Technical Support Group State-of-the-Practice Review of the Nondestructive Assay *in-situ* Holdup Program at the Savannah River Site

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Executive Summary

The Department of Energy (DOE) Savannah River Site (SRS) provided all of the necessary support needed for the Technical Support Group (TSG) to complete this review. Many of the Lines of Inquiry (LOIs) were addressed during the initial SRS briefing. All of the information presented during the briefing was confirmed during the interview process. It was clear that communication between nondestructive assay (NDA), engineering, operations, material control and accountability (MC&A), and DOE Site Office personnel was effective, bidirectional, and cordial. Communication appeared to be limited between criticality safety personnel and those from other organizations, including NDA. As the organization is currently structured, human interactions and effective communication are essential to the success of the SRS NDA holdup program. The recent and anticipated attrition of NDA staff at SRS is of concern, particularly in the areas of maintaining the necessary interactions and communications and skill-of-the-craft. One of the TSG's observations was that the NDA staff attrition will bring the staffing level from six people down to three, and the three leaving are the most experienced, best qualified, and the primary source of training for less experienced personnel.

Self- and external assessments appear to be systematic, routine, and effective. This was especially apparent during the interviews, where individuals were comfortable enough to answer "I don't know." Given the nature and details of the LOIs, this answer could be expected from interviewees at each site on some questions. Once again, the ease with which questions were answered provided evidence of the staff's comfort in participating in reviews. HB-Line is relatively new compared to most Department of Energy (DOE) production lines and incorporates many design lessons learned.

The HB Line tour was conducted by process-knowledgeable personnel. Observations included several holdup measurements and the calibration of a detector system. The TSG was also given a tour of 235-F, including locations where holdup measurements have been performed. Obstacles in performing measurements and safety conditions with regard to holdup measurements were observed. This report will not cover observations noted at 235-F other than those just stated.

A noteworthy strength of the SRS NDA Program is that the NDA Group Manager is the Chief Scientist, and is, himself, knowledgeable in technical aspects of the NDA measurement program. By having an NDA Program Manager with this scientific background, it is evident that management recognizes the attributes needed in selecting and training qualified members for the NDA Group. The TSG noted that there is a lack of formal qualifications for performing NDA holdup measurements. With the loss of senior measurement experience in the group, qualifications should be established to ensure continuity of measurement quality as less experienced personnel assume new responsibilities.

Below is a list of the types of training that would be beneficial for new or less-experienced NDA personnel:

- Formal holdup measurement training for individuals doing holdup calculations;
- Training on Holdup Measurement System 4 (HMS4) software to enable holdup measurements to be automated;
- Training on the statistical propagation of error;
- Training in additional quantitative field measurement software programs such as ISOTOPIC and ISOCS;
- Training in gamma measurement fundamentals, including available detector types and spectroscopy software; and
- Familiarization with, and documentation of, current measurement locations at SRS.

The TSG observed that effective communications took place during the document creation and review process, which helped to produce useful documents. Measurement procedures are higher-level in nature, describing how measurements are made in general and how some measurement specifics might be decided. There is no procedure for performing each of the individual holdup measurements. Individual measurements are made following a verbal briefing on the tasks that need to be performed, and skill of the craft (operator experience) is used for determining the best method for making the measurement in the field. The HB Line facility has procedures in place that require measurements to be performed, but it does not maintain any NDA-specific documents. Performance of NDA measurements was observed to be in accordance with documentation.

Measurements are exclusively performed based on the Generalized Geometry Holdup (GGH) modeling method. Several more recent refinements to the GGH modeling method have not been incorporated into routine calculations, such as finite-source correction for cases where the item does not precisely fit the model used and self-attenuation corrections. Background correction measurements are performed using a tungsten plug. The TSG noted that measurements were not routinely performed to investigate background radiation sources from the opposite side of the measurement location.

Because only a finite number of available NDA standards exists, matrix matching with unknowns is done wherever possible. The availability of representative standards for specific *in-situ* measurements is more difficult; standards that are "on-hand" are used instead. These standards are well characterized, have a well-documented analysis trail with uncertainties, and have been reviewed and approved by the MC&A organization. Independent verifications of calibrations and results have rarely been performed, but routine Limit of Error Inventory Differences (LEIDs) have helped to validate some results.

Although the NDA Program is intended to meet MC&A and safeguards requirements, it is funded through the operating projects' operating budgets. Staffing for the NDA holdup measurement program is determined at the start of a budget cycle and is proportionate to

the amount of effort needed to meet MC&A and safeguards requirements. Current staffing needs, estimated to be five to six full-time equivalents, have been negotiated with the projects. Funding for performing holdup measurements for criticality safety purposes, which is drawn from existing safeguards and MC&A compliance resources, appears to be commensurate with the risk of criticality in HB Line.

Several people who were interviewed indicated that the accumulation of a mass significant to criticality safety would be realized through a loss of inventory that would be detected by MC&A personnel. The link between MC&A and criticality safety is through facility management and engineering and appears to rely heavily on professional knowledge. Interviews with criticality safety engineers indicate that NDA professionals are involved in the development of nuclear criticality safety evaluations (NCSEs). However, the final approval or acceptance of criticality safety controls impacting holdup measurements appears to be made by facility or Engineering acting as proxy for NDA management, as evidenced by the lack of an NDA program signatory on NCSEs.

Introduction

The Department of Energy (DOE) issued the Implementation Plan for Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 2007-01, *Safety-Related In Situ Nondestructive Assay of Radioactive Materials* (DNFSB Rec. 2007-01), dated October 24, 2007. The Implementation Plan outlines a process to be implemented by a Technical Support Group (TSG) that addresses the issues raised in the Recommendation. A significant portion of that process involves the evaluation of the extent-of-condition of *in-situ* nondestructive assay (NDA) programs in DOE facilities managed by the Office of Environmental Management (EM) and the National Nuclear Security Administration (NNSA).

The primary goal of the TSG visit to the Savannah River Site (SRS) was to identify the state-of-the-practice and good practices with respect to *in-situ* NDA assay. The intended purpose was to establish a baseline for future complex-wide development and program enhancement. The site review was not an assessment; any conclusions contained in this report are included for SRS to use at its own discretion. The final report submitted to DNSFB after the completion of all site reviews will not tie information to individual sites. This review covered the SRS HB Line. In addition, a peer review of *in-situ* holdup measurements and mass calculations at Building 235-F (the Plutonium Fabrication Facility, or PuFF) was also evaluated, but the results are not reported here.

After all planned reviews have been completed; the state-of-the-practice review reports will be evaluated for suggested improvements to DOE *in-situ* NDA measurement programs. The evaluation results will be used to provide recommendations on standardizing the methodologies for *in-situ* NDA holdup measurements and reporting.

The review criteria were provided to SRS before the site visit. A total of eight topical areas were reviewed. Seven of the review topics are explicitly required by the DOE Implementation Plan for DNFSB Recommendation 2007-1. These areas are 1) training and qualification; 2) design requirements for new facilities and equipment; 3) standards for conducting NDA holdup measurements; 4) implementation of standards; 5) research and development; 6) quality assurance; and 7) oversight. An eighth topical area was added during the development of the review criteria: roles and responsibilities.

TSG members toured the following facilities and observed the activities listed below:

- 235-F;
- HB Line;
- Holdup field measurements; and
- Calibration of holdup equipment.

The TSG interviewed the following individuals, identified by title or function:

- NDA Professional
- NDA Measurement Technician

- NDA Manager
- Training Coordinator
- Criticality Safety Engineer
- Criticality Safety Manager
- HB Line System Engineer
- HB Line Engineering Manager
- HB-Line Deputy Facility Manager
- HB Line Statistician
- Savannah River National Laboratory (SRNL) NDA Research and Development Professional
- Material Control and Accountability (MC&A) (Quality Assurance (QA))
- Savannah River Operations Office (DOE-SR) Criticality Safety Personnel
- DOE-SR Hazards Categorization Personnel
- DOE-SR Nuclear Program Manager
- DOE-SR Safeguards Personnel

State-of-the-Practice Review of Training and Selection of *in-situ* NDA Holdup Measurement Personnel at SRS

All issues pertaining to the training and selection of NDA holdup personnel must be framed within the context of the need and use of NDA holdup measurements at SRS. The holdup of plutonium, uranium, and neptunium appears to be small from an MC&A and a Nuclear Criticality Safety (NCS) standpoint. Active process equipment on the HB-line is monitored for holdup on a bimonthly frequency in support of nuclear MC&A (NMC&A) inventories; these data are shared with NCS personnel as well; however, the quantities measured are minimal. The current holdup is orders of magnitude smaller than the required criticality safety limits for the equipment. Furthermore, the holdup quantities typically have little impact on the total inventory or inventory difference (ID) calculations. Close mass-balance bookkeeping is relied upon to confirm inadvertent accumulation concerns indicated by holdup results and to identify measurement anomalies.

Within this context, holdup measurements are but one component of a larger NDA measurement program within the Analytical Laboratories Division at SRS. The NDA Group is responsible for maintaining an NDA laboratory that performs accountability measurements, and supports waste characterization measurement and decommissioning work. NDA Group staffing has been reduced from seven members four years ago to only three in 2009. The four members who left the group were the most senior in terms of qualification and experience. The NDA Group Manager (Chief Scientist Section) acknowledged the need for additional personnel and recognizes the importance and the challenges of selecting, training, and qualifying new group members. An effort is needed to re-establish the balance of qualifications within the staff and to add senior, experienced NDA professionals who are qualified to lead and direct the NDA program. SRS must currently rely on specialists from SRNL to address complex measurement concerns.

A noteworthy strength of the SRS NDA program is that the NDA Group Manager is the Chief Scientist, and is, himself, knowledgeable in technical aspects of the NDA measurement program. By having an NDA Program Manager with this scientific background, management should

recognize the attributes needed in selecting and training qualified members for the NDA measurement group. Management also relies on judgment and oversight to guide the work performed by the NDA Group. The delegation of work, recognition of aptitude, and provision of training and mentoring are often based on the judgment of the group manager. The TSG identified a lack of formal qualifications for performing NDA holdup measurements. With the loss of senior measurement experience in the group, qualifications should be established to ensure continuity of measurement quality as less experienced personnel assume new responsibilities.

Another strength of the SRS program is the strong interaction between NDA measurement personnel and engineering, NCS, and NMC&A staff for assessing criticality requirements, establishing controls, and developing implementing procedures. The TSG noted that SRS demonstrates an appropriate awareness of interdisciplinary impacts and did not see a need for additional training outside of the NDA Group.

A summary of the current training and qualification program for *in-situ* NDA holdup measurement personnel at SRS is shown in the table below.

Table 1: Summary of Holdup Measurement Training and Qualification Status at SRS

Formal holdup training course required	No
Formal holdup training provided to members performing calculations	No
Formal OJT holdup training or mentoring required	Yes
OJT holdup training provided	Yes
Formal transition mechanism in place for personnel turnover	Yes
Sufficient holdup training evident to perform simple holdup measurements	Yes
Sufficient holdup training evident to perform complex holdup measurements	No
Retraining mechanism in place to update measurement knowledge	No
Sufficient funding identified to properly train NDA individuals	Limited
Tests in place to demonstrate knowledge adequacy	No
Qualification program in place for each level of NDA measurement personnel in group	No
Appropriate manpower in place at each level of expertise to maintain a balanced program	No
Formal oversight of less experienced or qualified individuals performing measurements	Yes
NDA supervisors are knowledgeable about NDA	Yes
Understanding of holdup measurement uncertainty and limitations evident in customers using the data: NCS, MC&A	Yes

Since SRS will be transitioning current NDA Group members into new roles and will be assimilating new members, the necessary training needs to be identified.

Below is a list of types of training that would be beneficial at SRS:

- Formal NDA measurement training for individuals doing holdup calculations;
- HMS4 software training to enable automation of holdup measurements;
- Statistical propagation-of-error training;
- Training in additional quantitative field measurement software programs such as ISOTOPIC and ISOCS;
- Training in gamma measurement fundamentals, including available detector types and spectroscopy software; and
- Familiarization and documentation of current measurement locations at SRS.

A common theme heard during the interviews was the lack of funding available for formal training. One noteworthy practice found at SRS is the use of onsite training sessions; the trainers conduct the classes onsite at a fraction of the cost of sending individual class members out of town to attend a course. SRS also makes good use of vendor-sponsored training sessions, which are provided for free.

Design Requirements for New Facilities and Equipment

The TSG evaluated HB Line equipment and operations at SRS. Built in the early 1980s, there have been few modifications to HB Line in recent years. Lessons learned from other facility designs have been incorporated. However, there have been few opportunities to exercise the process for incorporation of NDA and holdup needs into new designs.

The SRS Conduct of Projects Manual contains requirements for establishing the core disciplines that need to provide input to a given project, including NDA, to incorporate their needs and requirements. Issues arising during the design review process are captured in the Site Tracking, Analysis, and Reporting (STAR) System with due dates for resolving issues in accordance with the project schedules. SRS Manual E.7 includes a Design Change Implementation Form that is used to document implementation of design changes, including those identified by the NDA staff or during walkdowns. It appears that the design review philosophy also applies to campaign operations involving changes in the material being processed.

The TSG observed that there appears to be close communication between the NDA Group and the Operations, System Engineering, and MC&A organizations. For example, the System Engineer is responsible for scheduling holdup measurement activities in the facility. This degree of communication appears to encourage timely and cooperative performance of the holdup measurement task in concert with operational schedules. The Deputy Facility Manager stated that NDA Group members were often involved in addressing operational issues because of their frequent presence. The NDA Group members work closely with the Material Balance Area (MBA) custodian to resolve measurement or data issues. Communication between the NDA Group members and the criticality safety organization appear to be considerably less.

The criticality safety analysis for the HB Line (N-NCS-H-00201, Rev. 6) includes several holdup-related requirements. Scenarios were developed for various portions of the system. One

such scenario is associated with a glovebox exhaust duct that accumulates fissile material via airborne contamination transport. The critical configuration for this scenario is 5 kg Pu-239 fissile gram equivalent and an *H/X* value of less than or equal to 20 with full reflection. The list of failures that would have to occur as a result of this scenario includes: failure of the holdup monitoring program to detect significant accumulations; failure of the material accountability program to recognize losses of material to the ductwork; the addition of reflection; high-efficiency particulate air (HEPA) filter installation errors; and cleanout failures. This extensive list of failures was developed to support an argument of incredibility for this scenario. The normal operating procedure (NOP 221-HB-4953) for this system incorporates a requirement to notify the cognizant engineer and the criticality safety engineer if the assay results exceed 5 kg Pu-239 fissile gram equivalent. A "tickler" (#257) has been established to remind the NDA Group to perform the measurements. Current measurements on this system run very low, so this limit is not challenged, which supports the incredibility argument.

It appears that the measured holdup values are considerably less than the LEIDs such that holdup rarely influences LEID resolution. Process material balances or missed containers or items result in much greater influences on the LEIDs.

Design-related comments about the current facility include the height and inaccessibility of the vessel vent filters near the ceiling. To simplify this, radiological control measurements using lighter-weight instruments are used to screen for changes. If no change is detected, no quantitative measurements are performed; however, if a change is noted, the NDA Group re-evaluates the area. Due to previous campaigns involving neptunium (Np)-containing materials that left behind residual contamination, only Np results are reported in some areas. As-built drawings appear to be adequate for holdup purposes, but they are confirmed with the System Engineers prior to use. The System Engineer commented that he would like ports installed through or under the gloveboxes to permit the insertion of detectors in awkward locations so that more precise detector locating could be permitted than can be achieved through glove ports alone. One lesson learned is to model the facility beforehand to enable identification of holdup measurement locations and permit design of measurement ports, fixed instrumentation, and lifting fixtures for heavy instrumentation.

The Engineering Manager commented that the NDA Group was small and getting smaller due to recent retirements and transfers.

Standards for Conducting NDA Holdup Measurements

Measurement Program

All typical NDA measurements (quantitative, confirmatory, shipper/receiver) are made at the site in support of criticality safety (engineering), MC&A, and operations (waste). Most of the measurements that are made are quantitative.

Measurement procedures are higher-level in nature, describing how measurements are made in general and how some measurement specifics might be decided. There is no procedure that describes how to perform the individual holdup measurements. Each measurement is performed

following a verbal briefing on what needs to be done. Skill–of-the-craft (operator experience) is used to determine how to best implement the measurement in the field. HB Line has procedures in place that require measurements to be performed, but it does not maintain any of the NDA-specific documents.

The TSG found evidence of good processes in place for developing and reviewing procedures. The procedures are clear and concise; unnecessary information is kept to a minimum. The documentation meets the needs of the intended audience (instrument operators) as well as facilities, engineering, and NDA supervisors and managers. Instrument operators wrote most of the documents, resulting in a very user-directed focus.

Good controls and oversight are in place to ensure procedural compliance. Some of these controls and oversight activities include management field observations, in-field reviews of anomalous measurements by technical supervisors, site and facility self-assessments, management field observations, and first-line reviews of results and documents.

Most NDA measurements are made using germanium detectors. Sodium iodide (NaI) is used for convenience of use (i.e., it is easier to handle, and no liquid nitrogen is required) when a single radionuclide is present. When a measurement or a group of measurements is completed, the data are analyzed and the results documented in a standardized calculation document designated N-CLC-#-#####. The final document includes the details of the measurements. The calculation document receives a technical review and a management review.

Because consensus standards are just beginning to be used, they are not currently referenced in any of the documentation. The main technical references cited in NDA-specific documentation are NDA training manuals and the book *Passive Nondestructive Assay of Nuclear Materials* (PANDA Manual). MC&A Manual 14Q, Chapter 3 is also an important reference. Document version control is maintained in the Savannah River Information Network Environment (ShRINE) database.

Changes to Procedures

All modifications to equipment or processes result in a review of NDA measurements and any effect those changes may have on the measurements. Lessons learned are integrated into procedural documentation on an as-needed basis. There are no formal requirements for reviewing or modifying NDA-specific documents. Facility documents are required to be reviewed periodically. There are tracking systems (i.e., the Measurements System and Evaluation files, the STAR database, and the Corrective Action Review Board (CARB).

The TSG observed a high level of cooperation and communication between operations, engineering, and NDA measurement personnel that allows all interested parties to remain cognizant of changes, needed revisions, and facility status. It was readily apparent, based on the responses received, that the level of communication and daily interaction described by the individuals interviewed was not being overstated. The level of cooperation between these groups is a noteworthy practice at SRS; however, it is unclear whether this system can maintain its effectiveness if personal relationships or job duties were to change dramatically. There is no

formal requirement for reviewing measurement assumptions or process changes if they are not deemed necessary or when personnel change positions, leading to the potential for discontinuity. For example, all of the measurement points in HB Line were defined by an individual who no longer works at SRS, yet these measurement points have not been redefined.

The TSG observed that the criticality safety engineers do not regularly interact with operations, engineering, and NDA measurement personnel.

Results and Calculations

Some spreadsheets used to calculate gram quantities of holdup are kept in a software repository that is configuration-controlled; others are not. Some spreadsheets are configuration-controlled, and some are not. Peer reviews and some calculation checks (i.e., data with a known answer are calculated using the spreadsheet) are used to check functionality.

Implementation of Standards

The TSG's review of standards implementation consisted of observations, briefings, and interviews to determine the state-of-practice of the implementation of standards and requirements for performing holdup measurements at SRS to support compliance with NCS limits.

An overview of holdup measurements was provided by the chief scientist for the Analytical Laboratories Project. Observations occurred during tours of the HB Line and 235-F. Reviews of documents occurred before and throughout the site visit. During the HB Line tour, glovebox measurements and the calibration verification location were observed.

Interviews provided consistent details concerning the implementation of holdup measurements at SRS. Lines of inquiry were used to examine the overall NDA program, of which holdup measurements are one function. Several NDA professionals perform the tasks required for characterization and quantification of holdup. None of the NDA staff is fully dedicated to performing or analyzing holdup measurements. Measurements are performed to support MC&A, NCS, and waste removal. The majority of measurements at HB Line are performed to support MC&A inventory requirements. In the case of HB Line, all areas where material processing occurred are measured every two months. NCS personnel discussed the use of ventilation ductwork measurements and vessel measurements to support NCS documentation. NCS personnel use a database (MAP1), developed for MC&A, to track and limit batch sizes for process vessels. Several interviewees indicated that all affected disciplines would review any procedural changes related to holdup measurements through the Unreviewed Safety Question (USQ) process. Additionally, NCS personnel maintain an extensive lessons-learned tracking program and issue a monthly newsletter.

Formality of the NDA program is implemented through the Conduct of Operations, Conduct of Engineering, and Conduct of Analytical Measurements Manuals. A review of current reports provided evidence of a formal review process and detailed documentation of measurement and

data analysis methods. The NDA measurement program complies with MC&A requirements, including those related to instrumentation and personnel qualification and training.

Site personnel estimate that 90 percent of the material holdup in H Area has been measured. Holdup in the canyons is inaccessible for measurements until equipment removal is complete, but the holdup remaining in F Canyon comprises approximately 10 percent of the facility total. Measurements are performed routinely for all gloveboxes where processing activities are currently ongoing.

Measurements are based exclusively on the GGH modeling method. The three models of point, line, and area are used. Several more recent refinements to the GGH method have not been incorporated into routine calculations, including the finite source correction for cases where the item does not precisely fit the model used and self-attenuation corrections. These improvements to the GGH modeling method are documented in LA-14206, *Gamma-Ray Measurements of Holdup Plant-Wide: Application Guide for Portable Generalized Approach*. Background radiation correction measurements are performed using a tungsten plug. Measurements to investigate sources of background radiation from the opposite side of the measurement location are not routinely performed. Calculations are based primarily on dimensions from drawings supplied and validated by the systems engineers. The TSG observed clean, well-lighted gloveboxes that support holdup measurements. Additionally, frequent communications between NDA, Operations, and SRS and DOE MC&A personnel support prompt action to resolve issues involving measurement locations.

Equipment in use at the site is well-maintained. Repairs are performed onsite and by offsite vendors as needed. The in-house maintenance program is well-supported. Detector positioning is standardized by placing the detector on a fixed-angle cart and placing the edge of the detector flush with a specified gloveport. Reports are stored in accordance with records management requirements, and measurement spectra are stored by the NDA professional performing the analysis.

Uncertainty calculations are detailed in the Conduct of Analytical Measurements Manual, as are the requirements for technical reviews. The actual reported calculations are based on historical methodologies as well as a review of how other sites calculate holdup uncertainty. For each material type, the measurement result is compared to the Critical Level (L_c) and the Minimum Level of Detection (MLD) for that material at that location. Thus, measurements below the level masked by background levels are reported at the minimum level detectable. Interviewees within the NDA Group agreed that the largest source of measurement uncertainty is caused by modeling assumptions. A statistician for H Area indicated that he has discussions with measurement personnel at least weekly to address the issue of measurement uncertainty. As mentioned previously, uniform detector positioning has been standardized in an attempt to minimize this source of measurement uncertainty. Holdup measurement results are incorporated into the LEID calculations, which examine the differences between beginning and ending inventory minus throughput. Holdup measurement personnel cited these calculations as a validation of the holdup models, but the statistician indicated that throughput would mask small errors in the measurement results. However, until additional material cleanout occurs, the LEID calculations can serve as an indicator of large measurement reporting errors. The measurement team tracks

trends in holdup results and reports the previous result at each location, as well as the current result.

Research and Development

The lines of inquiry for this section evaluate research and development (R&D) activities associated with NDA and NDA holdup measurements, including, but not limited to, instrumentation, data analysis, procedures, automation, uncertainty, process, techniques, nuclear material standards, and calculations.

One identified R&D need was an independent verification technique or a well-characterized test bed to verify holdup measurements performed at SRS. There have been no opportunities to compare cleanout campaigns with previous holdup measurements to verify the holdup measurement results. Any R&D needs are identified in the field by NDA operators and supervisors. Implementing a modified version of the holdup measurement software (HMS4) that simultaneously analyzes multiple energy lines would reduce data analysis time and the potential for human error. A correction factor was investigated to correct for area measurements performed at an angle relative to the nuclear material deposit; however, the correction has not been fully documented and is not generally used.

All of the equipment used onsite is commercially available and commercially supplied. Any equipment improvements that could be implemented at SRS would be made through commercial vendors; for example, upgrading to mechanically-cooled germanium (HPGe) detectors that are physically smaller and lighter than the liquid nitrogen-cooled detectors currently in use. Size-reduction is a frequent desire among the NDA measurement personnel. Advances that would be useful to the site are identified by vendor communication of new technologies and through information reported at various NDA conferences and workshops. Detector system reliability could be improved if more reliable or better protected connectors were used on the HPGe detectors.

The nuclear materials standards used at SRS are adequate for calibration and measurement control needs, but they are not always optimal (i.e., the point sources are rather large). SRS only has a few standards traceable to the National Institute of Standards and Technology (NIST), which are difficult to access. Consequently, in-house produced working standards that are indirectly traceable to NIST are heavily relied upon for all NDA measurement needs at SRS.

There is no R&D funding available at SRS, but the lack of funding is not seen as a problem since R&D is not the site's mission. However, the lack of R&D funding for holdup measurements across the complex is viewed as an issue. Currently, there is no known source of domestic R&D funding for NDA and no mechanism to make NDA R&D needs known to funding agencies. In the past, R&D needs were made known through the user needs call coordinated by the Office of Safeguards and Security.

SRS uses the DOE and the SRS ShRINE lessons-learned web sites to disseminate information.

Conference attendance is dependent on available funding. The goal is to send each NDA professional to at least one conference, workshop, or training course each year.

No NDA research is published from SRS. SRNL has published about 10 NDA-related publications over the last five years, of which 4 or 5 are holdup-related. A large percentage of the individuals who published this body of work either no longer work for SRS or SRNL, or now have job duties unrelated to NDA. However, there is a fairly close working relationship between the core NDA staff at SRNL and SRS in the form of technical reviews and discussions of measurement reports and measurement approaches.

State-of-the-Practice Review of Quality Assurance for *in-situ* NDA Holdup Measurements at SRS

Program Management

The overall responsibility for the Quality Assurance (QA) Program resides with the Cognizant Technical Function (CTF); i.e., NDA professionals. It is their responsibility to review all measurement control data for out-of-control conditions and to initiate response actions. Although there is no real QA Plan, the existing Measurement Control (MC) Plan serves to meet the requirements of a QA Plan. The NDA MC Program is reviewed both internally and externally (i.e., by MC&A and DOE) on a routine basis, and has had no findings to date. There have been no formal Data Quality Objectives (DQOs) established by the customers (Operations, MC&A and Criticality Safety). These customers also have seen no problems or issues with the NDA MC Program or data. Besides the internal MC data review by the NDA professionals, all MC data are routinely reviewed by MC&A. For each instrument or system, specified peak count rates, centroids, and full-width-at-half-maximum (FWHM) data are tracked. To date, no biases have been noted. For any warning or out-of-control situation, a calibration verification is required.

Documentation and Calibration

The MC Program follows the guidelines contained in the MC&A Manual (14Q) Procedures *Non-Destructive Assay Measurement Control* [3.06] and *Determining and Responding to Control Limits* [3.10]. In addition, all systems are required to be reviewed and validated before being put into operations, as described in MC&A Manual (14Q) Procedure *Selection, Validation, and Qualification of New Accountability Measurement Methods* [3.02]. The NDA professionals are responsible for verifying all MC data and identifying the current status of each instrument or system. NDA MC data are available via hard copy upon request. Recently, the MC data have been made electronically available to MC&A personnel to help facilitate their routine review process. The NDA professionals are also responsible for compiling all of the data generated by each NDA instrument or system, but there is no master database of results. Calibrations are performed on demand, not at a set frequency. All calibrations and MC data are identified by established document identification numbers and are filed at plant-level with a prescribed retention schedule. Operations logbooks are also kept on each instrument and system. The NDA Professionals are ultimately responsible for knowing the appropriate usage of each piece of equipment and controlling its use.

Nuclear Material Calibration Standards

Because a finite number of available NDA standards exists, matrix matching with unknowns is done wherever possible. The availability of representative standards for specific *in-situ* measurements is more difficult; standards that are on-hand are used instead. These standards are well-characterized, have a well-documented analysis trail with uncertainties, and have been reviewed and approved by the MC&A organization. The typical standards that are used consist of an oxide in diatomaceous earth; no metal standards are available. The standards are sealed, stored in a secure location, and have tamper-indicating devices. None of the standards have been re-sampled for verification. Calibrations and results have been independently verified only rarely, but routine LEIDs help to validate some results.

Check Sources and Control Charts

Control charts are kept on check source results for each instrument or system. This is done in accordance with the MC&A Manual (14Q). An out-of-control situation is usually identified immediately. Data are collected, input to an Excel spreadsheet, and plotted for review. Results outside of the prescribed warning or alarm limits generate a warning. The NDA Professionals and MC&A personnel review the data on a regular basis. Control data were previously transmitted by hard copy to the MC&A organization, but are now available in real-time via a shared computer folder. The MC program does not routinely use measurements of static process equipment for further control, but personnel expressed a desire to do so. All of the limits used in the MC program were established by valid statistical methods and approved by the MC&A organization. Yearly reviews by MC&A and DOE personnel are performed to examine the MC data.

Validating Measurement Results

Validation of NDA measurement results by alternate methods has not been routinely performed. However, the use of LEIDs provides some validation of results. An example was described of a holdup measurement, a cleanout (recovered value), a repeated holdup measurement, and a comparison of the measurements to determine the difference. The difference was within the typical *in-situ* estimated uncertainty of 30 to 50 percent. In most cases, this uncertainty is based solely on the scientific judgment of the NDA Professional. An interest was expressed in gathering further data or searching literature to help support and validate techniques and uncertainties used. Very little experimental data are generally available to document individual input parameter errors and their effect on the final results in the GGH methodology. As for software QA, the NDA Professionals are responsible for securing and verifying the spreadsheets and software used in the *in-situ* measurements. Only the software for one system is under plant-level configuration control. However, all spreadsheets used adhere to plant software QA requirements.

Oversight

The Oversight section is intended to query the feedback and improvement process for ensuring that the holdup measurements program continues to meet dynamic criticality safety requirements.

Criticality safety scenarios involving the performance of holdup measurements in the HB Line NCSEs have been determined by the site criticality safety engineers to be incredible. HB Line holdup measurements are, therefore, treated programmatically as defense in depth. HB Line holdup measurements are not reviewed by the criticality safety engineers for quality of measurements (i.e., consistency), trending of potentially accumulating deposits, or effectiveness. Interviews with criticality safety and NDA personnel reveal that NDA measurements are performed primarily to meet MC&A requirements. Given the remaining operational life expectancy of HB Line, it does not appear likely that changes in operational tempo (such as throughput or expected campaigns) will impact the bases for incredibility, hence the lower level of interaction between criticality safety and NDA personnel.

The NDA Program resides in the Analytical Laboratory Services Project. Although the NDA Program is intended to meet MC&A and safeguards requirements, it is funded through the projects' operating budgets. Staffing for the NDA holdup measurement program is determined at the start of a budget cycle and is proportionate to the amount of effort needed to meet MC&A and safeguards requirements. Current staffing needs, estimated to be five to six full-time equivalents, have been negotiated with both projects. Funding for performing holdup measurements for criticality safety purposes, which is drawn from existing safeguards and MC&A compliance resources, appears commensurate with the criticality risk in HB Line.

NDA Program effectiveness in meeting MC&A and safeguards requirements is routinely evaluated by various organizations. Assessments of NDA program elements are performed by DOE Headquarters, DOE-SR, and the contractor. NDA holdup measurements are not normally reviewed by Federal or contractor criticality safety staff, but are a part of reviewing and approving of safety basis documents that specifically identify or credit holdup measurements. Self-assessments are performed by contractor organizations. The Solid Waste organization has performed assessments of waste-related measurements. Management Field Observations (MFOs) have been performed by the Manager of the Analytical Laboratories and by Facility Operations. The contractor's Criticality Safety organization has not performed MFOs on the NDA organization. From a risk perspective, this appears to be consistent with the contractor's treatment of HB Line holdup measurements as defense in depth.

The DOE-SR Safeguards organization performs annual assessments of NDA measurements in each facility. DOE-SR Safeguards qualifies systems for operation and approves control charts. The Headquarters Office of Independent Oversight performs assessments of the NDA holdup measurements program, occasionally bringing in outside experts to assist with technical evaluations. Assessment findings are entered into the site issues tracking system. NDA issues impacting contractor compliance with safeguards requirements are routinely brought to the attention of DOE safety personnel.

Roles and Responsibilities

The Roles and Responsibilities section is intended to query the management process for ensuring that the holdup measurements program continues to meet dynamic criticality safety requirements.

Several people who were interviewed indicated that the accumulation of a mass important to criticality safety would be realized through a loss of inventory detected by MC&A personnel. The link between the MC&A and Criticality Safety organizations is through facility management and Engineering, and appears to be based significantly on professional knowledge. Interviews with criticality safety engineers indicated that NDA professionals are involved in developing NCSEs. However, the final approval or acceptance of criticality safety controls impacting holdup measurements appears to be made by facility or Engineering management acting as proxy for NDA management, as evidenced by the lack of an NDA program signatory on NCSEs.