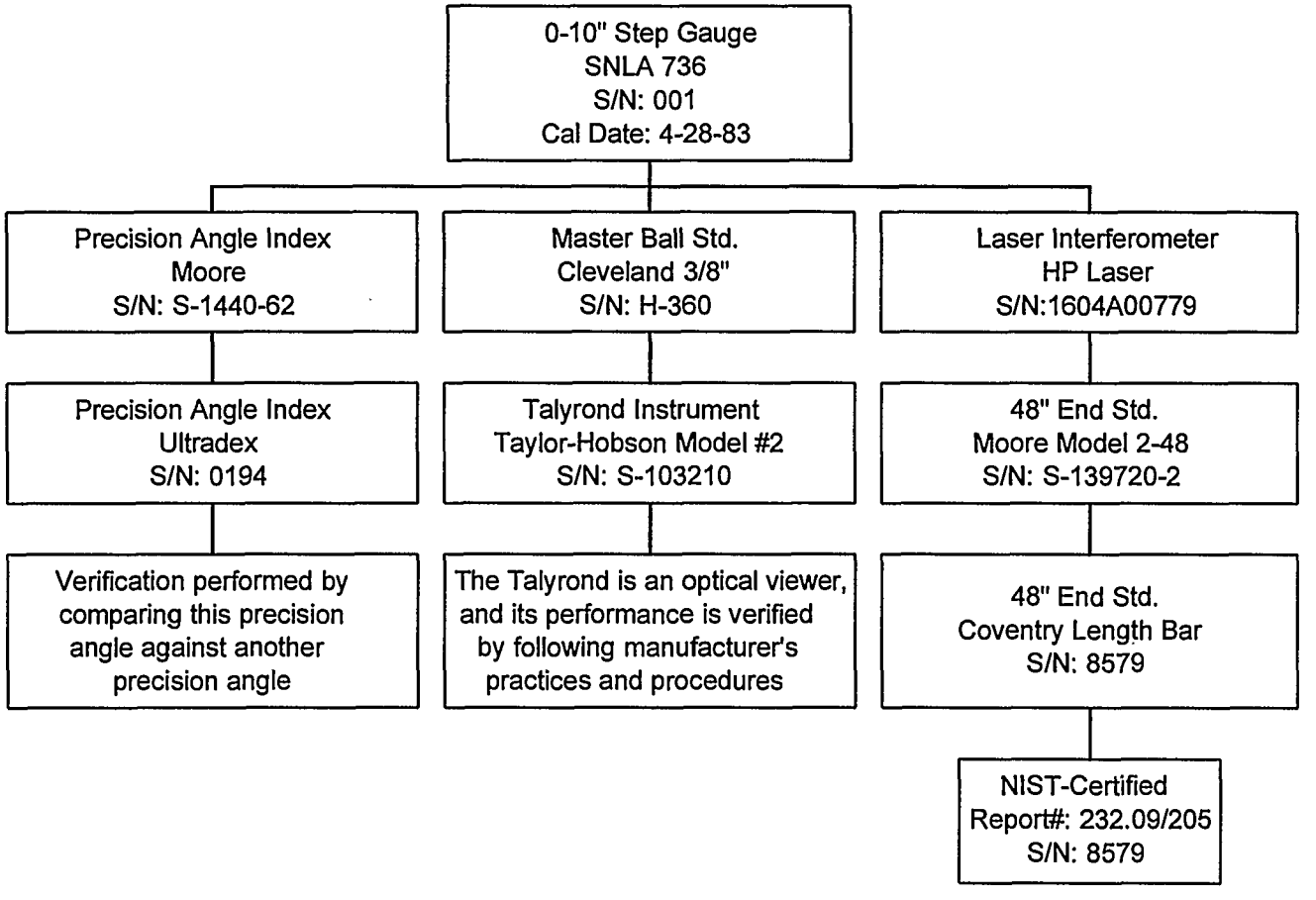

Figure 5.1 Length calibration process prior to 1989. Step-gauge length standards were used to calibrate closure gauges, extensometers, and LVDTs. The SSL has been the only laboratory to calibrate the step gauges used at WIPP. There were approximately three types used in the WIPP Site Calibration Laboratory and all of them followed a similar calibration process.

Calibration traceability to NIST for the Daedal rail table (length calibrations > 1989) was also via the He-Ne laser. The process the SSL used to verify the performance of the He-Ne laser was modified to include standards that were directly traceable to NIST. Once again, traceability to NIST for the He-Ne laser is based on the intrinsic wavelength of a helium-neon laser light source. The verification of the He-Ne laser was performed using a 12-inch step gauge and DoALL gauge blocks. The DoALL gauge blocks are certified by NIST. The Daedal rail table is calibrated every 2 years. It can be assumed that all length calibrations performed on the rail table during the 2-year calibration interval are also traceable to NIST. A review of the records for the Daedal rail table shows that the unit has been calibrated only three times since 1989. Given the small number of calibrations and the short traceability path to NIST, all SSL calibrations performed on the Daedal rail table were assessed. In all three cases, the table was calibrated using the He-Ne laser and the standards used to verify the laser performance were traceable to NIST following the same process defined in Figure 5.2.

One final note: for the purposes of this description, the focus is on the length standards used to calibrate closure gauges, extensometers, and LVDTs. It is recognized that other length standards which do not appear to fall under the same direct calibration traceability process were used in the SNL WIPP calibration laboratory. This includes items such as gauge blocks, micrometer length standards, Mike Master, micrometers, and calipers. In reviewing calibration records in the SSL and PSL, it is apparent that a majority of SNL WIPP length standards followed the same process identified for the Daedal rail table or the step gauges. For example, the SNL WIPP site gauge block traceability is established through the same DoALL gauge blocks referenced in Figure 5.2. At this point, most of the WIPP length calibrations appear to be traceable to NIST through the SSL and PSL. The SNL WIPP Calibration Laboratory did not use commercial sources to calibrate length instruments.

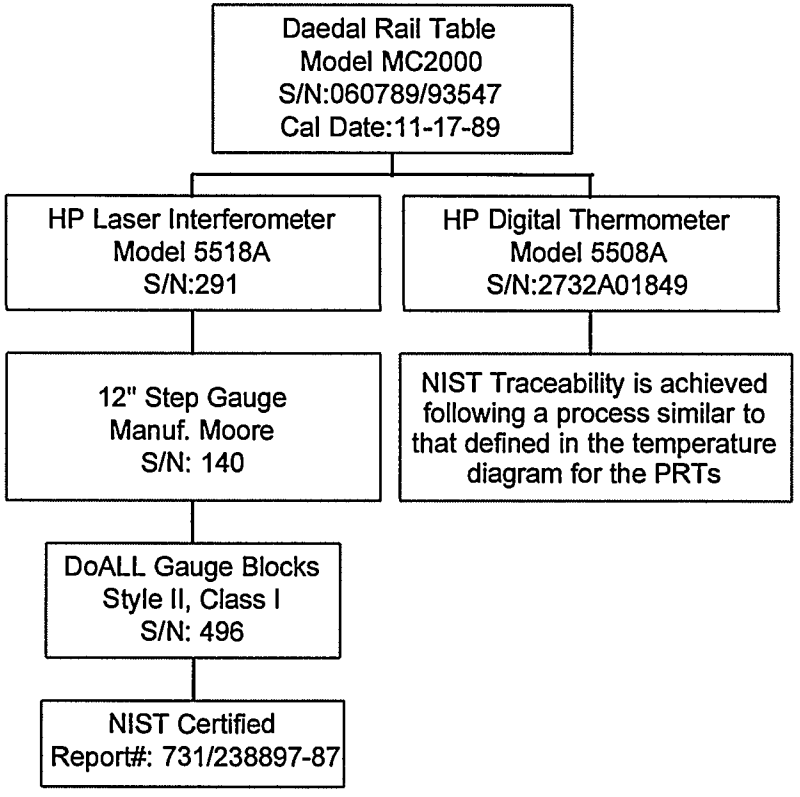

Figure 5.2 Length calibration process after 1989. The Daedal rail table has been the primary working standard for length calibrations in the SNL WIPP Site Calibration Laboratory since 1989. The rail table was primarily used to certify closure gauges, extensometers, and LVDTs. The Daedal rail table has always been calibrated by the SSL and the same general process displayed here was utilized. Although this flow chart only displays information for the 1989 calibration, it was verified that similar calibration records exist for the certification of the rail table in 1991 and 1993.

5.2 Calibration of dc Voltage

Direct current voltage has been identified as a critical measurement because most of the instrumentation at WIPP uses dc voltage as the output signal. This includes extensometers, pressure transducers, closure gauges, LVDTs, air velocity, strain gauges, flux gauges, thermocouples, humidity sensors, and strain gauge stress meters. Since the gauge output signals were generally dc volts, the data acquisition systems and multimeters were designed and calibrated to measure dc volts. The dc voltage traceability through the SSL/PSL was defined for the early 1980s and early 1990s. The two periods varied considerably in how traceability to NIST was established. In the early 1980s, the primary dc voltage reference standard was the standard cell air bath. By the 1990s, the standard cell air bath was being replaced by a Zener voltage standard and the Josephson volt. The Josephson volt standard is an intrinsic standard which uses a high-frequency (300-GHz range) signal injected across a helium vacuum to generate a very precise voltage level. The Zener voltage standard is the primary transfer standard which is compared against the Josephson volt. The resulting traceability studies for the two time periods covering dc voltage are displayed in Figures 5.3 and 5.4. Both studies started with an HP3456A multimeter, which was/is the cornerstone of the SNL WIPP Site DAS and the SNL WIPP Calibration Laboratory. The Mod-Comp DAS used the HP3456A exclusively in the underground sheds to measure the analog signals from the instrumentation and to convert this signal to a digital value. The HP3456A was also the primary voltmeter used in the calibration laboratory to measure gauge signal outputs during calibration. The HP3456A was calibrated at the WIPP site using an EDC501J, a Datron 1081 or 1281, and the guideline resistors. The calibration procedure for the HP3456A also included the ac volt function, but for this effort ac voltage traceability was not defined. The ac voltage function has never been used in any significant capacity to record test data, so the decision was made to focus on the primary measurement type. The EDC501J was calibrated on site using the Datron 1081 or 1281. The dotted line in the figures represent this calibration path. The guideline resistor calibration is discussed in Section 5.4. The Datron 1081 or 1281 was calibrated by the SSL using a Datron 4000 or 4708, depending on the time period. For the Datron 4000 and the Datron 4708, the traceability to NIST is through either the standard cell air baths or the 732A Zener voltage standard. The remaining instruments in the traceability path end up following the same process as that defined for resistance in Section 5.4.

An important aspect of the PSL's dc voltage traceability is the interlaboratory comparison process. Working with other primary quality laboratories in the United States and with NIST, the SNL PSL exchanges voltage standards on a periodic basis. Cross checks are performed to verify the consistency and accuracy of such items such as the Josephson volt and the standard cell air bath. A copy of two interlaboratory comparison programs is included in Appendix B.

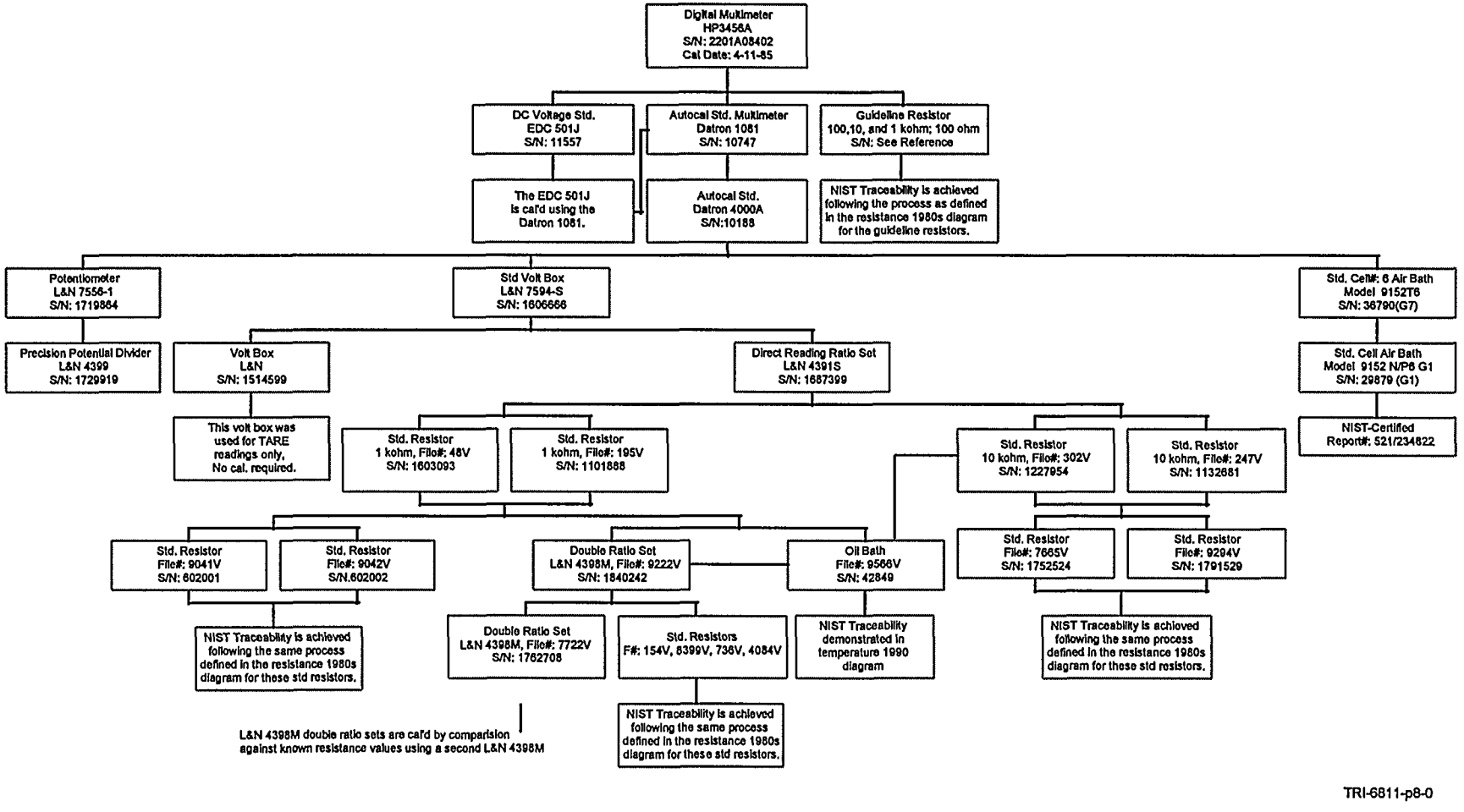

Figure 5.3 Calibration process for dc voltage in the 1980s. HP3456A digital multimeters were the primary instruments used to measure the sensor signals for the Mod-Comp DAS and to measure sensor outputs during calibrations. Only the dc voltage and resistance capability were traced to NIST; the ac function was generally never used to measure sensor outputs. The traceability path for the HP3456A is identical to the traceability path for all multimeter and voltmeters used at WIPP. The basis for the calibration is the Datron 1081, which was the transfer standard used to calibrate all meters.

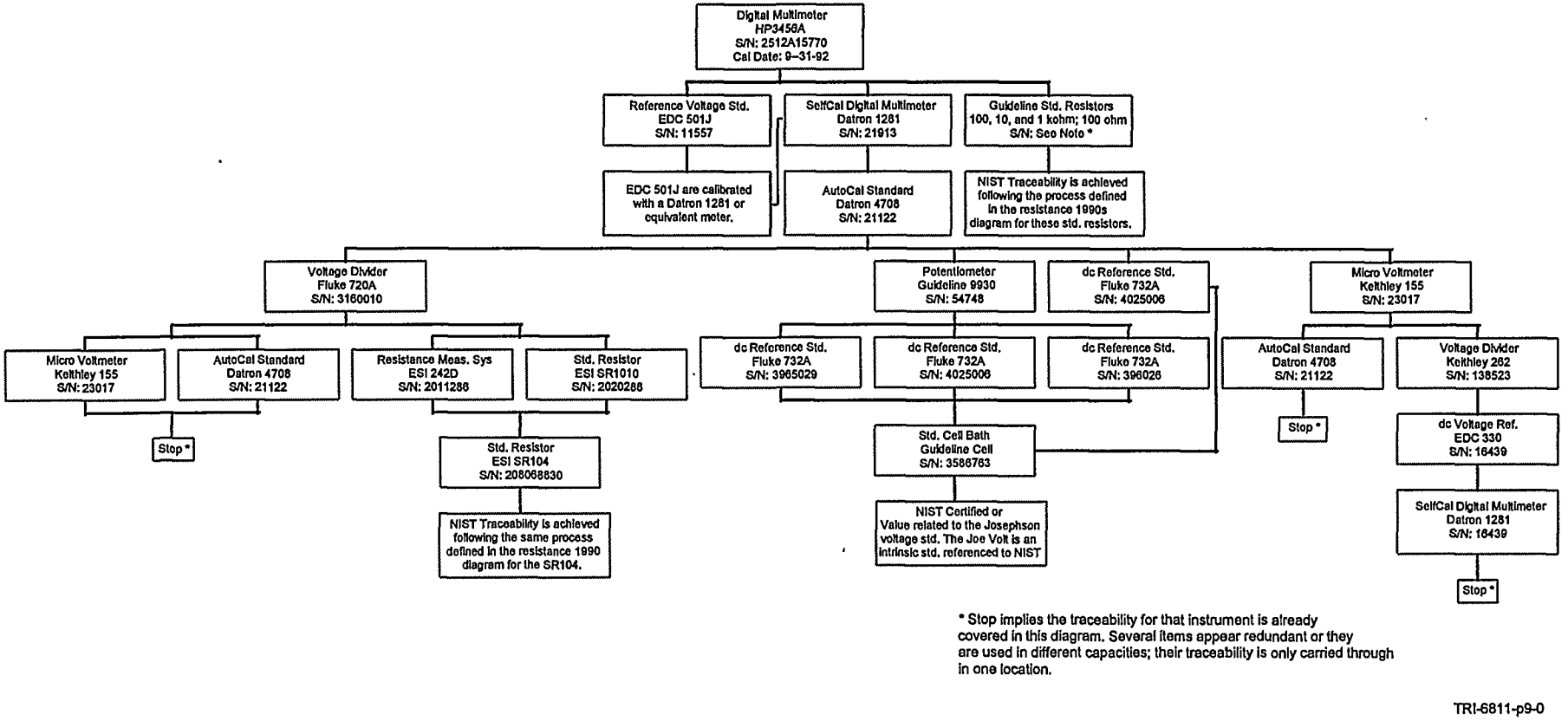

Figure 5.4 Calibrations for dc voltage in the 1990s.

5.3 Pressure Calibrations

Pressure calibrations have been an important part of several test programs at WIPP. These include the thermostructural interaction (TSI) experiments, Room Q, small-scale seals, Culebra, facilities permeability, hydrofracture, and disturbed rock zone. Because of the obvious importance of these tests, the traceability of pressure was deemed critical. Pressure traceability was reviewed at two different time periods, the mid-1980s and the early 1990s. These periods were selected because they corresponded with a change in the traceability of SNL WIPP pressure calibrations. In the early 1980s, SNL WIPP pressure calibration traceability was solely through the SSL/PSL. Starting in 1989, the primary SNL WIPP pressure traceability was through a commercial calibration laboratory, DH Instruments. In reviewing the pressure calibration records, it was noted that pressure transducers used in some of the experimental programs would on occasion be sent to CCLs other than the SSL/PSL or DH Instruments. This report does not address the traceability of some of the independent CCLs used to calibrate SNL pressure transducers at SNL WIPP.

The traceability of pressure transducers in the 1980s started with the Cosa deadweight tester used by the SNL WIPP Site Calibration Laboratory. The Cosa deadweight tester was sent to the SSL for calibration at periodic intervals of approximately every 3 years. The main traceability at the SSL/PSL was achieved using Ruska pressure gauge components and Troemner metric weights. The Ruska was directly calibrated by NIST; the Troemner weights were calibrated by the PSL using weights certified by NIST. The temperature sensor and a barometer were used to measure the ambient conditions. The ambient conditions would then be used in correcting the output of the Ruska and the Troemner weights. The temperature sensor traceability is covered in Section 5.3. The barometer traceability was also through the PSL using a Ruska deadweight piston gauge calibrated by NIST. Figure 5.5 displays the traceability process described above. By defining the pressure traceability for both the Cosa deadweight tester and the barometer, we have demonstrated the traceability to NIST for the two primary pressure standards used by the PSL.

Starting in 1989, the SNL WIPP Calibration Laboratory began using DH Instruments to calibrate their pressure standards and some of their pressure gauges (Figure 5.6). The change was made because SSL equipment was out of service, and the cost and turnaround time were reduced by using DH Instruments. At several different times throughout the early 1990s the SNL WIPP site laboratory did send pressure instrumentation to the SSL, but as a result of a finding in SNL Overview Report QAO94-01, the pressure calibrations performed by the SSL were invalidated from 1990 to 1994. This did not effect any of the pressure data as addressed in the close-out of overview QAO94-01. DH Instruments was audited by the PSL in 1990 and 1993 and copies of the audit reports are in Appendix E. This appendix also contains a listing of audits performed on DH Instruments by various commercial and governmental agencies. In addition, a sample of a DH calibration report has been included. The calibration report is an excellent example of how DH Instruments establishes their traceability to NIST.

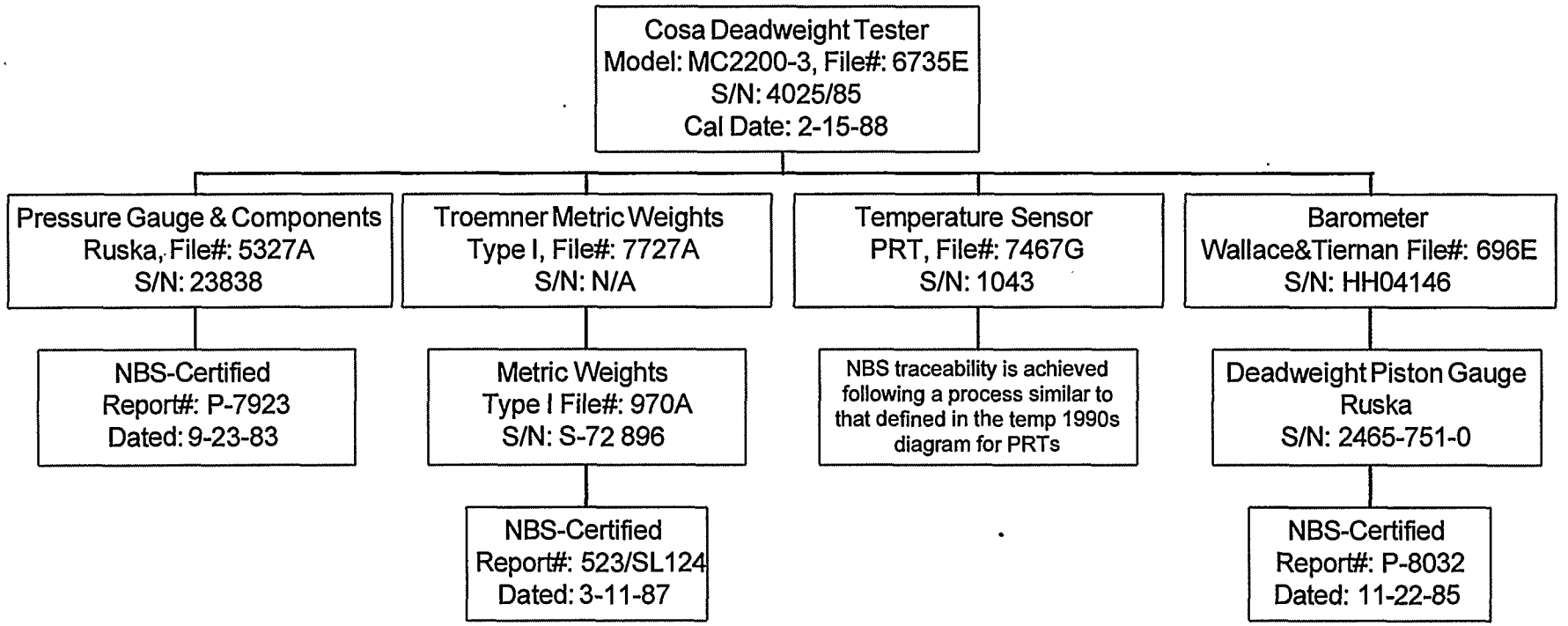

Figure 5.5 Pressure calibration process in the 1980s. In the 1980s the Cosa deadweight tester was the only pressure calibration system used in the SNL WIPP Site Calibration Laboratory. The primary use for the system was the calibration of Kulite pressure transducers. The Kulites were used to measure the pressure in the hydraulic stress meters installed in many of the TSI experiments.

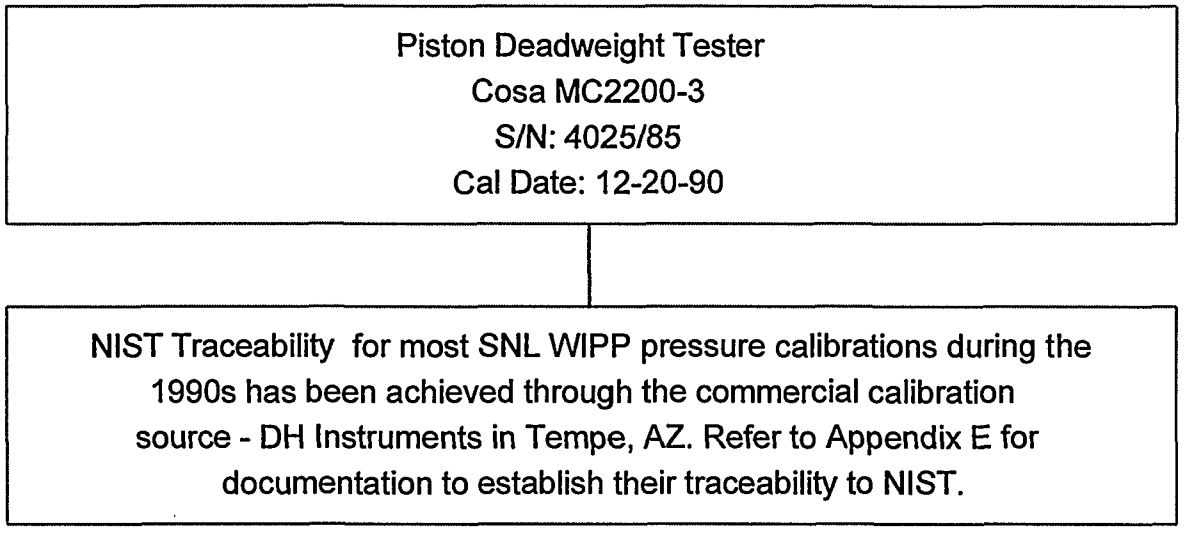

Figure 5.6 Pressure calibration process in the 1990s. Starting in approximately 1989, the Cosa deadweight tester was sent to DH Instruments for calibration. In addition the laboratory developed other pressure calibration systems, such the Druck 510. The traceability for all pressure calibration systems used at the WIPP followed DH Instruments calibration traceability. The deadweight tester and Druck 510 systems were used to calibrate pressure gauges for a wide variety of tests, including the TSI tests, DRZ tests, small-scale seals tests, hydrofacture tests, Culebra tests, grouting experiments, etc.

5.4 Resistance Calibrations

The traceability of resistance was deemed critical because several measurement types eventually establish elements of their traceability through resistance. For example, the process defined for dc volts, temperature, and pressure all have portions of their traceability which correlate to the resistance traceability. The initial resistance traceability was defined for the mid-1980s, with the second effort focusing on the early 1990s. The selection of these two time periods was based in part on a change in the calibration process. In the early and mid-1980s, the calibration of the WIPP site guideline resistors was performed by the PSL. By the early 1990s, the SSL was calibrating the WIPP site guideline resistors using different standards. Guideline resistors were the primary transfer standard used in the SNL WIPP calibration laboratory to certify the resistance functions on HP3456A and HP3466A multimeters, HP3497A scanner/voltmeters, HP3467A logging multimeters, and various data acquisition systems used at WIPP. This includes voltmeters used in the underground Mod-Comp sheds, as well as voltmeters used in the calibration laboratory. It is important to keep in mind that the resistance function on most voltmeters and data acquisition systems was not generally used to measure and record actual sensor outputs for use as data. The resistance functions on these instruments were primarily used to measure the input and output resistance of gauges during installation, calibration, and troubleshooting. Also, resistance measurements were used to verify cable continuity from the DAS to the gauge.

In the mid-1980s, the PSL performed resistance calibrations for SNL WIPP. The process of certifying WIPP resistance standards involved comparing the guideline resistors with higher accuracy resistance standards maintained by the PSL. To perform the comparisons, the PSL used a Leeds & Northrup (L&N) 4398M comparator and maintained the resistors in a temperature-controlled oil bath. The oil bath temperature is certified using a platinum resistive thermometer (PRT) which has a traceability similar to that defined in Section 5.6. The L&N 4398M comparator is calibrated by verifying its performance against another L&N 4398M comparator using known resistance standards. This is an acceptable process given that the L&N 4398M is only used as a ratio comparator between the resistor being calibrated and the standard resistor. In reviewing Figure 5.7 the process demonstrates that the calibration traceability continues to involve repeated comparison of resistors to higher accuracy resistors until the L&N standard 1-ohm (Thomas type) resistors are reached. These particular Thomas type resistors are sent to NIST for certification.

Resistance calibrations in the 1990s followed the same general process used to establish NIST traceability in the 1980s. The exception is that the calibration of the WIPP guideline resistors was performed by the SSL using the ESI 242D resistance measuring system. The ESI 242D was then calibrated using a standard resistor, ESI SR104. From this point on, the calibration process is the same as the 1980s process detailed above. See Figure 5.8 for additional details.

The process may appear a bit convoluted, but this is really not the case. The PSL has developed flow charts showing the exact traceability hierarchy to NIST for all of their resistors. These flow charts are included as Figures 5.9 to 5.12. The one apparent certainty is that all resistance calibrations will reach NIST through the three Thomas type 1-ohm, L&N standard resistors (S/N: 1631832, 1631825, 1631830). A review of the historical calibration records for the three Thomas type resistors shows sequential NIST calibrations dating back to at least 1980.

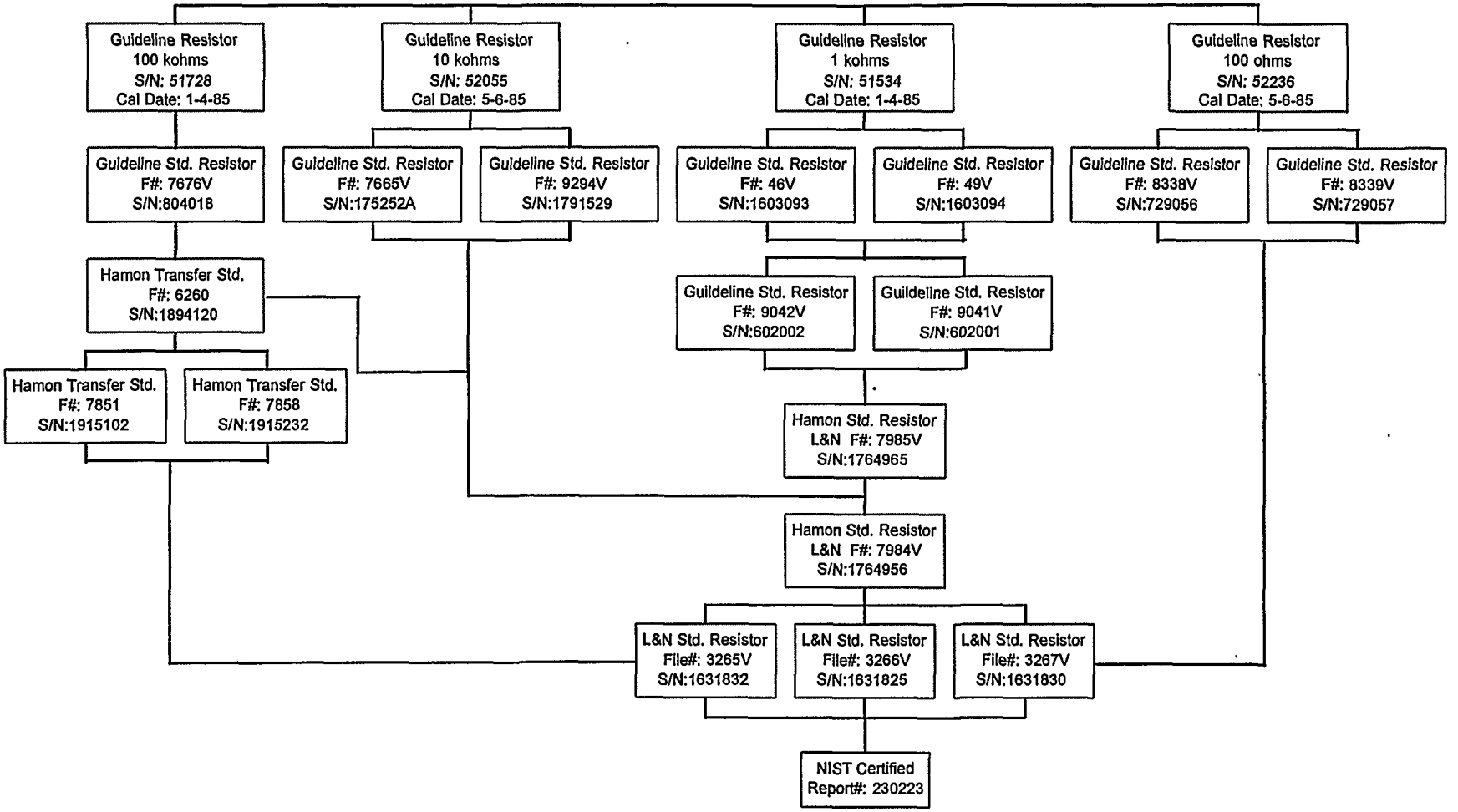

Figure 5.7 Resistance calibration process in the 1980s. The four guideline resistors were used to calibrate the resistance function on the HP3456A, HP3466A, and HP3467A multimeters and the HP3497A scanner/voltmeter. The resistance function on most meters was not used to record data from sensors used in testing. Resistance was used to establish input and output gauge resistance readings during calibration, installation, and troubleshooting. The resistance information would help identify when gauges were malfunctioning. In the early 1980s the resistors were sent directly to the SNL Primary Standards Laboratory.

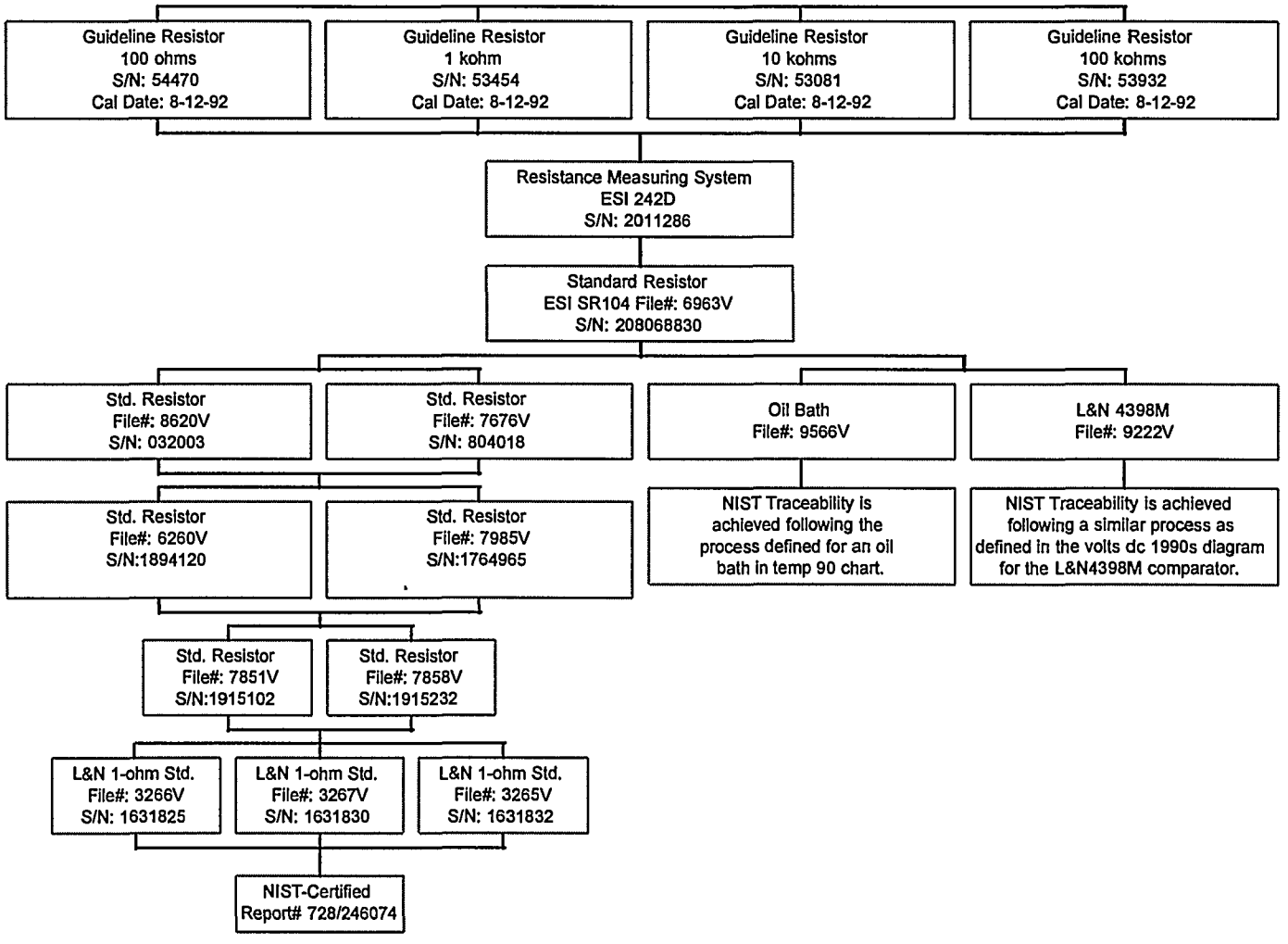

Figure 5.8 Resistance calibration process in the 1990s. The four guideline resistors were used to calibrate all voltmeters, multimeters, and DAS resistance measurement capabilities. Generally the resistance function on meters was not used to measure sensor signals; instead it was used to measure gauge input and output resistance during calibration, installation, and troubleshooting. In the late 1980s resistors started being certified by the SSL as opposed to the PSL. Actual traceability to NIST remained consistent.

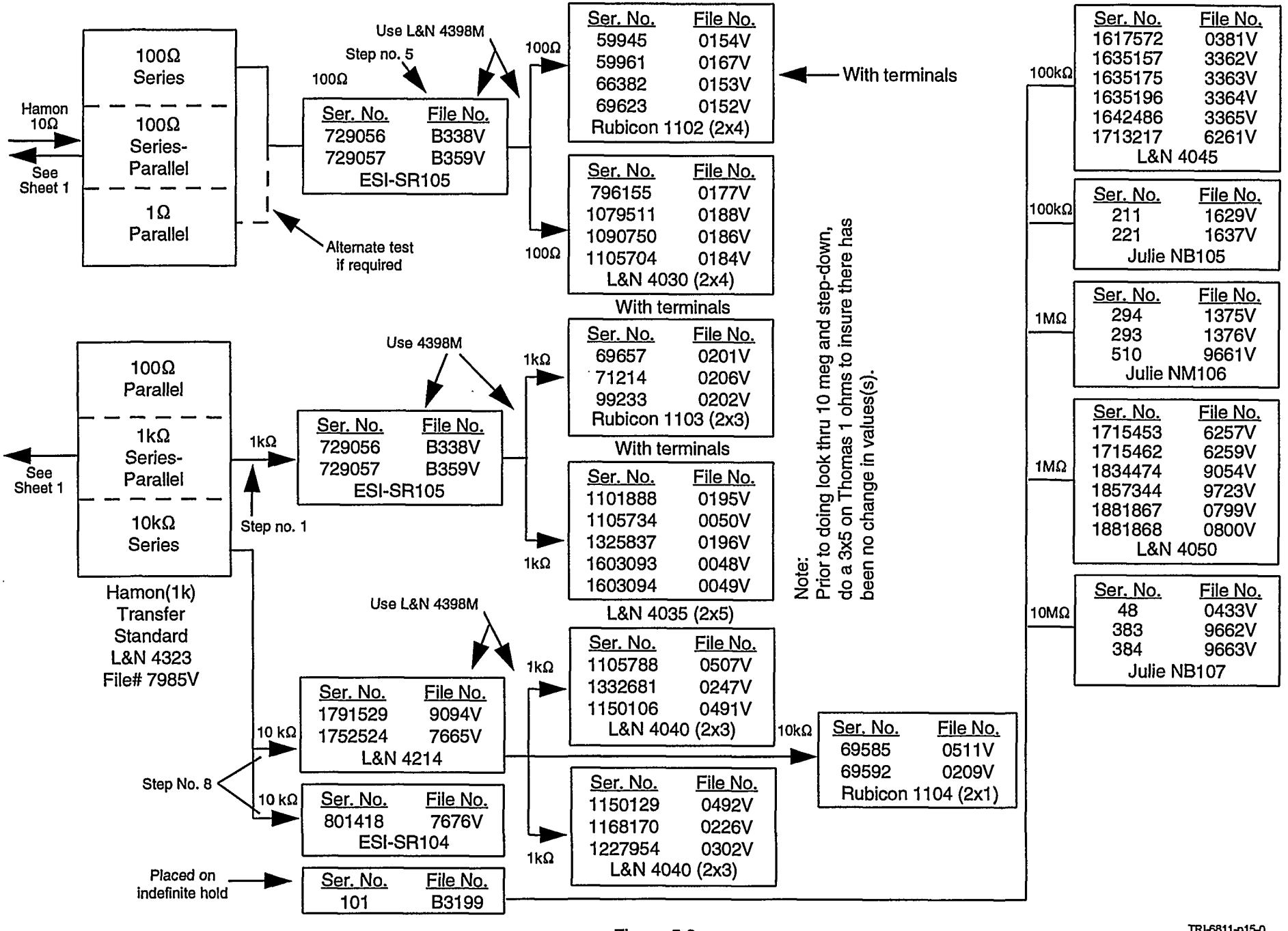
100Ω Series
100Ω Series-Parallel
1Ω Parallel
Hamon 10Ω
See Sheet 1
Alternate test if required
Use L&N 4398M
Step no. 5
100Ω
Ser. No. File No.
729056 B338V
729057 B359V
ESI-SR105
100Ω
100Ω
Ser. No. File No.
59945 0154V
59961 0167V
66382 0153V
69623 0152V
Rubicon 1102 (2x4)
With terminals
Ser. No. File No.
796155 0177V
1079511 0188V
1090750 0186V
1105704 0184V
L&N 4030 (2x4)
With terminals
100kΩ
Ser. No. File No.
1617572 0381V
1635157 3362V
1635175 3363V
1635196 3364V
1642486 3365V
1713217 6261V
L&N 4045
100kΩ
Ser. No. File No.
211 1629V
221 1637V
Julie NB105
1MΩ
Ser. No. File No.
294 1375V
293 1376V
510 9661V
Julie NM106
1MΩ
Ser. No. File No.
1715453 6257V
1715462 6259V
1834474 9054V
1857344 9723V
1881867 0799V
1881868 0800V
L&N 4050
10MΩ
Ser. No. File No.
48 0433V
383 9662V
384 9663V
Julie NB107
100Ω Parallel
1kΩ Series-Parallel
10kΩ Series
See Sheet 1
Hamon(1k) Transfer Standard L&N 4323 File# 7985V
1kΩ
Step no. 1
Use 4398M
Ser. No. File No.
729056 B338V
729057 B359V
ESI-SR105
1kΩ
1kΩ
Ser. No. File No.
69657 0201V
71214 0206V
99233 0202V
Rubicon 1103 (2x3)
With terminals
Ser. No. File No.
1101888 0195V
1105734 0050V
1325837 0196V
1603093 0048V
1603094 0049V
L&N 4035 (2x5)
Note: Prior to doing look thru 10 meg and step-down, do a 3x5 on Thomas 1 ohms to insure there has been no change in values(s).
Use L&N 4398M
1kΩ
Ser. No. File No.
1105788 0507V
1332681 0247V
1150106 0491V
L&N 4040 (2x3)
10 kΩ
Ser. No. File No.
1791529 9094V
1752524 7665V
L&N 4214
10kΩ
Ser. No. File No.
69585 0511V
69592 0209V
Rubicon 1104 (2x1)
Step No. 8
10 kΩ
Ser. No. File No.
801418 7676V
ESI-SR104
1kΩ
Ser. No. File No.
1150129 0492V
1168170 0226V
1227954 0302V
L&N 4040 (2x3)
Placed on indefinite hold
Ser. No. File No.
101 B3199
TRI-6811-p15-0

Figure 5.9

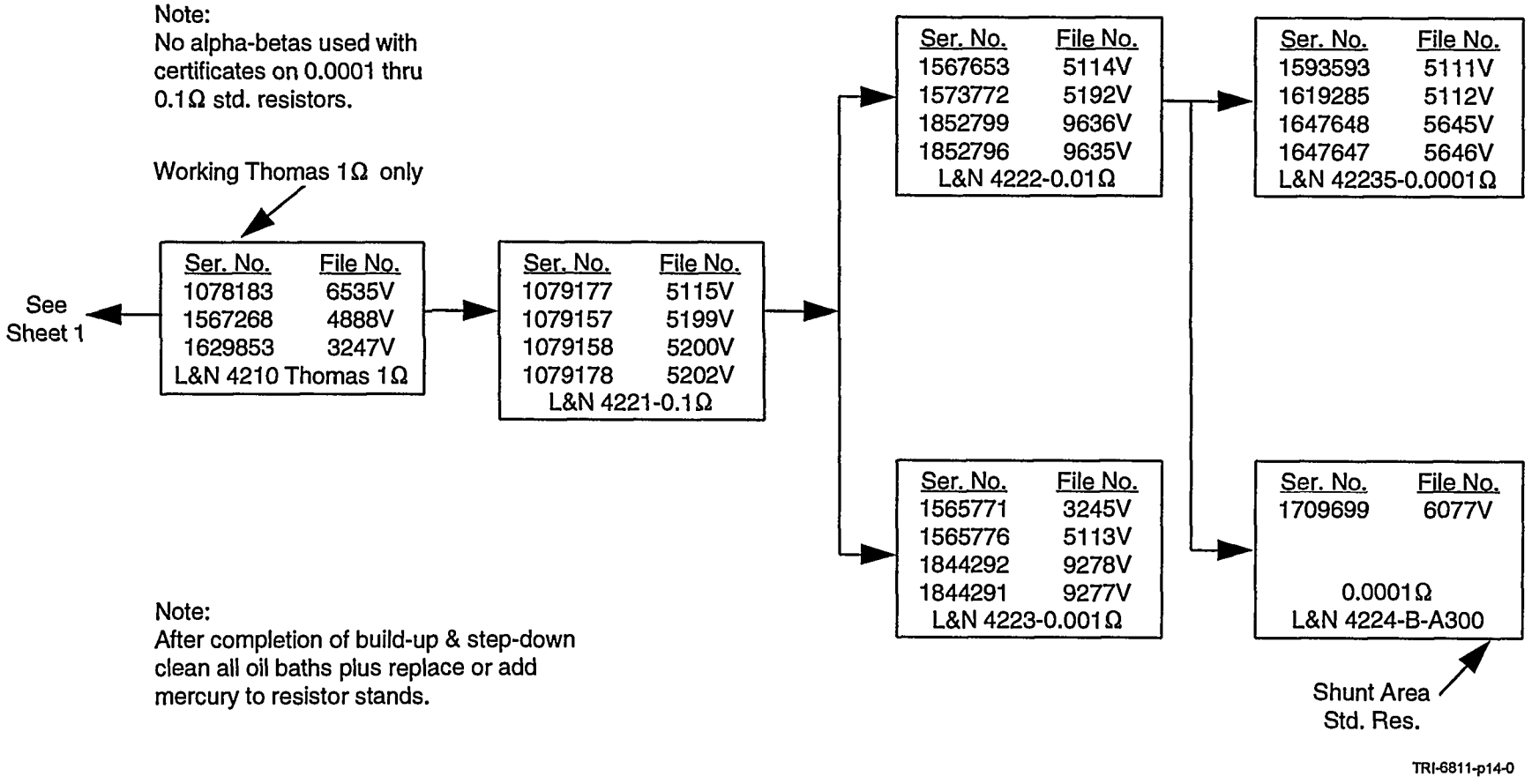
Note:
No alpha-betas used with certificates on 0.0001 thru 0.1Ω std. resistors.
Working Thomas 1Ω only
See Sheet 1
Ser. No. File No.
1078183 6535V
1567268 4888V
1629853 3247V
L&N 4210 Thomas 1Ω
Ser. No. File No.
1079177 5115V
1079157 5199V
1079158 5200V
1079178 5202V
L&N 4221-0.1Ω
Ser. No. File No.
1567653 5114V
1573772 5192V
1852799 9636V
1852796 9635V
L&N 4222-0.01Ω
Ser. No. File No.
1593593 5111V
1619285 5112V
1647648 5645V
1647647 5646V
L&N 42235-0.0001Ω
Ser. No. File No.
1565771 3245V
1565776 5113V
1844292 9278V
1844291 9277V
L&N 4223-0.001Ω
Ser. No. File No.
1709699 6077V
0.0001Ω
L&N 4224-B-A300
Shunt Area Std. Res.
Note:
After completion of build-up & step-down clean all oil baths plus replace or add mercury to resistor stands.
TRI-6811-p14-0

Figure 5.10

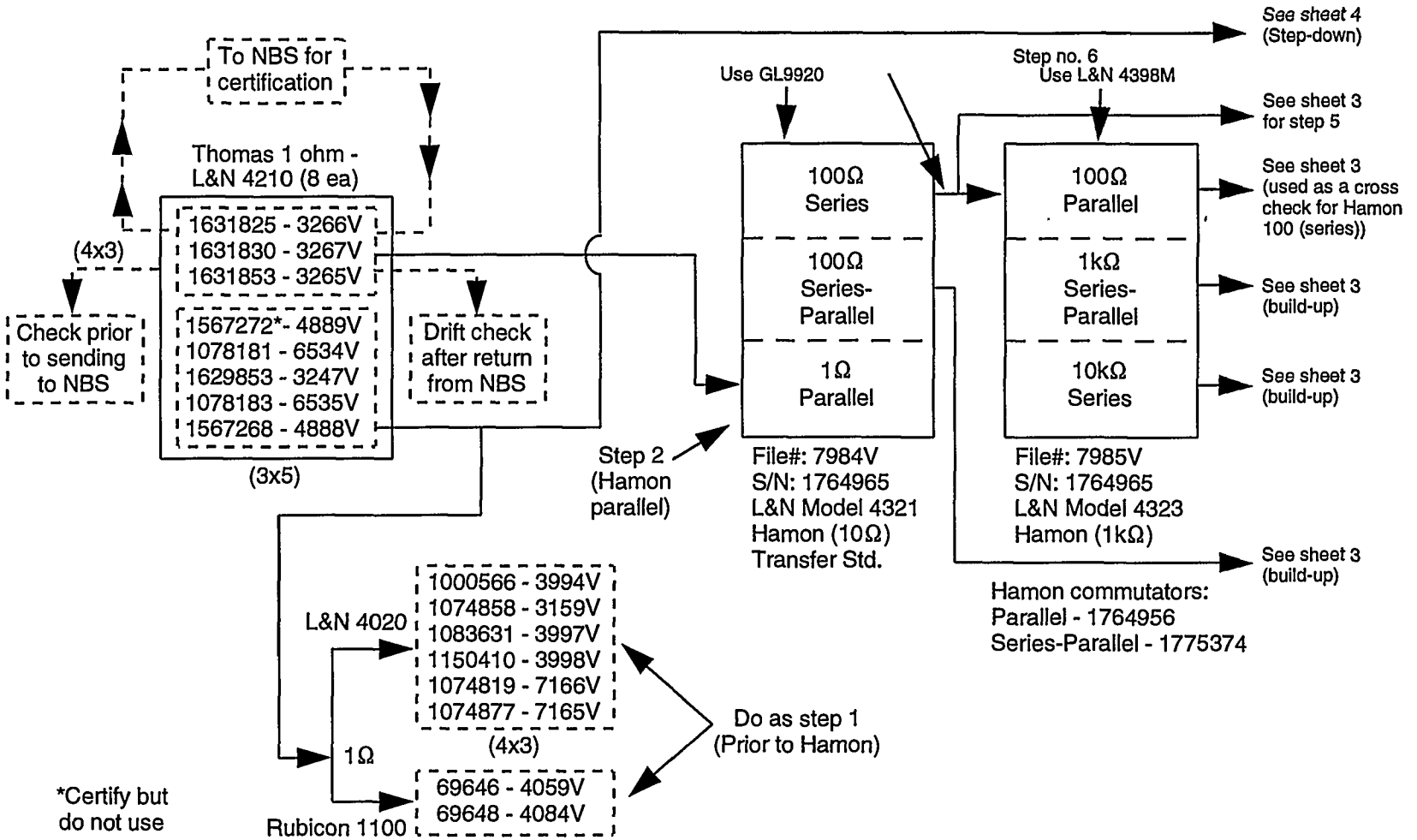

Figure 5.11 PSL standard resistor build-up/step-down.

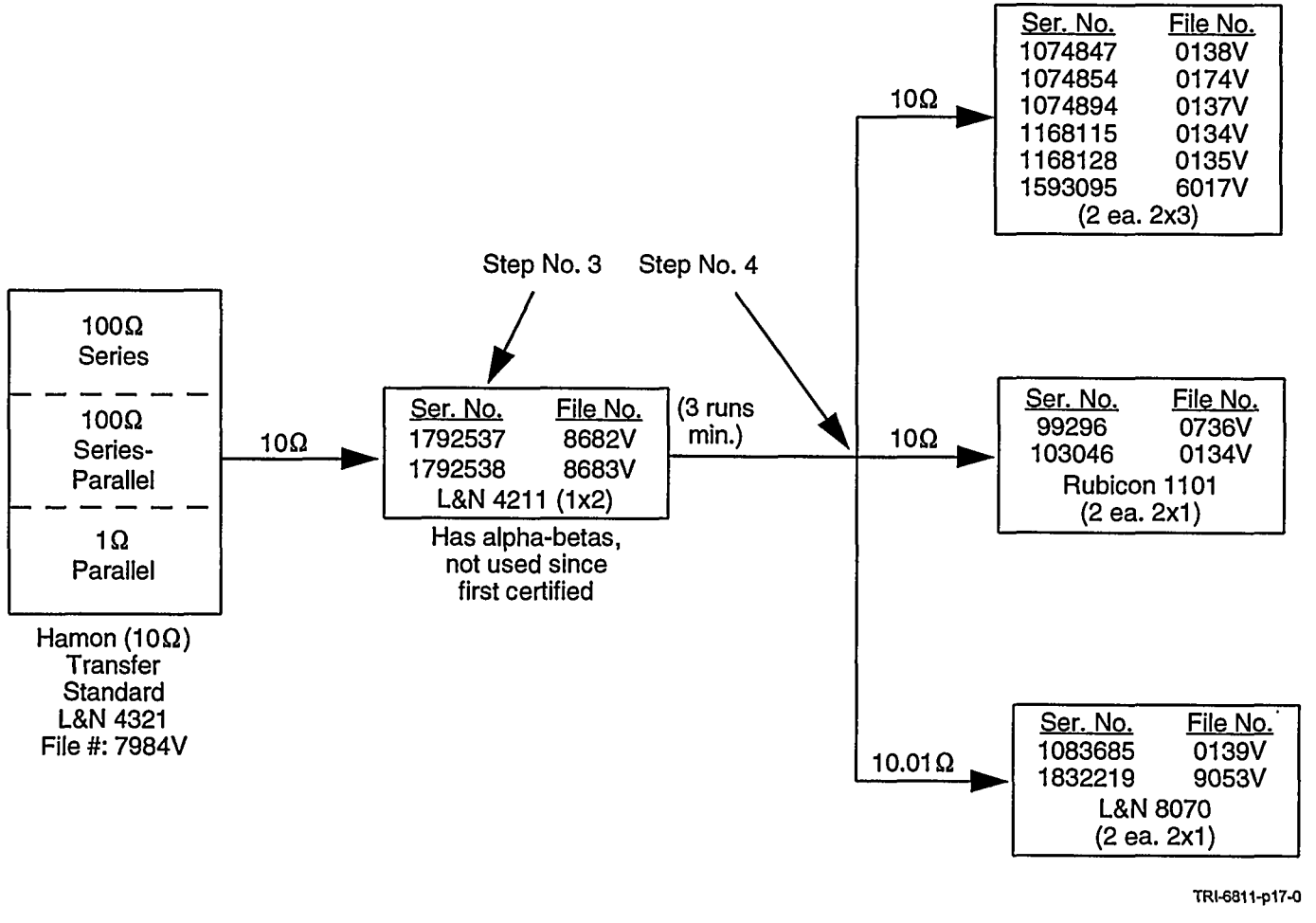
100Ω
Series
100Ω
Series-
Parallel
1Ω
Parallel
Hamon (10Ω)
Transfer
Standard
L&N 4321
File #: 7984V
10Ω
Step No. 3
Step No. 4
Ser. No. File No.
1792537 8682V
1792538 8683V
L&N 4211 (1x2)
(3 runs
min.)
Has alpha-betas,
not used since
first certified
10Ω
Ser. No. File No.
1074847 0138V
1074854 0174V
1074894 0137V
1168115 0134V
1168128 0135V
1593095 6017V
(2 ea. 2x3)
10Ω
Ser. No. File No.
99296 0736V
103046 0134V
Rubicon 1101
(2 ea. 2x1)
10.01Ω
Ser. No. File No.
1083685 0139V
1832219 9053V
L&N 8070
(2 ea. 2x1)
TRI-6811-p17-0

Figure 5.12

5.5 Weight and Balance Calibrations

Mass weights and balances have been used at the WIPP site since the early 1980s. Weights were generally used to certify or verify the performance of mass balances before use. On several occasions mass balances have been calibrated independently from the weights; these balances have primarily been used in laboratory settings. It is difficult to define a process which encompasses the NIST traceability for all mass balances and weights used by SNL. Over the years only a small portion of the weights and balances have actually been calibrated by the SSL/PSL; the others have been sent to various commercial calibration sources. The commercial calibration laboratories used by SNL WIPP include Dively Scale, Rice Lake Weighing Systems, Denver Instrument Co., Duke Scientific, New Mexico State Department of Agriculture Standards, and Troemner, Inc. The traceability of a CCL is not always clear, and establishing traceability by a review of the calibration records is not always possible. Dively Scale and the New Mexico State Department of Agriculture Standards have been audited and approved by the SSL. (Available audit reports are included in Appendix E.) In reviewing the calibration records supplied by the CCLs, Troemner Inc., Denver Instrument Co., and Duke Scientific Corp. have statements of traceability tied to an NIST report number. This helps establish creditability in their traceability, but it does not ensure that they have a quality program. Rice Lake Weighing Systems has not been audited by the SSL and their calibration reports do not include a statement of traceability to an NIST report. Their calibration traceability would need to be established via additional work or through auditing.

For the those weights and balances certified by the SSL/PSL, Figure 5.13 demonstrates the traceability to NIST. A set of five metric weights manufactured by Denver Instruments was used to define the calibration process. As displayed in the chart, the traceability process is very concise. The Troemner metric weights are the primary standard certified by NIST. These weights are used to calibrate analytical balances and other weights using a comparator. The calibration intervals for weights are generally 3-5 years. The weights documented in the chart are on a 5-year recall interval.

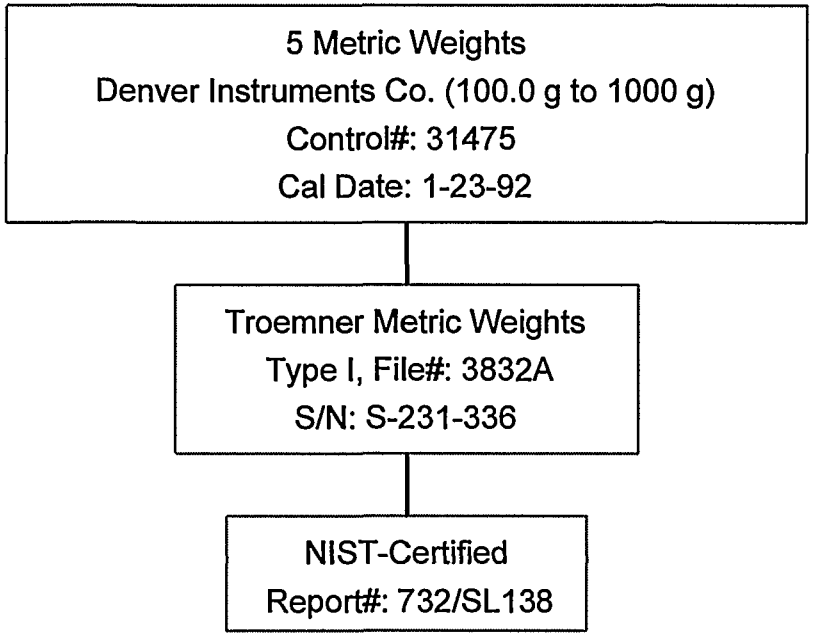

Figure 5.13 Mass/weight certification process. Mass/weights were used in several experiments to determine brine volume, standardized flow columns, or to control brine recipes. The traceability path shown is typical of the SSL/PSL, but in general not all weights used at WIPP were certified through the SSL/PSL; many were calibrated by commercial calibration laboratories and will need to be evaluated on a case-by-case basis.

5.6 Temperature Calibrations

A platinum resistive thermometer (PRT) calibrated in 1991 was used to define the temperature calibration process. A PRT works on the principle of measuring the change in platinum resistance, which changes in proportion to the temperature. The 1991 time period was based on a review of temperature calibration records which indicated that most of the temperature calibrations performed in support of SNL WIPP occurred after 1989. Also by 1993, the SNL WIPP Calibration Laboratory had developed the capability to calibrate temperature sensors [thermocouples and resistive temperature devices (RTDs)] on site. A PRT similar to the one used in defining the chart was used as the temperature standard in the calibration system at the WIPP site. The calibration system at the site was used to certify thermocouples and RTDs used in field tests. Therefore the traceability of thermocouples and RTDs would also be established by this process.

The traceability chart for temperature (Figure 5.14) is really not as complex as it appears. The primary reference standard for the SSL and the PSL is the special platinum resistive thermometer (SPRT). The difference between an SPRT and a PRT is the quality and purity of the platinum. The higher the purity of the platinum, the greater the accuracy, linearity, and sensitivity will be to temperature changes. The SPRT used by the SSL is calibrated against two other SPRTs which have been certified by NIST and maintained by the PSL. The process for calibrating the SPRTs is detailed in Figure 5.15, supplied by the PSL. The temperature calibration process relies on the intrinsic properties of the boiling point of argon and the triple point of water. The SPRT being calibrated is placed in these fixed reference temperatures with the NIST-certified SPRTs. The temperatures indicated by the SPRTs are compared. The Instrulab 4221-13 is used as a readout for the SPRT and measures the resistance of the SPRT and converts resistance into engineering units. The traceability of the Instrulab 4221-13 is identical to the calibration traceability of resistance, as defined in Section 5.4. The final item used to calibrate the PRT is a Datron 1081, which was used to measure the resistance of the PRT being calibrated by the SSL. The traceability of a Datron is described in greater detail in Section 5.2.

The NIST-certified SPRTs used by the SSL/PSL are calibrated to an accuracy of better than 0.001°C. The accuracy of the PRTs and SPRTs calibrated by the SSL for the SNL WIPP Calibration Laboratory is usually ±0.05°C to ±0.1°C. The PRTs are then used in the temperature calibration system at the site to calibrate thermocouples and RTDs with accuracies generally >± 0.5°C. In reviewing these accuracies, it can be established that at least a 4:1 accuracy ratio is maintained between a standard and the item being calibrated.

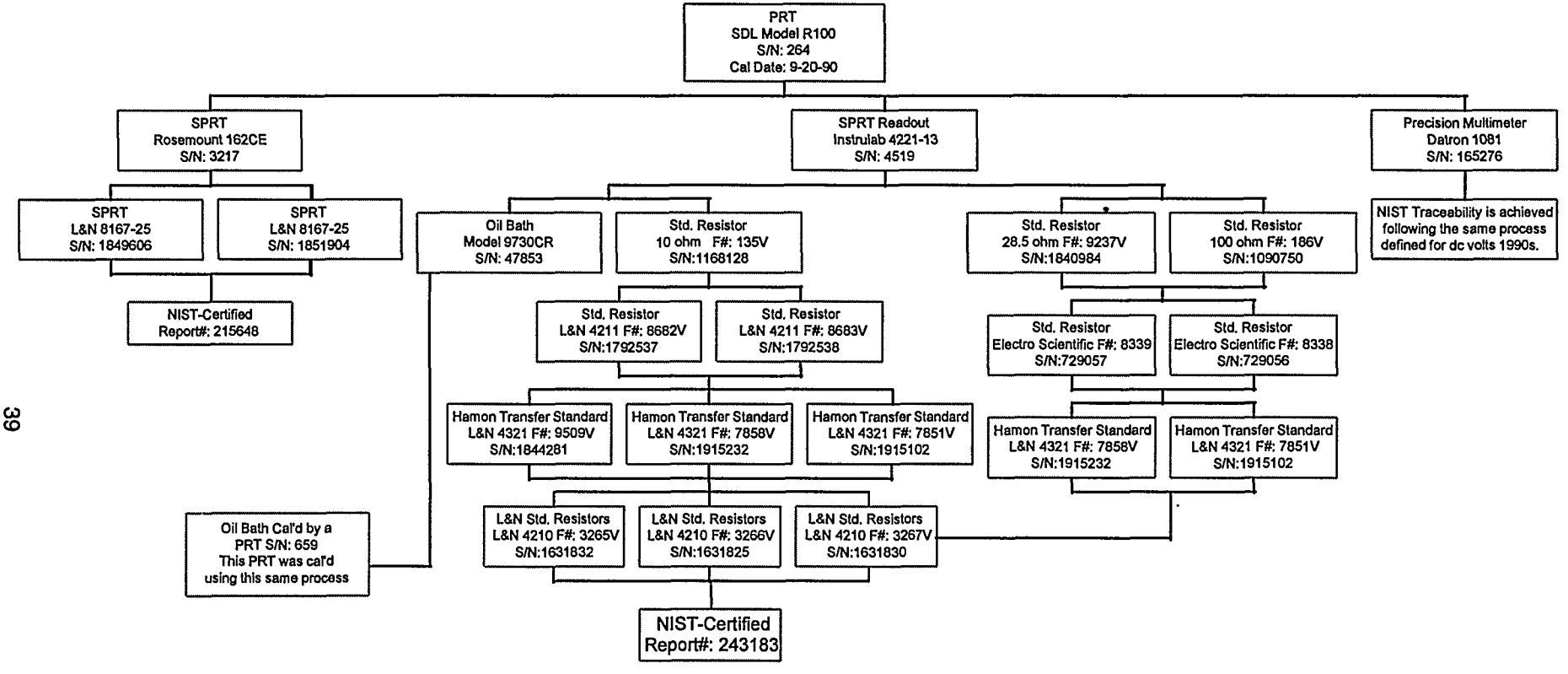

Figure 5.14 Temperature calibration process. The PRTs were used in the WIPP Site Calibration Laboratory to measure and record laboratory temperature during calibrations and as part of a temperature calibration system used to calibrate thermocouples and RTDs. This capability was established for the laboratory in 1993. All PRTs used at the site were sent to the SSL for calibration and they would have followed a similar calibration traceability process.

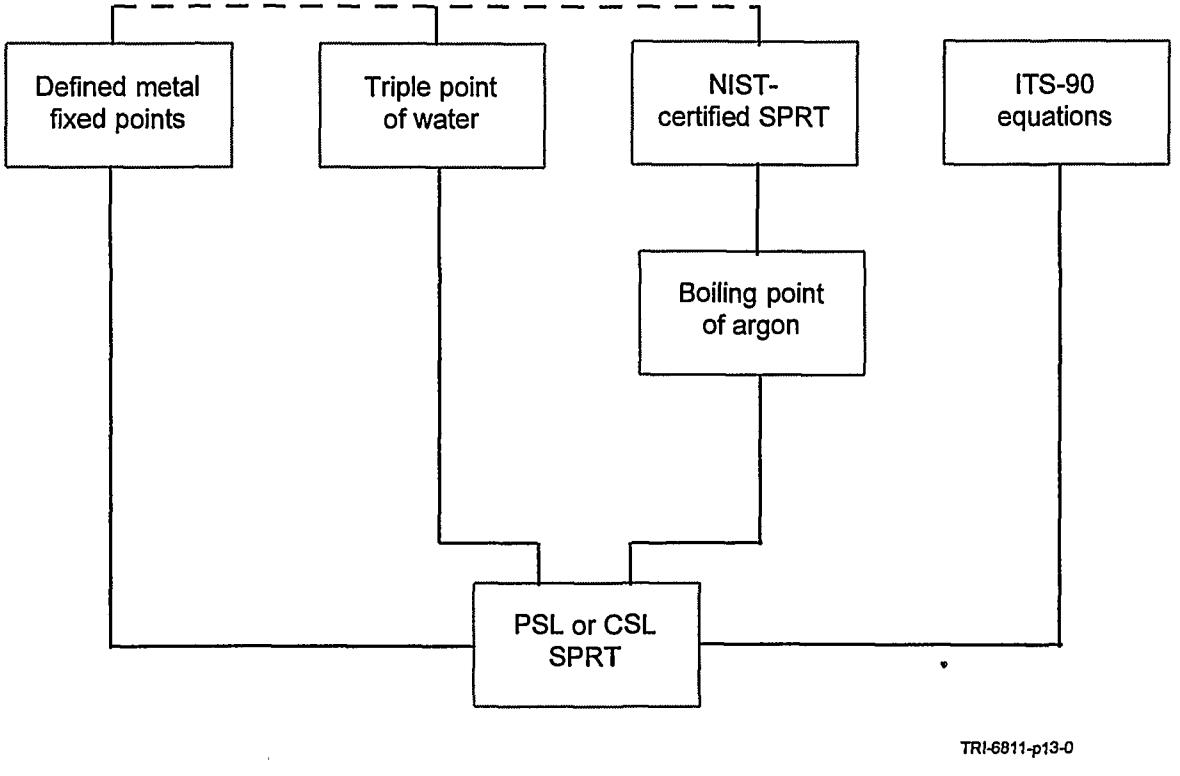

Figure 5.15 Standard platinum resistance thermometers (SPRT); -183 to 961.78° C.

5.7 Humidity Calibrations

Humidity calibrations were primarily performed in support of the Room Q experiment and the small-scale seals tests. The process for establishing traceability is shown in Figure 5.16. There are two different processes displayed. The first chart displays the traceability process using salt cells to calibrate humidity gauges. This process was used by the SNL WIPP Calibration Laboratory prior to 1992/1993. The basis for using a salt cell is that by combining chloride with other chemical components, specific humidity levels to within ±1% relative humidity (RH) can be generated. For example, fully saturated NaCl (sodium chloride) will generate 75.2% RH at 72°F. Salt cell standards are an intrinsic standard recognized by NIST. The salt cell standards used by the SNL WIPP Site Calibration Laboratory were procured from HY-CAL, Inc. Additional information on HY-CAL and the procurement of the salt cell standards is contained in the calibration notebooks in the Sandia WIPP Central Files.

The second process defined in Figure 5.16 refers to the Thunder Scientific humidity generator. This generator was initially used to calibrate humidity gauges at the WIPP Site Calibration Laboratory in 1993. The Thunder Scientific works on the principle of generating a known humidity by fully saturating a chamber with water at a specific pressure and temperature, then venting this into a chamber with a known pressure and temperature. By measuring the two pressures and the temperature, one can calculate the relative humidity. The two-pressure method of generating humidity is also recognized by NIST as a primary level humidity standard. The traceability of the Thunder Scientific generator is adequate upon reaching the pressure and temperature calibration processes. Pressure and temperature are covered in detail in Sections 5.3 and 5.5, respectively.

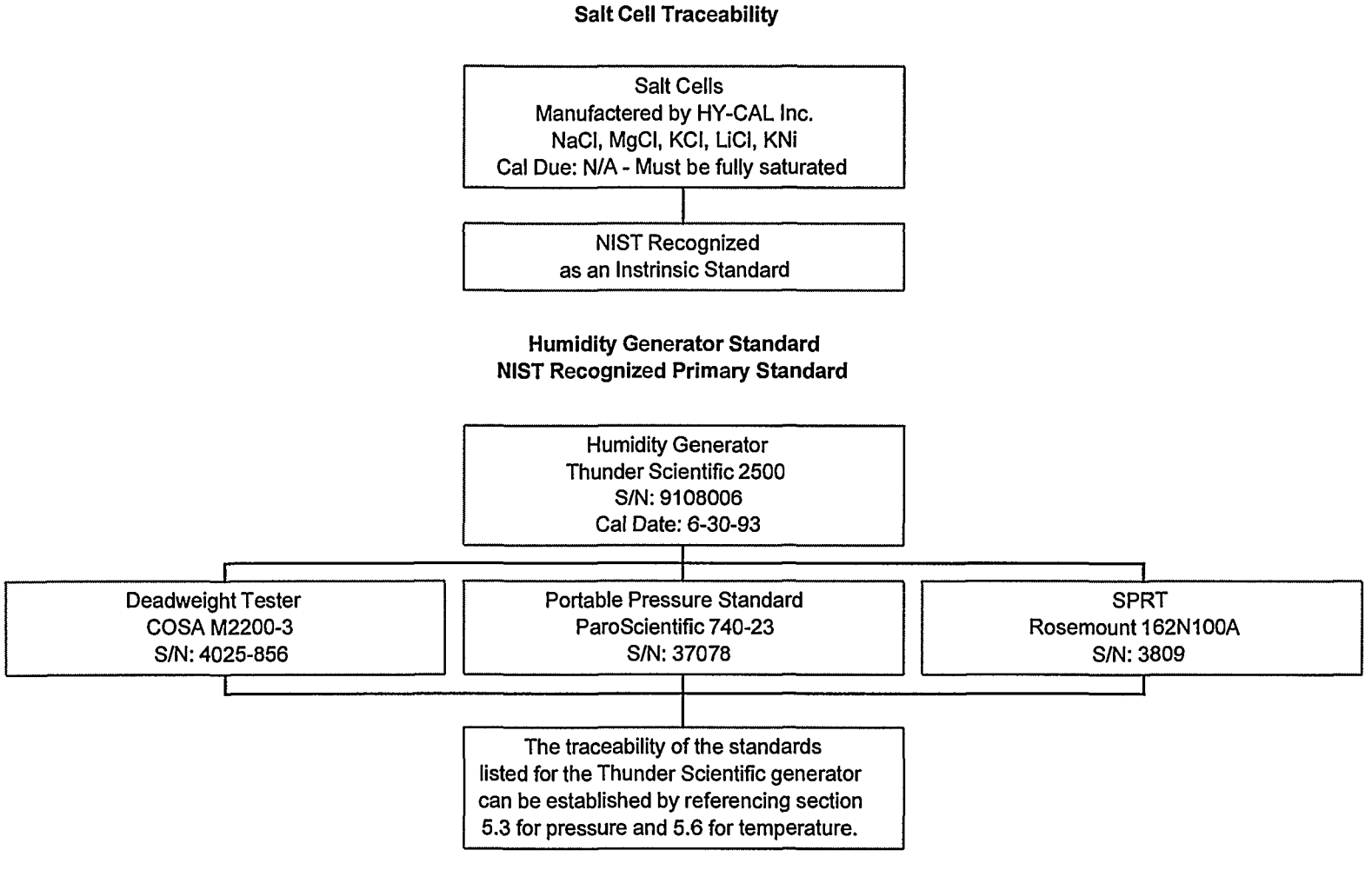

Figure 5.16 Humidity calibration process.

5.8 Load (Force) Calibrations

Load cell calibrations were performed by SNL in support of the WIPP project in two general locations. The first was in the SNL WIPP Site Calibration Laboratory, which used an Interface Model 1220-AE load cell to certify the performance of strain gauge stress meters (SGS). SGS gauges were used primarily in the TSI experiments to measuring formation pressures (load). The Interface load cell was calibrated by the SSL using a KIP MTS load press. A commercial calibration source, MTS Systems Inc., calibrated this press. Figure 5.17 details the load (force) cell calibration traceability process. A second area within the Sandia WIPP program which utilized load (force) measurement equipment is the Sandia Geo-Mechanical Laboratory, Organization 6117. A review of their calibration records indicates that most of the load cells (presses) located in this laboratory were also calibrated by MTS Systems. The load cells used in the laboratory presses were not removable, so the calibrations were usually performed on site by an MTS field technician and using MTS standards. Thus establishing the traceability of MTS would in all likelihood establish the traceability for the load cell calibrations performed by SNL.

MTS Systems, Inc. was approved by the SSL/PSL as a commercial calibration source in 1990. The audit report covering the SSL/PSL survey of MTS is included in Appendix E. The appendix also contains a flow chart that identifies MTS's traceability to NIST, which is well documented. The one concern is that since the initial audit in 1990, no additional audits have been performed. If the WIPP project were to continue to use MTS, it appears that a more recent audit would be needed.

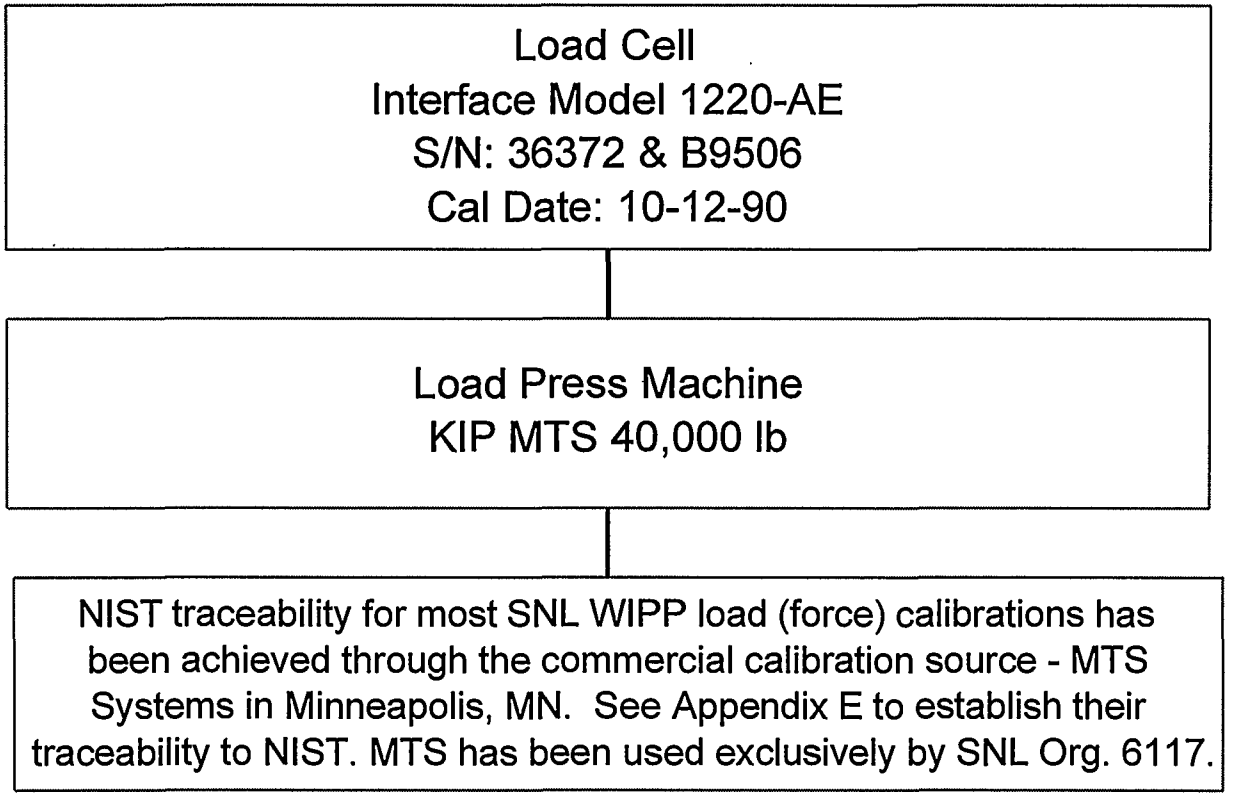

Figure 5.17 Load (force) calibration process. Load (force) calibrations were performed primarily in support of the TSI experiments at the WIPP site. Load calibrations have also been performed by SNL Org. 6117 in the Geo-Mechanical Laboratory. All SNL WIPP load (force) calibrations achieve traceability following the same process. This process eventually goes to the commercial calibration source called MTS Systems. MTS has been on the SNL Standards Laboratory-approved vendor's list since 1990.

6 STATISTICAL ANALYSIS OF TRACEABILITY

A possible approach to establishing additional confidence in calibration traceability, without reviewing every record, is to randomly sample a small number of calibration records and by applying statistics, develop a confidence level that all calibrations are traceable. To determine the feasibility of this approach, Bryan Rutherford of Sandia Div. 12325 developed an analysis and probability table. The table is based on using small sample sizes to establish a confidence level that WIPP calibrations would be a certain percent traceable. The memo and table are attached in Appendix G. The basic assumptions used in the analysis were that (1) there are eight measurement types with an infinite number of calibrations; (2) a sample size of five or ten calibrations per measurement type is desired; and (3) at a minimum, traceability success needs to be established at either 70%, 80%, or 90%.

The results for this statistical analysis indicate a 93% probability that performing ten additional traceabilities for a measurement type would establish only 70% traceability with a 50% confidence level. There is a 73% probability that these ten samples would establish an 80% traceability success rate with a 50% confidence level. Even given the high probability of success, we can establish only limited confidence in the NIST traceability of a measurement type. The limitation of this approach is in treating the traceability of one measurement type as a sample population of one. In actuality, in tracing one measurement type to NIST as many as 75 independent instrumentation calibration records could be reviewed.

By changing the statistical approach to the problem, confidence in the traceability of the SSL/PSL can be established without additional sampling. This confidence is developed by defining and demonstrating that a process and procedure showing NIST traceability was in place for the eight measurement types. Then all individual instrument calibration records reviewed became sample checks of this defined process/procedure. By applying this approach, 145 calibration records which demonstrated that a process/procedure was being followed were sampled during the development of this report. If these are combined with the efforts of the DOE EM-342 assessment, which looked at 190 individual instrument calibration records, 335 calibration records were reviewed in verifying calibration traceability. It is important to point out that this sample size is very conservative. In both the development of this report and the DOE EM-342 assessment, multiple calibration records covering the different calibration intervals for a piece of M&TE were reviewed. But in the sample size of 335 calibration records, a review of a specific M&TE's calibration records only counted as a sample size of one, regardless of how many records were actually reviewed. In addition, if any record could not be located, the sample was treated as unsuccessful, even if other calibration records covering different time periods were located for that M&TE. Within the sample population, only one record could not be located. With a sample size of 334 out of 335 calibration records successfully located, a statistical analysis indicates a 98.4% probability, with a 95% confidence level, that Sandia calibrations are traceable.*

* The statistical calculation was made using the equations in A.H. Bowker and G.J. Leiberman, *Engineering Statistics,* Prentice-Hall, Englewood Cliffs, NJ, 1972, p. 467.

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7 CONCLUSIONS

In performing this detailed assessment of calibration traceability, several conclusions were developed from the objective evidence reviewed. The Sandia WIPP testing program utilized eight basic measurement types composed of length, dc voltage, pressure, resistance, humidity, force, mass/weights, and temperature. The SSL/PSL has sufficient quality documentation in place to allow calibration traceability to be reconstructed for the eight measurement types. External assessments of the SSL/PSL have never raised concerns with the SSL/PSL calibration traceability. The SSL/PSL calibration program, based on DOE directive AL57XA, meets the requirements of NQA-101989 Basic Requirement 12 and Supplementary Requirement 12S-1. The fact that they meet these requirements is substantiated by their use of procedures to govern their work activities, thorough documentation of their calibration results, the method by which the documentation has been maintained, the existence of a recall system, a process for performing internal assessments, and their involvement in an interlaboratory comparison program with other primary standard laboratories and NIST.

To further bolster confidence in the traceability, twelve random instrument calibrations representing one of the eight measurement types were successfully traced from the WIPP site to NIST. These random samples helped define the process by which the eight measurement types reached NIST and demonstrated that the SSL/PSL had the appropriate quality assurance measures in place to ensure that traceability could be verified. In tracing twelve calibrations from the WIPP site to NIST, 145 calibration records were reviewed. When this number is combined with the results of the DOE EM-342 assessment, 334 out of 335 calibration records were located for the eight measurement types. Statistical analysis of a sample size of 334 out of 335 establishes a 98.4% probability, with a 95% confidence level that 99.7% of Sandia calibrations are traceable.

Given the overall evidence contained in this report, which defines the process by which measurement types are traceable to NIST, and the statistical confidence that 334 out of 335 successful samples provides, Sandia is confident of their calibration traceability. The processes and procedures used by the Sandia WIPP Site Calibration Laboratory, the Sandia Secondary Standards Laboratory, and the Sandia Primary Standards Laboratory in calibrating instruments from the eight measurement types is traceable to NIST.

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APPENDIX A: DOCUMENTS IN WIPP CENTRAL FILES

The following documents can be obtained from the WIPP control files:

1. DOE Order 57XA Rev1 and Rev. 2
2. Sandia Engineering Procedure EP401560
3. Operating Instructions OI28855-1144-1
4. Operating Instructions OI2855-1144-2
5. ANSI/NCLS Z540-1-1994 Standard
6. 94 EM 342-AS-01 DOE Assessment Report
7. All calibration records gathered during development of this report

APPENDIX B: EXTERNAL AUDITS OF THE SANDIA PRIMARY STANDARDS LABORATORY

Contents

SANDIA NATIONAL LABORATORIES, ALBUQUERQUE
YUCCA MOUNTAIN PROJECT DEPARTMENT 6302

QUALITY ASSURANCE SUPPLIER EVALUATION REPORT

of the

PRIMARY STANDARDS LABORATORY
SANDIA NATIONAL LABORATORIES
ALBUQUERQUE, NEW MEXICO

SUPPLIER EVALUATION REPORT No. PSL-SE93-01
Conducted March 22 through 25, 1993

James V Wright 4/20/93
Lead Evaluator Date

20 Apr '93
SNL YMP QA Department Manager Date

EXECUTIVE SUMMARY

The purpose of evaluating the Primary Standards Laboratories (PSL) at Sandia National Laboratories was to determine PSL's readiness to provide metrology services as a 'qualified supplier' for the Department of Energy Office of Civilian Radioactive Waste Management (OCRWM). As a qualified supplier the PSL would be responsible for providing a program to develop and maintain primary standards traceable to national standards and to calibrate and certify reference standards for other DOE facilities and programs.

The result of this evaluation indicates that the PSL is capable of becoming a "qualified supplier" to support the OCRWM programs. However, the items defined below as 'Opportunities for Improvement,' that do not meet OCRWM QA requirements, will need to be satisfactorily resolved prior to the PSL being designated a YMP qualified supplier. Appendix A of the evaluation report provides guidance on how to respond to the Opportunities for Improvement.

Summary of Opportunities For Improvement

1. Out-of-calibration (expired) measuring and test equipment (M&TE) in the work area were not being controlled as required. Expired M&TE should be tagged, segregated, or otherwise controlled to prevent use until they have been calibrated.

2. There is no system in place to provide for the prompt identification, control, and correction of items or activities that do not meet established procedures or requirements.

3. Superseded procedures are generally maintained as historical information with the current procedure, creating the possibility that obsolete versions may be used.

The 'Opportunities for Improvement' identified above do not detract from the technical excellence of the work performed by the Primary Standards Laboratory. In fact, several areas were identified that were exceptional in their performance. The quality awareness and positive attitude of the PSL management and staff are commendable, especially the extent of staff empowerment concerning facility, equipment, and process "ownership." The process for development of new calibration procedures is thorough, producing well thought out, usable procedures. Other noteworthy areas include an excellent computerized M&TE recall system; the use of metrics to manage PSL activity improvements; attention to good housekeeping, neatness, and in general good physical organization of workspaces; and an excellent process for handling and shipping M&TE.

The SNL PSL personnel contacted during this evaluation included:

NAME	ORGANIZATION
Ralph Johnson,	4307
Larry Azevedo,	4341
Bruce Barnaby,	4343
James Kwak,	4341
Robert Romero,	4341
Frank Burns,	4343
Julie Gregory,	4343
Sandra Anderson,	4341
David Braudaway,	4343
Philip Thacher,	4341
Turk Levy,	4343
Paul Spellman	4341

4. PERFORMANCE OF THE SUPPLIER EVALUATION

The evaluation opening meeting was held on the morning of March 22, 1993, with PSL personnel to (1) introduce the team, (2) review the evaluation plan, scope, and duration, and (3) establish necessary contacts to support various portions of the evaluation. The exit meeting was held on March 25, 1993, and results of the qualification evaluation were summarized at that time.

The SNL YMP evaluation team examined various laboratory work activities and documentation representative of compliance with appropriate elements of the OCRWM QARD. Compliance in the QA elements listed below was examined:

Organization
QA Program (Including training and qualification)
Implementing documents
Document Control
Nonconformances
Corrective Action and
Control of Measuring and Test Equipment

Other elements of the QA Requirements and Description were not examined because they were either not applicable to PSL activities in general or were not applicable to the role of the PSL as a provider of calibration services.

5.0 SUMMARY OF RESULTS AND EFFECTIVENESS OF PROGRAM ELEMENTS

The evaluation results indicate that the PSL calibration activities comply with the applicable quality assurance requirements of the YMP QARD, with several exceptions. The opportunities for improvement cited below do not detract from the technical adequacy or quality of the PSL work activities. On the basis of the interviews with PSL staff and management, examination of laboratory operations, and the review of work activity procedures and supporting documentation, the PSL Quality Program is determined to be effective as implemented. If the PSL chooses to develop and implement corrective actions in these areas, the PSL may be designated as an OCRWM qualified supplier:

Special note is made concerning the PSL personnel, who were knowledgeable of the PSL QA Program, supportive of this evaluation and its results, committed to the quality improvement process, and very capable in the delivery of quality products.

6.0 DETAILED EXPLANATION OF OPPORTUNITIES FOR IMPROVEMENT

1) OCRWM Requirement: QARD - DOE/RW/0333P, paragraph 12.2.3.B, states in part "Out-of-calibration measuring and test equipment shall be controlled. The controls shall include the following requirements:
   1. Out-of-calibration measuring and test equipment shall be tagged, segregated, or otherwise controlled to prevent use until they have been recalibrated."

   It was observed in several PSL labs that expired calibration M&TE were not segregated when possible from the work area.

2) OCRWM Requirement: QARD - DOE/RW/0333P, paragraph 16.2.3.A, states: "Conditions adverse to quality shall be documented and reported to the appropriate levels of management responsible for the conditions and to the quality assurance organization for tracking," and paragraph 16.2.5, states: "The QA organization shall verify implementation of corrective actions taken for all reported conditions adverse to quality and close the related corrective action documentation in a timely manner when actions are complete."

   It was observed that although the process has been implemented, there is no formal method proceduralized to describe how deviations to requirements are documented, reported to management, and verified.

3) OCRWM Requirement: QARD - DOE/RW/0333P, paragraph 6.2.5.C. states: "The disposition of obsolete or superseded documents shall be controlled."

   Superseded documents are sometimes maintained along with the current ones, providing the potential for using an obsolete procedure.

Appendix A defines the guidelines to be followed in responding to the above opportunities for improvement.

APPENDIX A

GUIDELINES FOR RESPONDING TO THE IMPROVEMENT OPPORTUNITIES

Remedial Corrective Action: Identify the actions taken to correct the specific problems identified. Be specific, record the items that were corrected and how they were corrected. Investigate similar areas or items that might have similar problems. Document this activity, identify items reviewed and the items corrected.

Actions to Prevent Recurrence: Identify what actions will be taken to prevent future occurrences. For any planned training sessions, identify the specific topics to be addressed and attendees.

Responsible for Corrective Action: For each identified action, document the individual or organization responsible for completing the action.

Completion Dates: Specify the last date for completion of the corrective actions or, alternatively, specify the dates above for completion of each action.

Sandia National Laboratories

Albuquerque, New Mexico 87185

date: June 11, 1993

to: Robert R. Richards, 6319

from: Ralph T. Johnson, 4307

subject: Response to SUPPLIER EVALUATION REPORT No, PSL-SE93-01, April 20, 1993

Appended below is the response of the Primary Standards Laboratory (PSL) of Sandia National Laboratories to the SUPPLIER EVALUATION REPORT No. PSL-SE93-01 on the Yucca Mountain Project Department 6302 survey of the PSL conducted March 22 through 25, 1993.

The response to the "Opportunities for Improvement" listed in the referenced report has been prepared in accordance with the guidelines for responding given in Appendix 3 of that report.

We are pleased that you found the PSL quality program effectively implemented and that we have a good calibration program.

RTJ:4307:amf

Distribution:
4307 J. A. Purcell
4341 L. J. Azevedo
4342 R. B. Pettit
4343 B. E. Barnaby
4343 D. W. Braudaway
4343 R. L. Crabb
4344 J. M. Simons
4307 R. T. Johnson

DATE AUTHENTICATED 6/21/93
AUTHENTICATED
☑ SUBJECT ACCEPTABLE AS IS
☐ OTHER TITLE-SUBJECT (PLACE ON RECORD)
☑ COPY TO YMP CRF
FILE CODE 94/1.2.11/VER/1.2/PSL-SE-93.01/QA
TOTAL NO. OF PAGES 4

RESPONSE TO YUCCA MOUNTAIN SURVEY; **OPPORTUNITY 1**

Survey Citation:

OCRWM Requirement: QARD-DOE/RW/0333P, paragraph 12.2.3.B, states in part "Out-of-Calibration measuring and test equipment shall be controlled. The controls shall include the following requirements:

1. Out-of-Calibration measuring and test equipment shall be tagged, segregated, or otherwise controlled to prevent use until they have been recalibrated."

It was observed in several PSL labs that expired M&TE were not segregated when possible from the work area.

Remedial Corrective Action:

The PSL will develop and implement a requirement to segregate out-of-calibration instruments wherever possible. This requirement will become part of the O&P Manual, Volume 5.1, "Calibration Guidelines." In addition all instruments will continue to be tagged or labeled to indicate in-calibration, calibration-not-controlled, out-of-service, or work-in-shop (out-of-calibration).

Actions to Prevent Recurrence:

Areas are being identified in each laboratory for segregation of instruments in two categories: work-in-shop (out-of-calibration) and in-calibration. In the specific laboratory addressed in the finding, cable adapters have been made available to eliminate the need to use an out-of-service instrument as the adapter.

Responsibility for Corrective Action:

Rick Crabb is responsible for the corrective actions.

Completion Dates:

The corrective actions are to be completed by September 30, 1993.

RESPONSE TO YUCCA MOUNTAIN SURVEY; OPPORTUNITY 2

Survey Citation:

OCRWM Requirement: QARD-DOE/RW/0333P, paragraph 16.2.3.A, states: "Conditions adverse to quality shall be documented and reported to the appropriate levels of management responsible for the conditions and to the quality assurance organization for tracking." and paragraph 16.2.5, states: "The QA organization shall verify implementation of corrective actions taken for all reported conditions adverse to quality and close the related corrective action documentation in a timely manner when actions are complete."

It was observed that although the process has been implemented there is no formal method proceduralized to describe how deviations to requirements are documented, reported to management, and verified.

Remedial Corrective Action:

The assessment team suggested that the Quality Council process be documented. We are writing a new section to the Business Plan (O&P Manual, Volume 1) where we will document how the Quality Council fullfills this requirement. This will include the process to follow for dealing with conditions adverse to quality, including documentation and close out. The Quality Council serves as the vehicle to identify, control, correct and improve processes across the PSL and is the "QA Organization" referred to in the OCRWM Requirement.

The second suggestion was to develop and document a method for identifying, promptly reporting, and correcting nonconforming conditions encountered during PSL work activities. This addresses those situations where a quicker response than the monthly Quality Council meeting cycle is needed. We are writing a section for the Business Plan (O&P Manual, Volume 1) that will provide guidance for prompt correction of nonconforming conditions.

Actions to Prevent Recurrence:

One of the PSL requirements is that all staff be trained to be familiar with the O&P Manuals. This includes required reading of the Business Plan. The normal training procedure will prevent recurrences of the observation. PSL management are responsible to insure that the training is performed.

Responsibility for Corrective Action:

Larry Azevedo is responsible the corrective actions.

Completion Dates:

The corrective actions are to be completed by September 30, 1993.

RESPONSE TO YUCCA MOUNTAIN SURVEY; **OPPORTUNITY 3**

Survey Citation:

OCRWM Requirement: QARD-DOE/RW/0333P, paragraph 6.2.5.C. states "The disposition of obsolete or superseded documents shall be controlled."

Superseded documents are sometimes maintained along with the current ones, providing potential for using an obsolete procedure.

Remedial Corrective Action:

Stamps bearing the word "SUPERSEDED" will be purchased and distributed to all O&P Manual holders. Stamping "SUPERSEDED" on procedures which are not current enhances distinction between the two and clearly indicates the difference. An Instruction will be written for inclusion in Volume 5.1 of the O&P Manual under "Calibration Guidelines" that will require all superseded procedures to be stamped "SUPERSEDED."

Actions to Prevent Recurrence: Review implementation on a periodic basis.

Responsibility for Corrective Action: Larry Azevedo is responsible for obtaining "SUPERSEDED" stamps and preparing the instruction for marking.

Completion Dates:

The corrective action is to be completed by September 30, 1993.

Sandia National Laboratories

Albuquerque, New Mexico 87185

date: June 25, 1993

to: Ralph T. Johnson, 4307

WBS: 1.2.11
QA

FOR RRR

from: Robert R. Richards, 6319

subject: Acceptance of Response to "Opportunities for Improvement"
Supplier Evaluation Report No. PSL-SE93-01, April 20, 1993
Yucca Mountain Site Characterization Project

The June 11, 1993 PSL response to the "Opportunities for Improvement" of the subject "Supplier Evaluation" has been reviewed and evaluated. The responses should adequately address the situations that were documented in our report. The action completion dates will be tracked and the corrective actions identified in your response will be verified at that time.

Your willingness to work with the Yucca Mountain Site Characterization Project and the requirements related to that project should provide a strong basis for contracting metrology services from the Sandia Standards Laboratory.

RRR:JVV:6319:mjh

Copy to:
6319 R. R. Richards
6319 J. V. Voigt
6352 94/1.2.11/VER/1.2/PSL-SE-93-01/QA
6352 YMP CRF

Sandia National Laboratories

Albuquerque, New Mexico 87185

date: April 22, 1993

to: Ralph T. Johnson, 4307

WBS: 1.2.11
QA

from: Robert R. Richards, 6319

subject: Report on the Supplier Qualification Evaluation of the Primary Standards Laboratory

The Yucca Mountain Site Characterization Project has concluded the first evaluation phase of Sandia National Laboratories' calibration facilities. The Supplier Qualification evaluation report is attached and is submitted for your action. Three items for improvement were identified by the evaluation team and are documented in the report. These items will need to be satisfactorily resolved prior to the PSL being assigned as qualified supplier within the Office of Civilian Radioactive Waste Management Program.

The overall assessment is that the PSL quality program appears to be effectively implemented and that the calibration program provides a traceable, repeatable, and defensible metrology service.

The YMP evaluation team would like to express their appreciation for the cooperation, responsiveness, and the courtesies extended to us by the SNL PSL personnel. I want to particularly compliment you on your project's effective use of the SNL "Integration Project" process to manage your quality program.

In preparing for phase two of the calibration capability evaluation, which will examine the Sandia Standards Labs, I would like to work with you to coordinate with the following individuals for access to their laboratories:

Warren Windle, 2414,
Clint Atwood, 2484-1,
Georgia Brown, 2414,
Harry Pike, 2414, and
Louanne Saylors, 2414.

JVV:6319:mjh
Attachment

Copy to: (w/attach.)
R. Spence, Director YMQAD
J. Blaylock, YMQAD
F. Ruth, EG&G Energy Measurements
6300 D. E. Ellis
6302 L. E. Shephard
6319 R. R. Richards
6319 J. V. Voigt
6352 94/1.2.11.3.2/VER/1.2/PSL-SE93-01/QA
6352 YMP CRF

Sandia National Laboratories

Albuquerque, New Mexico 87185

date: December 22, 1993

to: R. T. Johnson, 1040

WBS: 1.2.11.3.2
QA

from: R. R. Richards, 6319

subject: Supplier Qualification Evaluation for the
Primary Standards Laboratory, Sandia National Laboratories
Yucca Mountain Site Characterization Project — Department 6302

The Sandia National Laboratories Yucca Mountain Project Quality Assurance Department has completed the qualification evaluation of the Primary Standards Laboratory. This activity was begun in March of this year with the performance of a supplier qualification evaluation.

The overall assessment of PSL's quality assurance program for the calibration services was favorable. The QA program appeared to be effectively implemented and the calibration organization provided a traceable, repeatable, and defensible metrology service. Three areas for improvement were identified wherein actions were necessary to address weaknesses to the QA program. These areas have been adequately addressed, the actions performed verified, and the qualification evaluation is closed. SNL/YMP QA considers the SNL Primary Standards Laboratory to have a program consistent with the requirements of the Yucca Mountain Project requirements document, *Quality Assurance Requirements and Description.*

The SNL/PSL is considered qualified to provide calibration services for the SNL YMP measuring and test equipment and is recommended for placement on the YMP Qualified Suppliers List to provide calibration services for all YMP participants.

RRR:6319:jvv

Distribution:

YMPQAD D. J. Harris
6302 L. E. Shephard
6312 H. Dockery
6313 L. S. Costin
6319 R. R. Richards
6319 J. V. Voigt
6115 P. B. Davies
6300 D. E. Ellis
6116 M. C. Walck
6117 W. R. Wawersik
6351 R. E. Thompson
6352 S. E. Sharpton

File 94/1.2.11/VER/1.2/PSL-SE-93-01/QA
YMP CRF

NIST
UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899-0001

REPORT OF TEST

RESISTANCE MEASUREMENT ASSURANCE PROGRAM
AT THE 10 kΩ LEVEL

Sandia National Laboratories
Albuquerque, NM 87185

The difference between the unit of resistance at the 10 kΩ level maintained by the above laboratory (LAB) and the U.S. legal ohm, as maintained by the National Institute of Standards and Technology (NIST) in terms of the quantum Hall effect, was determined during the period between July 19, 1993 and August 15, 1993, and found to be:

$$OHM_{LAB} - OHM = (+0.126 \pm 0.111) \text{ ppm} .$$

The above value is based upon the test procedure described in Appendix A and the data summarized in Appendix B of this report. The expanded uncertainty of this difference given above is equal to

$$2\left\{s_{LAB}^2 + s_{NIST}^2 + t'^2 s_{transfer}^2 + \sum_{i=1}^{Z} u_B(i)\right\}^{1/2},$$

where s_{LAB} and s_{NIST} are the estimated Type A standard uncertainties based on the standard deviation of the measurements at the customer laboratory and NIST, respectively, $t's_{transfer}$ is the estimate of the variability of the transfer standards, and $u_B(i)$ is the estimated Type B standard uncertainty for each known component of uncertainty arising from a systematic effect (see Appendix A). The coverage factor 2 used by NIST is consistent with international practice.

If the measured difference between the unit of resistance as disseminated by the above laboratory and the U.S. legal ohm is greater in magnitude than the combined standard uncertainty (0.055 ppm), it is recommended that the assigned mean value of the laboratory's reference resistors be adjusted so that $OHM_{LAB} - OHM = 0$.

For the Director,

Norman B. Belecki, Group Leader
Electricity Division

Test No. 811-16-93
Date: November 2, 1993

NIST
UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899-0001

REPORT OF TEST

RESISTANCE MEASUREMENT ASSURANCE PROGRAM
AT THE 1 Ω LEVEL

Sandia National Laboratories
Albuquerque, NM 87185

The difference between the unit of resistance at the 1 Ω level maintained by the above laboratory (LAB) and the U.S. legal ohm, as maintained by the National Institute of Standards and Technology (NIST) in terms of the quantum Hall effect, was determined during the period between July 19, 1993 and August 29, 1993, and found to be:

$$OHM_{LAB} - OHM = (-0.014 \pm 0.108) \text{ ppm} .$$

The above value is based upon the test procedure described in Appendix A and the data summarized in Appendix B of this report. The expanded uncertainty of this difference given above is equal to

$$2\left\{s_{LAB}^2 + s_{NIST}^2 + t'^2 s_{transfer}^2 + \sum u_B^2(i)\right\}^{1/2},$$

where s_{LAB} and s_{NIST} are the estimated Type A standard uncertainties based on the standard deviation of the measurements at the customer laboratory and NIST, respectively, $t's_{transfer}$ is the estimate of the variability of the transfer standards, and $u_B(i)$ is the estimated Type B standard uncertainty for each known component of uncertainty arising from a systematic effect (see Appendix A). The coverage factor 2 used by NIST is consistent with international practice.

If the measured difference between the unit of resistance as disseminated by the above laboratory and the U.S. legal ohm is greater in magnitude than the combined standard uncertainty (0.054 ppm), it is recommended that the assigned mean value of the laboratory's reference resistors be adjusted so that $OHM_{LAB} - OHM_{NIST} = 0$.

For the Director,

Norman B. Belecki, Group Leader
Electricity Division

Test No. 811-16-93
Date: November 2, 1993

A U.S. INTERCOMPARISON OF JOSEPHSON ARRAY VOLTAGE STANDARDS

Kathleen M. Rodriguez
Eastman Kodak Company
1669 Lake Avenue
Rochester, New York 14652-4327

Les Huntley
Fluke Corporation
P.O. Box 9090
Everett, Washington 98206-9090

ABSTRACT

Qualification of intrinsic standards is a problem for laboratory accreditation systems. Accredited laboratories must demonstrate that their intrinsic standards actually provide the accuracy claimed. Ten standards laboratories have participated in an intercomparison of their Ten Volt Josephson Array Standards from June through October of 1993. The intercomparison program is described and results are presented.

INTRODUCTION

Many standards laboratories are now using intrinsic measurement standards which in principle do not require calibration to assure their agreement with national and international standards. Two such standards recently described by the National Conference of Standards Laboratories (NCSL) include the water triple point cell and the Josephson Array Voltage Standard [1,2]. Laboratory accreditation systems must ascertain that these intrinsic standards are maintained and operated in a way that realizes their standardized quantities. To provide confidence in these standards some form of interlaboratory comparison is needed. A recently reported international comparison of laboratory Josephson standards utilized a portable Josephson device operating at the one volt level [3]. Eight National Standards Laboratories participated in that intercomparison over a seventeen month interval with reported uncertainties in the differences between two arrays ranging from 0.2 to 0.8 nV, or 0.2 to 0.8 parts per billion (ppb).

An early draft of the National Institute of Standards and Technology's NVLAP Handbook for Calibration - DC Voltage stated:

> *For circumstances where measurement uncertainties smaller than ±0.2 ppm (3σ) are required, an evaluation transfer employing a portable Josephson Array system to compare the system's measurements with those of the system used at NIST for the U.S. representation of the (volt) shall be made.*

The most demanding calibrations of existing standards and test equipment require uncertainties on the order of 0.1 ppm, approximately three orders of magnitude larger than the uncertainties obtainable with portable array systems. Accreditation of intrinsic standards can be accomplished

with much lower expenditure of time and money if their assessment can be accomplished utilizing readily available commercial equipment rather than portable array systems.

There is a related issue. Industrial laboratories have been providing NIST-traceable calibrations of ten volt solid state reference standards with uncertainties of about 0.35 ppm (99% confidence; at calibration) [4] based on a NIST uncertainty of about 0.29 ppm. The resulting test uncertainty ratio (TUR) of approximately 1.2 is viewed with skepticism in some quarters. An experiment is needed to authenticate the uncertainty analysis for these calibrations. A successful experiment to determine any differences among ten volt arrays will automatically provide the needed confidence in the uncertainty analysis, since all the arrays are assumed to provide ten volts essentially without error. NCSL sponsored such an intercomparison program using four Solid State Reference Standards (SSRS) as transfer standards. Those laboratories that participated are listed in Table 1.

This paper describes the ten volt laboratory intercomparison program. Its emphasis is upon data reduction, uncertainty analysis, and implications for laboratory accreditation programs and remote calibration schemes using SSRS as transfer standards.

THE EXPERIMENT

In the Spring of 1993, the Measurement Assurance Programs Committee of NCSL agreed to sponsor an interlaboratory comparison of Ten Volt Josephson Array Systems operating in the United States. Ten laboratories participated, with the Fluke Corporation Standards Laboratory operating as the pivot laboratory. Four well characterized Fluke 732B DC Reference Standards, denoted D2102, D2103, D2104, and D2105, were supplied by the pivot laboratory to serve as transfer standards. These standards were monitored in the pivot laboratory for several months prior to starting the experiment to establish their drift and noise characteristics. They were also tested for sensitivity to atmospheric pressure (altitude), temperature, and humidity and found to be essentially insensitive to these influences.

It has long been recognized that long term noise in the outputs of SRSS limits the attainable transfer accuracy. This noise (~0.02 ppm 1σ, within periods of a few weeks to many months) is not subject to reduction by multiple measurements over periods of a few days [5]. To minimize the effects of long term noise, the experiment was operated in a "daisy" pattern, with the transfer standards returning to the pivot laboratory for further measurements after visiting each participating laboratory. To minimize the chance of loosing battery power in transit, the standard was shipped by overnight air freight.

Each laboratory received the transfer standard on Tuesday, made a minimum of five sets of measurements spread over several days, then shipped it to the pivot laboratory the following Monday. The pivot laboratory received the transfer standard on Tuesday, made at least five sets of measurements over the next several days, then shipped it to the next participant on the following Monday. Since two weeks were required for each participant-pivot loop and ten laboratories participated, the entire experiment required only 20 weeks for completion.

Several of the participants insisted upon complete anonymity of results as a condition for their participation. In order to comply with the participants' desire for anonymity, each participant chose a six character, alpha-numeric lab identifier. All data were reported using this code, and were presented in an alpha-numeric rather than a time sequence. The National Institute of

Standards and Technology (NIST) revealed their identifier (PICARD) to enable participants to determine how closely their laboratory agreed with the national standard. NCSL also required that its personnel not be able to identify any participant's results. To meet this requirement, a disinterested third party (Eastman Kodak Company's Corporate Metrology Center) performed data processing. Data were transmitted indirectly through NCSL headquarters to the data processor. Once processed, the results were returned to participants through the pivot laboratory. Rigorously following this procedure made it impossible for anyone except the participant to identify any results as having been generated by any laboratory.

Raw data were submitted in hard copy form as well as an Excel worksheet on floppy disk if possible. The data were processed as soon as they were received and the results, which included the difference from the pivot laboratory and an estimate of the transfer uncertainty, were returned to the participant. A preliminary report was issued at the program midpoint using a preliminary method of data analysis. This paper is the final report issued to all participants using a method of analysis developed based on the performance of the transfer standards throughout the entire program.

ANALYSIS AND RESULTS

The data submitted by the participants were processed using an Excel spreadsheet. In order to allow the pivot laboratory to be treated the same as another participant, it submitted a set of results obtained over a one week period. The following statistics were calculated from each laboratory's reported deviation from nominal for each transfer standard:

- mean, V_{ij}
- standard deviation, s_{ij}
- average measurement time, T_i

where i is the laboratory and j is the transfer standard

A graph of the standard deviations, s_{ij}, for each transfer standard in each laboratory is shown in Figure 1. Note that some data sets had outlying data points that resulted in an inflated standard deviation. Those standard deviations have been highlighted to show the value if the outliers were omitted from the calculations. However, a cause for the outliers has not been determined, therefore they cannot be omitted and were included in the calculations mentioned in the remainder of this paper.

Upon completion of the intercomparison program the pivot laboratory continued to take data on the transfer standards. These measurements, along with those taken before and during the intercomparison, are shown in Figures 2 through 5 with the linear regression and 95% confidence control limits. There are obvious departures from linearity for three of the four transfer standards, attributed to long term noise in their outputs.

The preliminary method of data analysis assigned pivot laboratory values at the participant's average measurement time T_i to each transfer standards using the linear regression over the whole time period. This would have resulted in unnecessarily large transfer uncertainties. Since long term noise over periods of a week or two appears not to be excessive, an alternative method was

used. A linear regression of the pivot's data, taken in the week before and after the standard was in the participant's lab, was used to assign a value, V_t, to each transfer standard at the participant's average measurement time, T_i. Then differences between the participant's measured value and pivot's assigned value were calculated.

The situation is as follows for a particular transfer standard:

$$V_t - V_p = \alpha \pm U_p \qquad (1)$$

$$V_t - V_l = \beta \pm U_l \qquad (2)$$

where V_t is the output voltage of the transfer standard, V_p is 10 volts as maintained by the pivot laboratory, V_l is 10 volts as maintained by the participant laboratory, and U_p and U_l are the uncertainty in $(V_t - V_p)$, and $(V_t - V_l)$, respectively. It is assumed that the transfer standard has the same value in the participant's laboratory that it had in the pivot laboratory. Generally this is not true, since the transfer standard is subject to the effects of drift and long term noise. To reduce the effects of these imperfections the method of assigning a value using the linear regression was used. Note that V_p is assumed to be constant throughout the experiment, with all variability assigned to the transfer standard.

Subtracting equation (2) from equation (1) gives:

$$V_l - V_p = \alpha - \beta \pm \sqrt{U_l^2 + U_p^2} \qquad (3)$$

There are ten such equations, one for each participating laboratory. This set of equations can be solved for a laboratory's difference from average by choosing one laboratory's difference from the pivot and subtracting the nine remaining differences. This removes V_p from the equation thus for the first laboratory:

$$\sum_{i=2}^{10}\left[\left(V_{l_1} - V_p\right) - \left(V_{l_i} - V_p\right)\right] = 9\left(V_{l_1} - V_p\right) - \sum_{i=2}^{10}\left(V_{l_i} - V_p\right) \qquad (4)$$

Adding and subtracting $(V_{l_1}-V_p)$ to both sides of the equation yields:

$$\sum_{i=1}^{10}\left[\left(V_{l_1} - V_p\right) - \left(V_{l_i} - V_p\right)\right] = 10\left(V_{l_1} - V_p\right) - \sum_{i=1}^{10}\left(V_{l_i} - V_p\right) = 10\left(V_{l_1} - \overline{V}\right) \qquad (5)$$

where $\overline{V}$ is the group average.

For convenience of notation, now define δ_i as the difference between the participant's value and the pivot' assigned value:

$$\delta_i \equiv V_{l_i} - V_p \qquad (6)$$

therefore for a particular participant's difference from the group average, Δ_i for a particular transfer standard, D2102, is:

$$\Delta_{1,D2102} \equiv V_{l_1} - \overline{V} = \frac{1}{10}\sum_{i=1}^{10}\left[(\delta_1)-(\delta_i)\right] \quad (6)$$

The differences for the remaining participants and transfer standards can be solved similarly. Note this is an exact solution of the set of ten equations, so this computation does not contribute to the uncertainty.

Each participant's difference from the group average for each transfer standard, Δ_{ij}, was calculated and is tabulated in table 2 and shown graphically in figure 6. All participants are within 0.4 μV of the group mean. Averaging the results for the four transfer standards provided the laboratory's average difference from the group average, Δ_i, shown in Figure 7. All laboratories were within 0.25 μV (25 ppb) of the group average, with 60% of the laboratories within 0.15 μV. Since the most accurate electrical instrumentation now available requires standards accurate to approximately ±100 ppb, all arrays were shown to be operating within acceptable accuracy limits.

The uncertainty, U_{ij}, in each laboratory's difference from the group average for each transfer standard, Δ_{ij}, is estimated by:

$$U_{ij} = \pm\sqrt{\left(U_{l_{ij}}^2 + U_{p_{ij}}^2\right) + \frac{\sum_{i=1}^{10}\left(U_{l_{ij}}^2 + U_{p_{ij}}^2\right)}{100}}$$

where U denotes uncertainty (1σ), l is the participant lab, p is the pivot lab, i is the laboratory index and j corresponds to the transfer standard index. The combined uncertainty in the laboratory's average difference from the group average, U_i, is the pooled uncertainty for the four transfer standards divided by two. A coverage factor of two was used to calculate the expanded uncertainty (table 2) and is indicated by the length of the bars in Figure 7. All laboratories have total 95% uncertainties smaller than 0.1 μV (10 ppb).

Uncertainties were calculated using the procedures recommended by the ISO Guide to the Expression of Uncertainty in Measurement [6]. All uncertainties were calculated at the 1σ level, then combined in quadrature. Degrees of freedom for the combined uncertainties were calculated using the Welsh-Satterthwaite equation, as recommended by the Guide. The uncertainty analysis assumed no systematic effects, as all measurements are assumed to be unbiased estimates of differences among standards maintained by the various laboratories.

The standard deviation of the Δ_i was calculated to be 0.16 μV. If the uncertainty analysis is correct, this value should be comparable to the total 1σ uncertainties of all laboratories, approximately 0.034 μV. An F-test relating the observed variability in Δ_i to the total uncertainty provides a test of comparability. The F-test failed, indicating that the two values are not comparable. Thus there are effects not addressed by the uncertainty analysis.

The effects not addressed by the uncertainty analysis are likely to be systematic effects, associated either with the arrays themselves, or with the transfer standards. Systematic effects can be detected by examining the data set for correlation between a given laboratory's

measurements of the four transfer standards. A Youden diagram [7] is a convenient means for graphically presenting correlation among measurements.

The x-axis of a Youden plot represents results of the measurement of one standard, and the y-axis the results of measurements of another. When systematic effects are present, plots of all the laboratories' results tend to be scattered along a line of slope +1. Random effects tend to produce a circular distribution of points. Figures 8 and 9 are two of the six possible plots obtained from four transfer standards. As can be seen, the proper interpretation of the plots is uncertain. A more sophisticated approach is needed.

Results of a correlation analysis for the ten measurements of the four transfer standards are presented in table 3. It can be seen that D2102 and D2103 are strongly correlated, as are D2103 and D2104, while D2102 & D2104 and D2104 & D2105 are less so. Correlation between D2012 & D2105 and D2103 & D2015 is almost nonexistent. An analysis of variance indicated significant differences between laboratories, and insignificant differences between transfer standards. How should this information be interpreted?

It is clear that the significant differences are related to laboratory and not to transfer standard. It is unlikely that these differences originate in the long term noise of the transfer standards, as that would tend to average to zero for the four instruments. The correlation among standards offers a clue. It is unlikely that this pattern of correlation could originate in differences among the Array standards, so the source of correlation is probably in the transfer standards. What is there about the transfer standards that can have caused these correlations?

Problems related to shipping were ruled out by performing a correlation analysis on the results of measurements in the pivot laboratory over the time span of the experiment. As can be seen, in table 4, the correlation is essentially nonexistent. Altitude effects can be ruled out by observing that the average altitude is perhaps 400 meters while two participating labs are at about 1500 meters. There are no negative elevations which would account for the observed deviations of approximately equal magnitude and opposite sign. Sensitivity to humidity and temperature can also be ruled out since all the instruments were tested and found to be essentially insensitive to these influences. Further it is hard to imagine an effect which would cause strong correlation between D2102 & D2103 and D2103 & D2104, but not between D2102 & D2104.

The correlation pattern suggests a proximity effect. Such an effect could be caused by temperature rise of instruments tightly grouped on the bench. A temperature rise might cause thermal emfs to be generated either in the instruments themselves or in the leads connecting the instruments to the arrays.

The four transfer standards were tested to determine the temperature of their output connectors both when tightly clustered on the bench, and when separated by five inches. Temperature rise was significant. When clustered and connected to power lines, the terminal temperature of the center instruments was about 5.3°C above ambient, and of the outer instruments, about 4.4°C above ambient. Change in the terminal temperature when the line power was removed was about 2.1°C for the inner instruments and 1.5°C for the outer instruments, over about three hours. For a five inch separation on the bench, temperature rise was about 2.6°C under power, decaying to about 1.2°C over a period of several hours with line power removed. Both temperature rise and rate of change of temperature can contribute to variability in measurements over time and among laboratories.

Terminal temperature rise for D2105 was different than for the other three instruments. The positive terminal was 0.4 to 0.6°C hotter than the negative terminal, depending on separation. This fact may explain the lack of correlation with other instruments.

Thermal emfs can be detected by making a measurement, reversing the connections to the instrument, and repeating the measurement. If thermals are in the measuring circuitry, the initial measured value will be different from that taken after reversing the connections; the difference being twice the thermal emf. With no thermals in the connecting leads, the measured values will not be affected by lead reversal.

These tests were performed on the transfer standards in the pivot laboratory by comparison to the J-array. With the instruments tightly clustered, the observed thermal emf was approximately -0.1 μV for D2105 and +0.2 μV for D2102, D2103, and D2104. With a separation of five inches between the instruments, the observed thermal emfs ranged from -0.07 to 0.06 μV, comparable to one standard deviation of the measurements. Differences in average outputs for the two separations, corrected for thermal emfs, were smaller than 0.06 μV, indicating that the major effects are external to the transfer standards.

In view of all this, we can say with confidence that the major cause of systematic differences among laboratories and among transfer standards was thermal emfs driven by temperature rise in the output terminals of the transfer standards. Because the transfer standards are unplugged from the power line during measurement, time dependent changes in measured outputs are virtually guaranteed. Reversing connections to the instruments and averaging can eliminate most of the error generated. Whether this will completely eliminate systematic differences among arrays can only be determined by repeating the round-robin experiment.

CONCLUSION

The NCSL 1993 Ten Volt Josephson Array intercomparison experiment was successful. All ten arrays made measurements acceptable for the most exacting calibrations of existing instrumentation. The Solid State Reference Standards were likewise shown to be equal to the task of certifying ten volt Josephson Arrays for these calibrations, a much more economical solution for laboratory accreditation than can be provided by portable array standards.

Small systematic effects detected in the experiment were almost certainty caused by thermal emfs generated by above ambient temperatures on the transfer standard output connectors. Proper procedure can minimize such effects.

This experiment was not so obviously successful in validating the statistical analysis used in assigning uncertainties to the calibration of voltage standards in remote facilitates. While the experiment showed all array systems to be operating with errors smaller than about 0.02 ppm, the uncertainty analysis assigned uncertainties smaller than 0.01 ppm. Until the observed differences from the mean can be identified and properly treated, a suspicion will remain that the analysis has overlooked some effects, and therefore provides estimates of uncertainty that are too small.

REFERENCES

[1] "Josephson Voltage Standard", NCSL Recommended Intrinsic/Derived Standards Practice. RISP-1, August 1991 (Revised November 1993)

[2] "Triple Point of Water Cell", NCSL Recommended Intrinsic/Derived Standards Practice. RISP-2, June 1992.

[3] D. Reymann and T. Witt, "International Comparison of Josephson Array Voltage Standards," IEEE Trans I&M, Vol. 42, No. 2, pp. 596-599, April 1993.

[4] Les Huntley, "The Fluke Direct Voltage Maintenance Program", Proceedings of the Measurement Science Conference, January 1984.

[5] John Emery, Ray Kletke, and Howard Voorheis, "A New Approach to Specifying a DC Reference Standard", Proceedings of the Measurement Science Conference, January 1992.

[6] Guide to the Expression of Uncertainty in Measurement, International Organization for Standardization, Geneva, Switzerland, 1993.

[7] W. J. Youden, "Graphical Diagnosis of Interlaboratory Test Results," in Precision Measurement and Calibration, H.H. Ku, Editor, NBS Special publication 300, Volume 1, pp. 133-136, February 1969.

Table 1. Participants of the NCSL sponsored intercomparison program.

Fluke Corporation, Everett, WA (Pivot Lab)
Hewlett Packard Co., Loveland, CO
Lockheed Missiles & Space Co., Sunnyvale, CA
Keithley Instruments, Cleveland, OH
National Institute of Standards and Technology, Gaithersburg, MD
Naval Standards Laboratory, Norfolk, VA
Naval Primary Standards Laboratory, San Diego, CA
Naval Weapons Assessment Center, Corona, CA
Sandia National Laboratories, Albuquerque, NM
U.S. Army TMDE Activity, Redstone Arsenal, AL

Table 2. Tabulation of participant's difference from the group mean for each transfer standard, Δ_{ij}, average difference from the group mean, Δ_i, uncertainty (2σ) in the average difference from the group mean, and effective degrees of freedom, ν_{eff}.

	Δ_{ij} (μV)				Δ_i (μV)	95%	
Lab Identifier	D2102	D2103	D2104	D2105	Average	Uncertainty	ν_{eff}
010516	0.321	0.346	0.214	-0.070	0.203	0.075	67.3
1988HD	-0.206	-0.344	-0.089	0.186	-0.113	0.086	26.9
20930J	-0.159	-0.400	-0.275	-0.181	-0.254	0.067	49.6
333333	-0.151	-0.155	-0.011	0.082	-0.059	0.062	30.3
5JPBSG	-0.026	-0.269	-0.246	-0.236	-0.194	0.043	100.0
613987	0.313	0.296	0.119	0.109	0.209	0.071	40.1
PICARD	0.014	0.279	0.054	-0.038	0.077	0.061	97.7
TVRLAC	0.143	0.038	0.006	0.221	0.102	0.060	29.8
XX3399	-0.062	0.082	0.152	0.112	0.071	0.064	56.2
ZA8DP9	-0.187	0.126	0.075	-0.184	-0.043	0.089	38.8

Table 3. Correlation of all measurements, Δ_{ij}, taken by all participants during the experiment.

	D2102	D2103	D2104	D2105
D2102	1.000			
D2103	0.713	1.000		
D2104	0.536	0.884	1.000	
D2105	0.187	0.125	0.380	1.000

Table 4. Correlation of all measurements of the transfer standards taken by the pivot laboratory over the duration of the experiment.

	D2102	D2103	D2104	D2105
D2102	1.000			
D2103	-0.167	1.000		
D2104	0.226	-0.100	1.000	
D2105	-0.137	0.134	-0.139	1.000

APPENDIX C: EXTERNAL AUDITS OF THE SANDIA SECONDARY STANDARDS LABORATORY

Contents

PRIMARY STANDARDS LABORATORY

Sandia National Laboratories, Albuquerque, New Mexico 87185 July 19, 1989

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

Subject: Technical/QA Survey of the SNL Albuquerque Standards and Calibration Program

Ref 1: Memorandum, R. B. Pettit, 7243, to C. N. Giles, 3424, subject: Survey of the Calibration and Repair Activity in Division 3424, dated October 10, 1988

2: Memorandum, C. N. Giles, 3424, to R. B. Pettit, 7243, subject: Proposed Improvements to Calibration Activity in Division 3424, dated December 13, 1988

Objective:

The survey was performed to evaluate the operation of the Sandia National Laboratories (SNL) standards and calibration program which supports the Nuclear Weapons activities and other operations in Albuquerque. The survey was conducted from April 5 thru April 14 in accordance with the schedule shown elsewhere in this report.

The survey was made to AL57XA, good laboratory practice, and to the Quality Plan for all the various Contractor Standard Laboratory (CSL) level organizations. These organizations are the Sandia Standards Laboratories (SSLs) and Sandia Standards Laboratory Extensions (SSLEs); the former are those actually within the Measurement Standards Department 7240, while the latter, although at the same calibration level, are a part of other organizations.

The SNL standards and calibration program is organized as follows:

The manager, R. T. (Ralph) Johnson, Jr., Measurement Standards Department 7240, has overall responsibility for the standards and calibration program for SNL. In Albuquerque, under Ralph Johnson, the supervisor of Division 7243, R. B. (Dick) Pettit, has direct responsibility for the SSL electrical/temperature/humidity project group; and the supervisor of Division 7241, L. J. (Larry) Azevedo, has direct responsibility for the SSL acceleration/pressure/flow/force project. In addition, Dick Pettit, with the assistance of the SSL project group leader, R. L. (Rick) Crabb, has coordination responsibility for all SSL, SSLE, and Approved Calibration Station (ACS) activities for the SNL Albuquerque standards and calibration program. For the SNL standards and calibration program at Livermore, the supervisor of Division 8285, D. P. (Paul) Van Dyke, has direct as well as coordination responsibility.

Mr. Richard B. Pettit
Division 7243

July 19, 1989

A summary of the SSLs, SSLEs, and ACSs at SNL in Albuquerque is:

Division 7243 SSL project (electrical/temperature/humidity and overall SNL Albuquerque coordination)

Division 7241 SSL project (acceleration/pressure/flow/force)

Division 7485 SSLE operation (dimensional/mass/force/torque)

Division 7542 SSLE operation (high force)

Division 3213 SSLE operation (nuclear radiation)

Division 3424 ACS operation (calibration and repair)

In addition to technical elements, the survey included QA elements in general for 7240 organizations and those QA elements which impact the standards and calibration program for organizations not part of 7240.

The permanent members of the PSL survey team were:

Turk Levy, lead auditor
Bruce Barnaby, supervisor
Phil Thacher, project leader

Ralph Johnson, as manager of the PSL, was an ex officio member of the team and participated as other commitments permitted.

Dick Pettit, having overall responsibility for the SNL Albuquerque standards and calibration program, accompanied the survey team to all locations as an auditee. Other auditees are shown below with *.

Non-permanent members offering pertinent technical expertise (in addition to QA/calibration inputs) are show below with **.

A summary of the places surveyed, the survey schedule, as well as those performing the survey, are as follows:

Places Surveyed:

3213 SSLE (Nuclear Radiation) *Al Stanley

7241 SSL (Acceleration, Pressure, Flow, Force) *Bill Leisher, *Larry Azevedo

7243 SSL (Electrical, Temperature, and Humidity) *Crabb

7485 SSLE (Mechanical: Dimensional, Mass, Force, and Torque) *Jake Gonzales, *Clint Atwood

7542 SSLE (High Force) *Bob Reese

Division 3424 ACS was not included in this survey since it had recently been surveyed jointly by the PSL and the SSL. Results of this survey and the survey responses are given in Refs. 1 and 2, respectively.

Survey Schedule and survey team members (in addition to the permanent members):

APRIL	5	WED	8:30A-12:00N	SSL	7243	Temperature/Humidity	**M. Odom
	6	THU	8:30A- 4:00P	SSL	7243	Electrical	**S. Booker, **P. Spellman
	7	FRI	8:30A- 4:00P	SSL	7241	all	**S. Thornberg, **J. Hartley
	11	TUE	8:30A- 4:00P	SSLE	7485	all	**D. Braudaway
	12	WED	8:30A-12:00N	SSLE	3213	all	**P. Thacher
	12	WED	1:00P- 4:00P	SSLE	7542	all	**D. Braudaway
	14	FRI	9:00A-12:00N	CLOSEOUT			

APRIL:	5	6	7	8	9	10	11	12	13	14
	WED	THU	FRI	SAT	SUN	MON	TUE	WED	THU	FRI
A 8:30	7243	7243	7241	-	-	-	7485	3213		CLOSE
M 12:00	TEMP	ELEC								OUT
P 1:00	-	7243	7241	-	-	-	7485	7542	-	-
M 4:00		ELEC								

Summary:

Overall, the standards and calibration program for SNL in Albuquerque was found to be in accordance with AL57XA, as well as with good laboratory and quality assurance practices, to an acceptable degree. There were no deficiencies or areas of concern. There are general comments and some specific discussion items for the operational and project groups evaluated, as noted below.

Subjects stressed by the survey team generally included: a) an increased effort toward more formal calibration procedures, where applicable, particularly as a good laboratory practice for training inexperienced persons; b) more complete documentation of computer software; c) the need for recording temperature and humidity in all labs and to set operational limits based on calibration and measurement requirements; and, d) quality assurance training of personnel.

Discussion:

General Comments:

1. Calibration Histories All calibration groups are keeping calibration histories, although the retention period varies. 7485 keeps data

3-6 months for customer calibrations in case the user has a question when they get their instrument back. 7542 keeps only the current calibration record, discarding the previous record when a new one has been satisfactorily generated. All other groups retain their records indefinitely.

2. Uncertainties are supported by the standards used and the equipment calibrated, although some improvement is indicated. All included the standard's uncertainty to the test measurement uncertainty. Few included drift over the interval or uncertainties from use conditions.

3. Personnel were generally well-trained and knowledgeable in measurement technique and data analysis (including uncertainties).

4. Certificates or reports reviewed had adequate information, but, as stated in 2. above, improvements are indicated.

5. Procedures are mostly in place, with a few still being written. Those checked looked good. Some procedures are computer-guided. As stated earlier in this report, this is an item where more attention is indicated.

6. Environmental recording and environmental controls are good in some labs and need improvement in others.

7. Improvements in equipment, as well as computer programs and automation, are in progress everywhere.

8. Turnaround is good to excellent in all labs except 7485 where the recent move had caused a significant disruption of their measurement/calibration activities.

9. Traceability is almost always to PSL/NIST or an approved lab, although in a few cases it is not. In the latter cases, the traceability appears to be adequate, with better documentation being addressed as discussed below.

10. Workload to resources ratios are increasing.

11. QA Indoctrination was usually provided to the calibration technicians informally by lead personnel in each area.

Specific Comments and Discussion Items:

1. Division 7243 SSL (Temperature/Humidity) (Rick Crabb, Project Leader)

This is a subgroup of the 7243 SSL project group (located in Bldg. 894) under Rick Crabb as project leader. There is one contract calibration technician, Jerry LaMarr. Work is done for the SSL, operating organizations of SNL in Albuquerque, as well as the PSL, e.g., PSL's Liquid In Glass (LIG), i.e., thermometers and working Platinum Resistance Thermometers (PRTs). There is good communication with personnel engaged in similar work in other areas of the SSL, as well as

the PSL. Turnaround time for customers, as well as from the PSL, is good. Construction work was in process in adjacent areas, which caused clutter and noise as an annoyance. Intervals for PRT and LIG thermometers are one year and for other devices are set initially per manufacturer's recommendations. Data storage is for the life of the device. Software backup is stored in the 892 SSL lab.

1a. This group is commended for its efforts toward the development of the homogeneity tester for thermocouple wires. These efforts should continue.

b. This group is commended for its increased attention to calibration histories as a factor in determining uncertainties over the calibration interval.

c. A formal documentation of the procedure used for the SPRT immersion test in the LIG thermometer bath calibrations is recommended.

d. A closing measurement should be made at the ice point for PRT calibrations for comparison with the initial ice point measurement.

e. If ice point checks show a substantial shift, annealing of the PRT should be considered.

f. Consideration should be given to setting up a Commercial Calibration Source (CCS) for temperature calibration work for Sparton Technology, Inc., Alltech, and/or transferring the lower-level calibration work to Allied Signal Kansas City's (ASKC) Albuquerque Microelectronic Operation (AMO).

g. A review should be made of the policy of assigning the same recall number to different serial numbered thermocouples after the previous thermocouple is replaced.

h. Commendation is made for participation in the PSL Tinsley Resistor/SPRT Simulation Round Robin.

i. Where one point calibrations are made for humidity indicators, the certificate wording should make this clear.

j. On certificates for PRTs and thermocouples where coefficients for temperature-resistance or temperature-junction voltage equations are given, reference to the NBS IPT68 relationship is recommended.

k. The ceiling and walls need to be refurbished.

The Handcarry PRT audit was successfully completed, as shown below. A temperature device was taken as a blind audit.

Mr. Richard B. Pettit
Division 7243

July 19, 1989

STANDARD PLATINUM RESISTANCE THERMOMETER (SPRT) (F/N 3348G)

Nom. Temp. °C	Measured Resistance Ratio PSL	SSL	Difference (Ratio;°C)	Uncertainties (±°C) SSL	PSL
-80	0.6769797	0.6769980	$0.183\ 10^{-4}$;0.004	0.1	0.03
30	1.1190374	1.1190808	$0.434\ 10^{-4}$;0.011	0.1	0.02
200	1.7732718	1.7734337	$1.619\ 10^{-4}$;0.043	0.1	0.03
490	2.8114588	2.8113724	$-0.864\ 10^{-4}$;0.025	0.1	0.05

2. Division 7243 SSL (Electrical/Time/Frequency) (Rick Crabb, Project Leader)

This group performs calibrations for the SNL Albuquerque operating groups in the electrical, time and frequency categories, as well as working standards and/or auxiliary calibrating devices for itself and other SSL and/or SSLE groups. In addition, it also performs calibrations for the PSL where uncertainties needed are within the capabilities of this group. Effort is underway to establish a microwave capability in this group to support the needs of the SNL operating groups for microwave instrument calibrations.

Rick Crabb (TSA) is project leader, reporting to Dick Pettit, Division 7243 Supervisor. Reporting to Crabb are two Sandia Labs STA calibration technicians, Harry Pike and Mel Salazar, seven contract calibration technicians, including Jerry LaMarr from the temperature/humidity subgroup and a contract computer programmer, L. B. Saylors, The contract calibration employees are: E. A. Benedict, J. R. Boren, F. G. Cajas, C. E. Sweeton, D. P. Thomas, and R. M. Walker.

2a. This group makes good overall use of computers for calibration, certificate preparation, data analysis, etc.

b. A particular example of good use of computers for automated calibration is the bringing on line of the Datron Porta Cal system for multimeters.

c. Three data folders requested for data record analysis could not be located during the survey. One way to reduce the frequency of this occurrence is to provide a sign-out card to be signed or initialed by the person removing a folder from the file. This card could then be placed in the file where the folder would normally be.

d. The records for the Tunnel Diode Pulser being calibrated by NBS/NIST need to show a cover sheet for the NIST report or an annotation on the NIST report itself showing a broadening of the NIST uncertainty band to allow for drift, etc., over the calibration interval.

e. Overall, temperature control is good in this lab. However, consideration should be given to additional sensors, and care should be

exercised in the orientation of temperature recorders which indicate differently when lying on a bench vs being attached vertically to a wall.

f. This lab is commended for initiating an effort to provide for computerized reverse traceability.

g. In the data folder for a Fluke 931B, Serial No. 3330009, S No. 545944, there was a xerox copy of the reverse side of a two-sided preprinted data form which contained data but did not identify the device being calibrated. The item being calibrated should appear on each sheet of data where multiple sheets, including such xeroxed copies, are included in a data package.

h. On the test data plots for a HP 3335A, S/N 2516A04261, the range of frequencies was not shown.

i. A review of the policy for including environmental information on certificates should be made to determine when, which, and to what extent environmental information would be relevant to the user.

j. No expired calibrations were found.

k. Traceability was excellent.

The Standard Capacitor and DC Voltage Standard Handcarry audits were successfully completed, as shown below. A GSI SRI Resistor was taken as a blind audit.

CERTA CELL, S/N 3245 (F/N 6595V)

Nominal Voltage	Measured Values (Volts) PSL	SSL	Difference (ppm)	Uncertainty (± ppm) SSL	PSL
1 V	0.999,997.76	0.999,998.4	0.64	25	5

STANDARD CAPACITOR, S/N 502 (F/N 424Z)

Nominal (pF)	Measured Values (pF) PSL	SSL	Difference (ppm)	Uncertainty (± ppm) SSL	PSL
At 1 kHz:					
100	99.98364	99.98344	2.0	15	5

3. Division 7241 SSL (Acceleration/Pressure/Flow/Force) (Bill Leisher, Project Leader)

This project group is located in Bldg. 828 and performs accelerometer, force, flow, low and high pressure calibrations, mainly for the SNL Albuquerque operating organizations. As is the case with the 7243 SSL, some work is done for other SSL and SSLE groups and the PSL.

Bill Leisher (MTS) is the project leader, reporting to Larry Azevedo, Division 7241 Supervisor. Also in the group is one Sandia TA calibration technician, Frank Rebarchik, and three contract employees, Brian Gonzales, Steve Harbor, and David Sanchez. Cross training of calibration technicians is emphasized in this group. Effort is underway to provide an acceleration system for improving the accuracy of calibrations at low g. QA orientation is provided informally.

3a. This project group has done extremely well in getting a large volume of work out.

b. A temperature/humidity monitor should be installed in both rooms.

c. Consideration should be given to tracking rejects, preferably on the computer.

d. This group has achieved a very low turnaround time.

e. Some labels were difficult to read due to wear. Worn labels, if still pertinent, should be replaced.

f. Records should be kept of notifying customers of out-of-tolerance experiences.

g. The 7241 SSL project leader is commended for providing valuable assistance in addressing periodic PSL problems, particularly in the acceleration area.

h. Accelerometer calibrations at low frequencies encounter difficulties which are being addressed in this group. This effort is very commendable.

i. The validity of the 70°F calibration temperature for the two 100,000 g Precise Sensors (S/Ns 22372 and 24731-1) should be checked.

j. A very good job of computer automation is being done in this group.

k. The practice of physically locating documentation, including histories for calibration systems, at the calibration system for easy reference is commended.

l. A temperature sensor and indicator should be located near the King Neutronics calibration station since the computer for this system has a temperature limit of 80°F.

m. A good job of cross training is being done.

The pressure transducer Handcarry audit was successfully completed, as tabulated below. An accelerometer was chosen as a blind audit.

PRESSURE TRANSDUCER (F/N 7680E)

Dial Gage Rdg. (mm Hg)	Reference Standard Rdg. PSL (mm Hg)	SSL (mm Hg)	Diff. (%) (SSL-PSL)	Uncert. (± %) SSL	PSL
500	500.080	500.640	0.112	0.075	0.04
1000	1000.073	1000.586	0.051	0.075	0.04
1500	1499.997	1500.504	0.034	0.075	0.04
2000	1999.865	2000.409	0.027	0.075	0.04
2500	2499.690	2500.250	0.022	0.075	0.04
3000	2999.496	3000.031	0.018	0.075	0.04
3500	3499.353	3500.117	0.022	0.075	0.04
4000	3999.322	4000.054	0.018	0.075	0.04
4500	4499.370	4500.134	0.017	0.075	0.04
5000	4999.489	5000.151	0.013	0.075	0.04

4. Division 7485 SSLE (Dimensional/Mass) (Jake Gonzales, Division/Clint Atwood, Section)

This operation is part of the development shop organization's Mechanical Measurements Section. Clint Atwood is Section Supervisor (7485-5), reporting to Jake Gonzales, 7485 Division Supervisor. There are three craftsmen (Paul Cunningham, Ken Conrad, and Walter Schuster) performing measurements and calibrations in the dimensional, mass, and low-level force areas for SNL operating organizations, other SSLs and SSLEs, as well as the PSL. There is presently a contract with Rocky Flats to perform calibrations of gage blocks, weight sets, and torque wrenches to handle the workload which exceeds the capacity of the present Sandia staff. This operation was recently moved from Bldg. 894 to Bldg. 878, and stable environmental control operating conditions had not been achieved at the time of the survey.

4a. Some calibration documents (Reports or Certificates) did not have accuracy statements.

b. Although the environmental controls were not working at the time of the survey (they had recently moved into their new quarters), independent monitoring of temperature was being accomplished to minimize adverse effects of temperature on measurement results.

c. Notwithstanding the environmental control problems which are being addressed, 7485 has a good new facility.

d. When work on the environmental controls has been completed, the lab environment should be checked using calibrated monitors.

e. Personnel are well-trained in measurement techniques and are careful in their work.

f. Although all certificates did not provide an uncertainty, when one was provided, it was done correctly.

g. 7485's policy is that white-labeled instruments (PSL calibrated) are required to calibrate blue-labeled (SSL/SSLE level) instruments, which, in turn, calibrate green-labeled instruments (below SSL/SSLE level). For this operating group, this policy is an aid in controlling calibration efforts.

The Aluminum 1 kg Weight Handcarry audit was successfully completed, as shown below. A set of thread wires and gage blocks were chosen as a blind audit.

ALUMINUM WEIGHT AUDIT MASS 3 (F/N 3514A)

Nominal (grams)	Measured Values (grams) PSL	SSL	Diff. (ppm) (SSL - PSL)	Uncertainties (± ppm) SSL	PSL
1000					
True Mass:	1016.120100	1016.123	2.9	6.0	1.0
Apparent Mass vs Density 8.0 g/cc:	1015.874235	1015.877	2.7	6.0	1.0

5. Division 3213 SSLE (Radiation) (Al Stanley, Division Supervisor)

The calibration/measurement functions of this operation involve activities which are undertaken in Bldgs. 869 and 818 under the supervision of A. L. (Al) Stanley, 3213 Health Instrumentation Division Supervisor. There is one Sandia employee, David Sinton, and one contract technician, Ned Smith involved in the calibration functions. An additional staff position has been approved but has not yet been signed off.

With the increase of workload in the ES&H, resulting from increased oversight in the past 3 or 4 years (e.g. DOE HQ in 1985, DOE/AL in 1986, and a TSA in 1988), additional manpower is being requested. Overall, there are now about two audits (surveys) per year conducted by various DOE groups. In addition to the staff employee authorized, an additional three to five more persons are needed in the near future starting with one staff employee and two technicians now, with a total of 15 additional employees estimated to handle the increased workload to address ES&H concerns between 3213 and George Tucker's 3212 Health Physics Division.

Division 3213 supports the SNL calibration requirements for radiation instruments, as well as, by contract agreement, the AMO's ES&H activities. Dosimetry measurements are being made for α, β, γ, neutrons and flash X-rays, including verification of shield wall integrity.

5a. A good R chamber cross-check and PIX6 humidity study have been made.

b. Use of a humidity recorder in Bldg. 819 should be considered.

c. Users of instruments should be notified if the range is ever found to be out of calibration and this fact documented

d. R chambers and neutron sources should be put in the recall system.

e. The PSL agreed to provide information on tritium gas calibration, though their present supplier appears reliable.

No Handcarry audit was submitted to this group; however, a radiation monitoring device was chosen as a blind audit.

6. Division 7542 SSLE (High Force) (Bob Reese, Lead Engineer)

This group is engaged in calibrating and measuring load cells, load producing machines, etc., in support of testing operations for SNL Albuquerque organizations. They are located in Bldg. 860 and in Area III. The Area III operation was not surveyed at this time.

Overall, this project is well-run both for their testing functions and their supporting calibration functions. Their excellent technical responses were evidence of a thorough knowledge of the measurements being made and the performance of their measurement systems. In addition, they showed a very high degree of inventiveness in the application of their measurements. Bob Reese is the lead engineer, reporting to Tom Priddy, Supervisor of Experimental Mechanics Division II. There are two Sandia employees, Larry Dorrell and Rod May, performing high-force testing and calibrations and one contract employee, Mel Heisler. Two calibration and maintenance contractors have been maintaining the load machines, MTS and Metallurgical Supply, Inc. They also maintain additional load machines at Sandia Albuquerque.

6a. Temperature or relative humidity are not controlled or recorded. Although the accuracy level at which this group is operating does not require tight controls on these environments (except when testing nylon parts, at which time special precautions are taken), installation of a temperature/humidity recorder is recommended, as well as a memo put in file addressing the mode of operation regarding temperature and/or humidity effects, including any exceptions such as discussed above.

b. Accuracy statements were missing from some certificates. This procedure should be reviewed. A recently-published report, SAND88-2847, prepared by R. L. Crabb with Division 7542 cooperation, provides some general guidance regarding the importance for many users of uncertainty/accuracy statements. This document should help in this review.

c. Consideration should be given to sending the 10^6 lbf load cell to NIST for calibration.

d. Steps should be taken to have MTS and Metallurgical Supply, Inc. approved as a CCS for the calibration of the load machines.

A 10 Klbf load cell handcarry audit was submitted to this group for measurement on two different machines. This served as two audit exercises. Both were successfully completed, as shown below. A blind audit was not chosen from this group.

10KLBF LOAD CELL (F/N 6826A) (ON THE TINIUS OLSEN SYSTEM)

Nominal (LBF)	Measured Values (LBF) PSL	SSL	Difference (LBF) (SSL - PSL)	Uncertainties (± LBF) SSL	PSL
0	-0.1	0	0.1	200.0	5.0
1000	1031.8	1015	-16.8	200.0	6.0
2000	2063.7	2054	- 9.7	200.0	7.0
3000	3095.7	3071	-24.7	200.0	8.0
4000	4127.6	4111	-16.6	200.0	9.0
5000	5159.5	5132	-27.5	200.0	10.0
6000	6191.5	6171	-20.5	200.0	11.0
7000	7223.4	7213	-10.4	200.0	12.0
8000	8255.3	8244	-11.3	200.0	13.0
9000	9287.3	9276	-11.3	200.0	14.0
9980	10278.6	10278	- 0.6	200.0	15.0

10KLBF LOAD CELL (F/N 6826A) (ON THE MTS SYSTEM)

Nominal (LBF)	Measured Values (LBF) PSL	SSL	Difference (LBF) (SSL - PSL)	Uncertainties (± LBF) SSL	PSL
0	-0.1	0	0.1	200.0	5.0
1000	1031.8	1020	-11.8	200.0	6.0
2000	2063.7	2041	-22.7	200.0	7.0
3000	3095.7	3060	-35.7	200.0	8.0
4000	4127.6	4084	-43.6	200.0	9.0
5000	5159.5	5102	-57.5	200.0	10.0
6000	6191.5	6130	-61.5	200.0	11.0
7000	7223.4	7146	-77.4	200.0	12.0
8000	8255.3	8172	-83.3	200.0	13.0
9000	9287.3	9195	-92.3	200.0	14.0
10000	10298.6	10222	-76.6	200.0	15.0

Mr. Richard B. Pettit
Division 7243

July 19, 1989

The preceding items were discussed at a closeout meeting on April 14, 1989. Those in attendance were:

Name	Organization
C. L. Atwood	7485-5
L. J. Azevedo	7241
B. E. Barnaby	7242*
S. R. Booker	7241*
D. W. Braudaway	7242*
R. L. Crabb	7243
Jake Gonzales	7485
J. L. Hartley	7241*
R. T. Johnson, Jr.	7240*
W. B. Leisher	7241
W. G. T. Levy	7243*
J. J. LaMarr	7243
M. K. Odom	7241*
R. B. Pettit	7243
T. G. Priddy	7542
R. T. Reese	7542
P. J. Spellman	7241*
A. L. Stanley	3213
P. D. Thacher	7241*
S. M. Thornberg	7243*

*Representing the PSL as part of the survey team.

Please respond to the specific discussion items shown for each group visited (responses to commendation items are optional), as well as general discussion items, where applicable. Please provide your coordinated written response within 60 days of receipt of this survey report.

W. G. T. Levy, Surveys and
Audits Representative
Division 7243

R. T. Johnson, Manager
Measurements Standards
Department 7240

WGTL:7243:rmg
WGL8907031

Copy to:
3212 A. L. Stanley
7240 R. T. Johnson

Mr. Richard B. Pettit
Division 7243

July 19, 1989

7241	L. J. Azevedo
7241	W. B. Leisher
7241	J. L. Hartley
7241	P. J. Spellman
7241	P. D. Thacher
7242	B. E. Barnaby
7242	S. R. Booker
7242	D. W. Braudaway
7243	R. L. Crabb
7243	M. K. Odom
7243	S. M. Thornberg
7250	G. T. Merren
7485	J. F. Gonzales
7485-5	C. L. Atwood
7542	R. T. Reese
7243	W. G. T. Levy

Sandia National Laboratories

Albuquerque, New Mexico 87185

October 25, 1989

Mr. R. T. Johnson
Department 7240
Sandia National Laboratories
P. O. Box 5800
Albuquerque, NM 87185-5800

Subject: Technical/QA Survey of the SNL Albuquerque Standards and Calibration Program

Ref 1: Letter, R. T. Johnson and W. G. Levy, 7240, to R. B. Pettit, dated July 19, 1989, subject: Same

The referenced survey was performed to evaluate the operation of the Sandia National Laboratories (SNL) standards and calibration program which supports the Nuclear Weapons activities and other operations in Albuquerque. The survey was conducted from April 5 thru April 14, 1989.

Responses to the General Comments and the Specific Comments and Discussion Items are listed below.

Responses to General Comments:

1. Calibration Histories All calibration groups are keeping calibration histories, although the retention period varies. 7485 keeps data 3-6 months for customer calibrations in case the user has a question when they get their instrument back. 7542 keeps only the current calibration record, discarding the previous record when a new one has been satisfactorily generated. All other groups retain their records indefinitely.

   Response: As noted in response 6b, division 7542 will retain all calibration data and certificates so that historical trends can be examined. In addition, Division 7485 now maintains a file of all certificates, reports, traceability, and reference standards documentation indefinitely.

6. Environmental recording and environmental controls are good in some labs and need improvement in others.

   Response: See specific responses below in 2e, 4d, 5b, and 6a.

Mr. R. T. Johnson
Department 7240

October 25, 1989

8. Turnaround is good to excellent in all labs except 7485 where the recent move had caused a significant disruption of their measurement/calibration activities.

Response: The move from Bldg. 894 to Bldg. 878 has been completed, and Division 7485 is presently working to improve the turnaround time.

Responses to Specific Comments and Discussion Items:

1. Division 7243 SSL (Temperature/Humidity)

1c. A formal documentation of the procedure used for the SPRT immersion test in the LIG thermometer bath calibrations is recommended.

Response: The immersion test results have been evaluated and a summary will be added to the affected procedure.

1d. A closing measurement should be made at the ice point for PRT calibrations for comparison with the initial ice point measurement.

Response: Closing ice point measurements are considered to be not important on customer PRTs since the assigned uncertainty is ±0.1°C or greater. However, an ice point reading is obtained for the PSL calibrated SPRT on a minimum 6 month interval and the results documented.

1e. If ice point checks show a substantial shift, annealing of the PRT should be considered.

Response: When ice point readings so indicate, annealing will be done when it does not damage the PRT.

1f. Consideration should be given to setting up a Commercial Calibration Source (CCS) for temperature calibration work for Sparton Technology, Inc., Alltech, and/or transferring the lower-level calibration work to Allied Signal Kansas City's (ASKC) Albuquerque Microelectronic Operation (AMO).

Response: Establishment of a CCS to provide calibration service to Sparton and Alltech is under consideration.

1g. A review should be made of the policy of assigning the same recall number to different serial numbered thermocouples after the previous thermocouple is replaced.

Response: A file number is assigned to each thermocouple supplied to a customer. The "model number" in the recall system, in this case, identifies the certified roll of wire that the thermocouple was manufactured from, while the serial number indicates the Julian date when the thermocouple was made. When a replacement thermocouple is made from the same roll of wire, a new serial

number is assigned; the new serial number, certification date, and expiration date are entered in the recall system under the original file number. Thus the former serial number is lost in the recall system. In order to keep track of all serial numbers, a separate INGRES database is being constructed which will contain information on all thermocouples issued from each roll of thermocouple wire.

In addition, in cases where special calibrations are performed on a thermocouple from a certified roll, the model number will include the words "SPECIAL" to indicate that a special test was performed. Then when a replacement is needed, the technician will be reminded to check the previous certificate and data pack for the special tests requested.

1i. Where one point calibrations are made for humidity indicators, the certificate wording should make this clear.

Response: With the acquisition of an automated humidity generator from Thunder Scientific, one point humidity calibrations are no longer being performed in the SSL.

1j. On certificates for PRTs and thermocouples where coefficients for temperature-resistance or temperature-junction voltage equations are given, reference to the NBS IPT68 relationship is recommended.

Response: Reference to the NBS IPT68 relationship has been added to pertinent certificates.

1k. The ceiling and walls need to be refurbished.

Response: Refurbishment of the temperature/humidity laboratory walls and ceiling are being evaluated.

2. Division 7243 SSL (Electrical/Time/Frequency)

2c. Three data folders requested for data record analysis could not be located during the survey. One way to reduce the frequency of this occurrence is to provide a sign-out card to be signed or initialed by the person removing a folder from the file. This card could then be placed in the file where the folder would normally be.

Response: The use of sign-out cards to indicate removed files is being examined. However, since the technician, the project leader, the scheduling clerk, and the secretary may all handle the file before it is replaced, tracking down the individual who removed the file may not help in locating it. In addition, files are now being sent to the AMO facility for calibrations performed there; thus the person who removed the file only mailed it to a technician at AMO.

Mr. R. T. Johnson
Department 7240

October 25, 1989

2d. The records for the Tunnel Diode Pulser being calibrated by NBS/NIST need to show a cover sheet for the NIST report or an annotation on the NIST report itself showing a broadening of the NIST uncertainty band to allow for drift, etc., over the calibration interval.

Response: Records for the Tunnel Diode Pulser (Tektronix S-52 Pulse Generator Head) have been corrected by increasing the NIST uncertainty appropriately.

2e. Overall, temperature control is good in this lab. However, consideration should be given to additional sensors, and care should be exercised in the orientation of temperature recorders which indicate differently when lying on a bench vs being attached vertically to a wall.

Response: Additional better quality sensors have been added.

2g. In the data folder for a Fluke 931B, Serial No. 3330009, S No. 545944, there was a xerox copy of the reverse side of a two-sided preprinted data form which contained data but did not identify the device being calibrated. The item being calibrated should appear on each sheet of data where multiple sheets, including such xeroxed copies, are included in a data package.

Response: Technicians have been advised to insure that instrument and date identification must appear on each sheet of instrument data.

2h. On the test data plots for an HP 3335A, S/N 2516A04261, the range of frequencies was not shown.

Response: The data plot mentioned does not plot frequencies but plots relative drift in the time base as a function of real time in hours.

2i. A review of the policy for including environmental information on certificates should be made to determine when, which, and to what extent environmental information would be relevant to the user.

Response: This topic is very complicated and determining general guidelines very difficult. In cases where the environment is important, such as for standard resistors measured in a constant temperature oil bath, this environmental information is being included on the certificate. Guidelines for a policy governing environmental information to be included on certificates from the PSL would be appreciated. A policy for the SSL electrical lab is under evaluation.

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Department 7240

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3. Division 7241 SSL (Acceleration/Pressure/Flow/Force)

3b. A temperature/humidity monitor should be installed in both rooms.

Response: When the PSL has selected a suitable temperature/humidity recorder for general department usage, two will be obtained for installation in Bldg. 828, rooms 6 and 10. There is an existing memorandum in file discussing the temperature variations in these rooms and the minimal effects on the transducers that are calibrated there.

3c. Consideration should be given to tracking rejects, preferably on the computer.

Response: A method for tracking rejected transducers in the computer files has been instituted. The method will indicate rejections during a directory listing on a model number and during a history search for a specific instrument. Calibration sequence numbers will be maintained in order, even though the instrument may have been repaired. The method has been incorporated into the existing software and has required no major file structure change.

3d. Some labels were difficult to read due to wear. Worn labels, if still pertinent, should be replaced.

Response: Worn labels, if still pertinent, will be replaced.

3f. Records should be kept of notifying customers of out-of-tolerance experiences.

Response: Several methods for recording notification of an owner on an out-of-tolerance condition are under consideration at this time.

3i. The validity of the 70°F calibration temperature for the two 100,000 g Precise Sensors (S/Ns 223/2 and 24731-1) should be checked.

Response: Conversations with ASKC personnel indicate that the usual ambient temperature of their Harwood Piston Gage is 23-24°C (73-75°F). The reported temperature of 70°F should have no effect on the usage or uncertainty of the transducer.

3l. A temperature sensor and indicator should be located near the King Neutronics calibration station since the computer for this system has a temperature limit of 80°F.

Response: A calibrated temperature readout has been installed by the King-Nutronics pressure calibrator to prevent usage at an ambient temperature above 80°F (factory specifications). This unit

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Department 7240

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will be returned to the factory in late 1989 and we will ask them to increase the operating temperature range.

4. Division 7485 SSLE (Dimensional/Mass)

4a. Some calibration documents (Reports or Certificates) did not have accuracy statements.

Response: Accuracy/uncertainty statements will be included with reports and certificates on all future items calibrated. A memorandum of record, dated April 12, 1989, from C. L. Atwood, 7485-5, provides guidelines for the use of measurement uncertainty statements on certificates and reports. In addition, SAND 88-2847, "An Uncertainty Analysis for the Structural Mechanics Laboratory," has been reviewed by Division 7385 calibration personnel.

4d. When work on the environmental controls has been completed, the lab environment should be checked using calibrated monitors.

Response: The environmental control problems in the new calibration area have been corrected and are being verified using calibrated monitors.

4f. Although all certificates did not provide an uncertainty, when one was provided, it was done correctly.

Response: See response under 4a.

5. Division 3213 SSLE (Radiation)

5b. Use of a humidity recorder in Bldg. 818 should be considered.

Response: When a reliable humidity recorder has been identified by the PSL, it will be purchased and placed in Bldg. 818.

5c. Users of instruments should be notified if the range is ever found to be out of calibration and this fact documented.

Response: A notice will be sent to users of devices found to be out of calibration. The notice will list the observed characteristics of the device and its current status. The user will determine the impact on their operation.

5d. R chambers and neutron sources should be put in the recall system.

Response: These devices will be placed in the Division 3213 recall system.

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5e. The PSL agreed to provide information on tritium gas calibration, though their present supplier appears reliable.

Response: The division is in continuous contact with personnel at both REECO (Dick Hill) and LANL (John Haynie and Ken Groves) concerning the verification of the activity of tritiated methane mixtures from sources besides the supplier. Any assistance from the PSL will be appreciated.

6. Division 7542 SSLF (High Force)

6a. Temperature or relative humidity are not controlled or recorded. Although the accuracy level at which this group is operating does not require tight controls on these environments (except when testing nylon parts, at which time special precautions are taken), installation of a temperature/humidity recorder is recommended, as well as a memo put in file addressing the mode of operation regarding temperature and/or humidity effects, including any exceptions such as discussed above.

Response: There are no temperature controls in Bldg. 860, room 115 or in the test area immediately to the west of this laboratory. It is not feasible to have these controls added to this work area since it would involve extensive modifications and be very costly. Temperatures have been measured to vary by ± 15°F in this area. Humidity levels have not been monitored. However, a temperature/humidity recorder will be ordered and used in this area starting next fiscal year.

6b. Accuracy statements were missing from some certificates. This procedure should be reviewed. A recently-published report, SAND 88-2847, prepared by R. L. Crabb with Division 7542 cooperation, provides some general guidance regarding the importance for many users of uncertainty/accuracy statements. This document should help in this review.

Response: We have revised our records/history retention procedures and the information contained in our certificates and reports. Accuracy statements will be included on certificates, following the general guidelines mentioned in the referenced SAND report. We also will now retain all previous calibration data to examine it for trends with time. We have separated our proof-test memoranda and related items from the calibration records.

6c. Consideration should be given to sending the 10^6 lbf load cell to NIST for calibration.

Response: The one million pound-force load cell will be sent to NIST for calibration in approximately November 1989.

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6d. Steps should be taken to have MTS and Metallurgical Supply, Inc. approved as a CCS for the calibration of the load machines.

Response: We are working with Division 7243 personnel in certifying these companies as a CCS or DCSL. The maintenance and calibration service they provide are effective in maintaining our equipment and do not divert resources away from our testing service.

R. B. Pettit, Supervisor
Division 7243

RPB:7243:MEMO13

Copy to:
3212 A. L. Stanley
7241 L. J. Azevedo
7241 W. B. Leisher
7243 R. L. Crabb
7250 G. T. Merren
7485 J. F. Gonzales
7485-5 C. L. Atwood
7542 R. T. Reese
7243 W. C. T. Levy
7243 Day File
7243 R. B. Pettit

PRIMARY STANDARDS LABORATORY

Sandia National Laboratories, Albuquerque, New Mexico 87185

March 19, 1992

Mr. R. C. Lindsey
Division 2414
Sandia National Laboratories
P. O. Box 5800
Albuquerque, NM 87185-5800

Subject: Technical/QA Survey of the SNL Albuquerque Standards and Calibration Program

Ref: Memorandum, R. T. Johnson, 7240 and W. G. T. Levy, 7243, to R. B. Pettit, 7243, subject: Technical/QA Survey of the SNL Albuquerque Standards and Calibration Program, dated July 19, 1989

Objective:

The survey was performed to evaluate the operation of the Sandia National Laboratories (SNL) standards and calibration program which supports the Nuclear Weapons activities and other operations in Albuquerque. The survey was conducted from October 22 through October 24, 1991, in accordance with the schedule shown elsewhere in this report.

The survey was made to AL57XA, good laboratory practice, and to the Quality Plan for all the various calibration level organizations. These organization are the Sandia Standards Laboratories (SSLs) and the Sandia Standards Laboratory Extensions (SSLEs); the former are those actually within the Secondary Standards and Instrument Repair Division, while the latter, although at the same calibration level, are a part of other organizations (7715, 2485, 2741).

There have been significant changes in the organization of the SNL Albuquerque Standards and Calibration Program since the last Technical Survey in July 1989. The SSL at that time was in the same department as the Primary Standards Lab (PSL), under R. T. Johnson, 7240, as manager with overall responsibility. R. B. Pettit, 7243, had direct responsibility for the SSL electrical/temperature/humidity project group as well as coordination for all SSL, SSLE, and Approved Calibration Stations (ACS), and L. J. Azevedo, 7241, had direct responsibility for the SSL acceleration/pressure/flow/force project. The SNL was separated from the PSL in late 1989 and became the direct responsibility of C. N. Giles, 7414, with Tom Young, 7410, asuming overall responsibility for the Sandia Albuquerque Standards and Calibration Program. In May of 1991, C. N. Giles retired and was replaced by R. C. Lindsey. The SNL Albuquerque Standards and Calibration Program is now organized as indicated in attachment 1 of this report. A summary of the SSLs, SSLEs, and ACSs at SNL in Albuquerque is:

Division 2414 SSL project (electrical/temperature/humidity and overall SNL Albuquerque coordination)

Division 2414 SSL project (physical)

Division 2414-1 ACS operation (calibration and repair)

Division 2485-5 SSLE operation (dimensional/mass/force/torque)

Division 2741 SSLE operation (high force)

Division 7713 SSLE operation (health physics)

In addition to technical elements, the survey included QA elements in general for 2414 organizations and those QA elements which impact the standards and calibration program for organizations not part of 2414.

The permanent members of the PSL survey team were:

Frank Garcia, 4343, lead
Richard Pettit, 4342, supervisor
Rob Duncan, 4342, SMTS

Ralph Johnson, as manager of the PSL, and Turk Levy, as Survey and Audits representative for the PSL, were ex officio members of the team and participated as other commitments permitted.

Bob Lindsey, having overall responsibility for the SNL Albuquerque Standards and Calibration Program, and Rick Crabb accompanied the survey team to all locations. Other responsible partners are shown below with *.

Non-permanent PSL members offering pertinent technical expertise (in addition to QA/calibration inputs) are shown below with **.

A summary of the places surveyed, the survey schedule, as well as those performing the survey, are as follows:

Places Surveyed:

2414 SSL (Electrical, Temperature, and Humidity)
**R. D. Moyer, 4342

2414 SSL (Acceleration, Pressure, Flow, Force)
*W. B. Leisher, 2414

2485-5 SSLE (Mechanical; Dimensional, Mass, Force, and Torque)
*J. F. Gonzales, 2485-5 *C. L. Atwood, 2485-5

2741 SSLE (High Force)
*Bob Reese 2741, **P. D. Thacher, 4341

7713 (Nuclear Radiation)
*D.L Sinton 7715, **P. D. Thacher, 4341

Survey Schedule was as indicated in attachment 2, AGENDA FOR TECHNICAL SURVEY KICK-OFF MEETING, of this report.

Summary:

Overall, the standards and calibration program for SNL in Albuquerque was found to be, to an acceptable degree, in accordance with AL57XA, as well as with good laboratory and quality assurance practices. There were no deficiencies or areas of concern. There are general comments and some specific discussion items for the operational and project groups evaluated, as noted below.

Discussion:

General Comments:

1. Calibration Histories are retained permanently.

2. Uncertainties are supported by the standards used and by uncertainty analyses, although the analyses range in formality. The records included the standard's uncertainty in the test measurement uncertainty.

3. Personnel are well trained and knowledgeable in measurement technique and data analysis. All of the contract personnel in the Electrical, Temperature, and Humidity group, and some of the Sandia staff, are graduates of the DoD PMEL Metrology Training Program.

4. Certificates and reports reviewed during the survey had adequate information.

5. Calibration Procedures are in place but in some cases are being rewritten to comply with recent quality initiatives.

6. Environmental recording and controls are good in most of the labs except as noted elsewhere in this report.

7. Improvements in facilities, equipment, procedures, and organization are evident throughout the Sandia Standards and Calibration Program.

8. Turnaround is excellent in all labs.

9. Traceability is almost always to PSL/NIST or an approved lab, although in a few cases it is not. In the latter cases, the traceability appears to be adequate, with better documentation being addressed as discussed below.

10. Workload continues to increase, and in some areas, there is serious understaffing as discussed below.

11. QA Indoctrination is provided to personnel through ongoing Sandia initiatives and informally by lead personnel in each area.

Specific Comments and Discussion Items:

1. Division 2414 SSL

This group performs calibrations for the SNL Albuquerque line organizations in the electrical, time and frequency disciplines, as well as working standards and/or auxiliary calibrating devices for itself and other SSL, SSLE and ACS groups. In addition, it also performs calibrations for the PSL where uncertainties needed are within the capabilities of this group.

Rick Crabb (MTS) is project leader and overall coordinator for the standards and calibration program, reporting to R. C. Lindsey, Division 2414 Supervisor. Reporting to Crabb are three Sandia Labs STA metrologists, Harry Pike, Mel Salazar, and Georgia Brown; and seven contract calibration technicians, including Jerry LaMarr and F. G. Cajas from the temperature/humidity subgroup, L. B. Saylors, E. A. Benedict, J. R. Boren, M. K. Deveraux, T. P. Douglas and R. M. Walker from electrical standards.

W. B. Leisher (SMTS) is project leader of the Physical Standards group, reporting to R. C. Lindsey. Reporting to Leisher are Sandia Labs TA metrologist F. N. Rebarchik, and S. A. Harbour, and D. A. Sanchez, contractors.

Building 892 SSL Electrical; Time, Frequency, Division 2414 (Rick Crabb, Project Leader)

1a. The Sandia Standards Laboratory operation needs to institute a formal review procedure for certifying the proper operation of new calibration systems or procedures before they are used for customer certifications.

b. A temperature/humidity recorder in 892/111, file T1977, had an expired calibration label, expiration date 10/19/91, and no indication of its current expired status. Personnel in the area indicated that the recall notice for this device was sent to J. J. Lamarr in building 894.

c. The SSL is commended for investigating the need to control the M&TE used by contractor service technicians who may "calibrate" Sandia equipment. In addition, the SSL is investigating the traceability and proper labeling of balances at Sandia that are also serviced under contract.

d. The SSL calibration data file storage system in 892/111 does not currently provide sufficient protection from fire or water damage. Consideration should be given to upgrading the file protection especially in the new WPPSL building.

e. Checks among the recall system, calibration data and the calibration labels all agreed.

f. A Newport temperature probe used in an oil bath in 892/111, file T1211, is calibrated to an uncertainty of ±0.1°C. On the certificate, data are given for the true temperature reading along with the actual readings of the Newport probe and differences of 0.05°C are common. It was not clear from the statement on the certificate that the uncertainty applied to corrected readings of the device, not the actual readings. Personnel using the device stated the uncertainty applied to the actual readings. Therefore, the statement on the certificate or the uncertainty needs to be clarified.

g. A Singer Gertsch Model 1011 AC Ratio Standard, file number E915, S/N 614 quotes two different uncertainty values dependent on the frequency range of operation, one for 50 Hz ≤f ≤1 kHz, and one for 1 kHz ≤f ≤10 kHz. The calibration was performed at only one frequency, and that frequency was not recorded in the calibration data file. This calibration should be performed at a minimum of one frequency in each of the two ranges listed in the certificate, and the actual frequency of calibration should be recorded with the calibration data.

h. The SSL has done an excellent job interfacing Fluke 732A DC voltage references (in place of standard cells) to their Guildline 9930 potentiometers. They maintain logs of the daily variation of the DC voltage reference potential.

The Handcarry Standard Capacitor audit was successfully completed, as tabulated below.

GR Standard Capacitor, Mod 1403A, (F/N 0101Z)

Nominal (pF)	Measured Values (pF) PSL	SSL	Diff.* (ppm)	Uncertainties (±) ppm) SSL	PSL	(PSL + SSL)
1000	1000.53	1000.5	0*	500	200	700

*For a PSL value rounded to one decimal.

Building 894/151 SSL Temperature Lab, Division 2414 (Rick Crabb, Project Leader)

2a. A liquid in glass thermometer in 894/151, file T188, was calibrated on June 19, 1991. At the calibration point of 91.146°C, the thermometer read 91.00°C, a difference of 0.146°C. Since the uncertainty of the thermometer is ±0.10°C, this calibration point was out of tolerance. However there was no indication in the data file that the out of tolerance condition was transmitted to the user.

b. On the Special Platinum Resistance Thermometer (SPRT) used as a temperature standard in 894/151, PSL file 1010G, the certificate states that the calibration expires whenever R_o changes by more than 0.001 Ω.

The R_o value reported by the PSL was 25.5769 Ω. Several checks of R_o have been performed by the temperature laboratory, and on February 1991 R_o was measured as 25.5784 Ω, a change of 0.0015 Ω from the initial value. Based on the expiration criteria, the calibration of the SPRT should have been expired and the device returned for calibration.

Building 828/6 SSL Acceleration, Pressure, Flow, Force, Division 2414 Bill Leisher, Project Leader)

3a. In the physical calibration laboratory in 828/6, all calibration data are stored on computer systems and long term backup is on magnetic media. While this media is currently stored in fire proof safes, the readability of the backup files remains in question since computer systems and hardware are constantly changing. Therefore, some thought should be given to the long term storage medium so that retrieval will not become a problem in the future.

b. The environmental control in 828/6 is less than desirable and the area is subject to large temperature and humidity variations. While the laboratory temperature is being continuously monitored, there are no criteria for suspending calibrations in specific areas if the temperature or humidity is outside defined limits. Large temperature variations may be a particular problem for Baratron pressure devices and piston gages.

c. In building 828/6, the mechanical calibration data on the Sierra gas flow system glass tubes (serial numbers 89, 610, and 431) were not available during the survey. When the data are located, the computer analysis program that uses these data should be checked for proper data entry.

d. Uncertainty budgets are in place for only two out of eight calibration stations, the shaker & the small centrifuge. Plans are to implement the same for all systems, and the survey team encourages the plan.

e. The centrifuge speeds are monitored by a magnetic proximity detector which detects each of the 600 teeth on a gear mounted to the spinning portion. If only one of the 600 teeth being counted is magnetically 'soft' and hence missed, then the indicated rotation rate would be 0.2% less than the actual rate. The PSL suggests doing both of the following:

1. Rotate the centrifuge through 360° and confirm that the counter counts 600 teeth.
2. At high speeds, one can do a FFT of the counter output. The indicated output spectrum should have only one peak at a frequency of 600 Ω, where Ω is the rotation rate. Any peak at 300 Ω would indicate that one tooth was being skipped: at 200 Ω that two teeth in a row were being skipped, etc. This seems like a cheap yet very

effective quality control technique. It could also be automated quite readily.

f. ARI Model RTD, serial number 8292-2 was expired and also did not have half of the decal.

g. There was inconsistency in the use of out-of-service tags. There were two cases where out-of-service tags were not filled out although others were. The policy on use of these tags should be reviewed and implemented.

h. The operating procedure on the Unholtz-Dickie, 100g Shaker was exceptionally well written.

Building 20245 ACS Instrument Repair Section, 2414-1 (Bob Fleming, Section Supervisor)

4a. The staff is looking into the need for calibration of the instruments used by the factory service representatives. The PSL commends this effort and recommends resolution.

b. In light of the recent move into this building, the facility was found to be very orderly.

Buildings 869, 818 SSLE Health Physics Facility, Division 7715, Radiation (A. L. Stanley)

5a. Org 7715 is commended for its obvious increased emphasis in fulfilling the requirements of DOE Order 57XA.

b. They have very good follow up recall policy after second notice are ignored.

c. As the intent is to fully conform to 57XA, the survey team suggests that the following areas need to be addressed/considered:

* No uncertainties on labels, and uncertainties are assumed to be manufacturers specifications.
* Lack of program to determine when an artifact should be readjusted or called out-of-tolerance.
* Need to identify, somehow, all standards used on the calibration data sheets to insure traceability.
* If environmental parameters affect the instrument, the user should be made aware of them.
* Particularly in building 818, a number of instruments were found with no labels or improperly labeled. A program to correct the labeling problem needs to be emplaced.

Organization 7715 can contact appropriate PSL personnel for help in addressing these issues.

d. Calibrations are to manufacturer's specifications, but these specifications are not easily found in the manufacturers publications. Some kind of covering document could supplement the instrument sticker and alert the user to tolerance limits, whether adjustments need to be made at the time of calibration, and special conditions of use.

e. Gamma calibrations are based on Victoreen, which is given a US Health Physics Association evaluation but not an evaluation by NIST. Division 7715 should reevaluate the rational for not obtaining calibration from NIST.

f. Separate, marked areas should be used for out of service equipment, or the equipment should be so labelled.

g. Org. 7715 has a serious lack of manpower for all the extra safety-related calibration work.

Building 860 SSLE High Force Facility, Division 2741 (Bob Reese)

6a. The uncertainty analysis for the Structural Mechanics Laboratory which culminated in a SAND document (SAND88-2847) was very good.

b. A BL pressure transducer S/N 10003 was expired and not tagged to be out-of-service.

c. A Precise Sensor pressure transducer S/N 19990 was expired and not tagged to be out-of-service.

Building 878 SSLE Mechanical Support Section, Organization 2485-5 (C. L. Atwood, section supervisor)
(Very limited survey)

7a. Environmental controls not working at the time of the last survey (because of the move into the new facility) are now adequate.

b. The facility and equipment are very orderly and well kept.

c. Reverse traceability is manual and very slow but adequate for the limited need encountered.

The Handcarry gage block audit was successfully completed, as tabulated below.

English Gage Blocks (F/N 2506A)

Nominal (inches)	Deviation (SSL) (μ inches)	Deviation (PSL) (μ inches)	Difference SSL-PSL (μ inches)	Uncertainties PSL (μ inches)	SSL (μ inches)	PSL+SSL (μ inches)
0.050	+5	+4.7	+0.31	±3	±7	±10
0.1001	-1	-1.7	+0.7	±3	±7	±10
0.128	0	+0.1	-0.1	±3	±7	±10
0.142	+1	+1.5	-0.5	±3	±7	±10
0.600	+2	+0.5	+1.5	±3	±7	±10
3.000	- 13	-12.7	-0.3	±5	±9	±14

Comments at end of closeout meeting:

Concerns voiced at the survey closeout meeting by the SSL:

1. More communication and coordination is needed among the PSL, SSL, and SSLEs.

2. A mechanism needs to be developed for getting PSL obligations mentioned in the closeout meeting onto an action list.

As a result, R. T. Johnson, 4340, and R. C. Lindsey, 2414, established a PMT for CSL concerns as well as for survey actions.

The preceding items were discussed at a closeout meeting on October 24, 1991.

Those in attendance were:

Name	Organization
F. Garcia Jr.	4343
H. Pike	2414
R. L. Crabb	2414
R. G. Fleming	2414
M. Salazar	2414
R. T. Johnson Jr.	4340
R. C Lindsey	2414
D. Zelnio	2414
W. G. T. Levy	4343
W. B. Leisher	2414
R. D. Moyer	4342
G. Brown	2414
C. Atwood	2485-5
R. B. Pettit	4342
R. Duncan	4342
P. D. Thacher	4341
D. Sinton	7715
J. F. Gonzales	2485

PRIMARY STANDARDS LABORATORY

Sandia National Laboratories, Albuquerque, New Mexico 87185

February 8,1994

Mr. J. M. Eckart, Chief
Quality Programs Branch
Weapons Quality Division
DOE Albuquerque Operations Office
P. O. Box 5400
Albuquerque, New Mexico 87115

Subject: Survey of the Standards and Calibration Program of Sandia National Laboratories/New Mexico (SNL/NM), December 13-17, 1993

Objective:

The survey was performed to evaluate the SNL/NM standards and calibration program for conformance to AL Supplemental Directive 57XA (AL57XA), EP401560 which is the SNL implementation of AL57XA and to good laboratory practice with particular emphasis on the technical aspects of the program.

Introduction:

In conformance with the specific requirements of AL57XA, 6.e.(1) and 6.(f)(2)(a), Sandia National Laboratories has established a Standards and Calibration Program (SCP) including a Contractor Standards Laboratory (CSL) function. Weapons and weapons related, general operations, and non-weapons activities which affect quality are covered by the SCP. Such activities which include, but are not limited to: obtaining reportable data; measuring environmental, safety, and health (ES&H) related parameters; establishing design specifications; evaluating or testing materials or systems; or testing product must be accomplished using instruments which are calibrated to the degree necessary to meet program requirements. SNL's SCP is governed by EP 401560, "Engineering Procedure, Calibration Program". It is the responsibility of the user to determine which instruments require calibration. However, once the determination is made, the calibration requirements of EP 401560 apply. Oversight of the validity of the user's decision is the responsibility of whoever oversees compliance with QC-1, QC-2 and/or MIIP (Management Integration and Implementation Project whose requirements are intended to comply with both DOE Order 5700.6C and Conduct of Operations, DOE Order 5480.19). Oversight of the process for obtaining calibration, however, is the responsibility of the CSL as a continuing function and the PSL as part of its periodic oversight of each Nuclear Weapons Contractor's (NWC) SCP.

At its New Mexico facility the CSL function consists of the following:

The Sandia Standards Laboratory (SSL) for Physical; Electronic, Time and Frequency; and Temperature and Humidity in Department 1744, the SSL Extension (SSLE) for Industrial Hygiene in Department 7712, the SSLE for Ionizing Radiation in Departments 7713 and 7715, the SSLE for High Force in Department 2742 and the SSLE for Dimension, Mass and Force in Organization 2484-1.

The manager of Department 1744 provides the coordination and oversight of the CSL function both of the SSLs within his department and the SSLE whatever their organization. He also oversees the SCP of operating organizations throughout the SNL.

Because the PSL is an organization under SNL, Mr. Eugene Dorneman, DOE/AL, Weapons Quality Division, Programs Planning Branch, agreed to attend the survey as part of the survey team. Usually when DOE/AL personnel accompany the PSL on a technical survey of the SCP of a NW Contractor, they function as observers. However, in this case as a team member Mr. Dorneman provided independence.

Summary:

There were no deficiencies. However there was one area of concern and some items for discussion listed below. Replies are requested to the area of concern as well as discussion items which have a "(R)" at the end of the item.

CHANGES IN ORGANIZATION:

At the time of the last survey the two SSLs had recently been transferred from projects within the PSL to a separate division, 2414, under Mr. Robert C. Lindsey. The Physical Lab had been a project within the Primary Physical Standards Division while the electrical SSL Lab had been a project within the PSL Measurement Standards Division. All PSL divisions reported to Mr. Ralph Johnson, manager of Department 7240. Mr. Lindsey, who also supervised the Instrument Calibration and Repair group, 2414-1, reported to Mr. Tom Young, Manager of the Electronic Interconnections, Packaging, and Calibration Department, 2410, in the Manufacturing Technologies Directorate, 2400, under Mr. W. E Alzheimer.

Since the last survey the 2414 and 2414-1 organizations were once again placed under the same program management as the PSL, and as a result of restructuring, they became part of the "PSL Program Office", which then became the "Measurement Standards Program Office, 4307, with Mr. Johnson as Program Manager. At that time Mr. Johnson, all three PSL department managers, 4341-43, and Mr. James M. Simons, manager, Dept. 4344, reported to Center Director, Mr. Charles Tapp, 4300, who in tern reported to Mr. C. P. Robinson, Vice President (VP) 4000. Mr. Simons had replaced Mr. Lindsey after the latter's retirement and Mr. Leroy Holmes had replaced Mr. Robert G. Fleming as team leader of 4344-1 when Mr. Fleming retired.

At the time of the survey (Dec. 13-17, 1993), officially, the Measurement Standards Program Office had been transferred to the Research & Exploratory Technology Division, 1000, under VP A. R. C. Westwood with all department managers in the Office reporting directly to Mr. Westwood. Their organizations merely changing the first two digits from 43 to 10 except for the Office itself which changed from 4307 to 1040. (effective on January 7, 1994 the Office became part of the 1000 Division's 1700 Center under Mr. Robert J. Eagan, Director. Note: Henceforth in this report the current organization numbers will be used.

In the SSL a reduction in staff of one Sandian and one contractor was experienced in the Physical area and in the Electrical area a reduction of one Sandian was already in effect and soon a reduction of two contractors are expected, one effective in January and one in February 1994.

In Organization 2484-1 there was a decrease of one Sandian.

In Dept. 7711 the was a decrease of one Sandian. In Dept. 7713 an increase of one Sandian and one contractor was experienced while in Dept. 7715 an increase of one Sandian had occurred.

NEW AND UPGRADED EQUIPMENT

In the electrical area a new automated multi-channel potentiometer and a Fluke 8000A MET/CAL software system for automated calibrations of most electronic devices including multimeters and oscilloscopes had been added to their equipment inventory.

In the physical lab an upgrade of their Vacuum Calibration System was accomplished by the receipt of new capacitance monometer reference standard heads.

AREAS SURVEYED [Surveyors (FTST = full time survey team)]

Environmental Test Org, Bldgs 860 (Temperature & Vibration); 882 (Shock) [FTST]

Bldg 891 Tube Lab, Org 2566-1 [FTST plus P. Thacher]

Bldg 643 Exploratory Batteries, Dept. 2523 [FTST]

Bldg 20245 Calibration and Repair, Org 1744-1 [FTST]

Bldg 828 SSL Physical Lab, Dept. 1744 [FTST plus J. Gregory and R. Romero]

Bldg 869 SSLE Industrial Hygiene, Dept. 7712 [FTST plus J. Guthrie and P. Thacher]

Bldg 878 SSLE Dimensional/Mass/Low Force, Org 2484-1 [FTST plus J. Kwak]

Bldg 869 Radiation Protection and Engineering, Dept. 7715 and Dept. 7713, respectively [FTST plus J. Guthrie and P. Thacher]

Bldg 860 High Force, Dept. 2742 [FTST plus J. Gregory]

Bldg 894 Temperature/Humidity, Dept. 1744 [FTST plus PJ Spellman]

Bldg 892 Electrical Lab, Dept. 1744 [FTST plus S. Booker and PJ Spellman]

Environmental Restoration Dept. III 7584 [L. Azevedo]

Discussion:

The overall status of the of the SNL Standards and Calibration Program is as follows: (Detailed discussions are presented by organization in the discussion items below)

a. Substantial improvement has occurred since the last (October 1991) survey in the calibrating organizations, SSL, SSLEs and calibration stations, visited during this survey. Some further improvements indicated for these organizations, are itemized below by organization in the discussion items. Overall they are adequately implementing standards and calibration programs in accordance with AL57XA/EP401560.

b. There is a wide range of conformance on the part of the three operating organizations to SNLs calibration program requirements with a large factor being awareness of requirements. Each organization should have a documented process for addressing calibration issues. Special emphasis should be placed on the type of devices requiring calibration, intervals and sources of calibration and proper process for reporting and resolving outside of tolerance (OOT) conditions. Dept. 1744 should be contacted for assistance.

c. Technical competence overall is high for both operating and calibrating organizations visited.

d. In-depth error analyses were found to be lacking in several areas. Guidance from the PSL is available. All calibrating groups are encouraged to address this subject to enhance the quality of calibrations across SNL. This is especially important with computer-driven calibration processes in which the software performs the error analysis. With a change in personnel, new personnel may not understand all of the sources of error in a measurement. A graded approach for documenting error analyses should be used with emphasis on adding value and enhancing service to the customer.

e. Conformance to the Management Integration and Implementation Program (MIIP) by the line organizations with required documentation was generally good. Improvements need to be made to the process, however, as it does not appropriately address calibration needs for line organizations. As a result, line organizations just perform the MIIP documentation and then create their own implementing process without appropriate pointers to existing support organizations at SNL and existing procedures.

f. Attention to procedures for procurement of calibration services from commercial suppliers needs improvement for operating organizations and SSLE. Finalization of PSLM 28 will provide DOE/AL complex-wide guidance in this area and should permit SNL to adequately address this subject and provide consistency for outside calibration procurement. Pending finalization of the SNL outside calibration plan implementing the PSLM 28 guidance for procurement of such calibrations, organizations should contact Dept. 1744 for assistance.

g. Facilities and equipment were adequate as was housekeeping except as noted below.

h. Environmental controls in the SSL, SSLE and calibration stations visited in general were adequate. There is a policy to suspend operations when conditions were judged to be outside of acceptable bounds.

AREA OF CONCERN

The area of concern was in Dept: 2523's Exploratory Batteries Bldg 643 test area. There was a lack of calibration of a substantial number of test systems and/or instruments being used to test devices in the area. Not only were items being used that had never been calibrated but a test had been started earlier that day on a test system, where three out of the four chambers that are normally calibrated, were out of calibration. The user was not familiar with EP401560, SNL's calibration program which implements the DOE/AL Supplemental Directive AL57XA. The survey team recommends EP401560 be obtained by Dept. 2523 and a calibration program commensurate with their needs be established with the assistance of the Dept. 1744 SSL as appropriate. The implementation should be reviewed by Dept. 1744. Because of the limited number of operating organizations visited during this survey it is not known whether the Dept. 2523 Lab in Bldg 643 was representative of operating organizations in Dept. 2523 or other Dept.s at Sandia. Internal audits by cognizant assessors with metrology inputs is one way to answer such questions and aid in providing a remedy if such is the case.

DISCUSSION ITEMS

The discussion items mentioned above are as follows:

Dept. 2742 Environmental Test Area (Temperature and Vibration in Bldg 860 and Shock in Bldg 882)

1. In the 2742 environmental test areas visited in both Bldgs 860 and 882, MIIP implementation and documentation was noteworthy. One particular example is that when the "special measurement" block is checked, a management overview is performed.

2. Also in the Bldg 860 area, a review of procedures for use of such tags as "Limited Calibration" and "Equipment Not In Use", etc. is indicated. There were several instances where these tags were not used properly.(R)

3. There were inconsistencies in the performance of chamber characterizations, i.e., temperature gradient determinations, by 2742. The required yearly measurements had not routinely been performed at that frequency.(R)

4. In Dept. 2742's Shock Testing Area of Bldg 882, operations were properly conducted with the calibration procedure for the Nicolet 4094B particularly noteworthy.

Org 2566-1's Bldg 891 Tube Lab

5. The Tube Lab relies heavily on commercial calibration suppliers for everything but temperature. Some examples are determinations or calibrations for gas mixtures, balances, film thicknesses and surface roughness. A review is needed to determine whether other options including internal support are indicated and which of those outside sources which will be used should be made a Commercial Calibration Laboratory (CCL) or a

Designated Calibration Source (DCS) in accordance with AL57XA, Rev 2. The SSL and, where appropriate the PSL, should be requested to provide consultation and assistance.(R)

6. An example of a Tube Lab area where help may be in order is for balances. Check weights could be calibrated for this area by the 2484-1 SSLE and used by the Tube Lab to monitor the performance of their balances.(R)

7. Another such Tube Lab area is in the measurement of film thickness where 2566-1 has ordered equipment which utilizes backscattered electrons to infer film thickness. Messrs Thacher and Kwak of the PSL's Radiation and Dimensional projects, respectively, can provide consultation for these measurements.(R)

Org 1744-1 Calibration and Repair area (Bldg 20245)

8. In the 1744-1 Calibration and Repair area less than half of items recalled are actually returned. Since AL57XA requires a reasonable effort to achieve loop closure for calibrated items which have been used since their last calibration, more diligence is needed in the follow-up of cases where there is not a satisfactory response to recall notices.(R)

9. 1744-1 should review their policy for applying "Tamper-Evident" seals to instruments which they have calibrated. The application of such seals is presently not being uniformly implemented.(R)

10. 1744-1 should also review their Out of Tolerance (OOT) notification procedures to insure that the OOT situation is clearly stated. In two cases an OOT notice for a Honeywell, Model CL111, 2 Pen Temperature Recorder and one for a Honeywell, Model CL112, Temperature Recorder were checked with the customer in Org 2471-2. Complete information was not available on the notices for the customer to determine whether the OOT conditions were likely to affect his processes. In the latter (CL112) case the term "significant" was used which would normally suggest referring to the calibration record. "Significant" was not used in the former (CL111) case. The OOT Action Form (Notice) should quantify the amount of deviation relative to the tolerance. In the former, CL111, case the deviation was from 15°C at 100 °C to 5.9°C at 1000°C vs a 4.8°C tolerance and in the latter, CL112, case the deviation was approximately 15°C for the whole range of 100 to 1100°C vs a 3.6°C tolerance. The customer is currently evaluating the effects of these OOT occurrences on his processes although the CL111 recorder has been used only in the range above 1000°C where the maximum deviation was 3.3°C. As an aid to the improvement of OOT procedures use of the Radiation Protection Engineering Department (7713) "Out Of Tolerance Reporting" procedure (#RIP-01-0016) as a guide document is recommended.(R)

SSL Physical Calibration Lab (PCL) Dept. 1744, (Bldg 828)

11. In the Bldg 828 SSL PCL consideration might be given to assigning an ID# to each device being calibrated, at least those calibrated for another calibration organization.(R)

12. The SSL PCL is commended for their program to cross train their calibration personnel.

13. Supplemental calibration information that was provided by the PCL to a customer for an Ashcroft (1305D) deadweight gage was not retrievable by the PCL due to limitations in the data storage method on the HP 1000 computer. The PCL should develop a method to keep additional information for such special cases. A separate handwritten log book could be maintained for recording supplementary calibration data.(R)

14. The follow-up from the last survey report was completed except for error analyses. A good start has been made but considerable effort remains. One analysis (for the shaker) considers only the case for a capacitor with a 0.1% uncertainty, however, there are cases where other capacitors with uncertainties up to 1.0% are also used. The current RSS analysis results in an uncertainity of 2.7%. Although the 2.7% uncertainty is not much tighter than the 2.9% value, (the larger uncertainty results from a more detailed analysis which includes the worst case 1% capacitor and a 0.5% allowance for the uncertaintity of the linear fit not presently included), a complete analysis should be made for each calibration system.(R)

15. There is considerable room for improvement in overall housekeeping in the PCL.(R)

16. The PLA overall is providing good services for their customers.

17. With the use of the Hewlet Packard (HP) 1000 the PLA can retrieve historical calibration data in a very efficient manner.

18. The uncertainty given on the calibration report for the pressure transducer calibrated by Allied-Signal/KC did not include an allowance for the uncertainty of the standards used. If Allied-Signal/KC does not include the uncertainty contribution of the standards the SSL should do so. A total uncertainty and interval should be assigned to all certifications, if not by the calibrating organization then by the user.(R)

19. The accelerometer and pressure transducer measurement audits were successfully completed as detailed in the tabulations later in this report.

Industrial Hygiene Dept. (IHD) 7712 (Bldg 869)

20. There has been improvement in the IHD in general since the 1991 survey; records in particular look good.

21. Only one of the outside calibration sources, "Instrument Services" had been surveyed and approved as a CCL. An additional source had been visited but no particular procedure had been followed and the results had not been documented. The other sources had not been assessed. Sources for calibration of instruments making high impact measurements should be made a CCL or DCS. High impact measurements should be identified and documented. The overall subject of procuring calibrations from commercial contractors using a graded approach should be addressed with assistance from the SSL as necessary.(R)

22. Documentation of cross-checks performed on instruments as they leave and come back should be implemented.(R)

23. MIIP conformance is good

Org 2484-1 SSLE Dimensional, Mass and Low Force

24. 2484-1 is commended for their overall good job under rather adverse conditions, including planning for an expedited move to a new building.

25. The data sheet for a force gage, SNL-2045, C-15, had measured values at 4 lbs and 7 lbs (nominal) which were out of tolerance (4.2 and 7.2 lbs or approx. 3 and 5 %, respectively, vs a 2% tolerance). This OOT condition was not noted on the certificate or elsewhere.(R)

26. Cross checks of reference gage blocks sent to and received from the PSL are not being performed. Cross checks should either be performed or the rationale for not so doing should be documented.(R)

27. Concern was expressed by this SSLE that two temperature devices, a mercury in glass thermometer and a digital thermometer system (both calibrated by the SSL Temperature/Humidity Lab) which usually tracked closely seemed at the time of the survey to differ by larger than expected amounts. Since data were not available, it is suggested that data be collected from the two devices sensing essentially the same location to verify whether or not the differences are within that expected by their uncertainties.(R)

28. The gage block measurement audit was successful completed as detailed in the tabulations later in this report.

Radiation Protection Measurements Dept. 7715 and Engineering Dept. 7713, (Bldg 869)

29. The issues raised from the 1991 survey have been properly addressed except that the R chamber calibration using Victoreen still needs to be resolved. Three possible ways to resolve the R chamber calibration question is to evaluate Victoreen as a CCL, use NIST, or use K&S Associates, Nashville, TN, which has been approved as a CCL by the Mason & Hanger Pantex Plant's CCL. In any case the rationale for the 3 ± 4 % offset between Victoreen and NIST should resolved. Mr. Phil Thacher, PSL Radiation Project Leader should be consulted further is this area.(R)

30. Substantial overall progress has been made in these radiation measurement and engineering areas since the 1991 survey especially in the area of documentation in general and procedures in particular. One procedure that is particularly noteworthy and is being recommended to other groups as a guide is the procedure for "Out Of Tolerance Reporting".

31. Also they are commended for their participation in measurement intercomparisons with other facilities.

32. A review of the present calibration intervals is recommended. Data may permit an increase in some intervals with a consequent saving of resources.(R)

33. Beta measurements are presently not formally traceable through the PSL. The PSL will review its resources to determine how help in the beta calibration area could be accomplished.(R)

34. Mr. Bruce Barnaby is presently consulting on some aspects of tritium calibrations.

SSL Temperature/Humidity Lab 1744, (Bldg 894)

35. R_0 for Standard Platinum Resistance Thermometers (SPRT), i.e. the SPRT resistance at 0°C, is not routinely being recorded for SPRTs. The SSL's SPRT is calibrated by the PSL which, as stated on the SPRT calibration certificate, establishes the expiration criteria as a shift in the R_0 value of greater than 0.001 ohms. The recording of the R_0 value is necessary to document that the SPRT is still within its calibration interval.(R)

36. No certificate had been written on the gallium cell. The PSL will assist in this area. An intercomparison should be performed to serve as the basis for writing the gallium cell certificate.(R)

37. Error analyses need to be reviewed for temperature in general and for SPRT in particular. The PSL will consult with the SSL on this matter also. This project will integrate with the PSL when the move to the new building is completed for the PSL and SSL projects at which time the error analyses can be completed. In the interim, assistance in all areas of temperature measurement is available from the PSL.(R)

SSL Electrical Lab Dept. 1744, (Bldg 892)

38. The OOT process in general is being implemented and documented very well.

39. This Lab is commended for its maintenance of its primary frequency standard system which includes daily monitoring of the system.

40. A Rubidium Frequency Standard (F/N 5668) was calibrated on 6/29/92 (expiring 3/29/93). It had subsequently been adjusted on 1/4/93 from (532 to 548 on the fine frequency dial) but no new certificate had been written

although any adjustment performed after a calibration nullifies the preadjustment calibration. A determination of the effect, if any, on measurements made with this device should be made and appropriate action taken. (R)

41. A Fluke 5200A AC Calibrator (F/N 850) had been certified on 12/15/92. However, the last recorded frequency data was 9/5/89. In addition notations of "Bad Connector" and "Failed" for 5 voltage data points had been made on the data sheet dated 12/14/92 but there was no such notation on the certificate. Also the certificate showed tolerances for the 10 to 30 Hz frequency range but did not show how frequency measurements in this range were made nor did they show their method for measuring or inferring voltages below 1 volt, particularily below 50 Hz. This calibration and calibration procedure should be reviewed. (R)

42. The SSL is starting to use calibration procedures received from Newark AFB without verifying them. All procedures should be checked out before an actual calibration is made regardless of the source. (R)

43. Several data points on an automated system show "marginal" in the pass/fail column but there is no confirmation that they really are marginal. Since this program was written in PASCAL with which the SSL has little experience they should either become more familiar with the language or obtain help from someone who is PASCAL trained and able to modify the software. (R)

44. The SSL successfully passed a 100 mH inductor, a 30 dB attenuator, a Thomas 1 ohm and 1 Mohm resistor measurement audit. (See detailed tabulations later in this report.) However, although the 17 ppm difference for the Thomas 1 ohm is well within the 50 ppm uncertainty claimed by this Lab it is somewhat greater than would normally be expected. This measurement should be jointly investigated by the SSL and PSL to determine whether the measuring system used for the Thomas 1 ohm resistor might yield better accuracies should a future need arise for a smaller measurement uncertainty or whether an alternate measurement system would be required in such a case. (R)

45. Where feasible consideration should be given to putting a thermometer in the well of the resistor when such is being used outside an oil bath. (R)

46. When calibrating a multifunction device where more than one resistor of the same value are used to calibrate two different functions, some method should be found to indicate which resistors were used for each function. (R)

47. Overall traceability and uncertainties were good.

48. The SSL is commended for listing the actual tolerances against which the calibration is performed rather than calling out "manufacturer's tolerance". When this is done confusion is eliminated as to which set of manufacturer's tolerances are intended.

SSLE High Force Lab Dept. 2761-3 (Bldg 860)

49. Substantial overall progress has occurred since the 1991 survey particularily in proper documentation and personnel commitment.

50. The label for a plug-in card for an 22 klbf MTS load machine had expired. The last calibration was in 1987.(R)

51. This SSLE lab is commended for a overall good calibration and certificate written on each of two 2500 lbf load cells, S/N 08997-1 and S/N 010248-2, performed by Mr. S. L. Toledo, 2742. One improvement should be made on future certificates by an addition "Of Range" or "Of Reading" as the case may be to the tolerance statement.(R)

52. Presently customers items are not being recalled. Consideration should be given to establishing a recall system or using the SSL recall system to recall appropriate items.(R)

53. Several expired items were found: pressure transducers in an equipment drawer, a Wallace and Tiernan gage and a load cell on one of the work benches.(R)

54. The MTS certificates need to identify the uncertainties or tolerances to which load cells are calibrated. SATEC, formerly Metallurgical Consultants, not only indicates the tolerances on their certificates but also the standards used and the expiration dates of the standards.(R)

55. Approval of both MTS and SATEC as CCLs has expired. Dept. 1744 should assist this group in arranging for the reapproval of these two contractors unless other arrangements for calibrating the load machines can be made.(R)

Environmental Restoration III, Dept. 7584

56. Mr. Larry Azevedo of the survey team discussed the status of the calibration program for the Environmental Protection Organization with Ms. Sharissa Young of Dept. 7584. Considerable help is needed from and will be provided by the SSL and/or the PSL in setting up a system.(R)

HANDCARRY MEASUREMENT AUDITS

The SNL/NM measurement audit exercises handcarried for comparison were all graded as "Successfully Completed." The data for these measurement audit exercises confirm measurement differences to be within the combined PSL and SNL/NM uncertainties are tabulated below. ***

1 OHM NBS RESISTOR (F/N 4889V) &1 MOHM NBS RESISTOR (F/N 9723V)

Nominal	Measured Values (Ohms)		Diff. (ppm)	Uncertainties (±ppm)		
(OHM)	PSL	SNL/NM	(SNL/NM-PSL)	SNL/NM	PSL	SNL/NM+PSL
1	0.999999	0.999982	17***	50	1	51
1 M	10,000,008.	10,000,019.	11	50	7	57

*** See Discussion Item # 43.

1482L INDUCTOR STANDARD, (F/N 5325Z)

NOMINAL	MEASURED VALUES (mH)		DIFF. (ppm)	UNCERTAINTIES (± ppm)		
(mH)	PSL	SNL/NM	(SNL/NM-PSL)	SNL/NM	PSL	(SNL/NM+PSL)
100	100.013	100.06	470	1000	240	1240

NARDA 30 dB ATTENUATOR (F/N 4507)

Freq.	S21 Mag. (dB)		Diff. (dB)	Uncertainties (±dB)		
(MHz)	PSL	SSL	(SSL-PSL)	SSL	PSL	(PSL+SSL)
2500	-29.942	-29.935	0.007	0.260	0.216	0.476
4500	-29.941	-29.951	-0.010	0.270	0.228	0.498
5500	-29.931	-29.958	-0.027	0.276	0.235	0.511
7500	-29.894	-29.895	-0.001	0.292	0.254	0.546
9500	-29.792	-29.776	0.016	0.312	0.276	0.588
12400	-29.219	-29.218	0.001	0.343	0.311	0.654

Freq.	S11 Mag.		Diff.	Uncertainties (±)		
(MHz)	PSL	SSL	(SSL-PSL)	SSL	PSL	(PSL+SSL)
2500	0.0333	0.0350	0.0017	0.0353	0.0118	0.0471
4500	0.0370	0.0403	0.0033	0.0359	0.0135	0.0494
5500	0.0337	0.0361	0.0024	0.0363	0.0146	0.0509
7500	0.0418	0.0454	0.0036	0.0374	0.0171	0.0545
9500	0.0542	0.0527	-0.0015	0.0388	0.0199	0.0587
12400	0.0420	0.0434	0.0014	0.0412	0.0244	0.0656

Freq.	S22 Mag.		Diff.	Uncertainties (±)		
(MHz)	PSL	SSL	(SSL-PSL)	SSL	PSL	(PSL+SSL)
2500	0.0101	0.0242	0.0141	0.0353	0.0118	0.0471
4500	0.0217	0.0207	-0.0010	0.0359	0.0135	0.0494
5500	0.0217	0.0241	0.0024	0.0363	0.0146	0.0509
7500	0.0175	0.0081	-0.0094	0.0374	0.0171	0.0545
9500	0.0459	0.0301	-0.0158	0.0388	0.0199	0.0587
12400	0.0451	0.0555	0.0104	0.0412	0.0244	0.0656

PAROSCIENTIFIC PRESSURE TRANSDUCER, 0-100 PSIA, (F/N 7680E)

nominal value (torr)	PSL diff. (torr)	SSL diff. (torr)	SSL-PSL (torr)	SSL uncty. (±torr)	PSL uncty. (±torr)	SSL+PSL uncty. (±torr)
0.00	-0.96	1.43	2.39	10	2	12
500.00	-0.77	-0.90	-0.13	10	2	12
1000.00	-0.68	-1.43	-0.75	10	2	12
1500.00	-0.53	-1.37	-0.84	10	2	12
2000.00	-0.36	-1.16	-0.80	10	2	12
2500.00	-0.24	-0.98	-0.74	10	2	12
3000.00	-0.01	-0.95	-0.94	10	2	12
4000.00	0.28	-0.54	-0.82	10	2	12
4500.00	0.40	-0.53	-0.93	10	2	12
5000.00	0.28	-0.76	-1.04	10	2	12
2500.00	-0.21	-0.90	-0.69	10	2	12
0.00	-1.07	1.82	2.89	10	2	12

LENGTH 12, 10 GAGE BLOCKS, (F/N 10832)

Nominal Size (in)	Serial No.	Measured Deviation from nominal (μin) PSL	SSLE	Difference SSLE - PSL (μin)	Uncertainties (±μin) SSLE	PSL	PSL+SSLE
0.05	S584B	+2.3	+2.3	0.0	7	3	10
0.0625	S473A	+0.8	+2.0	+1.2	7	3	10
0.1003	S953A	-2.6	-3.6	-1.0	7	3	10
0.1008	S248B	-2.4	-2.3	+0.1	7	3	10
0.106	S736B	-0.4	-1.2	-0.8	7	3	10
0.12	4524	+1.4	+1.4	0.0	7	3	10
0.2	S853B	-0.5	-1.5	-1.0	7	3	10
0.4	S331B	-2.6	-1.6	+1.0	7	3	10
0.75	S352B	+7.4	+7.2	-0.2	7	3	10
2.0	S232B	+7.0	+7.2	+0.2	8	4	12

VIBRATION ACCELEROMETER, KISTLER 8081K, (F/N 4195F)

Vib. Freq. Hz	Accelerometer (PSL)	Sensitivity PC/G (SSL)	Diff % SSL-PSL	Uncertainties (±%) SSL	PSL	SSL+PSL
10	1.0225	1.04645	2.29	3.5	2.5	6.0
30	1.0231	1.02910	0.58	3.5	2.5	6.0
50	1.0235	1.02850	0.49	3.5	2.5	6.0
100	1.0249	1.02664	0.17	3.5	2.5	6.0
200	1.0254	1.02794	0.25	3.5	2.5	6.0
500	1.0256	1.02864	0.30	3.5	2.5	6.0
1000	1.0266	1.02941	0.27	3.5	2.5	6.0
1500	1.0284	1.03142	0.29	3.5	2.5	6.0
2000	1.0291	1.03379	0.45	3.5	2.5	6.0
2500	1.0320	1.03595	0.38	3.5	2.5	6.0
3000	1.0375	1.04994	1.18	3.5	2.5	6.0
3500	1.0397	1.04396	0.41	3.5	2.5	6.0
4000	1.0441	1.04873	0.44	3.5	2.5	6.0
4500	1.0489	1.05116	0.23	3.5	2.5	6.0
5000	1.0528	1.05575	0.28	3.5	2.5	6.0
5500	1.0570	1.06389	0.65	3.5	2.5	6.0
6000	1.0644	1.06895	0.43	3.5	2.5	6.0
6500	1.0685	1.07387	0.50	3.5	2.5	6.0
7000	1.0747	1.07582	0.10	3.5	2.5	6.0
7500	1.0823	1.08103	-0.12	3.5	2.5	6.0
8000	1.0894	1.09023	0.08	3.5	2.5	6.0
8500	1.0995	1.09956	0.01	3.5	2.5	6.0
9000	1.1074	1.11057	0.29	3.5	2.5	6.0
9500	1.1174	1.11950	0.19	3.5	2.5	6.0
10000	1.1262	1.13329	0.63	3.5	2.5	6.0

BLIND AUDITS

In addition three blind audits were chosen: an alpha survey meter, four weights from a Christian Becker weight set, which will be shipped to Sandia for measurement by the PSL and an HP 5316A Frequency Counter which belongs to the PSL AC Project and had been calibrated for this Project by the SSL Electrical Lab on 12/7/93. These devices will be measured by the PSL and results compared to those on the most recent SNL/NM data sheets received during the survey or in the case of the HP 5316A the SSL certificate which, like the device itself, is already in the possession of the AC Project.

The survey results were discussed at a close-out meeting attended by the following: (Note: The survey team consisted of those marked with an *, part time members are marked with **)

Name	Organization
L. J. Azevedo*	1741
B. E. Barnaby	1743
S. R. Booker**	1742
Georgia Brown	1744
Ken Conrad	2484-1
R. L. Crabb*	1743

Neil Davie	2742
E. T. Dorneman*	DOE/AL WQD
L. E. Duda*	1742
J. J. Gregory**	1743
Greg Guidarelli	7712
J. W. Guthrie**	1743
J. F. Kwak**	1741
W. G. T. Levy*	1743
Warren Lewis	7715
Frankie Potts	2742
R. R. Romero**	1741
Marlene Shields	2742
J. M. Simons	1744
P. J. Spellman**	1741
P. D. Thacher**	1741
W. F. Windle	1744

For questions regarding the subject survey please contact Mr. W. G. T. Levy, SNL/NM Department 1743, Area Code (505) 845-8268.

W. G. T. Levy, Surveys and
Audits Project
Department 1743

Bruce E. Barnaby, Manager
Measurement Standards
Department 1743

WGTL:1743:wgtl
s93 s/tlx.aa9

Copy to:

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1741	L. J. Azevedo
1742	R. B. Pettit
1743	B. E. Barnaby
1743	R. L. Crabb
1743	W. G. T. Levy (3)

Sandia Standards and Calibration Department
Sandia National Laboratories, Albuquerque, New Mexico 87185-0665

February 1, 1995

K. A. Carlson, Area Manager
DOE Kirtland Area Office
P. O. Box 5400
Albuquerque, New Mexico 87115-5400

Subject: Response to Report of Survey of the Standards and Calibration Program of Sandia National Laboratories/New Mexico, December 13-17, 1993.

The following is Sandia's response to the one Area of Concern and several items for discussion. The excerpts from the discussion paragraphs are repeated in this response for the readers convenience.

AREA OF CONCERN

The area of concern was in Dept. 2523's Exploratory Batteries Bldg. 643 test area. There was a lack of calibration of a substantial number of test systems and/or instruments being used to test devices in the area. Not only were items being used that had never been calibrated but a test had been started earlier that day on a test system, where three out of the four chambers that are normally calibrated, were out of calibration. The user was not familiar with EP401560, SNL's calibration program which implements the DOE/AL Supplemental Directive AL57XA. The survey team recommends EP401560 be obtained by Dept. 2523 and a calibration program commensurate with their needs be established with the assistance of the Dept. 1744 SSL as appropriate. The implementation should be reviewed by Dept. 1744. Because of the limited number of operating organizations visited during this survey it is not known whether the Dept. 2523 Lab in Bldg. 643 was representative of operating organizations in Dept. 2523 or other Depts. at Sandia. Internal audits by cognizant assessors with metrology inputs is one way to answer such questions and aid in providing a remedy if such is the case.

Response:

The manager of Department 2223 (formally 2523), Dan Doughty, was notified of this area of concern and was provided a copy of EP401560. He responded by having the Sandia Calibration Laboratory calibrate the test systems. Dan also reviewed all of the measuring and test equipment under his control to determine their calibration needs and submitted those items requiring calibration to the Sandia Calibration Laboratory for calibration. He also informed his staff of the need to use calibrated equipment when making measurements that affect quality.

The survey teams (and DOE's) concern as to whether this problem is representative of other organizations is well founded and is also a concern to the Sandia Standards Program personnel. An investigation, requested by DOE, of the Standards and Calibration Program identified five major problems that indicate that the problem seen in the Exploratory Batteries test area exists

in other areas at Sandia. A report of the investigation with action plans was provided to your organization by R. J. Eagan on May 23, 1994. The corrective actions are being implemented and are expected to bring Sandia into compliance with the requirements of AL 57XA which reflect those of "Best Industry Practice." Please note that these corrective actions also address several of the Discussion Items that follow.

DISCUSSION ITEMS

Note: The number before each paragraph corresponds to the discussion paragraph number in the survey report. Not all discussion items listed in the survey report require a response.

Org 2566-1's Bldg. 891 Tube Lab

5. The Tube Lab relies heavily on commercial calibration suppliers for everything but temperature. Some examples are determinations or calibrations for gas mixtures, balances, film thickness and surface roughness. A review is needed to determine whether other options including internal support are indicated and which of those outside sources which will be used should be made a Commercial Calibration Laboratory (CCL) or a Designated Calibration Source (DCS) in accordance with AL 57XA, Rev 2. The SSL and, where appropriate the PSL, should be requested to provide consultation and assistance.
6. An example of a Tube Lab area where help may be in order is for balances. Check weights could be calibrated for this area by the 2484-1 SSLE and used by the Tube Lab to monitor the performance of their balances.
7. Another such Tube Lab area is in the measurement of film thickness where 2566-1 has ordered equipment which utilizes backscattered electrons to infer film thickness. Messrs Thacher and Kwak of the PSL's Radiation and Dimensional projects, respectively, can provide consultation for these measurements.

   Response:

   A Production Metrology Team has been formed to address a number of calibration issues including these issues found by the survey team. The team members consists of staff from the metrology organization and various production and design organizations including two staff from the Tube Lab. Each issue identified by the team is being addressed by establishing sub-teams to define and implement corrective actions. The team feels that this process will help insure proper calibration of measuring and test equipment used for production and design activities at Sandia.

Org 1744-1 Calibration and Repair area (Bldg. 20245)

8. In the 1744-1 Calibration and Repair area less than half of the items recalled are actually returned. Since AL 57XA requires a reasonable effort to achieve loop closure for calibrated items which have been used since their last calibration, more diligence is needed in the follow-up of cases where there is not a satisfactory response to recall notices.

Response:

Presently a recall notice is sent to the owner of equipment due for calibration one week before the due date. A second recall notice is sent to the owner and his/her manager if no response is received within 30 days. Along with the second notice a memo reminding the manager of the requirement to perform a calibration or loop closure before an item can be removed from the calibration program is included. No further attempt is made to recall the instrument.

Two actions are being taken to eliminate this problem. First, a new recall system has been developed that is (we hope) "user friendly" yet fully states the requirement to respond to the notice. In this new system, if there is no response to the recall notice on or before the due date a reminder notices will be sent to the next level of management. If there is still no response then the calibrating organization will establish a person-to-person contact with the owning organization to resolve the problem. The item will remain in the recall system until a satisfactory response is received.

9. 1744-1 should review their policy for applying "Tamper-Evident" seals to instruments which they have calibrated. The application of such seals is presently not being uniformly implemented.

Response:

The 1144-1 (formally 1744-1) now uses Tamper-Evident seals on instruments which they have calibrated.

10. 1744-1 should also review their Out-of-Tolerance (OOT) notification procedures to insure that the OOT situation is clearly stated.

Response:

The current OOT form allows for complete explanation of an OOT condition. The two cases of OOT notices reviewed by the survey team indeed were not clearly stated. Two actions have been taken to correct this problem. First, all metrologists have been instructed to clearly state the OOT condition on the form, regardless of the percent of error found, and always include the as-found and as-left data along with the tolerance or uncertainty of the measurement Secondly, a copy of the completed OOT notice must by returned to the calibrating organization for inclusion with the calibration data file. The calibrating organization also must follow-up on all OOT notices not returned within 30 days.

SSL Physical Calibration Lab (PCL) Dept. 1744, (Bldg. 828)

11. In the Bldg. 828 SSL PCL consideration might be given to assigning an ID# to each device being calibrated, at least those calibrated for another calibration organization.

Response:

The present device identification system allows for positive ID of devices calibrated by the PCL. Devices are uniquely identified in the database by manufacture name, model number and serial number. An additional ID# might be useful in some cases but because many of the devices calibrated are to small to mark, it does not appear that an ID# would be functional. The present identification system will not be changed at this time.

13. Supplemental calibration information that was provided by the PCL to a customer for an Ashcroft (1305D) deadweight gage was not retrievable by the PCL due to limitations in the data storage method on the HP 1000 computer

Response:

Not all of the data for a specific calibration are stored in a single file on the computer. In fact, some supplemental data is not electronically stored at all; however, all supplemental calibration information for any calibration performed is available manually from logbooks and other sources that are maintained within the PCL.

14. The follow-up from the last survey report was completed except for error analyses. A good start has been made but considerable effort remains.

Response:

Error analyses has been completed and reviewed by the PSL for the King Neutronics station, the Force station, the dropball station and the two acceleration stations. The flow station has been eliminated which leaves four stations requiring error analyses work. Work is continuing on these station but reduction in the PCL staff has impacted our ability to support this effort. Consolidation with the Primary Standards Laboratory will hopefully allow support of this effort.

15. There is considerable room for improvement in overall housekeeping in the PCL.

Response:

The PCL is in a very old rundown facility and always looks bad. However, the general housekeeping in the PCL does need improvement. Since the survey, the PCL has made considerable progress in housekeeping. The project leader is taking the lead to insure housekeeping is not ignored.

18. The uncertainty given on the calibration report for the pressure transducer calibrated by Allied Signal/KC did not include an allowance for the uncertainty of the standards used. If Allied Signal/KC does not include the uncertainty contribution of the standards the SSL should do so. A total uncertainty and interval should be assigned to all certifications, if not by the calibrating organization then by the user.

Response:

This problem was also identified during a survey by the WIPP project for calibrations performed on WIPP equipment by the PCL. Effective January 1994 all certificates state the tolerance or uncertainty assigned to the measurement.

Industrial Hygiene Dept. (IHD) 7712, (Bldg. 869)

21. Only one of the outside calibration sources, "Instrument Services" had been surveyed and approved as a CCL.

Response:

The IHD has established procedures and instituted a program to survey all of the outside calibration sources they use. They have completed several surveys of the major calibration sources and have a goal of completing all surveys by the end of FY96.

22. Documentation of cross-checks performed on instruments as they leave and come back should be implemented.

Response:

A cross-check program has been documented and implemented; however, due to the lack of reference standards not all instruments can be cross-checked. Functional checks are always performed as instruments leave and come back.

Org 2484-1 SSLE Dimensional, Mass and Low Force

25. The data sheet for a force gage, SNL-2045, C-15, had measured values at 4 lbs and 7 lbs (nominal) which were out of tolerance (4.2 and 7.2 lbs or approx. 3 and 5 %, respectively, Vs a 2% tolerance). This OOT condition was not noted on the certificate or elsewhere.

Response:

An OOT report is normally issued on all OOT conditions found in this calibration lab. There is no known reason for this OOT condition not being reported and this problem is assumed to be an oversight on the part of the metrologist. The procedure for OOT reporting is well documented and no changes, except as noted in # 10 above, are planned.

26. Cross checks of reference gage blocks sent to and received from the PSL are not being performed. Cross checks should either be performed or the rationale for not so doing should be documented.

Response:

Cross checking measurement standards certainly adds value to any program. However, due to cuts in budget and staffing within the dimensional laboratory the cross check activities are at a minimum. For the most part the lab has eliminated duplicate reference standards which are required to perform a cross check. Laboratory personnel do, however, review the PSL report and investigate any shifts in the data as appropriate. They also visually inspect the shipping container and the standard for damage (shipping of standards

between the PSL and the dimensional laboratory is very well controlled). The current policy of not performing a cross check on all measurement standards is considered low risk and will continue until such time that staffing and budget allows the lab to maintain the standards necessary to perform cross checks.

27. Concern was expressed by this SSLE that two temperature devices,, both calibrated by the SSL seemed at the time of the survey to differ by larger than expected amounts.

Response:

Following the survey, both temperature devices were checked by the Sandia Standards Temperature Laboratory for proper operation and found to meet the uncertainty stated on the certificate. The liquid in glass (LIG) thermometer and the digital thermocouple thermometer in question are very different in the way they respond to temperature changes. The LIG response time to a temperature change is much greater than the thermocouple thermometer response time which may account for the difference seen during the survey. Several personnel were in and around the area where the temperature devices were located and in fact were leaning over to read the thermometers. This may account for the difference in the readings. At the advise of the temperature laboratory, the LIG thermometer was removed from service and the more accurate digital thermometer is being used to monitor the temperature in that area. Also, the temperature laboratory has furnished several more digital thermometers for use by the dimensional laboratory. No further problems have been seen.

Radiation Protection Measurements Dept. 7715 and Engineering Dept. 7713, (Bldg. 869)

29. The issues raised from the 1991 survey have been properly addressed except that the R chamber calibration using Victoreen still needs to be resolved.

Response:

The difference in the calibration factors between the NIST and Victoreen calibration have not been resolved and as such the Victoreen data were never used. The NIST calibration factors have always been used and future calibrations of the R chamber will be performed by NIST.

32. A review of the present calibration intervals is recommended. Data may permit an increase in some intervals with a consequent saving of resources.

Response:

The Radiation Lab currently has no written procedure for changing intervals. However, laboratory personnel do set intervals based on instrument history and federal regulations that limit the interval to a maximum of 12 months. Intervals are set at 4, 6 or 12 months. Laboratory personnel agree that a written procedure is needed and one will be drafted as time permits.

SSL Temperature/Humidity Lab 1744, (Bldg. 894)

35. R_0 for Standard Platinum Resistance Thermometers (SPRT), is not routinely being recorded for SPRTs.

Response:

R_0 is now routinely reviewed and recorded on a form supplied by the PSL.

36. No certificate had been written on the gallium cell.

Response:

With the help of the PSL, a certificate has been written on the gallium cell.

37. Error analyses need to be reviewed for temperature in general and for SPRT in particular.

Response:

The SSL temperature laboratory has consolidated with the PSL temperature project. The project leader is reviewing the error analyses used for SSL temperature calibration activities.

SSL Electrical Lab Dept. 1744, (Bldg. 892)

41. A Fluke 5200A AC Calibrator had been certified on 12/15/92. However, the last recorded frequency data was 9/5/89. In addition notations of "Bad Connector" and "Failed" for 5 voltage data points had been made on the data sheet dated 12/14/92 but there was no such notation on the certificate. Also the certificate showed tolerances for the 10 to 30 Hz frequency range but did not show how frequency measurements in this range were made nor did they show their method for measuring or inferring voltages below 1 volt, particularly below 50 Hz. This calibration and calibration procedure should be reviewed.

Response:

The procedure for this instrument has been completely revised. The Air Force "K" procedure, 33K8-4-835-1 is now used. Also, the certificate has been updated to indicate the proper tolerances. As to the "Failed" voltage data points, there should have been an OOT issued. This was an oversight on the metrologist part. Fortunately, this instrument is a backup in the 1144-1 Calibration Laboratory and was not used for calibration work prior to the OOT condition being found.

42. The SSL is starting to use calibration procedures received from Newark AFB without verifying them. All procedures should be checked out before an actual calibration is made regardless of the source.

Response:

All procedures used by the SSL are reviewed by the metrologist using them. We have, on a number of occasions, found major manufactures calibration procedures to be wrong. We

sometimes miss a problem but we do review all procedures for completeness and accuracy before using them. No changes in our policy for reviewing procedures are planned.

43. Several data points on an automated system show "marginal" in the pass/fail column but there is no confirmation that they really are marginal. Since this program was written in PASCAL with which the SSL has little experience they should either become more familiar with the language or obtain help from someone who is PASCAL trained and able to modify the software.

Response:

The SSL no longer uses any automated programs written in PASCAL. All programs are now in BASIC and the SSL has several experts in BASIC program. All automated programs are fully checked, including marginal pass/fail criteria, before they are used for calibration activities.

44. The SSL successfully passed a 100 mH inductor, a 20 dB attenuator, a Thomas 1 ohm and 1 Mohm resistor measurement audit. However, although the 17 ppm difference for the Thomas 1 ohm is well within the 50 ppm uncertainty claimed by this Lab it is somewhat greater than would normally be expected.

Response:

The SSL has up-graded the resistance station and revised the procedure for certifying resistors. Preliminary tests indicate an improvement in measurement accuracy.. The SSL has requested that the PSL provide another resistor audit to verify the new procedure is accurate.

45. Where feasible consideration should be given to putting a thermometer in the well of the resistor when such is being used outside an oil bath.

Response:

The SSL has, for the past several years, monitored the temperature when calibrating resistors. Recently, a Fluke 2176 temperature monitor was added to the resistance station and when feasible the temperature of the resistor is monitored in the well of the resistor.

46. When calibrating a multifunction device where more than one resistor of the same value are used to calibrate two different functions, some method should be found to indicate which resistors were used for each function.

Response:

As a result of this survey the procedures have been changed to identify which standard was used for what function when two or more of the same type of standard are used to perform the calibration.

SSLE High Force Lab Dept. 2761-3, (Bldg. 860)

50. The label for a plug-in card for an 22 klbf MTS load machine had expired. The last calibration was in 1987.

Response:

The label in question should have been removed from the plug-in card. This card is calibrated with the system and in fact was not expired. The 22 klbf MTS load machine is calibrated as a system and was in current calibration at the time of the survey.

51. This SSLE lab is commended for a overall good calibration and certificate written on each of two 2500 lbf load cells. One improvement should be made on future certificates by an addition "Of Range" or "Of Reading" as the case may be to the tolerance statement.

Response:

As a result of this survey the SSLE High Force Lab now includes "Of Range" or "Of Reading" ("Of Reading" is the most common) on all certificates.

52. Presently customers items are not being recalled. Consideration should be given to establishing a recall system or using the SSL recall system to recall appropriate items.

Response:

The Sandia Metrology has formed a Recall Team to determine the requirements for instrument recall for all calibration laboratories. The goal is to fold all of these requirements into a single recall system that supports everyone's needs. A new recall system is expected to be fully defined by mid 1995 and fully implemented by September 1995.

53. Several expired items were found.

Response:

All expired items were either sent in for calibration or marked "Out-of-Service." The new recall system being implemented at Sandia should eliminate the possibility of a recall notice being ignored.

54. The MTS certificates need to identify the uncertainties or tolerances to which load cells are calibrated.

Response:

The tolerance to which the load cells are calibrated are now stated on the MTS certificate.

55. Approval of both MTS and SATEC as CCL's has expired.

Response:

Both MTS and SATEC were surveyed during calibration activities and have been re-approved as CCL's.

Environmental Restoration III, Dept. 7584

56. Mr. Larry Azevedo of the survey team discussed the status of the calibration program for the Environmental Protection Organization with Ms. Sharissa Young of Dept. 7584. Considerable help is needed from and will be provided by the SSL and/or the PSL in setting up a system.

Response:

The Sandia Metrology Program Office has initiated a program to identify organizations that need guidance in defining and implementing their calibration programs. The Environmental Restoration organization has indicated they want our help. We stand ready to assist them in any way we can as they develop their calibration program.

James M. Simons,
Manager, Sandia Standards and
Calibration Department

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MS 0651	D. J. Thompson, 7715
MS 0665	R. T. Johnson, 1140
MS 0665	L. J. Azevedo, 1141
MS 0665	R. B. Pettit, 1142
MS 0665	W. G. T. Levy, 1144
MS 0958	J. W. Munford, 2484
MS 1350	D. Stermer, 7584
MS 2566	L. E. Pope, 2566

SANDIA NATIONAL LABORATORIES, ALBUQUERQUE
YUCCA MOUNTAIN PROJECT DEPARTMENT 6302

QUALITY ASSURANCE SUPPLIER QUALIFICATION REPORT

of the

SANDIA STANDARDS LABORATORY (SSL) AND
SANDIA STANDARDS LABORATORY EXTENSION (SSLE)
SANDIA NATIONAL LABORATORIES
ALBUQUERQUE, NEW MEXICO

SUPPLIER QUALIFICATION REPORT No. CSL-SQ93-01
SSL Conducted May 21 through 26, 1993
SSLE Conducted June 10 through 11, 1993

James V. Voigt 7/13/93
Lead Evaluator Date

SNL YMP QA Department Manager 7/13/93
Date

EXECUTIVE SUMMARY

SANDIA STANDARDS LABORATORY SUPPLIER QUALIFICATION

The purpose of evaluating the SSL and the SSLE at Sandia National Laboratories was to determine the readiness to provide metrology services as 'qualified suppliers' for the Yucca Mountain Site Characterization Project (YMP). As qualified suppliers the SSL and SSLE would be responsible for providing metrology services traceable to national standards for YMP artifacts.

The result of this evaluation indicates that the SSL areas of electrical, pressure, and temperature metrology and the SSLE areas of length, force, and mass metrology are capable of being "qualified suppliers" to support the YMP programs for instrument calibration. Some areas of the SSL and SSLE QA Programs that do not meet the OCRWM QA requirements, can be satisfactorily resolved by any of the following actions:

1) Addressing the appropriate items in the department Quality Plan. This plan is in draft form now and will be finalized in the near future,
2) In the future, adopting portions of the quality program being established by the Primary Standards Laboratory.
3) Including the descriptive requirements of any missing elements in an SNL YMP Work Agreement or Service Order and providing the implementing procedures as part of the basis for any metrology work requested.

Summary of Findings

1. QA Element 1 was assessed as indeterminate - appropriate management responsibilities and organizational functions have not yet been adequately defined in the quality plan. Interfaces with and responsibilities of the quality function is not defined and the mechanisms for performance of management self-assessments is not defined.

2. QA Element 2, for the areas examined appeared to be well implemented, especially the SSL method for identifying personnel qualifications and training requirements; the SSLE program requires the implementation of a documented training program. It is recommended that as the SSL program matures and is better established that a training database be developed and maintained. This training database would help to identify who needs what type of training, who has received what training, and who is delinquent in required training.

3. QA Element 6 was assessed as indeterminate - For traceability purposes the specific revision/version of calibration procedures were either not available or not recorded on calibration records.

4. QA Elements 15 and 16 were assessed. The out-of-tolerance process appeared to be very well controlled and understood by the staff. The documentation and client notification for nonconforming M&TE also appears to be well established. However, out-of-tolerance reporting is currently the only type of deficiency that is documented and investigated. Other deficiencies that may be identified generally are corrected on-the-spot with no specific documentation being generated. Another SSL area that appeared to be weak was in the application of the red 'Do Not Use' tags. This process does not appear to be consistently understood and practiced by all personnel.

5. QA Element 12, the 'Control of Measuring and Test Equipment' identified several commendable processes including (1) Records and standards traceability were well maintained throughout the laboratory; (2) The process for uniquely identifying M&TE and the traceability to relevant documentation and the subsequent integration into the recall system were effective and efficient; (3) The system for tracking standards used to calibrate various customer M&TE is well documented, and in the case of the SSLE a system is soon to be in place that will provide timely traceability of standards used; and (4) the program followed to seal M&TE units to ensure adjustments are not tampered with is also commendable.

   An SSL area requiring further investigation within QA Element 12 is the practice of negotiating with customers, changes in instrument accuracy when an out-of-tolerance condition is identified. This is done in lieu of following the standard reporting practice of documenting the nonconformance on a "out-of-tolerance" form. It has the effect of "masking" the possibility that the out-of tolerance condition may have affected measurements taken during the prior calibration interval.

The work performed by the Sandia Metrology Laboratories shows a high degree of technical excellence. The efficient and traceable metrology program, the depth of technical expertise and the positive quality attitude of the SSL/SSLE management and staff are commendable.

1.0 INTRODUCTION

A supplier qualification evaluation for metrology services was performed of the Sandia Standards Laboratories (SSL) and Extension Laboratories (SSLE) at Sandia National Laboratories (SNL), Albuquerque, New Mexico, on May 21-26, 1993, and June 10-11, 1993 for the SSLE. The purpose of this evaluation was to examine the quality assurance and operational programs of the Sandia Metrology Laboratories and to determine their ability to comply with the Office of Civilian Radioactive Waste Management QA requirements, in order to determine if the SSL and SSLE could be designated as "qualified suppliers" for the OCRWM Program. Special emphasis was placed on verifying that the M&TE calibration standards used were traceable to higher nationally recognized standards.

2.0 SUPPLIER EVALUATION SCOPE

The scope of this evaluation was to evaluate the degree to which the SNL metrology laboratories current quality assurance practices meet with the Office of Civilian Radioactive Waste Management (OCRWM) QA program as defined in the Quality Assurance Requirements and Description -- DOE/RW/0333P.

3.0 EVALUATION TEAM AND PERSONNEL CONTACTED

The SNL Yucca Mountain Site Characterization Project (YMP) team consisted of the following personnel:

James V. Voigt, Lead Evaluator (SNL/MACTEC), Department 6319
Robert R. Richards, Evaluator (SNL), Department 6319 Manager

The SNL SSL personnel contacted during this evaluation included:

NAME	ORGANIZATION	
Ralph Johnson,	4307	Department/Program Manager
Jim Simons	4344	Acting Department Manager SSL
Harry Pike	4344	Acting Project Leader Electrical Standards Lab
~~Warren Windle~~	4344	Project Leader Pressure Standards Lab
Judith Wills	4344	Standards Recall
~~Melquiades Salazar~~	4344	Electrical Lab
Georgia Brown	4344	Temperature Lab
~~Jerry Lamarr~~	4344	Temperature Lab
~~Frank Rebarchik~~	4344	Pressure Lab
David Sanchez	4344	Pressure Lab

The SNL SSLE personnel contacted during this evaluation included:

NAME	ORGANIZATION
Clint Atwood	2484-1 SSLE Department Manager
Ken Conrad	2484-1 Precision Components Lab

4.0 PERFORMANCE OF THE SUPPLIER EVALUATION

The evaluation opening meeting was held on May 21, 1993, with SSL personnel to (1) introduce the team, (2) review the evaluation plan, scope, and duration, and (3) establish necessary contacts to support various portions of the evaluation. The exit meeting was held on May 26, 1993, and results of the qualification evaluation were summarized at that time. The SSLE evaluation activities occurred on June 10 and 11, 1993.

The SNL YMP evaluation team examined various laboratory work activities and documentation representative of compliance with appropriate elements of the OCRWM QARD. Compliance in the QA elements listed below was examined:

Organization
QA Program (Including training and qualification)
Implementing documents
Document Control
Nonconformances
Corrective Action and
Control of Measuring and Test Equipment

The remaining elements of the QA Requirements and Description were not examined because they were either not applicable to metrology activities in general or were not applicable to the role of the SSL and SSLE as providers of calibration services.

5.0 SUMMARY OF RESULTS AND EFFECTIVENESS OF PROGRAM ELEMENTS

The evaluation results indicate that with some exceptions, the SSL and SSLE calibration activities comply with the applicable quality assurance requirements of the YMP QARD. On the basis of the interviews with SSL and SSLE staff and management, examination of laboratory operations, and the review of work activity procedures and supporting documentation, the SSL and SSLE Programs are determined to be effective as implemented. The opportunities for improvement cited below do not detract from the technical adequacy of the SSL or SSLE work activities.

Special note is made concerning the SSL and SSLE personnel, who were supportive of this evaluation and its results, committed to the quality improvement process, and very capable in the delivery of quality metrology service.

6.0 DETAILED EXPLANATION OF FINDINGS

1. QA Element 1 was assessed as indeterminate - appropriate management responsibilities and organizational functions have not yet been adequately defined in the quality plan. Interfaces with and responsibilities of the quality function is not defined and the mechanisms for performance of management self-assessments is not defined.

2. QA Element 2, for the areas examined appeared to be well implemented, especially the SSE method for identifying personnel qualifications and training requirements; the SSLE program requires the implementation of a documented training program. It is recommended that as the SSL program matures and is better established that a training database be developed and maintained. This training database would help to identify who needs what type of training, who has received what training, and who is delinquent in required training.

3. QA Element 6 was assessed as indeterminate - For traceability purposes the specific revision/version of calibration procedures were either not available or not recorded on calibration records.

4. QA Elements 15 and 16 were assessed. The out-of-tolerance process appeared to be very well controlled and understood by the staff. The documentation and client notification for nonconforming M&TE also appears to be well established. However, out-of-tolerance reporting is currently the only type of deficiency that is reported and investigated. Other deficiencies that may be identified generally are corrected on-the-spot with no specific documentation being generated. Another SSL area that appeared to be weak was in the application of the red 'Do Not Use' tags. This process does not appear to be consistently understood and practiced by all personnel.

5. QA Element 12, the 'Control of Measuring and Test Equipment' identified several commendable processes including (1) Records and standards traceability were well maintained throughout the laboratory; (2) The process for uniquely identifying M&TE and the traceability to relevant documentation and the subsequent integration into the recall system were effective and efficient; (3) The system for tracking standards used to calibrate customer M&TE is well documented, and in the case of the SSLE a system is soon to be in place that will provide timely traceability of the standards used; and (4) the program followed to seal M&TE units to ensure adjustments are not tampered with is also commendable.

   An SSL practice requiring further investigation within QA Element 12 is the way of negotiating with customers, changes in instrument accuracy when an out-of-tolerance condition is identified. This is done in lieu of following the standard

reporting practice of documenting the nonconformance on a 'out-of-tolerance form. It has the effect of "masking" the possibility that the out-of-tolerance condition may have affected measurements taken during the prior calibration interval.

Sandia National Laboratories

Albuquerque, New Mexico 87185

November 1, 1994

R. R. Richards, 6319, MS1333
Quality Assurance Department
Nuclear Waste Management Center

Dear Bob:

Ref: SSL Actions taken in response to Yucca Mountain Project QUALITY ASSURANCE SUPPLIER QUALIFICATION REPORT No. CSL-SQ93-01.

GENERAL INFORMATION AND COMMENTS

This letter details the actions taken by the Sandia Standards Laboratory (SSL) of the Sandia National Laboratories (SNL) Measurements Standards Program (MSP) in response to the concerns raised in the QUALITY ASSURANCE SUPPLIER QUALIFICATION REPORT No. CSL-SQ93-01. We note and offer apology for the significant delay in time between receiving the referenced report and submitting this response. The delay is the result of:

A. Intense activity in completing the new Facility for Standards (Building 827) and moving both the Primary Standards Laboratory (PSL) and the SSL into the new quarters. The move is not yet completed but progressing well.

B. A major consolidation effort, not including 2484-1, which has optimized major parts of the metrology function at Sandia, has brought additional capability under control of the MSP, and is bringing portions of these extra capabilities into the new facility where practical.

C. A move of the Length Mass and Force operation in 2484-1 back to previously occupied quarters in Building 894 where the environmental control is nonfunctional and the measurements capability is severely reduced. The environment problem will not be corrected for some time. Accordingly, only a few comments made below apply to this operation. Specific parts of the MSP Operations and Procedures (O&P) Manual have been requested by 2484-1 and have been supplied.

Because of the delay in preparing this response, it is appropriate to describe the current status of actions taken. With the description of the major changes listed above and the actions taken below, this letter will serve also as a status report on the SSL.

GENERAL QUALITY IMPROVEMENT PROCESS

At the time of the survey, effort had begun to bring the SSL under the MSP Operations and Procedures Manual requirements. However, this effort was in its initial phase and the many reviews required by staff and management to achieve implementation had not been accomplished. In addition, consolidation has given further opportunity to extend the O&P Manual requirements. This implementation effort is well along the way but not yet complete; some specific examples are cited below.

As may be seen from the descriptions offered, the SSL and the PSL also are benefitting from the new facility and from the implementation of the O&P Manual requirements. The broadening of the capabilities offered by consolidation allow the MSP to offer a more complete range of calibration to customers and to fill-in where some capability may be unavailable.

SPECIFIC RESPONSE TO THE SURVEY FINDINGS

1. Action in response to the finding under QA Element 1.

   Folding the SSL operation into the same organizational plan followed by the PSL and the additional rearrangement to accommodate consolidation have provided a more clearly defined responsibility structure. Furthermore, the entire MSP (PSL and SSL) operates with a single Quality Coordinator interacting with all levels of calibration. The intense restructuring and move activities have precluded formal self-assessments for the time being. However, the structure and the operation have been submitted to complete scrutiny during this time period with many changes and improvements.

   One example of the scrutiny is a review of the frequency each specific discipline receives an Out-Of-Tolerance within the MSP for an instrument calibrated by the SSL and the potential impact on customers. The initial results of this effort are being factored into the rework of the SSL recall system to permit easier identification of potential problem areas. This has not been done as a formal review but, rather, as a matter noted and investigated.

2. Action in response to the finding under QA Element 2.

   Effort is under way to apply the training and database requirements of the O&P Manual, Section 6, to the SSL operation. This puts into database:

   A. Metrologist Qualification Record listing relevant training education and experience.
   B. Record of training in the MSP O&P Manual requirements.
   C. Metrologist Certification.
   D. Specific Measurement System Training and Authorization records.

Except for final review and approval (under way), the full set of training records has been completed for the electrical metrologists of the SSL. Other areas and calibration functions resulting from the consolidation effort are also being brought into compliance but are not as far along.

Note 1: The SSL continues to keep on file existing training records for the electrical metrologists.

Note 2: In both the SSL and the PSL, the project leader is responsible for assignment of the metrologist to a particular calibration and discusses any unusual measurement or procedural requirement with the metrologist. In addition, the results and comparison with the calibration history of the instrument/standard are reviewed by the project leader before certificate signoff to identify any unexpected results. This practice produces a nearly complete analysis of the calibration and results as well as any training needed on a real-time basis. Several requirements of the O&P manual are met by this process.

3. Action in response to the finding under QA Element 6.

Written procedures generally are in place for relatively long periods of time. Those in use are considered revision 0 and will be brought properly into the system as changes are required. Most of the calibration in the SSL is performed by software driven programs. Software programs remain in place for relatively short periods of time and may be subject to frequent revision. As rapidly as practical, software calibration programs are being reviewed and assigned version identification. This effort will meet the requirements of O&P Manual, 5.2.2, Requirements for Calibration Procedures.

4. Action in response to the finding under QA Elements 15. and 16.

Other than the specific requirement for Out-Of-Tolerance documentation, observation of instrument/standard condition, corrections of unusual conditions and/or readjustment to center instrument performance in the tolerance range are types of calibration actions that are documented on the certificate for the specific instrument. For most conditions, the initial or as-found data, which is kept in the file, will indicate the as-received function of the instrument. In a few instances, such as a connector needing cleaning, preclude potential degradation of the calibrating standards or instruments, as-found data cannot be satisfactorily obtained (a similar situation exists with mass where cleaning before calibration and before use is mandatory if weights must be moved or have been placed in their storage box). Most unusual or unexpected behavior is communicated to the instrument owner by phone to add understanding of the nature of the observation, its potential impact, and to alert the owner to the problem.

This item also listed a concern over understanding of the the red "Do Not Use" tags. The update of the training included review of the MSP O&P Manual labeling requirements and has been completed for the electrical metrologists in the SSL. The labeling requirements includes the red "Do Not Use" tags.

5. Action in response to the finding under QA Element 12.

The practice of negotiating with customers an increase in uncertainty (or tolerance) when an Out-Of-Tolerance result is obtained has come about from two sources and is practical only under certain conditions which often exist within Sandia. The best example is:

> The practice of attempting to use manufacturers specifications to establish calibration tolerance limits in lieu of negotiating with customers initially. It is noted that manufacturer's specification tolerances for many standards and instruments cannot be met on delivery from the manufacturer (gage blocks are an excellent and well established example -- they are not adjustable and the calibration laboratory is often forced to state measured length rather than to use tolerance limits -- in use they are often hand-held and subjected to a temperature of about 33°C along with the device being checked). Many customers do not know their requirements well and simply expect manufacturer's tolerance verification in calibration. The after-the-fact negotiation forces an awareness of the limitations of the instrument/standard and almost always includes an evaluation of the customer's needs but, unfortunately, complete documentation is not normally practical.

For those customers where specific requirements exist and where negotiation of realistic expectations has been accomplished at the inception of the calibration responsibility, a formal Out-Of-Tolerance report is the only option. This is the case expected with outside Sandia calibration and with those customers inside Sandia having specific predetermined requirements. Note that such Out-Of-Tolerance documents have often led to a reevaluation of the actual needs of the requirement and, in some instances, a relaxation of those requirements (as above but formally). Alternatively, selection of different measuring instruments/standards may be necessary to meet the requirement.

David W. Braudaway, 1142, MS0665
Quality Coordinator
Measurements Standards Program

Copy to:
MS0665 R. T. Johnson, 1140
MS0665 L. J. Azevedo, 1141
MS0665 R. B. Pettit, 1142
MS0665 D. W. Braudaway, 1142
MS0665 B. E. Barnaby, 1143
MS0665 J. M. Simons, 1144
MS0665 W. G. Levy, 1144
MS0665 H. H. Pike, 1144
MS1333 J. V. Voigt, 6319

13308

WIPP Waste Isolation Pilot Plant	Title: Sandia National Laboratories WIPP QA Overview Report (INFORMATION ONLY) Effective Date: 3-18-93	Sandia National Laboratories Procedure QP 35-7 457 Revision 2/4/94 0 Form No. 216-B Page 1 of 4

Originator: Janis Trone Date: 1-12,13-94 Report No.: QAO-94-01
Activity/Procedure: Sandia Standards Lab Rev.: —
Personnel Contacted: J. Simons, W. Windle, H. Pike Org. 1044

Comments: See attached memo

Suggestions from personnel for improvement: na

Unacceptable Conditions: See attached memo

Required to stop work untill condition is corrected? YES (NO)

Actions Items and Responsible Party:	Date to be Completed:	Initials and Date Completed:
See attached memo	see attached	all completed by 3/20/95

Nonconformance: ( ) YES (∞) NO NCR No.: _____

See NCRs 94-015 — 023, 95-08 & 95-09 Generated as a result of the overview QA 3/20/95

Distribution:
~~S.Y. Pickering, 6300~~ QA 2/4/94
Originator
Personnel contacted
Responsible PI/Supv. - P. Jones 6743
- Y. Harper-Slaboszewicz 6743
- T. Dean 6743/RSI
- M. Schuhen 6743/RSI
- J. Johnson 6743

Janis Trone 2/21/94
Signature of Overviewer Date

Comments:
On January 12 and 13, 1994, J. Johnson, M. Schuhen and J. Trone performed an overview of the Sandia Standards Laboratory (SSL). The overview performed by WIPP QA was in response to a preliminary audit of the WIPP Site performed by EM-342 (DOE Headquarters) and Russell Brown of Sandia. As part of the EM-342 preliminary audit, a visit was made to the SSL Precision Components Lab 2484-1, where they identified some concerns about the calibrations performed in support of the WIPP Site. The concerns centered on the documentation generated by the Sandia Standards Lab (SSL). when calibrating WIPP equipment and the traceability of the calibrations performed. It was DOE's suggestion that WIPP QA perform additional internal overviews of the SSL before the comprehensive EM-342 Assessment is initiated.

As part of the WIPP QA overview, an introductory meeting was held with J. Simons, W. Windle and H. Pike on Jan. 12, 1994. The focus of the meeting was identifying the unique QA requirements of the SNL WIPP Site calibration laboratory and how it affects the SSL. Following this meeting, a walk through was performed of the electrical standards lab, the pressure standards lab and the temperature lab. As a result of the WIPP QA overview several problems were noted. The problems will be split into two general categories; action items to be implemented at the SSL and the Sandia WIPP Site Calibration Laboratory, and observations of the Sandia Standards Laboratory program. The observations of the SSL are only provided as feedback mechanism to the SSL. At this time the observations are not expected to affect the WIPP Site's ability to utilize the services of the SSL. It is the option of the SSL to respond to the observation as they deem necessary.

SSL and WIPP Site Calibration Laboratory Action Items:

Problem #1: The SNL WIPP Cal Lab is not providing the standards laboratory with sufficient detail on the metrology parameters (ranges, test conditions, accuracies, etc.) at which to calibrate our Measurement and Test Equipment (M&TE) and measurement standards. Additionally the SSL is not always clear on who to contact if they have questions or concerns about the calibration of WIPP equipment. Completed

Action Item #1: 6743 will establish a single point of contact for the standards laboratory. This point of contact will prepare a form for each M&TE and measurement standard that is sent to the standards laboratory for calibration. The form will describe the ranges, test conditions, accuracies and intended uses for the test equipment. The process will be described in a SNL WIPP procedure. Developed Calibration Request Form 290. Eff. date 5-6-94 N.C. Simmons 5-9-94
This action item has been assigned to P. Jones (6743) and it will be completed by Mar. 15, 1994.

Problem #2: The shipping/handling of M&TE between the WIPP Site and the SSL does not meet the requirements of EP401560. The current practices used by the WIPP Site do not include sufficient guidelines regarding personnel qualifications and training, methods for transporting equipment, documentation, and receipt inspections. A single point of contact needs to be established between the WIPP Site calibration laboratory and the SSL Instrument Repair Laboratory. The SSL currently has 10 possible individuals to contact when there are questions concerning the shipping and handling of WIPP equipment.

Action Item #2: WIPP QAP 12-1 (currently in draft) will establish the guidelines for the shipping and handling of M&TE and measurement standards at the WIPP Site. From these guidelines a procedure shall be developed to identify the methods, documentation, personnel, training and receipt inspections to be required on M&TE and measurement standards. Finally, a point of contact for the shipping and handling of equipment will be identified. WIPP Procedure # 497 Calibration Form & Equip. Transportation. Effect date
This action item has been assigned to P. Jones (6743) and it will be completed by Mar. 15, 1994. 5-6-94
QAP 12-1 effective 5-16-94 JK 6/1/94 Action Item #2 Closed. N.C Simmons

Problem #3: The current Sandia WIPP QAPD allows the use of commercial calibration sources without having an audit performed of the facility by a representative from the either the SSL or the SNL WIPP Site calibration laboratory or a person knowledgeable of calibration laboratory requirements and practices.

Action Item #3: This item will be reviewed by SNL WIPP management and the WIPP QA department. The WIPP Site's intent will be to change the current QAPD to require an audit/assessment be performed before a vendor is used. In addition, a program will be implemented at the site which will initiate audits of commercial vendors being used for the calibration of SNL WIPP M&TE.

This action item has been assigned to J. Trone (6700) and it will be completed by June 15, 1994.
The SNL QAPD is being revised to require the evaluation of suppliers 9-12-94
Before work is begun. See Sept 1, memo from JANIS TRONE N.C. Simmons
NCS 9-12-94

Problem #4: A majority of the calibration reports generated by the WIPP Site laboratory do not identify the uncertainty for the calibration.

Action Item #4: The calibration uncertainty for the M&TE is stated in the applicable calibration procedure as 'acceptance criteria'. In the future the uncertainty for the calibration will also be stated in the remarks or comments section of the calibration records.
implemented as a standard laboratory practice. 5-9-94 N.C. Simmons
This action item has been assigned to T. Dean (6743/RSI) and it will be completed by April 15, 1994.

Problem #5: Items were calibrated by the SSL pressure laboratory using standards that were of equal or less accuracy then the M&TE being calibrated. However the calibration reports did not state uncertainty numbers indicating the actual performance of the M&TE. The WIPP Site calibration staff assumed that without uncertainty numbers on the reports or status indications that performance had been reduced, the M&TE were certified to the manufacturer's specifications. An accepted industry practice is to use standards that have an accuracy ratio of at least 4:1 with respect to the unit under test or the uncertainty of the M&TE is reduced based on the accuracy of the calibration standards used.

Action Item #5:

A) Uncertainty statements shall be determined for the standards used by the SSL pressure laboratory in support of the WIPP Site. This should include the following standards: the King, the Ruska, and the load cell calibration station. The uncertainty statements shall cover from 1986 to the present. In the future all calibration reports should contain uncertainty values.

C

This action item has been assigned to J. Simons (1044) and it will be completed by April. 15, 1994.
Completed 9/20/94 OA 10/5/94 See memo attached from Simmons

B) The SNL WIPP calibration laboratory will need to identify all WIPP M&TE and measurements standards that have been calibrated by the pressure standards laboratory or using standards certified by the pressure laboratory. Based on the uncertainties for the calibration standards, adjustments will be made to the accuracies of the WIPP M&TE and measurement standards. On a case by case basis a determination will then be made by the Principal Investigator on whether or not a correction factor will need to be applied to the data taken with the affected M&TE. This process will be documented using an Event Impact Statement form.

This action item has been assigned to J. Johnson (6743) and M. Schuhen (6743/RSI) and it will be completed by Sept. 1, 1994. Completed 2/16/95 by Mike Schuhen. See NCR's 94-015, 94-016, 94-017, 94-018, 94-019, 94-020, 94-021, 94-022, 94-023, 95-02 and 95-03. QA 9/28/95

Problem #6: Many of the calibration records issued by the SSL do not include sufficient information to meet the requirements of the WIPP Site. The WIPP Site QAP 12-1 will require that calibration records include information about the standards used, the calibration laboratory environment, the procedure used, the technician who performed the work, and whether the data was as-found or as-left calibration results.

Action Item #6: This information is recorded on a 'green' sheet maintained by the SSL. A copy of the green sheet along with the certification will be supplied to WIPP when requested. The request for this information will be included with the form being generated in response to Action Item #1.
Action item #1 Completed. Neil Simmons 5-9-94
This action item is considered closed when action item #1 is completed.

Problem #7: The reports generated by the pressure calibration laboratory do not contain uncertainty statements identifying the M&TE accuracy.

Action Item #7: All future certifications or reports issued by the SSL in support of the WIPP Site, shall include uncertainty numbers for the item calibrated.

This action item has been assigned to J. Simons (1044) and it will be completed by Mar. 15, 1994.
Completed 9/30/94 Cpt 10/5/94 See attached memo J. Simmons

Observation of the SNL Standards Laboratory

Observation: Not all calibration activities have written procedures to follow and many of the existing procedures have not gone through a formal review and signature process.

Observation: The concerns identified by the Yucca Mountain Project overview with regards to the training records are the same concerns of the WIPP Site. The corrective actions implemented in support of YMP findings will meet the requirements of WIPP.

Observation: The SSL pressure calibration laboratory does not have a formal review process for their calibration reports.

Observation: There are inconsistencies between the various standards laboratories and their methods for reporting calibration results, maintaining calibration records and demonstrating traceability. These inconstancies make it difficult to review the SNL standards laboratories and provide the impression that the groups do not operate under the same procedure.

Sandia National Laboratories
P.O. Box 5800
Albuquerque, New Mexico

Managed by Martin Marietta
for the US Department of Energy

date: September 1, 1994

to: Memo of Record

from: J. R. Trone, 6700

subject: Response to SNL Overview QAO-94-01 Action Item #3

The overview (QAO-94-01) of the SNL Standards Laboratory action item number 3 was to review the current QA practices for acceptance of calibration by outside sources and recommended SNL revise the QAPD to require an audit/assessments be performed before a vendor is used as a calibration source.

The SNL QAPD is being revised and will require an evaluation of a suppliers before work begins. This change should adequatly control the selection of vendors as a calibration source.

copy to:
A. L. Stevens, 6306
Attach to QAO-94-01

Sandia National Laboratories

Albuquerque, New Mexico 87185-5800
Livermore, California 94551-0969

date: September 30, 1994

to: Janis R. Trone, 6700, MS 1395

James M. Simons

from: James M. Simons, 1144, MS 1004

subject: Response to WIPP Report QAO-94-01

The Sandia Calibration and Instrument Services Department has taken the following actions in response to Problem #5 and Problem #7. The Problems.and Action Items are listed for your connivance.

Problem #5: Items were calibrated by the SSL pressure laboratory using standards that were of equal or less accuracy then the M&TE being calibrated. However the calibration reports did not state uncertainty numbers indicating the actual performance of the M&TE. The WIPP Site calibration staff assumed that without uncertainty numbers on the reports or status indications that performance had been reduced, the M&TE were certified to the manufacturer's specifications. An accepted industry practice is to use standards that have an accuracy ratio of at least 4:1 with respect to the unit under test or the uncertainty of the M&TE is reduced based on the accuracy of the calibration standards used.

Action Item #5: A) Uncertainty statements shall be determined for the standards used by the SSL pressure laboratory in support of the WIPP Site. This should include the following standards: the King, the Ruska, and the load cell calibration station. The uncertainty statements shall cover from 1986 to the present. In the future all calibration reports should contain uncertainty values.

The following uncertainty information applies to calibrations performed for the WIPP Site by the Sandia Calibration Laboratory.

Load Cell Uncertainties. The following uncertainties are given to us by the Primary Standards Laboratory for the reference load cells and by the Electrical Calibration Laboratory for the HP3497A scanner. These uncertainties cover the time period from 1986 to the present:

Load Cell Range	Maximum Uncertainty
500 lb	0.15% of range
5,000 lb	0.20% of range
20,000 lb	0.15% of range

HP3497A Range	Maximum Uncertainty
0.10 V	0.012% of range
1.00 V	0.01% of range
10.00V	0.02% of range

Two voltmeter readings are required for each force determination. The equation is:

$$F=S_R \times V_O \times V_E$$

where S_R is the reference sensitivity, V_O is the bridge output voltage, and V_E is the bridge excitation voltage.

The Root-Sum-Square systematic uncertainty for each range is then:

Range	Uncertainty
500 lb	0.16% of range
5,000 lb	0.21% of range
20,000 lb	0.15% of range

Random Uncertainties. Normally, data for 10 points and the no-load zero are recorded. A least square straight line is fitted to the data with Force as the dependent variable and $\frac{(V_{output}-V_{zero})}{V_{excitation}}$ as the independent variable. The sample standard deviation, SSD, for the curve fit is determined and considered to be a reasonable approximation to the random error of the calibration and the test instrument. When an uncertainty to give a total time-of-measurement uncertainty with confidence level of 99%.

Sample Uncertainty Calculation. A subject force device with 1,000 lb capacity is calibrated using the 5,000 lb load cell. The systematic uncertainty of the load cell is 10.5 lb. If the SSD of the linear fit is 5 lb, then the total uncertainty is the square root of 110.25 + 225, or 18.3 lb.

Pressure Transducer Uncertainties. The following uncertainties are given to us by the Primary Standards Laboratory in certificate form for the reference load cells and by the Electrical Calibration Laboratory for the HP3497A scanner:

1) King Nutronics (4 transducers or 4 ranges) Model 3692-A Serial No. 7894

Time Period	Range 1 0-15 psia	Range 2 0 -100 psig	Range 3 100-2,000 psig	Range 4 2,000-10,000 psig
10-28-85 to 4-28-86	± .05% of reading	± .05% of reading	± .1% of reading	± .05% of reading
4-24-86 to 10-24-86	± .05% of reading	± .05% of reading	± .1% of reading	± .05% of reading
10-23-86 to 10-23-87	± .05% of reading	± .05% of reading	± .1% of reading	± .05% of reading
5-7-87 to 5-7-88	± .1% of reading	± .05% of reading	± .1% of reading	± .08% of reading
5-20-88 to 5-20-89	± .05% of reading	± .05% of reading	± .1% of reading	± .08% of reading
5-20-89 to 8-20-89 *	± .05% of reading	± .05% of reading	± .1% of reading	± .08% of reading
8-29-89 to 8-29-90	± .15% of reading	± .1% of reading	± .1% of reading	± .08% of reading
10-4-90 to 10-4-91	± .15% of reading	± .1% of reading	± .1% of reading	± .08% of reading
10-11-91 to 10-11-92	± .8% of reading **	± .1% of reading	± .1% of reading	± .08% of reading
1-20-92 to 10-11-92***	± .15% of reading			
10-14-92 to 10-14-93	± .15% of reading	± .15% of reading	± .1% of reading	± .08% of reading
10-19-93 to 12-19-93	± .15% of reading <13.51 psia, 2% of reading >13.5 psia	± .16% of reading	± .12% of reading	****

* Indicates extension of previous calibration

** A slow leak was found in this range of transducer and readings were adjusted in software.

*** A new 15 psia transducer was installed on 1-17-92.

**** A system manifold leak above 2000 psig was discovered and was sent for repair.

2) Ruska Model DDR 6000 Serial No. S-285603

Time Period	Uncertainty
8-27-85 to 2-27-86	± .08% of reading
2-27-86 to 8-27-86	± .05% of reading
8-22-86 to 2-22-87	± .05% of reading
2-17-87 to 8-17-87	± .05% of reading
8-12-87 to 2-12-88 *	± .3% of reading

* taken out of service

3) Ashcroft Model 1305B Serial No. 68536

Time Period	Uncertainty
11-1-85 to 11-31-90	± .15% of reading <7500 psig, 2% of reading >7500 psig
11-6-90 to 12-1-95	± .2% of reading

Uncertainties for the Ashcroft dead weight system were derived by the Sandia Calibration Laboratory.

Uncertainties derived by the Primary Standards Laboratory are the addition of the Historical, Systematic, and the 3 Sigma value of the randomness. Further information on how these uncertainties can be obtained from the Primary Standards Laboratory.

The uncertainties of auxiliary equipment used for pressure calibrations, such as voltmeters and resistors, are negligible and are not included in this report.

Problem #7: The reports generated by the pressure calibration laboratory do not contain uncertainty statements identifying the M&TE accuracy.

Action Item #5: All future certifications or reports issued by the SSL in support of the WIPP Site, shall include uncertainty numbers for the item calibrated.

The Sandia Calibration Laboratory now includes uncertainty statements for the M&TE being calibrated.

Copy to:
MS 0365 R. R. Romero, 1141
MS 1004 D. A. Sanchez, Southwest Engineering
MS 1004 J. M. Simons, 1144

Sandia National Laboratories

Albuquerque, New Mexico 87185-

date: August 21, 1995

to: M. D. Schuhen, Sandia 6706

from: T. A. Dean, WIPP Site Calibration Lab Supervisor

subject: Completion of QA Overview QAO-94-01

I have reviewed the QAO-94-01 Overview report and have verified that all seven findings have been completed.

Action items #1, #2 & #4 assigned to Perry Jones and myself have been completed as follow:

Action item #1; The single point of contact at the WIPP site for the Standards Lab is to be the Calibration Lab Supervisor currently represented by myself. A calibration request form 290, effective date: May 6, 1994 was developed to describe the ranges, test conditions, accuracy's, etc. of equipment being submitted to the SSL, PSL, SNL WIPP calibration lab and other calibration labs.

Action item #2; WIPP procedure 497, effective date: May 6, 1994, identifies the shipping and handling requirements for M&TE and measurement standards used at the WIPP site. Procedure 497 identifies the methods, documentation, training, and receipt inspections required when transporting M&TE and measurement standards. The single point of contact is the same as for action item #1. QAP12-1 has been released and is at revision 1, effective July 31, 1995.

For action item #4; The uncertainty for a given instrument/gage calibration is being included on the calibration record for the SNL WIPP calibration laboratory.

Action item #3; A memo of record from J. Torne has been written addressing this action item. The changes addressed in this memo have been implemented in paragraph 2.3.1.1 of QAPD revision R, effective July 31, 1995 and WP QAP 12-1.

Action items #5 and #7 have been closed and a memo from James Simons is attached to the QAO-94-01 report.

Action item #6 has been addressed in action 1. The green sheets have been received with calibrations.

If you have any further questions feel free to contact me at (505) 234-8668.

APPENDIX D: QUALITY ASSURANCE CHECKLISTS USED IN REVIEW OF THE PRIMARY AND SECONDARY STANDARDS LABORATORIES

Contents

Sandia Standards Laboratory (SSL) Scoping Checklist

Performed By: Michael Schuhen
Date: April 20, 1995

U = Undetermined

Criteria (based on NQA-1 & DOE AL57XA Rev. 2)	< 1980			1980 thru 1984			1985 thru 1989			1990 >			Comments
	Yes	No	U	Yes	No	U	Yes	No	U	Yes	No	U	
1. Calibration Procedures exist on items calibrated for SNL WIPP.	X			X			X			X			Calibration procedures or equipment operation manuals are available and used for calibration M&TE. Acceptance criteria is based on manufacturer's guidance.
2. Calibration Records or Data Files available establishing Traceability to the PSL or NIST.	X			X			X			X			The records are is good shape for the Electrical, Microwave, Humidity, and temperature sections of the SSL. The physical standards area had problems as noted below.
Records contain the following information: a. Calibration Uncertainty	*X			*X			*X			*X			Until recently this was not included by the physical standards group.
b. Date Calibrated	X			X			X			X			No problems identified.
c. Identification of Standards utilized.	X			X			X			X			Not supplied to WIPP until recently, information maintained by the SSL.
d. Identification of Calibrating Technician.	X			X			X			X			No problems identified.
e. Any use limitations.	*X			*X			*X			*X			Until recently this was not included by the physical standards group.
f. Calibration Interval	X			X			X			X			No problems identified.
3. A Recall System was established.	X			X			X			X			The calibration lab has maintained a effective recall system throughout their involvement with WIPP.
4. A Training Program was being implemented.		X			X			X		X			A formal training program for calibration technicians was only recently implemented (1993).

Sandia Standards Laboratory (SSL) Scoping Checklist

Performed By: Michael Schuhen
Date: April 20, 1995

U = Undetermined

Criteria (based on NQA-1 & DOE AL57XA Rev. 2)	< 1980			1980 thru 1984			1985 thru 1989			1990 >			Comments
	Yes	No	U	Yes	No	U	Yes	No	U	Yes	No	U	
5. Personnel Qualification Documentation Exists.		X			X			X		X			Prior to 1993 no formal documentation is available demonstrating personnel qualifications.
6. Documented Technical Surveys of the SSL by either the PSL, DOE, DOD are available.		X			X			X		X			The PSL started auditing the SSL in 1989. The only other external audit of the SSL was performed by the Yucca Mountain Project in 1993. To date the results of the YMP audit have not been resolved, but they are being addressed.
7. Documented Measurement Audits of the SSL are available.		X			X			X		X			Nothing existed prior to the 1990s.
8. Technical Surveys and or Measurement Audits are available for Commercial Calibration Sources used by the SSL.	X			X			X			X			The SSL uses very few commercial calibration sources. The majority of the CCLs they have approved have been at the request of other SNL organizations. The formality of the audits of the CCLs has increased considerably in the 1990's.
9. Miscellaneous													

Sandia Primary Standards Laboratory (PSL) Scoping Checklist

Performed By: Michael Schuhen
Date: April 20, 1995

U = Undetermined

Criteria (based on NQA-1 & DOE AL57XA Rev. 2)	< 1980			1980 thru 1984			1985 thru 1989			1990 >			Comments
	Yes	No	U	Yes	No	U	Yes	No	U	Yes	No	U	
1. Calibration Procedures exist on items calibrated for the SSL.	X			X			X			X			Calibration procedures or equipment operation manuals are available and used for calibration of M&TE. Acceptance criteria is based on manufacturer's guidance.
2. Calibration Records or Data Files available establishing Traceability to NIST or Intrinsic Standards.	X			X			X			X			Calibration records were readily available and they contained the appropriate information. File system for records in the PSL was consistent amongst the various organizations.
Records contain the following information:													
a. Calibration Uncertainty	X			X			X			X			No problems identified.
b. Date Calibrated	X			X			X			X			No problems identified.
c. Identification of Standards utilized.	X			X			X			X			No problems identified.
d. Identification of Calibrating Technician.	X			X			X			X			No problems identified.
e. Any use limitations.	X			X			X			X			No problems identified.
f. Calibration Interval	X			X			X			X			No problems identified.
3. A Recall System was established.	X			X			X			X			The calibration lab has maintained a effective recall system throughout their involvement with WIPP.
4. A Training Program was being implemented.		X			X			X		X			A formal training program for calibration technicians was only recently implemented (1993). Prior to 1993 the program was informally implemented.

Sandia Primary Standards Laboratory (PSL) Scoping Checklist

Performed By: Michael Schuhen
Date: April 20, 1995

U = Undetermined

Criteria (based on NQA-1 & DOE AL57XA Rev. 2)	< 1980			1980 thru 1984			1985 thru 1989			1990 >			Comments
	Yes	No	U	Yes	No	U	Yes	No	U	Yes	No	U	
5. Personnel Qualification Documentation Exists.		X			X			X		X			Prior to 1993 no formal documentation is available demonstrating personnel qualifications.
6. Documented Technical Surveys of the PSL by either NIST, DOE, DOD are available.		X			X			X		X			The PSL had not been formally audited until 1993, when the YMP project performed an audit of the facility. The PSL passed the YMP audit and has been placed on the approved vendors list.
7. Documented Measurement Audits of the PSL are available.			X			X	X			X			Internal measurement audits and reviews of the calibration systems have been performed for many of the calibration systems in the PSL. In addition some of the PSL organizations participate in a laboratory comparison program with other PSL level facilities.
8. Technical Surveys and or Measurement Audits are available for Commercial Calibration Sources used by the PSL.			X	X			X			X			The primary calibration source used by the PSL is NIST. Most other CCL are audited and approved at the request of external SNL organizations. All CCLs used by the PSL appear to have been audited.
9. Miscellaneous													

APPENDIX E: AUDITS OF THE KEY COMMERCIAL CALIBRATION LABORATORIES

Contents

Table E.1. Commercial Calibration Laboratories Used for WIPP.

Micro Foil Heat Flow Sensor	RdF Corporation 23 Elm Ave. Hudson, NH (603) 882-5195	Heat Flux gauges used in the TSI experiments, A-rooms, Rm H.	
Load Cells	HSI, Houston Scientific 4202 Directors Row Houston, TX 77092 (713) 681-9682	Micro-Fine Grouting Experiment in Room L4	NIST Numbers: load std. :248336 & 246253 electrical std.: 244770& 247089
Load Cells	Modern Machine & Tool CO. 11644 Jefferson Ave. Newport News, VA 23606	Micro-Fine Grouting Experiment in Room L4	(used by Houston Scientific) NIST Numbers: lab report no. 73207/G45863 Date 6/16/89
Hy-Cal RH gauges	Hy-CAL Engineering 99650 Telstar El Monte CA 81731	Room Q and SSSPT Data	4 month difference between HY-CAL calibration and SNL calibrations.
Kulite Pressure Transducers	Kulite Semiductor 1039 Hoyt Ave. Ridgefield, NJ (201) 945-3000	TSI Experiments, ISBT.	The kulite pressure transducer were recalibrated by the SNL site lab prior to use.
Air Velocity gauges	Kurz Instruments 20 Village Square PO Box 849 Carmel Valley, CA 93924 (408) 659-3421	TSI Experiments in Rm B, RmH.	some cals as early as 1984. Started being calibrated by the SNL lab in 1987.
LVDT	Bourns Instruments PO Box 2112 6134 Magnolia Ave. Riverside, CA 92506 (714) 781-5148		Gauges were recalibrated by the site lab prior to use.
Weights	Troemner, Inc 6825 Greenway Philadelphia, PA 19142 (215) 724-0800 Contact: Mark Kline	SSSPT	NIST Numbers: 731/243669
Weights	Rice Lake Weighing Systems Metrology Lab, 230 W. Coleman PO Box 272 Rice Lake, WI 54868 (715) 234-9171 Contact: Richard Calkins	Small Scale Brine Inflow Experiments	Traceable cert no. 21246 NIST Number: 731/242697

Table E.1. Commercial Calibration Laboratories Used for WIPP (continued)

eights	Denver Instruments Co. 6542 Flg St. Arvada, CO 80004 (303) 431-7255 Contact: Don Hunt	SSSPT	Standard Test Number 09566 S/N: 1003
Particle Size Standards Catalog # 4210A & 4210B	Duke Scientific Corp. 1135D San Antonio Rd. Palo Alto, CA 94303		NIST Cal Report # 5524 NBS # 1690, 1960, 1961 and 1962 BCR # 165A, 166A, and 167A
Pressure Transducers	T-Hydronics, Inc. 921 East Wind Dr. Suite 104 Westerville, OH 43082 (614) 882-2122	Used in measuring pressure in the WID cribs. Not PA related data.	Model: TH-LCV range 10,000 psis, Gauges turned over to WID
Viscosity Standard	Brookfield Engineering Lab, Inc. 240 Cushing Street Stoughton, MA 02071-2398 (617) 344-4310 Contact: David Dicorpo		
Cylinder, Pyrex	Corning, Inc. Corning, NY 14831	SSSPT & DRZ	ASTM E542 ASTM E1272
Strain Indicator, Calibrator	Instrument Division Measurements Group, Inc. PO Box 27777 Raleigh, NC 27611	ISBT, strain gauges installed as part of the borehole closure gauges.	Gauges were recalibrated by the Sandia site lab prior to use.

PRIMARY STANDARDS LABORATORY

Sandia National Laboratories, Albuquerque, New Mexico 87185

Survey Report

Location:

DH Instruments Inc.
1905 West Third Street
Tempe, Az 85281
(602)967-1555
FAX (602)968-3574

Survey Participants:

Frank Garcia Jr.,, Contractor for the Measurement Standards Department 1743, Sandia National Laboratories, New Mexico

Key Contractor Personnel
Michael L. Bridge, Director of Quality Assurance, DH Instruments Inc.

Objective:

The survey was conducted December 14, 1993 to evaluate DH Instrument's standards and calibration program for conformance to the requirements of Department of Energy (DOE) Supplemental Directive AL57XA and good laboratory practices with emphasis on both the technical as well as administrative aspects of the program. The survey was conducted for the Sandia Standards and Calibration Program and in order that the DOE Weapons Complex have alternate sources for the calibration of pressure sensing devices.

Summary:

The survey team was provided a copy of the DH Instruments Quality Assurance Manual which describes the company's entire calibration and standards process The company wishes to continue as a pressure instrument calibration source for the DOE/AL Complex. They provided the team with a list of their approved suppliers and a copy of the checklist by which DH

evaluates those suppliers.

The survey team surveyed all aspects of the calibration program and, in general found DH Instruments to be an excellent pressure gage calibration facility. The team recommends that DH Instruments be accepted as a Commercial Calibration Laboratory for Sandia as well as for the DOE/AL Weapons Complex for pressure sensing devices in the range from 0.2 to 150,000 psi. It is further recommended that the approval include the mass measurements for weights used for piston gages.

Discussion:

General:

In general, the team found everything in good order and in conformance with good laboratory practice. DH Instruments has been preassessed for ISO9002 and is expecting certification in June 1994.

Policy:

The standards and calibration programs are well documented in the Quality Assurance Manual and quality plans. Calibrations are designed to meet contractual agreements with the customer and are usually Mil-STD-45662A or NRC regulations 10 CFR and 10 CFR21.

Personnel:

All personnel contacted were well trained and competent. Training and certification of calibration personnel are established through a documented program. Most personnel are ex PEMEL technicians from the US Military Services. Personnel qualifications, certification, and training are reviewed annually and maintained on file by the Director of Quality Assurance.

Facilities:

The metrology buildings and equipment have sufficient environmental control and environmental records are maintained.

Storage and Transportation:

Instruments and standards are stored, handled and transported in accordance with documented requirements and in a manner which does not affect calibration and/or operation.

Calibrations and traceability:

All calibrations are performed using certified standards whose accuracy is adequate for the purpose intended The traceability of standards used is clearly established and are to NIST and acceptable sources (list of suppliers provided). Claimed uncertainties were defendable and established through uncertainty analysis.

Procedures:

Calibration procedures are in place for all calibrations performed.

Data Files:

Data files are kept on each calibrated instrument. The records meet the requirements of AL57XA.

Identification:

All instruments are sufficiently labeled or tagged to indicate calibration status.

Intervals:

Calibration intervals are established according to documented procedures and minimize out-of-tolerance conditions.

Recall System:

A recall system is in place to accommodate DH Instruments needs and for those customers who desire recall.

Tamper-Evident Seals:

Tamper-evident seals are in use, and their use is referenced in procedures and the QA manual

Out-Of-Tolerance Conditions:

A program for notification of users/owners of instruments that are found to be out-of-tolerance is in place, functional, and is documented in the QA manual.

Surveillance:

A program for the control of purchased material and services, including the approval of "approved suppliers" is in place and referenced in the QA manual This program was found to be acceptable.

Capabilities:

DH Instruments can calibrate any pressure gage, transmitter or transducer within a pressure range of 0.2 to 150,000 psi in compliance with military standards and federal regulations (MIL-STD-45662 and/or NRC regulations 10CFR and 10CFR21) or will calibrate to a customers requirements. This survey established a base uncertainty of 100 ppm (effective area of piston gage). Lower uncertainties may be achievable but must be approved on a case by case basis. DH Instruments is also capable of calibrating weights, used with piston gages, in the range applicable to the above pressure ranges.

Future surveys:

A resurvey of the facilities will normally be performed every two years. The resurvey process requires a day or less, if no significant changes have taken place. Major changes in personnel or facilities will require resurvey before the two - year interval. If significant changes occur, DH Instruments must notify Sandia.

Last Survey Follow-up Items: (From survey of December 1989)

Discussion item no. 9

"The team was somewhat concerned over the fact that the resonant frequency of the DH Model 20000 is not known and it could be possible to develop a bias in some situations.

DH Instruments has decided that it would be too hard to quantify resonant frequencies under all configurations. DH Instruments will recommend to their customers that their use area be vibration controlled to avoid interfering resonance. The survey team concurs.

Discussion item no. 10

"The team felt that if there is any "weakness" in the calibration program, perhaps the pressure

arena below 15 psi might be singled out. DH Instrument's main strength is from 15 to 150,000 psi.

DH Instruments has incorporated new instrumentation, the PGA series of air dead weight testers, which was demonstrated to overcome any previous "weakness".

Measurement Audits:

Measurement audits were not employed in this survey but may be used in future surveys.

Frank Garcia Jr.
Contractor
Measurement Standards Program
Department 1743

Distribution:

M/S 0823 B. E. Barnaby, 1743
M/S 0823 W. G. Levy, 1743
M/S 1004 W. Windle, 1744
M/S 1004 J. M. Simons, 1744
M/S 1004 H. H. Pike, 1744

INFORMATION ONLY

CALIBRATION REPORT NO. 12880
Delivered August 16, 1994 **To:**
SANDIA NATIONAL LABORATORIES
CARLSBAD, NEW MEXICO
P.O. No. AA-2903
Calibration of A
Paroscientific Model 740-23A Pressure Transducer, No. 37078

CALIBRATION CONDITIONS

All calibrations are performed by the DH Metrology Service in a controlled environment by qualified personnel using instrumentation and methods which guarantee that specifications claimed are reliable. When requested, the calibrations conform to all conditions of MIL-STD 45662 and/or NRC regulations 10CFR50 and 10CFR21.

The laboratory reference standards for mass and effective area are traceable to:

- The National Institute of Standards & Technology, UNITED STATES, through the DH Tempe, Arizona laboratory facility which maintains master piston-cylinders 116, 512 and 26 and master mass set R100 bearing test report numbers TN-249770-92 (dated 2/92), TN-250722-92 (dated 8/92), TN-251820-93 (dated 6/93), and MS 17/MS 23 (dated 3/92) respectively. The traceability to NIST of standards for secondary measurements is established through laboratories approved by the DH Instruments quality assurance program.

- The National Research Laboratory for Metrology, JAPAN, through master piston-cylinders 116, 512 and 1063 bearing NRLM test report numbers 380017, 350305 and 350306 respectively.

- Le Bureau National de Metrologie, FRANCE, through the Desgranges et Huot Paris, France laboratory facility which the BNM regularly inspects and approves.

- Physikalisch Technische Bundesanstalt, WEST GERMANY; National Physical Laboratory, GREAT BRITAIN; Institute Colonnetti, ITALY, through the French national standards maintained by the Laboratoire National d'Essais, France.

David P. Kennedy
Metrologist

Laboratory Representative

:calibration sticker corresponds to the calibration certificate with which it is delivered
equired by DH Quality Control Procedures.

:ommended expiration date is given. DH recommends that the sticker be affixed to
orresponding storage box or test instrument and that the expiration date be
ected. Your particular quality assurance requirements may supersede these
nmendations.

DH Instruments, Inc. • 1905 West Third Street • Tempe, AZ 85281 • 602 967-1555 • Fax 602/968 3574

TEST IDENTIFICATION

The instrument tested consists of a Paroscientific Model 740-23A Pressure Transducer, No. 37078 with a stated accuracy of ±0.02% F.S..

TEST CONDITIONS

- Reference pressures were applied by DH working standard No. 103 with accuracy better than ±(0.0035% of reading + 0.00005 psi).
- Four hours were allowed for the test instrument temperature to stabilize before commencing the test. Ambient temperature throughout the calibration was 20°C ±1°C.
- Ambient humidity: 10 to 50% RH.
- Local gravity: $9.7947870\ m/s^2 \pm 3x10^{-8}$
- The test instrument reference level: pressure connection.
- Where no special tools or disassembly were required to adjust the gauge zero, the zero was adjusted at the start of the calibration.
- Pressure transmitting medium: nitrogen

TEST RESULTS

A table for each test run lists the following:

1. Reference pressure: Pressure defined by the reference at equilibrium.
2. Test reading: Pressure displayed by the instrument under test.

DH Instruments, Inc. • 1724 West Third Street • Tempe AZ 85281 • 602/967-1555 • Fax 602/968-3574

TEST RESULTS (AS RECEIVED)

REFERENCE PRESSURE (psia)	TEST READING (psia)
0.7253	0.7272
4.3476	4.3478
8.6944	8.6940
13.0411	13.0428
17.3879	17.3879
23.1836	23.1837
17.3879	17.3882
13.0411	13.0434
8.6944	8.6942
4.3476	4.3479
0.7253	0.7272

Indicates out of tolerance data under the auspices of NRC 10 CFR 21, Mil-Std-45662, or other quality assurance requirements. An out of tolerance condition is considered to exist when the disagreement between the test instrument and the reference, plus the accuracy of the reference exceeds the stated accuracy of the test instrument.

DH Instruments, Inc • 1905 West Third Street • Tempe, AZ 85281 • 602/967-1555 • Fax: 602/968 357-

RUN 1 (AS LEFT)

REFERENCE PRESSURE (psia)	TEST READING (psia)
0.7253	0.7260
4.3476	4.3468
8.6944	8.6932
13.0411	13.0421
17.3879	17.3874
23.1836	23.1834
17.3879	17.3877
13.0411	13.0427
8.6944	8.6933
4.3476	4.3469
0.7253	0.7260

DH Instruments, Inc • 1905 West Third Street • Tempe AZ 85281 • 602 967-1555 • Fax 602 968 1574

Sandia National Laboratories

Albuquerque, New Mexico 87185

date: November 13, 1990

to: MEMORANDUM OF RECORD

from: F. Garcia, 7343

subject: Subject: Technical Survey of the Calibration Program of DH Instruments Inc. at Tempe, Arizona, December 19-20, 1989

Objective:

The survey was performed to determine the degree of conformance of the standards and calibration program of DH Instruments to the requirements of the DOE/AL Weapons Complex and to good laboratory practice with emphasis on both the technical aspects as well as administrative aspects of the program. It was the goal of the survey to determine the suitability of DH Instruments as a Commercial Calibration Source in order that the DOE/AL Weapons Complex have alternate sources for the calibration of pressure sensing devices.

Summary:

The standards and calibration program at DH Instruments is administered by Mr. Michael L. Bridge, the Director of Quality Assurance. DH instruments has put together an excellent Quality Assurance Manual, which was given to the survey team, that describes the company's entire calibration process. The company is very interested in becoming a pressure instrument calibration source for the DOE/AL Complex and welcomes technical surveys from any source. They provided the team with a list of QA audits of DH performed since 1986.

The survey team surveyed all aspects of the calibration program and, in general found DH Instruments to be an excellent pressure gage calibration facility. The team recommends that DH Instruments be accepted as a Commercial Calibration Source for the DOE/AL Weapons Complex for pressure sensing devices in the range from 0.2 to 150,000 psi. It is further recommended that the calibrations include the mass measurements for weights used for piston gages.

Areas surveyed included:

Facilities
Instrument shipping and receiving
Research and development
Calibration personnel and equipment
Capabilities
Standards
Uncertainties
Computer usage

Discussion

1. In general, the team found everything in good order and in conformance with good laboratory practice.

2. Calibrations are designed to meet contractual agreements with the customer and are usually Mil-STD-45662A or NRC guidelines.

3. The buildings and facilities are quite nice and the equipment appears to be relatively new ~~and~~ in good order.

4. Traceabilities and uncertainties were found to be good and defendable.

5. A good recall system has been initiated for those customers who desire recall and the company appears to be making good use of computerization.

6. Calibration personnel demonstrated themselves to be qualified. Calibration personnel are recruited from Buttler College.

7. The equipment appears to be relatively new, in good order and with enough redundancy to survive breakdowns and calibration overloads.

8. Computers are being used efficiently for data reduction, recall, and report generation. Automated data acquisition is widely used in the research and development areas and in the new products from the company but very little is evident in the calibration area. However, DH plans to expand automated data acquisition into the calibration group in the near future.

9. The team was somewhat concerned over the fact that the resonant frequency of the DH Model 20000 is not known and it could be possible to develop a bias in some situations. DH will be addressing the subject.

10 The team felt that if there is any "weakness" in the calibration program, perhaps the pressure arena below 15 psi might be singled out. DH Instrument's main strength is from 15 to 150,000 psi. However, DH plans to incorporate, in the near future, new instrumentation demonstrated to the team that should remedy the situation.

Noteworthy achievements and comments

1. A recent addition to the DH product line, the Positive Pressure Controller, from all indication, will be a top-of-the-line device which industry appears to be accepting quickly. The device demonstrates the company's ambitious R&D position.

2. DH is independent of the original parent French company. This eliminates concerns which some agencies have had with respect to technical direction, traceability, and availability of parts and supplies.

3. A hand carried audit package, File No. 6786, a 0 to 775 torr Paroscientific transducer was calibrated by DH. The audit data and uncertainties from the calibration were well within the PSL results.

4. A transducer, Astra Serial No. ADH-01551 which had calibration history, was sent to DH for calibration in March, 1990 and was used as further evaluation of the DH calibration program. The results of this calibration were also well within the previously established historical uncertainty bounds of the device.

The results of the survey were discussed at a close-out meeting attended by:

DH Instruments	PSL
M. Girard	Frank Garcia
Don Topping	S. L. Husa
Michael L. Bridge	W. B. Leisher

The survey team consisted of the PSL close-out attendees listed above.

FG:7343

LISTING OF QA AUDITS PERFORMED AT DHI

COMPANY	AUDITOR	DATE
WESTINGHOUSE, NUCLEAR TECHNOLOGY DIV.	J.F. BROZ	05/86
MOTOROLA INC., GOVERNMENT ELECTRONICS GROUP	JIM HINES	11/86
ROSEMOUNT INC., AIROSPACE DIV.	RICHARD BARNES	01/87
PACIFIC GAS AND ELECTRIC	CHARLES T. LEWIS	02/87
NORTHEAST UTILITIES	CHARLES MARES	03/87
UNITED TECHNOLOGIES, HAMILTON STANDARD	CLINT REMILLARD	06/87
TEXAS UTILITIES	R.W. CRAWFORD	08/87
FORD AEROSPACE & COMMUNICATIONS, AERONAUTIC DIV.	RAY WADE	09/87
LORAL SYSTEMS GROUP	B. PEREZ	09/87
PRE-CAL SERVICES, INC.	MICHAEL J. BALOG	10/87
SOUTHERN CALIFORNIA EDISON	SAM WONG	11/87
BECKMAN		
PRECISION MEASUREMENTS	MICHAEL FRANCKOWISK	
SIMCO ELECTRONICS	S. MOSS	03/88
ARIZONA NUCLEAR POWER PROJECT	RICHARD F. PHELPS	05/88
MCDONNEL DOUGLAS, DOUGLAS AIRCRAFT CO.	D.P. PETERSON	06/88
UNITED TECHNOLOGIES, CHEMICAL SYSTEMS DIV.	BILL ELSEROUGI	07/88
DRESSER INDUSTRIES, INDUSTRIAL VALVE DIV.	ROD R. THOMAS	07/88
NORTHROP CORP., VENTURA DIV.	ART HERNANDEZ	07/88
ALLIED SIGNAL, GARRETT AUX. POWER DIV.	EDWARD J. STEHLE	09/88
WESTINGHOUSE ELECTRIC CORP., E & ISD	ED BOOTH	10/88
TENNESSEE VALLEY AUTHORITY	ED MCAMIS	10/88
OTIS ENGINEERING CORPORATION	PHILIP E. WEBB	01/89
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Sandia National Laboratories

Albuquerque, New Mexico 87185

date: October 10, 1990

to: Distribution

from: C. N. Giles, 7414

subject: Approval of MTS Systems As A Commercial Calibration Source

According to the SNL property records, your organization uses equipment built by MTS Systems. Representatives from Secondary Standards and Instrument Repair, Organization 7414, recently surveyed the MTS Systems facilities pursuant to appointment as a Commercial Calibration Source (CCS) in accordance with DOE Order AL57XA. This DOE designation accepts MTS Systems to perform force and extensometer calibrations in-situ as well as in their laboratory. Other calibrations that can be performed in their laboratory include dimensional, pressure, AC/DC voltage, resistance, acceleration, and time/frequency.

If you are required by SLI 6610-2 or other obligations to have calibrated equipment and have a contract with MTS Systems for maintenance and repairs on their equipment, they will furnish the necessary uncertainty and traceability certification upon request. Note that the certificate must be specifically requested in the purchase order for the work, otherwise it will not be included.

Point of contact for information abou MTS Systems's plant laboratory and field calibration capabilities is Mr. G. DeGroot who can be reached at (612) 937-4442.

If you have any questions regarding the survey and designation, please feel free to call W. B. Leisher at 844-2755 or R. L. Crabb at 844-2558.

WBL:7414:df

Copy to:
7341 W. G. Levy
7410 T. J. Young
7414 C. N. Giles
7414 R. L. Crabb
7414 W. B. Leisher

Distribution:
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8311

Sandia National Laboratories

Albuquerque, New Mexico 87185

date: September 18, 1990

to: W. G. Levy, 7343

from: R. L. Crabb, 7414

subject: Survey of MTS Systems Corporation

On September 12, 1990, a survey of the facilities of MTS Systems Corporation was performed by R. L. Crabb and W. B. Leisher, 7414. The mailing address for MTS is P.O. Box 24012, Minneapolis, MN 55424. The survey was done to appoint MTS as a Commercial Calibration Source (CCS) in accordance with DOE order AL57XA. The need for appointment as a CCS is based on the number of MTS machines at Sandia, some of which are used in materiel acceptance, and the need to contract for a maintenance technician from MTS. That technician is probably most qualified and equipped to perform calibration in conjunction with the maintenance process.

The persons present for the survey were R. L. Crabb and W. B. Leisher of Sandia; William J. Nordstrom, MTS Program Manager, Materials Testing Division; and Gaylord M. DeGroot, Manager, Quality Resources Technical Support. Mr. DeGroot is the MTS contact for calibration matters. He may be reached at (612) 937-4442. After the initial meeting, Mr. DeGroot provided a tour of the manufacturing and calibration facilities.

Calibration capability at MTS includes AC/DC voltage, Resistance, Pressure (2-100,000psi), Force (10-100,000lb), Acceleration (0-50g, 5-2kHz), Dimensional (1 microinch-100ft), and Time/Frequency. A copy of their capability chart is attached. They have expressed interest in performing calibrations in their laboratory as well as the in-situ calibrations being performed at Sandia.

Certificates are available upon request for calibrations performed. The certificates and calibration data contain uncertainty statements and expiration. Stickers are applied which indicate calibration date and expiration date, as well as technician identification. A recall system is in place. A copy of the MTS quality document was provided, which describes an extremely thorough calibration program, with out-of-tolerance notification forms, calibration forms and procedures, recall forms and procedures, and examples of all forms and labels in use. Housekeeping in all areas reflected good laboratory practice, and environmental control and records were in good order.

In light of the above, it is appropriate to appoint MTS as a CCS. Please add them to the list of approved CCSs, and list them appropriately in the next Primary Standards Laboratory (PSL) Semi-Annual Report.

Distribution:

7410 T. J. Young
7414 C. N. Giles
7414 W. B. Leisher
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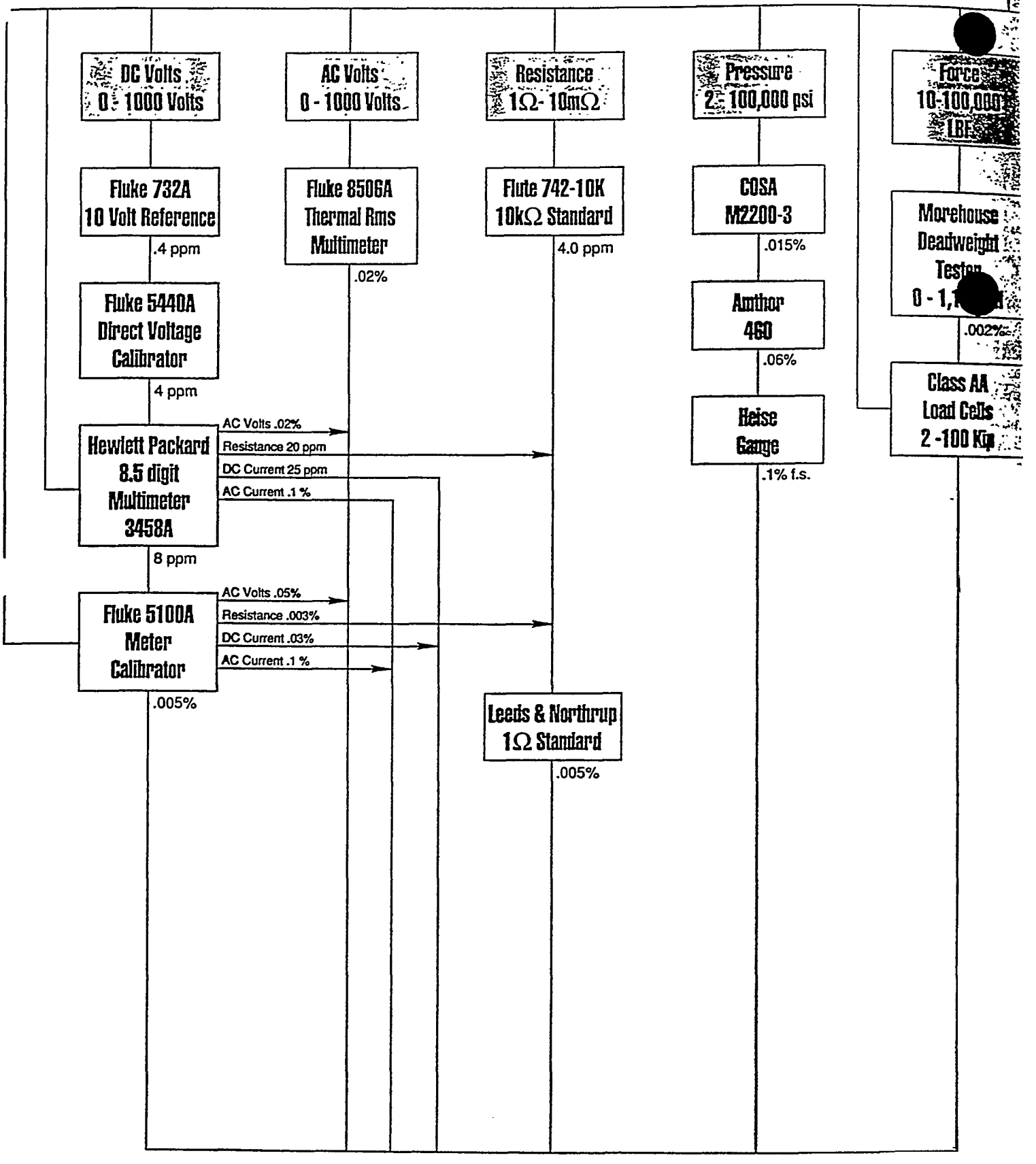

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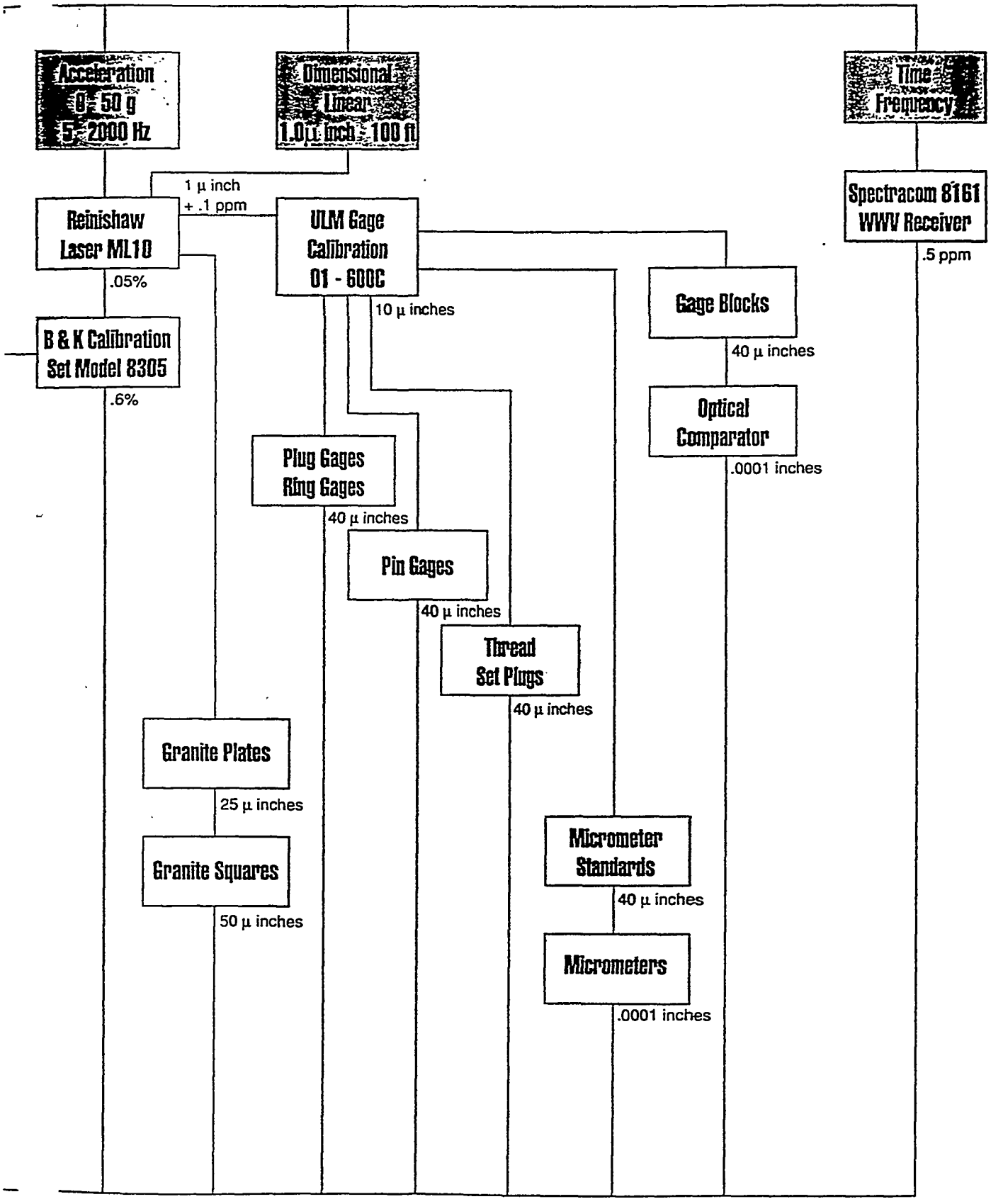
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Dimensional
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1.0µ inch - 100 ft
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Laser ML10
.05%
ULM Gage
Calibration
01 - 600C
10 µ inches
Spectracom 8161
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B & K Calibration
Set Model 8305
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40 µ inches
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Granite Plates
25 µ inches
Granite Squares
50 µ inches
Micrometer
Standards
40 µ inches
Micrometers
.0001 inches

Sandia National Laboratories

Albuquerque, New Mexico 871[illegible]

September 7, 1990

Mr. Gaylord DeGroot
Director, Metrology
MTS Systems Corporation
Box 20412
Minneapolis, NM 55424

Dear Mr. DeGroot:

Many pieces of MTS's equipment are in use here at Sandia National Laboratory. This equipment is normally maintained and calibrated by MTS service people under contract. The instruments used during this servicing have been calibrated by and, we understand, are traceable to NIST through your organization.

Because this equipment is used for product and material acceptance testing, the USDOE requires that the calibrating agency be surveyed and certified by one of the DOE contractor standards laboratories. The Sandia Standards Lab has been requested to make this survey of your documentation, procedures, and traceability and to provide the certification. This certification will then be valid for all contractors in the DOE weapons complex. The requirements are similar to those found in Mil Spec 45662.

As we discussed on September 6, we plan to arrive around 0900 on September 12. I will be accompanied by Rick Crabb, my fellow Project Leader in the Sandia Standards Lab. We will not be leaving the Minneapolis area until September 13, so we should have plenty of time. We will be leaving Albuquerque on September 11 for Minneapolis.

Sincerely,

W. B. Leisher

W. B. Leisher
Senior Member of the

243 cc to:
~~7473~~ W. G. Levy
7414 C. N. Giles
7414 R. L. Crabb
7414 W. B. Leisher

Sandia National Laboratories

Albuquerque, New Mexico 87185

date: February 24, 1989

to: R. B. Pettit, 7243

from: W. B. Leisher, 7241

subject: Certification of MTS Systems Corp.'s Calibrations

It is requested that MTS Systems Corporation be approved to make in-place calibrations on their equipment which is in use at SLA. The instruments on their equipment which require calibration are load cells, readout/power supplies, and displacement gages. There are an estimated 90 instruments involved. The SSL (Physical) does not have the portable equipment or know-ho to do the in-place servicing.

In-place calibration is necessary for the following reasons:

(1) The majority of these instruments are used in the servo control loops of load machines so the complete control system has to be adjusted as the last step of the calibration.
(2) Alignment of the instruments with the load direction is critical to proper performance.

Obviously, both of these reasons require knowledge of the equipment and its systems. MTS has a local, cleared serviceman, John Laing, who spends approximately half time at Sandia servicing these machines. He is presently performing the calibrations using transfer standards calibrated by the MTS metrology lab in Minneapolis, Minnesota. Laing says that their transfer standards are certified traceable to NIST and will have a copy of their QA Calibration Procedures sent to us. This copy is to be treated as Proprietary Data.

Two of the machines being so calibrated are used by Division 7542 in their operation as the Calibration Station for force.

If you need further information, please call.

WBL:7241:amf

Copy to:
7241 L. J. Azevedo
7243 R. L. Crabb
7241 W. B. Leisher

APPENDIX F: TRACEABILITY OF HE-NE LASER PERFORMANCE

UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234

October 18, 1976

RECEIVED
OCT 20 1976
METROLOGY

Mr. Glenn Herreman
Manager, Dimensional Metrology
Hewlett Packard
1501 Page Mill Road
Palo Alto, California 94304

Dear Mr. Herreman:

The question you raise concerning the traceability to national standards of interferometers utilizing the 0.633 μm line of the He-Ne laser is one that we have faced before. It is our opinion that such devices are *a priori* traceable and that no calibration by NBS is required.

Our position is based on the following considerations. The Comite Consultalif pour la Definition du Metre, the ultimate authority for the international definition of length, has accepted the 0.633 μm line of the He-Ne laser as a secondary standard of length (Recommendation M1 1973). The physical principles of laser action preclude any He-Ne laser from producing light of a wavelength which differs from the accepted value of $632991.399 \times 10^{-12}$ m by more than 1 part in 10^6. Hence for all technical purposes an He-Ne laser which produces a beam realizes the international and U. S. standard of length to accuracy sufficient to the needs.

Modern stabilization techniques can and, when functioning, do reduce this uncertainty to perhaps 1 part in 10^9, they cannot by misfunction degrade the performance below the 10^{-6} level.

The remainder of the interferometer involves modern digital electronics whose failure mode is catastrophic and hence is easily detected by the operator by use of the built-in test circuits in modern interferometers. Calibration by NBS would not provide further assurance of in use functioning and the inevitable mistreatment of transport to and from NBS would in fact be counterproductive.

In view of these facts, NBS does not provide a routine calibration for laser interferometers and considers all such devices traceable to national standards in all the usual contexts.

Sincerely,

John A. Simpson
Acting Chief
Mechanics Division

APPENDIX G: MEMO FROM B. RUTHERFORD ON ESTABLISHING TRACEABILITY TO NIST FOR WIPP CALIBRATIONS THROUGH RECORD VERIFICATION

Sandia National Laboratories

Albuquerque, New Mexico 87185-0829

date: May 23, 1995

to: Michael Schuhen, 6706, MS1341

Brian Rutherford

from: Brian Rutherford, 12323, MS0829

subject: Establishing Traceability to NIST for WIPP Calibrations Through Record Verification

I have enclosed a table that can be used to provide a rough assessment of the prospects for demonstrating calibration traceability to NIST standards through a record verification procedure based on sampling individual calibration records and confirming their traceability. The table provides probabilities associated with providing a successful demonstration using this record verification method for a few discrete scenarios.

The table can be viewed as three separate tables differing in their confidence level. The confidence level and the column headings, "Percent that must be demonstrated", are quantities that must be negotiated with the verification entity. Together, these negotiated quantities would play the following rolls in the sampling and evaluation procedure. Given a set of sample calibrations analyzed for their traceability to NIST standards, the confidence level will determine a lower "bound" on the percentage that are traceable. The higher the confidence level, the lower this bound will be because of the reduced allowance for error (not including the true percentage). The bound is then compared to the required demonstration level P%. If the bound exceeds P, the demonstration is considered to be a success.

The row headings in the table are hypothetical quantities associated with the sample plan and true percent traceability, say P*%. The sample plans five and ten samples, are two that we discussed earlier. The 80% and 90% listed under either plan are hypothetical values for P*. In constructing this table, I made the assumption that for each of the eight "measurement type" categories, there is a large enough number of calibration records to treat them as an infinite population. P* is the percentage of calibrations in this population that can be traced successfully to NIST standards.

The entries in the table are probabilities for a successful demonstration of traceability under the conditions specified by the column and row headings and the confidence level, under the assumption I mentioned earlier. Determining the probabilities is a straight forward, two-step procedure. The first step is to determine how many of the samples would have to be traceable in order to demonstrate the appropriate percent with the required confidence. The second

step is to compute the probability of this happening using the hypothetical values for P*. Missing values in the table indicate that the first step could not be accomplished, even if every sample showed traceability. The methods required for both steps are fairly standard procedures based on a binomial probability distribution (see Ostle (1963) for example). The assumptions listed earlier are sufficient to justify this method of analysis.

Table of Successful Demonstration Probabilities for Specific Scenarios

		Percent that must be demonstrated		
90% Confidence		70%	80%	90%
5 samples				
	80%			
	90%			
10 samples				
	80%	.11		
	90%	.35		

		Percent that must be demonstrated		
75% Confidence		70%	80%	90%
5 samples				
	80%	.33		
	90%	.59		
10 samples				
	80%	.37	.11	
	90%	.73	.35	

		Percent that must be demonstrated		
50% Confidence		70%	80%	90%
5 samples				
	80%	.33	.33	
	90%	.59	.59	
10 samples				
	80%	.67	.37	.11
	90%	.93	.73	.35

I hope these probabilities are helpful in your selection of a verification approach. If I can be of assistance through clarification of the issues discussed here, or by generating further information to fill gaps in the table, please contact me at 844-3120.

References:

Ostle, B. (1963), "Statistics in Research", Second Edition, The Iowa State University Press, Ames, Iowa.

Copy to:

MS1341 Al Stevens, 6706

MS1341 Debra Coffey, 6706

MS0829 Kathleen Diegert, 12323

MS0829 File (BMR) 12323

WIPP
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Office of Prog. & Resources Mgmt.
Office of Contract Business Mgmt.
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Analysis & Verification Division
Associate Director, RW-30
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Oak Ridge, TN 37831

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R. Pelletier, EH-231
Washington, DC 20585

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Fuel Processing & Waste Mgmt. Division
785 DOE Place
Idaho Falls, ID 83402

US Environmental Protection Agency (2)
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ANR-460
Washington, DC 20460

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Defense Nuclear Facilities Safety Board
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Washington, DC 20004

Nuclear Waste Technical Review Board (2)
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Santa Fe, NM 87504-1508

Environmental Evaluation Group (3)
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