NVLAP ACTIVITIES AT DEPARTMENT OF DEFENSE CALIBRATION LABORATORIES

D. M. Schaeffer[(1)]

Abstract - There are 367 active radiological instrument calibration laboratories within the U.S. Department of Defense (DoD). Each of the four services in DoD manages, operates, and certifies the technical proficiency and competency of those laboratories under their cognizance. Each service has designated secondary calibration laboratories to trace all calibration source standards to the National Institute of Standards and Technology. Individual service radiological calibration programs and capabilities, present and future, are described, as well as the measurement quality assurance (MQA) processes for their traceability. National Voluntary Laboratory Accreditation Program (NVLAP) programs for dosimetry systems are briefly summarized. Planned NVLAP accreditation of secondary laboratories is discussed in the context of current technical challenges and future efforts.

INTRODUCTION

Within DoD, four services, the Navy, Army, Air Force, and Marine Corps, individually manage and operate their own radiological calibration programs. Each service has made some degree of commitment to becoming involved in seeking accreditation of one or more of its calibration laboratories under the NVLAP. The purpose for such accreditation is to establish a few laboratory centers which can be certified as having credible traceability of all their radiation source standards to the National Institute of Standards and Technology (NIST) and also to carry the chain of standards traceability in a reliable fashion down to each of their subordinate field calibration laboratories. This chain of traceability is vitally important considering that each service has a separate worldwide and sometimes diverse complex of calibration laboratories which must suit specific service missions, customer needs, and technical emphasis, and also serve key operational centers to which they are proximally located. DoD participates in two main NVLAP activities: dosimetry system and secondary radiological calibration laboratory accreditation programs. In the first activity, DoD laboratory centers which process dosimetry have become technically mature under NVLAP. This activity is driven by the Code of Federal Regulations (CFR 1992) which require certification once

(1) Senior Health Physicist, Radiation Policy Division, Defense Nuclear Agency, Alexandria, Virginia 22310-3398.

every two years under NVLAP (ANSI 1982). The second activity, NVLAP accreditation of calibration laboratories, is somewhat in its early stages. This NVLAP program, however, is not governed as a mandatory certification under Federal Regulations and, therefore, does not have quite the impetus for implementation as there was historically for the dosimetry NVLAP. That is not to say there are no incentives for accrediting calibration laboratories. Each of these laboratories, which must be licensed by the U.S. Nuclear Regulatory Commission (NRC) for the use of its source standards, needs to conform to "good practice" guidelines under various NRC regulatory guides and standards (NRC 1981, 1985, 1987; ANSI 1978).

The guides, based on health physics operational requirements, specify that sources used to calibrate instruments should be traceable to national standards to within $\pm 5\%$. It is this required tolerance which gives rise to the need for MQA through a NVLAP program.

The purpose of this paper is to describe the DoD laboratories involved in NVLAP activities as well as the various processes for maintaining MQA throughout the complex of service laboratories. Dosimetry system accreditation will be briefly summarized. Most of the discussion will concentrate on radiological calibration laboratories, the quality processes now in effect for each service calibration program, the challenges presented by the NVLAP accreditation process, and future radiological functions which might benefit from an MQA program.

DESCRIPTION OF THE VARIOUS DOD PROGRAMS

The various DoD programs are described in the following.

NVLAP Dosimetry Laboratories

Each service has its own centralized laboratory for processing personnel dosimeters and maintaining historical dose records, except for the U.S. Marine Corps, which obtains its dosimetry from the Navy. In addition, the Navy operates another separate dosimetry system to support the Naval Nuclear Propulsion Program under its strict guidelines. That system, thought to be the largest completely decentralized dosimetry program in the world, provides on-site and work-site processing of personnel dosimeters in the field. Table 1 shows where each service dosimeter processor is located, the equipment used, number of organizations monitored, the current transaction rate per year, and the frequency for reading personnel dosimeters. For the second Navy system, the location named is the organization responsible for the NVLAP accreditation. Each location for the centralized processors currently carries NVLAP certification and has successfully maintained it since 1986. The Navy's decentralized system has also been continuously accredited under NVLAP from 1989 onward. The accreditation categories for each dosimetry system are given in Table 1.

Each centralized processor's dosimetry system is operated under locally established and approved procedures. They specify how often the readers are to be properly adjusted and calibrated and what measures are to be taken if dosimeters, which are given known exposures and randomly seeded within processing runs, identify out-of-tolerance conditions. Individual dosimeters are checked for proper sensitivity to and registration of radiation before they are sent back to various customers. Multiple processing frequencies, where shown, are structured to require personnel with a potential for higher exposure to get their dosimeters evaluated more often, and likewise for lower exposure potentials less often. The Navy's decentralized dosimetry system, however, is treated differently, but also subjected to stringent controls. Each processor must have its dosimeters checked for proper sensitivity at least every 6 months and dosimetry readers calibrated at least every year. Calibration standards are replaced at every fifty uses. Additionally, and most importantly, each processor receives inspection each year from an independent organization of examiners or the program office to demonstrate the proficiency of personnel operating the dosimetry equipment. Also, the dosimetry equipment is subjected to a performance test each year to prove whether it meets specified criteria or needs correction of its out-of-tolerance condition (USN 1988). All corrections are followed up by retests. Personnel dosimeters are processed daily if used in shipyard work, up to monthly if used in shipboard activities, or the same day after leaving a high-radiation area. The unique and all-encompassing quality assurance test process for this dosimetry system is depicted in Figure 1. Tight control of 160 processors to a single calibration reference at the Naval Shipyard, Puget Sound, Washington, and yearly internal performance testing keep this system well within NVLAP tolerances. It is also an excellent example of a proven and successful MQA process.

In general, the services have maintained mature and smooth operating dosimetry programs which have benefitted from NVLAP accreditation. The long-term success of these NVLAP programs owes to the early 1980's participation of the services in the University of Michigan pilot program for dosimetry processor accreditation (Plato and Hudson 1980). The early collaboration of both processor and test organizations allowed organizations to make the proper corrections and refinements to their dosimetry equipment. In turn, the testing organization was able to identify and amend unrealistic performance criteria before the NVLAP was established. This joint effort contributed to the high degree of acceptance of the dosimetry NVLAP even before mandatory certification became a requirement by federal law (CFR 1992).

DoD Calibration Laboratories

Each service within DoD has its own radiological instrument calibration program, supporting management structure, operating directives and policies, technical procedures, and inspection and audit process for maintaining MQA and traceability to NIST. Table 2 describes the relative sizes of various service radiological calibration programs in terms of calibration transactions performed per year and also the size of the instrument inventory supported. It also breaks out the number of instruments identified in the operational category, which are employed in daily, routine health physics applications. The rest of the inventories fall under warfare preparedness and contingency planning. The calibration frequencies for the instruments reflect the ranges of the above applications.

U.S. Navy Program

The Navy's radiological instrument calibration program is managed by Naval Sea Systems Command in Washington, D.C. while its operation has been delegated by NAVSEA authority to the Naval Electronic System Engineering Center (NAVELEXCEN), Charleston, South Carolina. The latter organization has the responsibility for the secondary calibration laboratory, and its basic function is to hold NIST-traceable calibration source standards for the Navy and ensure that all other radiological calibration laboratories within the Navy trace their measurements to these sources. NAVELEXCEN Charleston also manages the operation and inspection of all subordinate laboratories listed in Table 3. There are 30 laboratories within NAVELEXCEN's area of responsibility, 16 laboratories on board tenders or repair ships, 10 within the continental United States, and 4 outside the continental United States. The secondary calibration laboratory at Charleston carries a high-intensity, open-range capability for gamma radiation; an open-air range for neutrons; and large-area sources for alpha radiation.

The 30 calibration laboratories listed in Table 3 presently trace their calibration sources to those described for the Charleston laboratory. Each of these laboratories has similar capabilities, depending on whether a tender or a shore organization is performing calibrations. The shipboard laboratories, stationed throughout the world and deployable to other locations to support military forces in international conflicts, do not use open-range sources. To fit the confines of the ship, box calibrators for gamma and neutron sources are required. The shore laboratories, however, having greater space allocations, calibrate with open-air ranges where possible. NAVELEXCEN Charleston plans to become accredited as a secondary laboratory under NVLAP within the next few years. In the upgrade of its capabilities, it will phase in a multisource, uncollided beam Cs-137 gamma calibrator, in place of the current AN/UDM-1A, and also an open-range Co-60 source. The large-area alpha sources in the AN/UDM-7 series will be replaced with large-area electroplated Amersham-type sources. Also, a 320-kVp x-ray range will be added to its capability. The same gamma calibrators will eventually be installed at all shore laboratories, replacing all AN/UDM-1A calibrators.

The Navy's structure for maintaining MQA throughout its laboratory organizations is summarized in Figure 2. There are four management directives (USN 1989a, 1989b, 1992a, 1992b) which cover all aspects of the operation and control of the calibration program. The administrative and operational directive (USN 1989a) establishes calibration priorities and frequencies. Table 2 indicates that equipments used for operational health physics applications form a significant part of the Navy inventory. For the Navy, the operational applications for reactor, medical, radiation safety, radiography, and nuclear weapons functions are the highest priority and require 6-month calibration periods (3 months for radiography) for its needs. Emergency response, training, and warfare preparedness are the lowest priority categories and have longer instrument calibration periods. A local field office structure, which reports through NAVELEXCEN Charleston, is required to oversee the operation of local calibration laboratories. These responsibilities include seeing that a weekly quality assurance sample of instruments is drawn and inspected for proper calibration and completion of repairs and documentation, reviewing personnel training requirements and competencies for laboratory work, performing monthly on-site surveillances to ensure that equipment calibrations are performed according to calibration directives, conducting twice-a-year formal reviews to observe and test for strict word-for-word adherence to formally published instrument calibration procedures (USN 1992b), and preparing for once every 12 to 18 months audits of the entire program by NAVELEXCEN Charleston.

The audit program (USN 1989b) certifies the fitness of the laboratory to deliver NIST-traceable calibrations for the instruments used by various Navy customers. It covers factors from laboratory environmental control, radiological safety, work space and support equipment standards, ability to follow calibration procedures, and utilization and currentness of technical publications and management directives to the retention of calibration certificates. Each laboratory is given a certification, an interim certification, or decertification, depending on the number and severity of findings. Remedial actions are required if a less than full certification is received and another audit visit is scheduled. Laboratories unable to receive full certification are given a limited remedial period for correcting deficiencies or are not permitted to operate. This audit program is also supplemented throughout the year by inspections from the Nuclear Propulsion Program if calibrations at a given laboratory are performed for its application. The Office of the Chief of Naval Operations through the Radiological Affairs Safety Office (RASO) in Yorktown, Virginia, holds the Navy's NRC master material license and directs once every 3 years inspections of all calibration laboratories for compliance with NRC requirements which prescribe the safe and proper control and handling of radioactive materials.

The secondary laboratory at Charleston maintains the update and control of all radiological instrument calibration procedures which are distributed to all concerned (USN 1992b). It also operates under its own policy directives and procedures (USN 1992a) for the traceability of all laboratory sources to NIST. This directive covers personnel training of the technical team which visits each laboratory once every 3 years, or sooner if there is technical assistance required in repairing a calibrator. The directive instructs how to analyze the field calibration data, what verification methods to use, and what data to report to the calibration laboratories. There is no formal program in place yet to independently audit this function in the Navy's calibration program. NVLAP certification is proposed to supplement the audit of this program.

U.S. Army Program

The Test, Measurement, and Diagnostic Equipment (TMDE) Activity, which resides at Redstone Arsenal, Alabama, both manages and operates the Army's radiological instrument calibration program. TMDE's responsibility for source traceability is identical to that for the Navy's laboratory at Charleston. It serves as a secondary calibration laboratory for the Army's basic radiation source standards. TMDE Activity formulates and distributes policy for the operation and management of subordinate calibration laboratories, as listed in Table 4. However, the inspection function for all laboratories, including the secondary laboratory, is handled through an independent organization at TMDE called the Inspection and Policy Compliance Division. There are 203 radiological calibration laboratories which trace their calibration sources to standards held at TMDE Activity. They have all been categorized as to level 1, 2, or 3 laboratories and have stratified levels of accuracy in their calibration capability. Level 3 laboratories have the same source capabilities as level 2, but mostly check and calibrate instruments to a 30% tolerance level and refer instruments to the next level laboratory if they require a tighter degree of tolerance. Out of the eight level 1 laboratories, two are outside the continental United States and six are within. All ten level 2 laboratories are within the continental United States. Table 4 also describes the degree of planned consolidation of Army calibration activities over the next few years.

In addition, the dosimetry processing function, now at the U.S. Army Ionizing Radiation Dosimetry Center (USAIRDC), Lexington, Kentucky, will move to be combined with the TMDE function at Redstone Arsenal, Alabama. The current capability at Redstone's secondary calibration laboratory includes a high-intensity, open-air gamma source, the AN/UDM-1A, small-area alpha standards, AN/UDM-6, a beta source calibrator for low-range survey meters, and 320- and 50-kVp x-ray machines. Its planned capability as a secondary laboratory, when its new laboratory is constructed and all organizational consolidations are completed, will propose the following capabilities for NVLAP certification: Shepherd series 81 with open-air Cs-137 and Co-60 calibration ranges; a Cs-137 box calibrator; both large- and small-area, electroplated Amersham-type alpha source sets; the beta calibrator with standard (Sr-90, Pr-147, and Tl-204) sources and beam flatteners; the 320- and 50-kVp x-ray machines; and an open-range PuBe neutron source.

Level 1 laboratories differ from level 2 and 3 laboratories in that they have high-intensity gamma capability and the others use AN/UDM-2 source sets instead. This means that the need for instrument calibrations using a high-intensity gamma range calibration would have to be fulfilled at the level 1 hierarchy. In Table 2, it can be seen that, unlike the Navy's mission, which is heavily influenced by operational health physics requirements, the Army's mission is geared to servicing instruments for contingency and warfare preparedness applications.

The Army organizational structure for maintaining MQA is given in Figure 3. There are four main Army directives (USA 1989, 1990, 1991, 1992) which set policies for the management and operation of Army radiological calibration laboratories. The overall policy directive (USA 1989) establishes TMDE at Redstone Arsenal, Alabama, as the responsible agent for the Army's radiological calibration program and empowers it to set requirements and distribute procedures for the operation of calibration laboratories at subordinate organizations. Calibration frequencies for instrument calibrations are influenced by the use category of the instrument (USA 1992). Instruments are categorized into the following uses: active, radiographic, or medical; "REACT" for emergency teams; and warfare contingency. The category "active" means that the instrument is in daily use around ionizing radiation sources. Instruments in the first category grouping are calibrated every 90 to 120 days, depending on instrument performance data; those in the second category every 90 days, and those in the last every 5 years. Calibration procedures and methodologies along with calibration intervals are contained in published references (USA 1991, 1992). The calibration protocol requires adjustment only if the measured value exceeds the specified tolerance. Otherwise, no adjustments are made. This method is contrasted with the Navy and Air Force practices to adjust instruments to the optimum set points any time a user submits an instrument for calibration.

The published methodologies also describe a QA program wherein TMDE Activity analyzes calibration frequency data, fields questions and problems from the users and laboratories, and examines the findings of technical audits and inspections for abnormal behavior trends. From this field link, TMDE Activity is able to modify policies and procedures to implement needed improvements and refinements. TMDE Activity personnel within the secondary calibration laboratory check the source standards at each calibration activity (including their own) every 18 to 24 months to ensure its sources are kept traceable to NIST. Under procedures and check lists for quality assurance tests (USA 1990), the TMDE independent compliance team mentioned earlier inspects each laboratory every 18 to 24 months. Its findings, if serious enough, can be reported through the U.S. Army Inspector General for resolution. The report from this team decides the suitability of the laboratory for continued calibration of instruments. In addition, because the calibration sources of all levels of laboratories are licensed radioactive material, the Army Environmental Hygiene Agency (AEHA) conducts NRC compliance inspections once every 3 years to ensure laboratories are handling and transporting sources correctly and safely.

U.S. Air Force Program

The Aerospace Guidance and Metrology Center (AGMC) at Newark Air Force Base (AFB), Ohio, manages and operates the Air Force's radiological instrument program. AGMC is responsible for maintaining basic radiological source standards traceable to NIST and acting as the secondary calibration laboratory to which all other Air Force radiological calibration laboratories trace their source standards. The AGMC, like the Army's TMDE Activity, formulates and distributes policy to the operation and management of subordinate laboratories listed in Table 5. The inspection and audit function for all laboratories, including the secondary one at AGMC, belongs to a separate AGMC organization responsible for laboratory compliance. There are 128 radiological calibration laboratories within the Air Force, 8 depot level laboratories, and 120 Precision Measurement Equipment Laboratories (PMEL). They trace their source standards to AGMC. Locations for the major depots are listed in Table 5. Six depots are within the continental United States; two are outside. The 120 PMELs are spread through various field units. Depots at Patrick AFB and Brooks AFB are special cases in that Patrick AFB only has a high-intensity gamma capability to support the work of the space program and Brooks AFB has expanded capabilities in support of special medical health physics consultation functions. Given the level of health physics expertise at Brooks AFB and the variety of capabilities for its mission (see Table 5), Brooks AFB also plans to become accredited as a secondary calibration laboratory. The current capability at AGMC includes two open-air ranges: one for a high-intensity Cs-137 gamma source and medium intensity neutrons from PuBe. Also, there are large-area and small-area alpha source standards, the AN/UDM-7 and CS-1, respectively. A box calibrator for checking pocket dosimeters with a Cs-137 source rounds out AGMC's capability. In AGMC's future plans as an accredited secondary calibration laboratory, a 320-kVp x-ray machine and electroplated Amersham-type large-area alpha source (to replace the AN/UDM-7) will enhance its current capability. In its special consultation support within the Air Force, Brooks AFB will bring two x-ray machines, 160 and 420 kVp, a beta source calibrator, and three neutron sources in a low scatter facility (one PuBe and two Cf-252), along with its regular depot capability, into its intended scope of NVLAP accreditation. In addition to high-intensity gamma capability, depots are given low-intensity bench-top gamma capability (D0062) and small-area alpha source sets (AN/UDM-6). PMELs only have bench-top gamma and small-area alpha source capabilities. From Table 2, it can be noted that, even though the total Air Force inventory of instruments calibrated is appreciably smaller than the Navy's or the Army's, there is sizable support required for operational health physics instruments.

The Air Force organizational structure for maintaining MQA is shown in Figure 4. Four main policy directives (USAF 1992a, 1992b, 1992c, 1992d) control the management and operation of the Air Force radiological instrument program. Unlike the other services discussed thus far, these directives apply to all test and monitoring equipment calibration throughout the Air Force, and radiological equipment is only one small part in these directives. As can be seen in Figure 4, the management, operational, and independent inspection and audit processes are the same for the Air Force as they were for the Army. Within the directives, however, there are some programmatic differences. The overall policy directive (USAF 1992b), establishes AGMC as the secondary radiation laboratory through which all subordinate calibration laboratories derive their radiation source standards. This directive also specifies the general standards for calibrating radiological instruments, the documentation for calibration certificates, the performance data to be collected, and the locations of both Air Force and other services' calibration laboratories. It includes the requirements for an independent audit of all calibration laboratories once every 2 years. During this audit, the greater of 15 or 1% of all instruments on the "ready" shelf are sampled for conformance to technical and documentation requirements. A failure rate of greater than approximately 15% is a major deficiency for the laboratory. This team is also empowered to decertify and close laboratories found to be in non-compliance with Air Force calibration policies. On-site QA is also in effect between audits. Quality Visual Inspections (QVIs) are performed on 1% of outgoing equipment each month. Also, each technician is subjected to two Over the Shoulder (OTS) inspections each year to monitor his proficiency in complying with Air Force Calibration Procedures (USAF 1992c). There are inspection checklists for each outgoing instrument. Reports are maintained on the above activities for supervisory review. If QVI and OTS results show a pattern of unacceptable work, technicians are temporarily removed from calibration work and given retraining to restore the proper level of proficiency. Another directive (USAF 1992a) specifies the calibration frequencies for the instruments and the end-use application. For example, radiography survey meters are calibrated every 3 months, instruments supporting use of byproduct material and academic programs are calibrated every 6 months, and instruments involving medical and laboratory safety are calibrated every 12 months. All other instruments maintained for war reserve and mobilization are calibrated every 18 months. There is also a directive (USAF 1992d) which is a compilation of the procedures and methods for the AGMC secondary calibration laboratory to follow in demonstrating traceability of all laboratory source standards to NIST. Source traceability measurements are performed at least once every 3 years. In addition, as in the other services, the NRC master material license granted to the Air Force gives the Brooks AFB the responsibility for conducting compliance inspections every 3 years at calibration laboratories to ensure the safe use and handling of radioactive material.

U.S. Marine Corps Program

The Office of the Commandant of the Marine Corps is the centralized management organization for the Marine Corps' radiological instrument program. By a broad policy directive, each of the Marine Corps' three laboratories, located as shown in Table 6, manage their own operations. Depending on whether the radiological instruments are Navy or Army in their design and application, the calibration laboratories will follow either Navy or Army calibration procedures (USA 1992, USN 1992b). The Marine Corps laboratories fall under the jurisdiction of the Navy's NRC master material license and, as such, must meet the $\pm 5\%$ source traceability criteria found in regulatory guides applicable to the use of byproduct material. The RASO conducts license compliance visits at each Marine Corps laboratory once every 3 years. The alpha source standard at each laboratory in Table 6 traces to NIST via the Navy's secondary calibration laboratory at Charleston, South Carolina. As regards the high-intensity gamma calibrators, the Office of the Commandant of the Marine Corps plans within the next 2 years to set up the Barstow, California, laboratory as the secondary laboratory to be accredited under NVLAP, and also establish an audit program to inspect the laboratories for proficiency and competence to perform instrument calibrations.

SUMMARY

With the exception of the Marine Corps, each service has its own elaborate MQA process, which tracks radiation calibration source standards from the lowest level laboratory to NIST. The Army and Air Force programs rely on independent inspection and audit processes to demonstrate performance and conformance to program policy, directives, and procedures. The Navy, on the other hand, concentrates inspections and audits at the lowest laboratory level, where there is strong interaction with customers receiving the calibration program's benefits. This emphasis is evident in an extensive field office organization which reports to the management of the secondary calibration laboratory at Charleston, South Carolina (USN 1989a). Customer involvement in the audit process adds an extra dimension to management's judgment of program quality. However, this attribute should complement the independent audit process, which evaluates every step in the NIST traceability hierarchy.

CHALLENGES IN MEASUREMENT QUALITY ASSURANCE

Since the introduction of the NVLAP requirements for accrediting secondary calibration laboratories (NIST 1990), there has not been a great deal of energy exerted within individual services to press on with laboratory certification. At the moment, there appears to be a level of frustration with the documentation requirements which must be met before an on-site visit is granted and proficiency testing is started. Most prospective laboratories have voiced the opinion that there is no incentive to become certified under NVLAP. As long as each service provides calibration only for its own internal customers, the certification is merely a prestige. With the pressures of reducing the defense budget, some consider the cost of accreditation too high. On the other hand, it is known only too well that NVLAP did enhance the performance and quality of personnel dosimetry processing within DoD. So long as such participation became a mandatory NRC requirement and applicable across both federal and private sector lines, all dosimeter processors within DoD became willing and eager to embrace the program. There is some thought that, if secondary laboratory accreditation is made an NRC requirement, most, if not all, DoD laboratories will aggressively pursue bringing their organization up to technical performance standards and quickly seek NVLAP accreditation. There is one impediment here that the private sector will need to back the concept of required NVLAP certification. Some laboratories find the technical criteria a worthwhile aspiration and, given the time and resources available, will become accredited, even if not required by law. In time, however, the expectation is that all DoD secondary calibration laboratories will meet the call for technical excellence which NVLAP accreditation represents.

Another area of great consternation is the development of the quality manual described in the recommended program standard (ISO 1990). The emphasis on producing a quality manual to describe the quality program as a stand-alone entity is going against the grain of what is being introduced today in the precepts of total quality management. There is a definite clash of cultures here, which is confusing laboratory organizations seeking accreditation. Quality, as it is being described today, is process oriented and also something that must be integrated into our work processes in order to be effective. The task of producing the quality manual is being viewed as requiring the extraction of the requirements from the process rather than showing how they are integrated. The topical requirements, which are listed in the NVLAP accreditation handbook (NIST 1990) and its related standard (ISO 1990), are reasonably sound and really need to be addressed in the calibration laboratories' management and operational processes. A mere semantical change might help erase the frustration. Rather than call it a quality manual, rename it as follows: *Operational and Administrative Processes for the Technical Management of a Secondary Calibration Laboratory*. This will do two things: it will orient laboratories to think of their work in terms of processes and also allow the quality requirements of the NVLAP technical standards to be built into the processes. The small change in philosophy of concentrating on what should be in the process rather than how the requirements should be described should go a long way in giving initiative and enthusiasm to organizations becoming NVLAP accredited.

To boost enthusiasm for secondary laboratory accreditations, it might be helpful to step back and follow the paradigm of the dosimetry NVLAP. Some thought that instituting a pilot program where there is a trial period of performance and proficiency testing would be enlightening to those laboratories unsure and somewhat apprehensive about meeting the certification standard on their first try. Certainly, the trial, no-fault, non-attribution performance period opened a dialogue between the test administrators and tested organizations to learn, not only how the quality requirements were to be met, but perhaps that some of the test requirements had to be refined or modified based on knowledge of collective laboratory experiences. If secondary laboratory accreditation moves toward becoming a legal requirement for the calibration of instruments used in NRC-licensed programs, a pilot program will be a great incentive to the program participants, especially if one is started now. A pilot program would also allow the opportunity for some "give and take" on the implementation of quality requirements in laboratory processes.

FUTURE NVLAP EFFORTS

There are still other processes within the practice of health physics which lend themselves to certification. Examples of areas where proficiency testing would benefit and enhance performance consistency are:

- biodosimetry/bioassay programs
- counting laboratories
- extremity monitoring
- radiological instrument testing
- brachytherapy
- medical accelerator treatment.

Should some of these areas above be considered, it might be necessary to merge similar certification programs which fall under the Health Physics Society (HPS) or the American Association of Physicists in Medicine (AAPM), or enter into joint programs with these organizations. Also, if there is a movement to add more radiological processes/programs to NVLAP, a general NVLAP handbook for health physics programs should be developed so that, as individual parts are possibly adopted, they will be add-on rather than stand-alone programs. It would then allow the experiences drawn from the other parts to influence positively the implementation efforts of new programs.

Under consideration is NVLAP accreditation for the gamma and neutron sources at Naval Surface Warfare Center (NAVSWC), where instruments continue to be calibrated to characterize the output signatures for various weapon systems under the DoD Intrinsic Radiation (INRAD) Program. With the passage of Public Law 102-578, the DoD will most likely be asked to collaborate with the Department of Veterans Affairs in undertaking a health effects study of those veterans who were engaged in weapons maintenance and handling and exposed to measurable levels of neutrons by today's standards. Because neutron dosimetry was insensitive or unavailable in the pre-1970's, measurable doses to this population are not known. NAVSWC's dose equivalent measurement capability can be used to remeasure the old systems in configurations in which workers serviced them. These measurements can then be used to reconstruct the personnel doses for the health effects study. Also foreseen are the possibilities of joint programs involving the U.S. Department of Energy (DOE). Public Law 102-484 and currently proposed legislation have identified civilians engaged in the same type of work for medical follow-up. It would enhance the credibility of such studies to know that the reconstructions trace back to NVLAP-accredited source standards and methodologies.

ACKNOWLEDGEMENTS

I express my sincere appreciation to all of those who briefed me on their radiological programs at the various service organizations I visited in preparation for this paper. I am also grateful to my colleagues at Defense Nuclear Agency and JAYCOR for the helpful discussions and support in the production of this report.

REFERENCES

American National Standards Institute (ANSI). 1978. "Radiation Protection Instrumentation Test and Calibration." N323-1978, ANSI, New York.

American National Standards Institute (ANSI). 1982. "Criteria for Testing Personnel Dosimetry Performance." N13.11-1983, ANSI, New York.

Code of Federal Regulations (CFR) Title 10, Part 20. 1992. "Radiation Protection Standards." Superintendent of Documents, Washington, D.C.

International Organization for Standardization (ISO). 1990. "General Requirements for the Competence of Calibration and Testing Laboratories." ISO Guide 25, ISO, Geneva.

National Institute of Standards and Technology (NIST). 1990. "Draft NVLAP Program Handbook for Secondary Calibration Laboratory for Ionizing Radiation." NIST, Gaithersburg, Maryland.

Plato, P. and G. Hudson. 1980. "Performance Testing of Personnel Dosimetry Services, Supplementary Report of a Two Year Pilot Study, Oct 77 - Dec 79." NUREG/CR-130, U.S. Nuclear Regulatory Commission, Washington, D.C.

U.S. Air Force (USAF). 1992a. "Technical Manual—TMDE Calibration Notes." TO 33K-1-100-1, AGMC, Newark AFB, Ohio.

U.S. Air Force (USAF). 1992b. "Technical Manual—Air Force Metrology and Calibration Program." TO 00-20-14, AGMC, Newark AFB, Ohio.

U.S. Air Force (USAF). 1992c. "Technical Manual for RADIAC Equipment Calibration Procedures." TO 33K7-X-XX-X Series, AGMC, Newark AFB, Ohio.

U.S. Air Force (USAF). 1992d. "Technical Manual for Calibration Procedures for RADIAC Calibration Standards." TO 33K7-5-XX-X Series, AGMC, Newark AFB, Ohio.

U.S. Army (USA). 1989. "Maintenance of Supplies and Equipment: U.S. Army Test, Measurement, and Diagnostic Equipment Program." AR 750-43, Headquarters, Department of the Army, Washington, D.C.

U.S. Army (USA). 1990. "Maintenance of Supplies and Equipment: Army Test, Measurement, and Diagnostic Equipment (TMDE) Calibration and Repair Support Program." TB 725-50, Headquarters, Department of the Army, Washington, D.C.

U.S. Army (USA). 1991. "Army Calibration Program for RADIAC Meters." TB 9-6665-285-15, Headquarters, Department of the Army, Washington, D.C.

U.S. Army (USA). 1992. "Calibration and Repair Requirements for the Maintenance of Army Material." TB 43-180, Headquarters, Department of the Army, Washington, D.C.

U.S. Navy (USN). 1988. "Quality Assurance Procedures for Navy CaF_2 Thermoluminescent Dosimetry System." SE700-AA-MAN-240/RADIAC, Naval Sea Systems Command, Washington, D.C.

U.S. Navy (USN). 1989a. "Policies and Administrative Procedures for the RADIAC Equipment Calibration Program." SE700-AA-MAN-210/RADIAC, Naval Sea Systems Command, Washington, D.C.

U.S. Navy (USN). 1989b. "Certification of Navy RADIAC Calibration Laboratories." SE700-AA-MAN-230/RADIAC, Naval Sea Systems Command, Washington, D.C.

U.S. Navy (USN). 1992a. "Operational and Administrative Procedures for RADIAC Calibration Standards Program." SE700-AA-MAN-220/RADIAC, Naval Sea Systems Command, Washington, D.C.

U.S. Navy (USN). 1992b. "RADIAC Equipment Calibration Procedures." SE700-AA-MAN-250/RADIAC (2 Vols), Naval Sea Systems Command, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1981. "Preparation of Applications for Use of Sealed Sources and Devices for Performing Industrial Radiography." Regulatory Guide 10.6, NRC, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1985. "Draft U.S. NRC Regulatory Guide FC 412-4, Guide for the Preparation of Applications for Licenses for the Use of Radioactive Materials in Calibrating Radiation Survey and Monitoring Instruments." NRC, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1987. "Guide for the Preparation of Application for Medical Use Programs." Regulatory Guide 10.8, NRC, Washington, D.C.

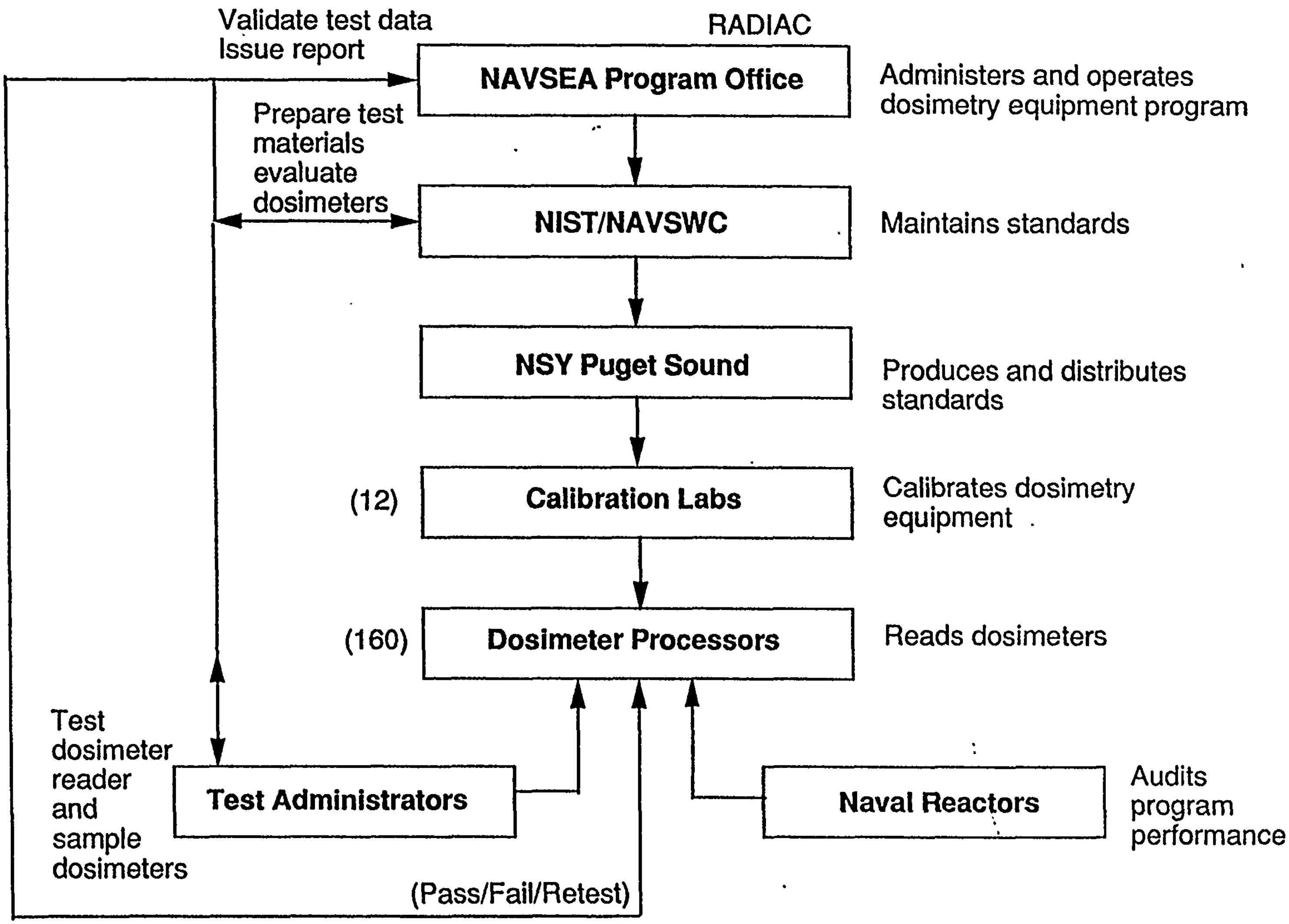

Figure 1 - Description of Quality Assurance Program for the U.S. Navy Calcium Fluoride Thermoluminescent Dosimetry System

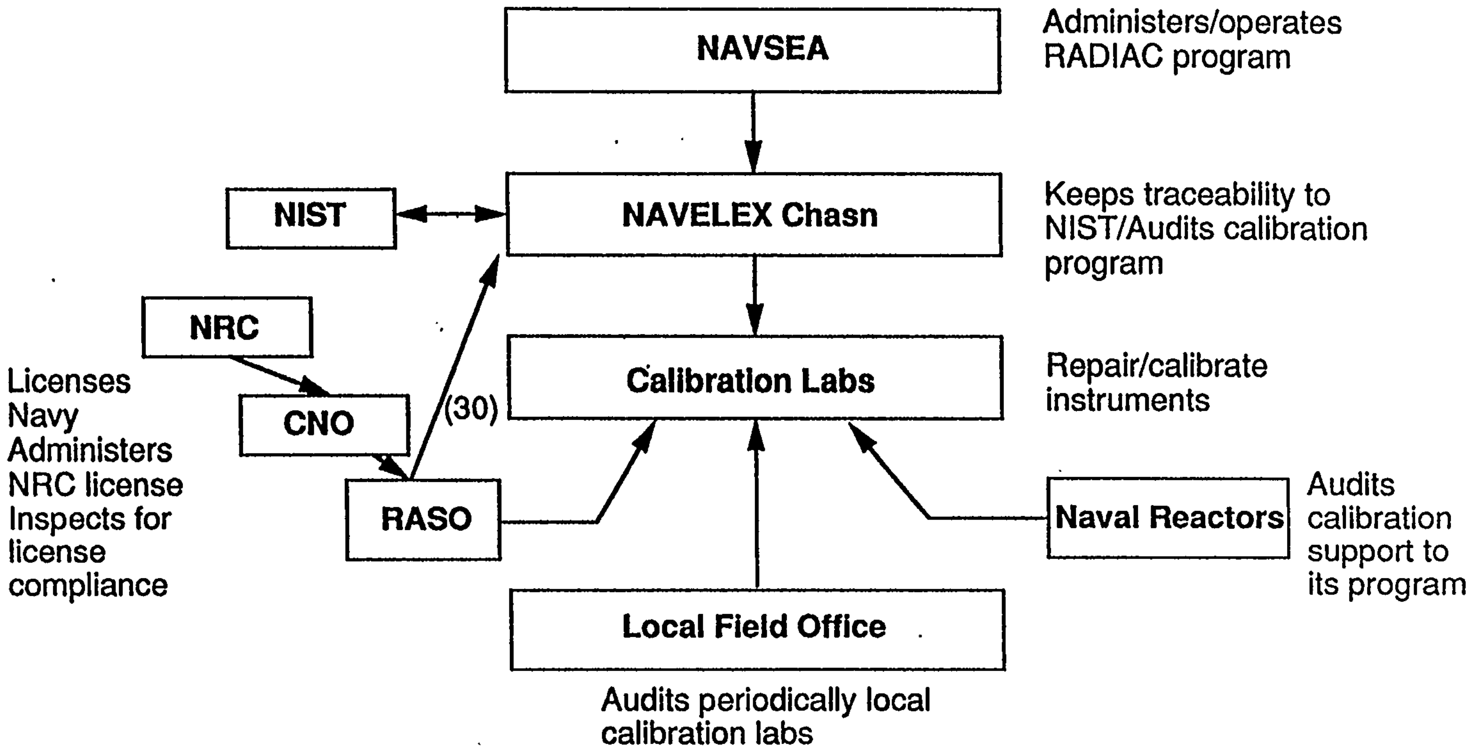

Figure 2 - Description of the Quality Assurance Accountability Process for U.S. Navy Radiological Calibration Labs

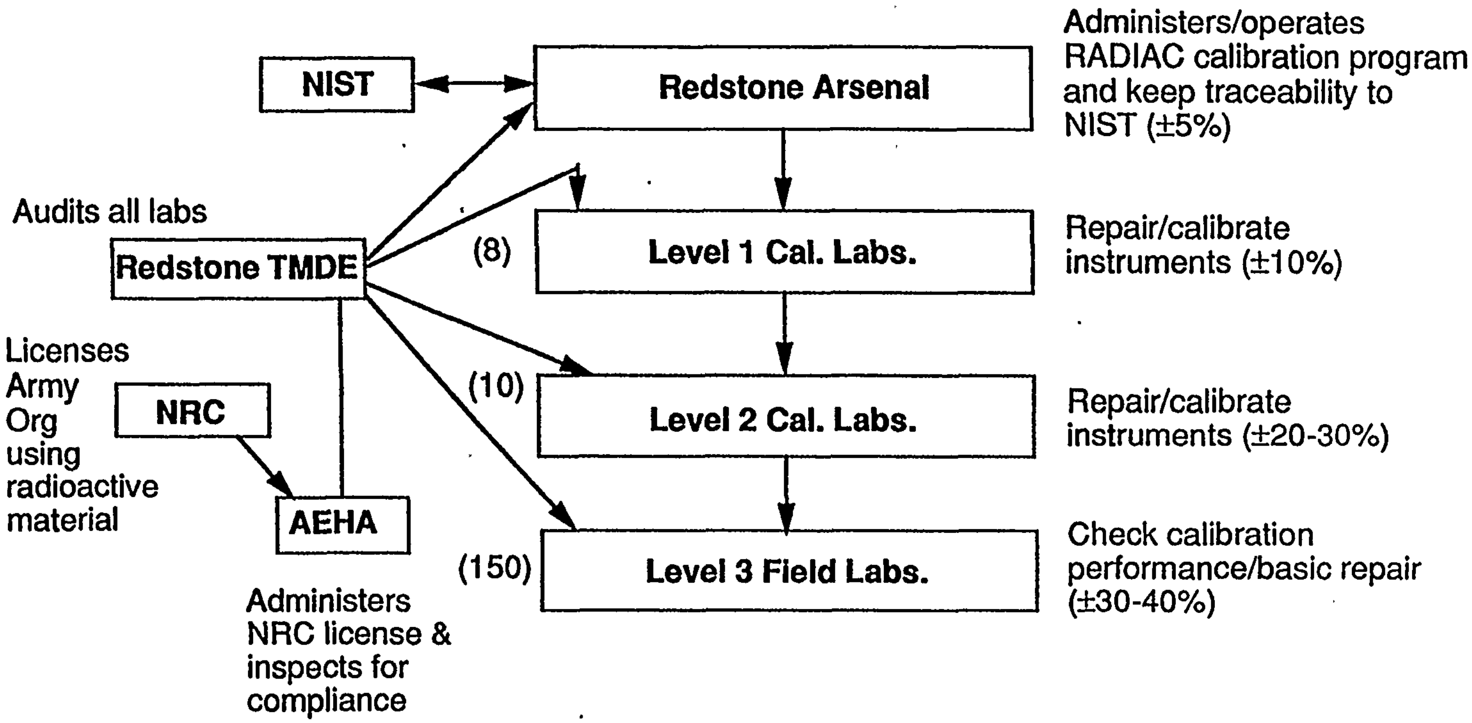

Figure 3 - Description of the Quality Assurance Accountability Process for U.S. Army Radiological Calibration Labs

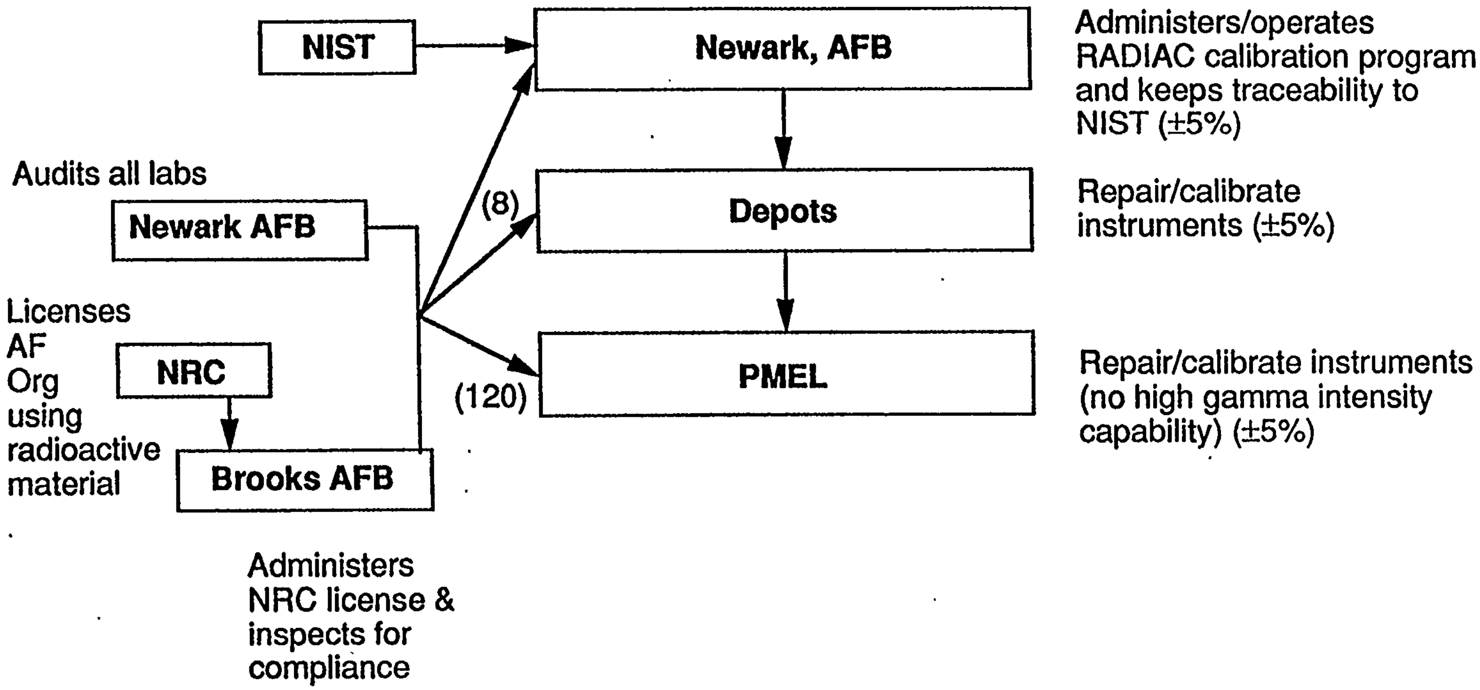

Figure 4 - Description of the Quality Assurance Accountability Process for U.S. Air Force Radiological Calibration Labs

Table 1 - Department of Defense (DoD) Dosimeter Processors Accredited under NVLAP

Service	Location	Dosimetry System	Number of Orgs. Monitored	Transactions per year	Processing Frequency	NVLAP Category
Navy*	NEHC Bethesda, MD	Harshaw 8000/8001/8002	415	395K	6-8 wks	All
Navy	Puget Sound NSY/Decentralized	Harshaw design DT-526-CP-1112	160	2.7M	daily/mo	II, IV
Army	USAIRDC Lexington, KY	Panasonic 710/UD802AS/UD874A-T	776	30K	wk/mo/qty	All
Air Force	Armstrong Lab Brooks AFB, TX	Panasonic 716/UD802AT/ISA Model 820	250	250K	mo/qty	All

*Includes Marine Corps Activities.

Table 2 - Individual Service Radiological Instrument Support

Service	Calibration Transactions per year	RADIAC Inventory (total/operational)	Calibration Frequency
Navy	250,000	130,000/60,000	3 mo/6 mo/12 mo
Army	31,000	81,500/3,800	90 d/120 d/5 yr
Air Force	38,000	30,000/8,000	3 mo/6 mo/12 mo/18 mo
Marine Corps	12,000	12,000/60	3 mo/6 mo/12 mo

Table 3 - U.S. Navy Radiological Instrument Calibration Laboratories and Their Capabilities

Secondary Calibration Lab	Current Capability	Capability Planned	Calibration Labs Traceable to Chasn	Capability
Naval Electronics Systems Engineering Center, Charleston, SC	AN/UDM-1A (Gamma ~120 Ci ^{137}Cs) AN/UDM-7 Series (Alpha ~810 ug ^{239}Pu) Fast Neutron Range (~5 Ci PuBe)	Shepherd Series 81 (~138 Ci ^{137}Cs) Shepherd Series (~300 Ci ^{60}Co) Amersham ^{238}Pu (Alpha) Fast Neutron Range (~5 Ci PuBe) 320 kVp x-ray	6 Destroyer Tenders 10 Submarine Tenders	TS-1216 (Gamma) (20 Ci ^{137}Cs) AN/UDM-10 (Neutron) (100m Ci AmBe) AN/UDM-7 Series (Alpha)
			Calibration Labs at Portsmouth, NH Groton, CT Portsmouth, VA Charleston, SC Mayport, FL Rota, Spain Bremerton, WA Vallejo, CA Pearl Harbor, HI Yokosuka, Japan Guam, MI San Diego, CA Yorktown, VA Idaho Falls, ID (30 Labs)	AN/UDM 1A or Shepherd Series 81 (Gamma) AN/UDM-7 Series (Alpha) Fast Neutron Range (Neutron) or AN/UDM-5 (Neutron) 5 Ci PuBe or AN/UDM-10 (Neutron)

Table 4 - U.S. Army Radiological Instrument Calibration Laboratories and Their Capabilities

Secondary Calibration Lab	Current Capability	Planned Capability	Level 1 Labs	Capability	Level 2 Labs***	Capability
Redstone Arsenal, Hunstville, AL	AN/UDM-1A (Gamma) (~120 Ci ^{137}Cs) AN/UDM-6 (Alpha) (~4 ug ^{239}Pu) AN/UDM-2 (Beta) (~185 m Ci ^{90}Sr) 320 kVp x-ray 50 kVp x-ray	Shepherd 81 Quad (Gamma) (~200 Ci ^{60}Co) (~100 Ci ^{137}Cs) Shepherd 89 Box (~400 Ci ^{137}Cs) Amersham ^{238}Pu, ^{239}Pu, ^{241}Am (Alpha) (~8u Ci each) (Large and Small area) 320 kVp x-ray 50 kVp x-ray Neutron source**** Beta Calibrator ($^{90}Sr/Y$, ^{147}Pr, ^{204}Tl)(~50m Ci)	Sacramento, CA* White Sands, NM Seneca, NY** Aberdeen, MD Lexington, KY* Redstone Arsenal, AL Pirmasens, GE Camp Carroll, KO (* Labs)	AN/UDM-1A AN/UDM-6 (±10%)	Tobyhanna, PA Letterkenny, PA Anniston, AL Tooele, UT** Sacramento, CA White Sands, NM Seneca, NY Lexington, KY Aberdeen, MD Redstone Arsenal, AL (10 Labs)	AN/UDM-2 AN/UDM-6 (±20-30%)

1. *Labs to be merged with Redstone Arsenal, Alabama
2. **Labs expected to be closed in the future
3. ***Level 3 Field Calibration @ ~185 locations
4. ****Neutron calibration capabilities using PuBe currently at Sacramento, California

Table 5 - U.S. Air Force Radiological Instrument Calibration Laboratories and Their Capabilities

Secondary Calibration Lab	Current Capability	Planned Capability	Depot Labs	Capability	PMEL	Capability
Newark AFB, OH	Shepherd Series 81 (~130 Ci ^{137}Cs) Fast Neutron Range (~16 Ci PuBe) Eberline CS-1 (Alpha) (~2u Ci ^{239}Pu) AN/UDM-7 Series (Alpha) (~810 ug ^{239}Pu) Dosimeter Calibrator (Gamma)(~20 Ci ^{137}Cs)	Shepherd Series 81 (~130 Ci ^{137}Cs) Shepherd Series 81 (~1000 Ci ^{60}Co) Fast Neutron Range (~16 Ci PuBe) Amersham (Alpha) (^{238}Pu) Eberline CS-1 320 kVp x-ray Dosimeter Calibrator (~20 Ci ^{137}Cs)	Kelly AFB, TX Hill AFB, VT McClelland AFB, CA Ramstein AFB, GE Kadena AB, Japan Newark AFB, OH Brooks AFB, TX* Patrick AFB, FL** (8 Labs)	Shepherd Series 81 (~130 Ci ^{137}Cs) D0062 (~120 m Ci ^{137}Cs) AN/UDM-6 Alpha (4 ug ^{239}Pu) AN/UDM-7 Alpha (±5%)	(120 Labs)	D0062 AN/UDM-6 (±5%)
Brooks AFB, TX		Shepherd Series 81 (~130 Ci/~130 m Ci ^{137}Cs) 420 kVp x-rays 160 kVp x-rays Beta Calibrator (~50 m Ci ^{90}Sr/ ~2 m Ci ^{90}Sr/ ~14 m Ci ^{204}Tl/~2 m Ci ^{147}Pr) Neutron Ranges (~5 Ci PuBe/2.2 and 0.1 mg ^{252}Cf)				

*Planned to become accredited as a secondary calibration lab for health physics instrumentation
**Shepherd Series 81 only

Table 6 - U.S. Marine Corps Radiological Instrument Calibration Laboratories and their Capabilities

Secondary Calibration Lab	Planned Capability	Calibration Labs (stand alone)	Capability	Planned Capability
(None now) Marine Corps Logistic Base, Barstow, CA (planned)	Shepherd Series 81 (Gamma) (~130 Ci ^{137}Cs)	Barstow, CA Albany, GA Okinawa, Japan	AN/UDM-1A (Gamma) (~120 Ci ^{137}Cs) AN/UDM-7 Series (Alpha) (~810 ug ^{239}Pu)* Shepherd Series 81 (Gamma) (~130 Ci ^{137}Cs)	Shepherd Series 81 (Gamma) AN/UDM-7 Series *

*Available from Naval Electronics Systems Engineering Center, Charleston, the U.S. Navy's Secondary Calibration Lab.