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**Department of Energy**
Washington, DC 20585

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November 18, 2009

The Honorable John E. Mansfield
Vice-Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue NW, Suite 700
Washington, DC 20004-2901

Dear Mr. Vice-Chairman:

This letter is to inform you of the completion of Commitments 5.2.4 and 5.2.5 in the Department of Energy (DOE) *Implementation Plan for Defense Nuclear Facilities Safety Board Recommendation 2007-01,* dated October 24, 2007.

Commitments 5.2.4 and 5.2.5 are to conduct Environmental Management (EM) and National Nuclear Security Administration (NNSA) state-of-the-practice reviews per the schedule established in Commitments 5.2.2 and 5.2.3 with the assistance of the Nondestructive Assay (NDA) Technical Support Group. Reports documenting the results of the reviews are attached.

If you have any questions or need further information, please contact me at (301) 903-4218.

Sincerely,

A Danielson for,

Richard H. Lagdon. Jr.
Chief of Nuclear Safety
Office of the Under Secretary
U.S. Department of Energy

cc:

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SEPARATION

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

**February 9 – 12, 2009**


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David Dolin (Savannah River)
Cynthia Gunn (Y-12)
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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.

SEPARATION

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# Technical Support Group State-of-the-Practice Review of the Nondestructive Assay *in-situ* Holdup Program at the Y-12 Security Complex

**June 22 – 25, 2009**


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## Executive Summary


The Y-12 facility has implemented several successful programs to monitor and control uranium holdup in process equipment with application to both Nuclear Criticality Safety (NCS) and Nuclear Material Control and Accountability (NMC&A). The total number of process equipment holdup monitoring points, the amount of uranium holdup in this equipment, and the measurement frequency of the holdup monitoring points are drivers of the Uranium Holdup Survey Program (UHSP). However, not all holdup measurement values are determined by the UHSP. Special campaign (e.g., to improve NMC&A inventory quantities) can generate substantially higher values than those of the UHSP.

The equipment holdup quantities measured for NCS are shared with NMC&A and vice-versa. This was not always true in the past. The assumptions and the interpretation of the data, especially the associated uncertainties, were often not applied in a uniform fashion by the two organizations. However, a new multidisciplinary Inadvertent Accumulation Prevention Program (IAPP) is now in place, which appears to be resolving these issues. The IAPP, in conjunction with UHSP and Technical Justification for Inventory Value (TJIV), appears to be working well in spite of some issues with outdated technology. The integration of MC&A measurement data under TJIV with criticality safety *in-situ* measurement data is a strength of the IAPP. The Technical Support Group (TSG) observed a high level of cooperation and communication between operations, engineering, criticality safety, and NDA measurement personnel, which allows all interested parties to remain cognizant of changes, needed revisions, and facility status. The TSG noted that the Criticality Safety, Waste Management, and NMC&A organizations are all competing for the same *in-situ* nondestructive assay (NDA) resources. There is also a fragmentation of NDA professionals across organizations (i.e., Waste, Analytical Chemistry, Engineering, and NMC&A).

The UHSP is a two-tiered program that first sends out teams of production personnel not trained in NDA to routinely survey process equipment with a simple, automated gamma rate meter system. This first-tier qualitative measurement covers a wide area and requires an easily reproducible survey at preselected locations. The readings taken are compared with previous or expected target values. Any potentially significant increases in holdup are flagged and investigated in the second tier of the program by the NDA holdup measurement group. A strength of the UHSP is the database used to maintain a record of all measurement point locations, action values, required measurement frequencies, and measurement results.

A combination of automated holdup software (HMS3 / HMS4) and spreadsheets developed on-site are used to perform gram quantity calculations. One noteworthy practice was the development of electronic mechanical drawings mapping the measurement points; these drawings are especially useful in areas of complicated piping.

The Y-12 Security Complex is presently designing a new processing facility that will replace aging existing facilities. The Uranium Processing Facility (UPF) design includes a system engineering review and interpretation of where NDA may interact with existing systems. Y-12 has retained a design team that includes a site NDA-knowledgeable individual who provides

continuous design review input that incorporates current and anticipated NDA measurement needs, adapts lessons learned from past operating experience, and adapts technology appropriate to the processing missions.

Y-12 holdup staff have performed several source checks to verify minimum-detectable-activity (MDA) calculations. While these checks have been performed primarily for waste container measurements, and these checks have not been formally documented, validating these calculations is a best practice for holdup measurements.

The peer and management review processes are effective methods for producing good results, improving technical capabilities, and increasing confidence that procedures are being followed.

The annual hands-on qualification of the measurement staff adds value in several significant ways. It allows the staff to exchange information related to recent events, and demonstrates to the measurement staff the MDA of the instrumentation, and verify the MDA calculations. Another part of the NDA group's training requirements is annual retraining. Within NDA Engineering, the lead engineer issues blind standards for assay to determine proper identification and quantification. Some measurement personnel who could benefit from advanced NDA training do not receive it. NDA training plans contain very few NDA-specific courses. The loss of trained measurement staff is an issue at Y-12, and the staff has personnel who are single-point failures if they leave.

The site performs cleanout of holdup deposits and compares measurements of the removed material with holdup measurements. This effort includes performing refinements to the models used for measurements.

The use of old NDA measurement equipment with limited automation leads to an increase in false measurements attributed to human error; also, the development of holdup technology at Y-12 is occurring less frequently than in the past.

# ACRONYMS

| | |
|---|---|
| CSE | Criticality Safety Engineering |
| CSO | Criticality Safety Officer |
| DNFSB | Defense Nuclear Facilities Safety Board |
| DOE | Department of Energy |
| EUP | Enriched Uranium Production |
| GGH | Generalized Geometry Holdup |
| HMS | Holdup Measurement System |
| HPGe | High-Purity Germanium |
| IAPP | Inadvertent Accumulation Prevention Program |
| IMS | Issues Management System |
| LANL | Los Alamos National Laboratory |
| LOIs | Lines of Inquiry |
| MC&A | Material Control and Accountability |
| MDA | Minimum Detectable Activity |
| NCS | Nuclear Criticality Safety |
| NDA | Nondestructive Assay |
| NMC&A | Nuclear Material Control and Accountability |
| ORNL | Oak Ridge National Laboratory |
| POC | Point of Contact |
| ROI | Region of Interest |
| TJIV | Technical Justification for Inventory Verification |
| TSG | Technical Support Group |
| UHSP | Uranium Holdup Survey Program |
| UPF | Uranium Processing Facility |
| Y-12 | Y-12 National Security Complex |
| YSO | Y-12 Site Office |

## 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* 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 Y-12 National Security Complex (Y-12) 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 Y-12 to use at its own discretion. The final report submitted to DNFSB after the completion of all site reviews will not tie information to individual sites.

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 Y-12 before the site visit. Eight topical areas were reviewed, seven of which 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.

Two notable programs implemented at Y-12 support safety-related *in-situ* NDA: the Uranium Holdup Survey Program (UHSP) and the Inadvertent Accumulation Prevention Program (IAPP). The extensive UHSP (procedure Y15-014), as its name implies, is an NDA surveillance program to monitor enriched uranium accumulations within process equipment and support systems that are not routinely accessed by visual observation or cleanout. The measurements support objectives for both material accountability and criticality safety, as referenced in the nuclear criticality safety program (procedure Y70-150). Both qualitative and quantitative analyses are reported. The qualitative NDA, performed by the Production organization by procedure (Y50-37-018) with a radiation survey gross gamma count ratemeter, is compared to action limits for each survey position. More than 80 percent of the UHSP survey locations are required by criticality safety documentation to be surveyed. Those survey readings that are above an action limit require disposition through UHSP procedure Y15-014. The UHSP response involves a review by NDA Technical Support that may include a qualitative review of the survey data, quantitative holdup measurements, trending analyses, and recommendation on whether to adjust the survey parameters. The UHSP requires the coordination of NDA Technical Support, Criticality Safety Engineering (CSE), Criticality Safety Officer (CSO), Nuclear Material Control and Accountability (NMC&A), and the UHSP Lead for concurrence and approval. Quantitative holdup measurements are performed by procedure Y17-69-418 at locations requiring mass values for periodic inventory or due to "high-point" survey results. The results are issued in a UHSP high-alarm gram quantity report, a Technical Justification for Inventory Value (TJIV) report, or similar holdup report.

The IAPP was initiated in response to a detailed review of three events discovered as a result of the UHSP. The comprehensive program is noteworthy for its multidisciplinary approach to material holdup evaluations and necessary corrective actions. The IAPP procedure (Y70-162) employs a review team of personnel from CSO, CSE, NDA, process or system engineering, or design authority, who perform assessments of fissile material systems by tabletop evaluations and field walkdowns. In addition, an accumulation control group of personnel such as the UHSP manager, chief CSE, and production and operations managers review these IAPP assessments for concurrence and recommend corrective actions. To date, Phase I of the IAPP has focused on its baseline reviews of systems performing fissile material activities, and is nearly complete with the prioritized implementation of its recommendations. Recommendations have involved equipment changes and cleanout and UHSP improvements for revising monitoring points. Improvements also include performing additional quantitative measurements and efficiency changes to the UHSP database and survey location labels. The IAPP will focus on process revisions as the program matures.

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

- 9215 Facility;
- 9212 Facility;
- Holdup field measurements; and
- Calibration of holdup equipment.

Three presentations were made to the TSG:

- NDA Engineering Uranium Holdup Survey Program by the Non-Destructive Assay Engineering Supervisor;
- Nuclear Criticality Safety and NDA Interfaces by a Nuclear Criticality Safety Engineer; and
- Inadvertent Accumulation Prevention Program by an Enriched Uranium Production (EUP) Criticality Safety Officer.

The TSG interviewed the following individuals:

- NDA Professional;
- NDA Measurement Technician;
- NDA Manager;
- Training Coordinator;
- Criticality Safety Engineer;

- Criticality Safety Officer;
- Criticality Safety Manager;
- Systems/Program Engineer;
- System Engineer/Process Engineer (SE/PE) Manager;
- 9212/9215 Operations Manager;
- NDA Research and Development Professional;
- Research and Development Professional;
- Research and Development Post-Doctoral Student;
- Material Control and Accountability (MC&A) (Quality Assurance (QA)); and
- Y-12 Site Office (NNSA-OR).

The following eight sections contain the results from the state-of-the-practice review at Y-12. The majority of the information was obtained during interviews covering the lines of inquiry (LOIs). Other sources of information included document reviews, tours, work practice observations, follow-up questions, and presentations given by Y-12 personnel.

## Training and Selection of *in-situ* NDA Holdup Measurement Personnel

*Overview*

The training and selection of NDA holdup personnel at the Y-12 National Security Complex is uniquely influenced by multidisciplinary requirements and the application of measurement technology at the site. The total amount of uranium holdup in equipment appears to be large from both an NCS and NMC&A standpoint. This large quantity, the total number of process equipment holdup monitoring points, and their measurement frequency to support NCS and NMC&A are all drivers of the UHSP. However, not all holdup measurement values are determined by the UHSP. Special campaigns (e.g., to improve NMC&A inventory quantities) can generate substantially more information about holdup than what is triggered by the UHSP.

The equipment holdup quantities measured for NCS are shared with NMC&A and vice-versa. This was not always true in the past. The assumptions and the interpretation of the data, especially the associated uncertainties, were often not applied in a uniform fashion by the two organizations. However, a new multidisciplinary approach is now in place, which appears to be resolving these issues. Because the quantities measured are typically not small, current holdup results are routinely being compared with the required criticality safety limits for the equipment. Furthermore, these large quantities often have an impact on the total inventory or inventory difference (ID) calculations. Routine monitoring and associated evaluations as part of the UHSP are relied on to address inadvertent accumulation concerns and to help identify measurement anomalies.

The UHSP is a two-tiered program that first sends out teams of production personnel not trained in NDA to routinely survey process equipment with a simple, automated gamma ratemeter system. This first-tier qualitative measurement covers a wide area and requires an easily reproducible survey at preselected locations. The readings taken are compared with previous or expected target values. Any potentially significant holdup increases are flagged and investigated in the second tier of the program by the NDA holdup measurement group.

In-Situ *NDA Measurement Personnel*

There are four survey coordinators and about a dozen production personnel involved in the first tier of the UHSP. Personnel currently engaged as survey coordinators were either trained at the onset of the UHSP program in the 1990s or have been given on-the-job training by a predecessor. Although there is a module listed in the facility training system for this position, no evidence was found to indicate that it has ever been provided to anyone performing this function. Personnel currently involved as part of a measurement team collecting the survey data were, likewise, either trained at the onset of the UHSP program or have been given on-the-job training by a predecessor. There is also a training module for the measurement team operators, but it, too, exists only as a formality and has never been provided to anyone.

The NDA holdup measurement group currently has 10 personnel engaged in performing uranium holdup measurements as the second tier of the UHSP. A majority of the personnel performing these holdup measurements acquired their NDA knowledge with on-the-job training (OJT) and classroom training at a DOE facility rather than at an educational institution. The group has been staffed by selecting personnel with a technical degree or a technical background (if possible) and an aptitude for fieldwork. The selected individuals were then trained in NDA and in performing holdup measurements.

The NDA holdup measurement group is subdivided into two categories of personnel. The highest category is the NDA Leads (professionals or specialists). They are responsible for calculating and reporting quantitative measurements and for interpreting the first-tier qualitative survey measurements. The second category is the NDA Technicians (operators). They are responsible for managing the holdup instruments, performing calibrations and repairs, and maintaining the qualitative measurement program. All of the personnel in the NDA holdup measurement group are responsible for conducting field measurements, which is typically performed in pairs. Because of the differences in roles and responsibilities, each group has some unique training requirements, as well.

The table below lists the NDA holdup measurement group personnel identified per the guidance in the ASTM International Standard C1490 – 04, *Standard Guide for the Selection, Training and Qualification of Nondestructive Assay (NDA) Personnel.*.

| Senior NDA Professional | NDA Professional | NDA Technical Specialist | NDA Qualified Instrument Operator |
|---|---|---|---|
| 0 | 1 | 5 | 4 |

In addition to the 10 personnel assigned to the NDA holdup measurement group, there are two more individuals in the field NDA organization who are available for measurement consultations. These two individuals have NDA knowledge and experience commensurate with the Senior NDA Professional category.

In-Situ *NDA Measurement Personnel Training*

All NDA holdup personnel are required to attend a formal holdup training course. This requirement can be met by taking DOE course MCA-243, offered at the Los Alamos National Laboratory (LANL), or by taking one of the week-long holdup courses taught in Oak Ridge. Several members of the Y-12 NDA group have taken multiple courses to improve their understanding and to update their hardware and software skills. Both of the formal courses offered by LANL and Oak Ridge National Laboratory (ORNL) cover the physics of gamma interaction and transmission, detection of gamma rays, gamma spectroscopy, holdup modeling and calibration, holdup calculations and correction factors, and measurement uncertainty. In addition, all personnel conducting holdup measurements have also attended a class on automated holdup measurements using Holdup Measurement System (HMS)3 and HMS4 software and hardware. Although these two courses are necessary for staff who conduct quantitative measurements, they do not constitute sufficient training. Any new member of the NDA group is also required to undergo approximately one year of on-the-job training and mentoring with experienced personnel before being allowed to work independently.

Another part of the NDA group's training requirements is the annual retraining that is used to reinforce skills needed to perform the requirements of each NDA position. Because the NDA technicians are responsible for supporting and performing qualitative measurements for the UHSP, the technicians are trained annually on the use of the qualitative survey procedure and the HMS software program. The NDA Leads have an annual requalification requirement of performing a quantitative measurement on a standard, masked as an unknown. The Leads also attend an annual classroom retraining module. The current form of the annual training module gives a review of holdup theory, includes new topics for improving measurements, and provides a refresher on sources of bias in measurements and how to minimize and correct for them. It is noted that there is a desire for these professionals to have an opportunity to practice these lessons, but a venue needs to be established.

A summary of the current training and qualification program for *in-situ* NDA holdup measurement personnel at Y-12 is provided in the following table.

**Table 1: Summary of Holdup Training and Qualification Status at Y-12**

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

*Not formalized, but OJT is provided.

Y-12 recognizes the need to continue building its ongoing annual training program. Further suggestions and training needs were provided and are listed below.

- Further understanding of measurement uncertainty is needed– what are the contributors and the magnitudes associated with each? Can traditional statistical methods be adapted to holdup measurement uncertainty calculations?
- Further understanding is needed in how transmission measurements in the field are best performed, and in how these are used to correct for self-attenuation and/or equipment attenuation.
- Further understanding is needed in performing volume measurements and making self-attenuation corrections when matrix materials are present.
- Further understanding of the uranium production processes and equipment design would enhance the understanding of holdup accumulation in the production areas.
- It is suggested that some of the NDA professionals retake the fundamental holdup course after some period of field experience for a deeper understanding of holdup theory.
- It would be useful to be able to recognize deficiencies and weaknesses in understanding through a standardized testing program.
- It would be useful to have a DOE NDA certification program that recognizes graduated measurement skill mastery.
- It would be informative to participate in a round-robin exercise with other facilities engaged in measuring holdup.
- It is important to have a hands-on opportunity to use the latest available instruments and software.

- Some NDA holdup cross-training with NCS and NMC&A personnel would help strengthen the mutual understanding of each of these disciplines.

There does not appear to be a critical lack of available funding for sending individuals for formal training. However, the increasing costs associated with travel, added to that of higher class tuitions, is a growing concern because of the size of the NDA group. It has been noted previously that another DOE site used onsite training sessions where the trainers are brought in rather than sending individuals out of town to attend a course. The next alternative would be to provide regional training, if possible.

## Design Requirements for New Facilities and Equipment

### *Design Process*

The Y-12 Site is presently designing a new processing facility that will replace aging existing facilities. The Uranium Processing Facility (UPF) is an advanced facility design process that has included system engineering review and interpretation of where NDA may interact with these systems. This effort has included a review of existing NDA-related features and incorporation of these features when possible. For example, the UPF design plans include engineering features to reduce unplanned accumulation. Y-12 has retained a design team that includes a site NDA-knowledgeable individual who provides ongoing design review input to incorporate current and anticipated NDA measurement needs for both MC&A and criticality safety and to consider lessons learned from past operating experience.

The system engineering team, including the engineer familiar with present challenges in NDA holdup measurements, conducts design reviews and evaluates the process features and their interaction with NDA measurement needs. There is significant reliance on engineered features; specifically, filters that protect geometrically unfavorable containers and systems from accumulations. Filters lend themselves well to maintenance and can reduce the number and frequency of measurements required further upstream. Thus, they are a preferred engineered design feature. Also, they have been proven effective in current operations, and design elements from existing processes are incorporated into the new designs. An example of an evolution in design is the plan to redesign vacuum systems from a centralized vacuum system to individual glovebox systems internal to specific locations. The vacuum systems are geometrically favorable by design.

The Y-12 site contractor does not have a procedure that requires a design review to identify needed *in-situ* NDA measurement capabilities in the design process. The Y-12 process is mostly an expert-based system that relies upon several disciplines: NDA, MC&A, criticality safety, and engineering.

### *Requirements Implementation in Existing Facilities*

Equipment and process modifications require reviews by NDA-knowledgeable staff prior to their implementation. This is accomplished through the facility change control process, a well-defined, mature process managed by the Engineering Division. An Operational Safety Board can also recommend reviews by NDA-knowledgeable staff during process design safety reviews. Any change to the Criticality Safety Evaluation invokes the IAPP, which invokes an NDA review at the discretion of NCS staff. Additionally, when the new or modified operation is implemented, the IAPP intends to provide assurance that engineering features will prevent inadvertent accumulation of material when possible and develop *in-situ* NDA requirements for locations where NDA experts have determined that such measurements can be successful.

New and modified designs receive a Design Verification Review, which includes walkdowns by the criticality safety staff. One of the important aspects of the Design Verification Review process is the incorporation of NDA *in-situ* measurement capability expertise and engineered process safety features. Engineered controls relied upon for safety are surveilled on a periodicity determined through examination of the historical operating data for the system. Conservative surveillance requirements are imposed initially and sometimes relaxed as appropriate.

### *Design Details that Aid in-situ Holdup Measurement and/or Control*

Although numerous traps, low points, and geometrically unfavorable locations may exist in process equipment, those areas are surveyed routinely utilizing the UHSP process. This process requires that *in-situ* measurements are made on a regular basis with a specific focus on historically problematic locations. Accessibility is considered in new designs and process modifications. Fixed instruments are not used for continuous monitoring. Y-12 believes that significant human interaction is necessary to ensure that suitable safety assessments and measurements are made and that they are accurate. Engineered controls are provided to limit material from entering process off-gas systems through the use of mist eliminators, mist-eliminating filters, and metal filters. These design features have a proven track-record at Y-12.

Cleanout ports and access points have been provided at accumulation points in the existing facility design. For the new facility, the use of cleanout ports for ducts is under consideration, but the design is still evolving. Process-knowledgeable staff members are intimately involved in the design and design review processes. New glovebox designs incorporate surface finishes and radius of curvature that will enhance the ability to decontaminate. Glovebox surfaces will be polished stainless steel. The standards developed by the American Glovebox Design Standards committee are being used.

### *Containers*

Containers are, in general, designed to permit nondestructive analysis of the contents and minimize shielding where possible. Most containers used in the existing facility processes are amenable to NDA fixed counter measurement. Newer containers present challenges, as they are designed to be more robust to accommodate other safety concerns, but to date, this has not been shown to present a significant NCS concern.

### *Facility Issues*

In many locations, background radiation is unavoidable due to the proximity of the measurement locations to other equipment and materials. Because background radiation levels are unavoidable, they are evaluated; however, the lack of uniformity requires that the measurement team continuously evaluate and investigate this significant and variable source of measurement uncertainty. Key measurement points are not, in general, ergonomically located. However, the facility has designed appropriate tools to assist operations personnel in making the measurements accurately and quickly. "As-built" drawings exist and are used routinely by the NDA group in their measurement surveillance (i.e., UHSP) program implementation. The long measurement history and excellent involvement of the NDA team with operations and engineering have assisted in the characterization of attenuation correction factors. The facility makes use of alternative methods for controlling and preventing inadvertent accumulations; e.g.; cleanouts when NDA experts determine that measurements would not be successful, filters, mist eliminators, and other design features.

## Standards for Conducting NDA Holdup Measurements

### *Measurement Program*

Most *in-situ* NDA surveillances in support of criticality safety are qualitative. Other measurements that are made include qualitative scanning, quantitative verification, and confirmation. Management, operations, and NDA personnel are all involved in the procedure-writing process. The TSG found evidence of good processes in place for developing and reviewing procedures. The procedures are well-written, clear, and concise; unnecessary information is kept to a minimum. The documentation meets the needs of the intended audience (i.e., 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.

All measurements are performed according to approved procedures. Measurement procedures contain the appropriate level of specificity and are higher-level in nature, describing the process to make a measurement not how each individual measurement is made. Procedures also contain some guidance on how some measurement specifics might be decided. Skill-of-the-craft (operator experience) is used to determine how to best implement the measurement in the field.

The peer and management review processes are effective in producing good results, improving technical capabilities, and increasing confidence that procedures are being followed. The technical approach to *in-situ* holdup measurements is based on the methods described in the book *Passive Nondestructive Assay of Nuclear Materials*[1], the report *Gamma-Ray Measurements of*

[1] Doug Reilly, Norbert Ensslin, and Hastings Smith, Jr., Eds. *Passive Nondestructive Assay of Nuclear Materials*, U.S. Nuclear Regulatory Commission report NUREG/CR-5550 (March 1991).

*Holdup Plant-Wide: Application Guide for Portable, Generalized Approach* (LA-14206)[2], and LANL training manuals.

Y-12 has NDA instrumentation to meet nearly all of its measurement needs. NDA instrumentation, controlled and operated by NDA Analytical Chemistry, includes segmented gamma scanner, neutron multiplicity counter, calorimeter, solution assay system, active well coincidence counter. The *in-situ* holdup equipment and measurements are the responsibility of the Nondestructive Analysis Engineering organization. Nearly all of the *in-situ* measurements are made using sodium iodide (NaI) detectors, which provide adequate resolution, considering that nearly all of the measurements are performed on uranium isotopes. Some germanium systems are also in use at the site.

The UHSP is a major, necessary resource for the IAPP, which is the backbone upon which criticality safety is maintained across the site. The UHSP is intended to periodically monitor enriched uranium process equipment and ventilation systems to detect changes in accumulations in areas that are not readily or routinely accessed for visual observation or cleanout. The qualitative measurements under the UHSP are performed by plant operations personnel using a simple ratemeter to measure the gross gamma count rate. The qualitative measurements are used as a screening process to detect change against predetermined action values. A strength of the UHSP is the UHSP database that is used to maintain a record of all measurement point locations, action values, required measurement frequencies, and measurement results.

Under the UHSP, numerous routine qualitative holdup measurements are made to determine areas of possible uranium accumulation. Action levels are determined by measured count rates above historically defined count rates at all of the thousands of predefined measurement sites. All high count-rate measurements must be resolved either by a qualitative remeasurement at the predefined measurement location or a quantitative measurement in the area of the high reading. High qualitative measurements could be caused by increased holdup in the area of the measurement, not necessarily at the measurement point itself.

Any follow-up quantitative analysis measurements are performed by NDA Engineering personnel with NaI gamma-ray systems using two photopeak regions of interest (ROIs) at 60 keV and 186 keV and three background ROIs bracketing both photopeak ROIs. The results of any quantitative measurements are reported in grams and are evaluated by subject matter experts to determine the potential impact on criticality safety and/or MC&A.

The TJIV is a program that uses all existing measurement results to establish reasonable actions for inventory measurements including equipment cleanout, if indicated. These measurements for MC&A are also used for criticality safety purposes. If facility personnel know how the quantity and distribution of the material, they can identify unsafe situations. The integration of MC&A measurement data under TJIV with criticality safety *in-situ* measurement data from the UHSP is a strength of the Y-12 measurement program.

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[2] Phyllis A. Russo. *Gamma-Ray Measurements of Holdup Plant-Wide: Application Guide for Portable, Generalized Approach*, Los Alamos National Laboratory report LA-14206 (June 2005).

The IAPP limits material accumulations to low levels such that NCS concerns are minimal. Accumulation is limited by a combination of factors such as design features, process design, UHSP measurements, and/or routine maintenance activities.

### *Changes to Procedures*

Procedures are required to be reviewed every five years or less. Training on procedures occurs every year. Unlike the Analytical Chemistry organization, the NDA engineering program does not have any identified procedure writing personnel. Procedure changes can be implemented by anyone, but they must undergo a thorough review and approval process. Version control is effectively implemented via a web-based system.

Lessons learned are communicated well across the site. At Y-12, everyone is working with uranium; therefore, all lessons learned are relevant. Changes in the state of the facility are communicated to the measurement personnel by the operations supervisor and shift manager. The measurement leads are required to know facility conditions before commencing measurements. All modifications to equipment or processes should be noted when completing the Performance Documentation Checklist prior to making a measurement. Measurement leads check with the operation supervisor or shift manager at the beginning of each day and when they notice a change in the facility during the day.

The TSG observed a high level of cooperation and communication between operations, engineering, criticality safety, and NDA measurement personnel that allows all interested parties to remain cognizant of changes, needed revisions, and facility status.

### *Results and Calculations*

Calculations are typically performed using commercially available holdup software, either HMS3 or HMS4. Spreadsheets developed onsite may also be used to perform gram-quantity calculations; however, these spreadsheets are not controlled. One noteworthy practice was the development of electronic mechanical drawings mapping the measurement points. These mechanical drawings are especially useful in areas of complicated piping.

## 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 Y-12 to support compliance with NCS limits.

The NDA Manager gave an overview of holdup measurements. The holdup measurement personnel reside within the Engineering organization. While holdup measurement staff have been moved between several organizations, the Engineering Manager, who is a corporate vice-president, met with the TSG and demonstrated his substantial awareness of holdup measurements and staff. The TSG toured two major processing facilities and the NDA calibration facility, which is used to calibrate both qualitative and quantitative instruments, and observed holdup measurements being performed during the tours. Reviews of documents occurred before and throughout the site visit.

Interviews provided consistent details concerning the implementation of holdup measurements at Y-12. LOIs were primarily used to examine the holdup measurement program, although TSG members also interviewed NDA personnel who perform measurements not directly related to holdup measurements. The holdup measurement staff consists of a wide range of expertise and experience levels. All quantitative measurements are performed by the NDA staff, while qualitative scans are initially performed by operations personnel. When significant changes in scan results are identified, the NDA staff investigates, repeats, or performs quantitative measurements as indicated. The UHSP requires these scans for NCS monitoring against accumulation over long time periods. The quantitative measurements that result from high point investigations are used to support NCS and MC&A. Holdup measurements are performed to support MC&A, NCS, waste management, and decontamination and decommissioning activities. A work request system is being developed to allow site organizations to electronically notify the holdup measurement staff of upcoming work requests as well as issues related to the work requests.

Several efforts in recent years have strengthened communication between NCS, NDA, and operations personnel. One of these has been the creation of a point-of-contact (POC) within NCS who ensures that holdup results are made available to the appropriate NCS area lead, assists NCS engineers in the use of holdup data, and serves as the central communication point between the NCS and NDA organizations. Y-12 also has an active CSO program in which operations personnel work with NCS engineers to implement NCS requirements. CSO personnel were interviewed and conducted one of the building tours. They were very knowledgeable of holdup measurement results and associated issues. A third effort that has strengthened communication was the development and implementation of the IAPP. This program, which has been well-supported, has implemented multidisciplinary walkdowns of all systems with active NCS requirements. Walkdowns of inactive systems are currently in progress. These walkdowns have prompted further efforts when determined appropriate, such as requiring process cleanouts or engineering modifications.

Holdup measurements are performed using the Generalized Geometry Holdup (GGH) method, based on a LANL recommendation, primarily to support NCS and MC&A with additional measurements required to meet waste removal. The holdup measurement personnel are confident that most holdup at Y-12 has been measured. Accelerated decontamination and decommissioning efforts are reducing unidentified holdup locations. The majority of measurements are performed based on process knowledge and engineering drawings. Isotopic characterization is based on destructive analysis of process materials. In cases where material impurity could cause isotopic variation, either high-purity germanium (HPGe) or destructive analysis measurements are used to investigate these deposits.

Y-12 holdup personnel currently use HMS3 and are transitioning to HMS4, with a goal of completing this transition during calendar year 2009. HMS systems automatically record data at each measurement location and support the storage of logged data and calculated results. One significant benefit is the near-elimination of data entry errors. The HMS4 version includes algorithms to correct for finite-source and self-attenuation errors and to check counting statistics. ORNL personnel who helped develop the system are supporting the Y-12 transition.

The Y-12 holdup staff have performed several source checks to verify minimum-level-of-detection calculations. Although these checks have been performed primarily for waste container measurements, they have not been formally documented. Validating the calculations is a best practice for holdup measurements. Through these efforts, the holdup measurement systems can routinely identify less than one gram of U-235.

Personnel are taught to identify and document high background and other interferences through training. Observed field measurements indicated that holdup measurement personnel were well-trained in detector positioning to minimize interferences and in positioning lead plates to reduce background as needed. The Compton background is subtracted by the use of ROIs established during calibration. During data analysis and reporting, high attenuation locations are reviewed. Locations where transmission is less than 5 percent are investigated. Correction factors for shielding are calculated based on engineering drawings and ultrasonic testing.

Equipment in use at the site is well-maintained. Repairs to the qualitative and quantitative systems are performed onsite by two technicians who directly support this effort. The NDA group uses NaI detectors for most holdup measurements. The group owns, but does not routinely use, a cadmium-zinc-telluride detector. Holdup measurement systems are routinely stored in locked rooms within the Material Access Area. Sources are stored in the same area in approved source storage containers. Reports are stored in accordance with records management requirements. Measurement ROIs are stored by the NDA professional performing the analysis.

Although uncertainty calculations are incorporated into HMS3, they are further reviewed when quantification results are reported. Modeling calculations and errors have been refined based on cleanout results. MC&A statisticians support analysis of error propagation, including an evaluation of cleanout comparisons. Uncertainties from count time, sampling, and modeling have been considered. Modeling and sampling uncertainties have been determined to be the dominant sources of holdup measurement uncertainty. The measurement team tracks trends in holdup results and reports the previous result at each location, as well as the current result.

The TSG observed several strengths during this review. Clearly, the level of communications between NDA, NCS, engineering, and MC&A staff is important to ensuring that holdup personnel provide the results needed by end users and get the support they require to perform measurements useful to the end users. Maintaining these channels of communication should be a continuing, mutually beneficial effort. The site has started cleaning out holdup deposits and comparing measurements of the removed material with holdup measurements. As a result, the models used for measurements have been refined. Upgrading the holdup measurement systems and instrumentation is important to obtaining state-of-the-art measurements. The HMS4 upgrade requires significant site support, including information technology support, and delays will impact this implementation. The annual hands-on qualification of the measurement staff adds value in several significant ways. It allows the exchange of information related to recent events, demonstrates the MDA of the instrumentation to the measurement staff, and verifies these calculations. The loss of trained measurement staff is an issue at Y-12 and some of the staff are single-point failures if they leave. This is not unique to Y-12; it appears to be typical across the DOE complex.

## Research and Development

The LOIs for this section evaluated 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.

The TSG interviewed two pairs of individuals. The first interview pair was from the Analysis and Characterization Group of Applied Technologies. This pair had very limited *in-situ* holdup knowledge and limited NDA expertise in general. Nearly all of the R&D funding comes from the Plant Directed Research and Development program. The R&D projects touted as in support of holdup measurements through the Applied Technologies organization did not appear to be related at all to holdup or NDA.

The second pair interviewed was from the NDA Engineering organization. These individuals have been very prolific in conducting NDA-related research. Any practical R&D efforts in NDA measurements at the site appear to originate from the two NDA Engineering personnel. Research results and conclusions are disseminated via daily interactions, conferences such as those sponsored by the Institute of Nuclear Materials Management, and the DOE Information Bridge.

All of the equipment used onsite is commercially available and commercially supplied. The most pressing equipment improvement needs at Y-12 is improved ruggedization, miniaturization, and integration (fewer components). The identification of technology needs at Y-12 was recognized by the TSG as ineffective. When needs that would benefit the measurement program are identified, Y-12 NDA personnel are not clear as to how that need should be conveyed or which organization is to act upon the need. The technical staff views all of the onsite NDA holdup equipment as obsolete. The use of old equipment with limited automation increases the potential for false measurements due to human error, which, in turn, increases the measurement burden from remeasuring points that are not really above action limits. More importantly, mistakes could occur where a point that is above an action limit is measured low and no action would be taken, but the next bimonthly survey would more than likely remedy the mistake.

The only calibration sources available onsite are point sources. Recently, funding was secured to prepare much-needed line and area sources. All of the standards are working reference standards.

Lessons learned are conveyed via word of mouth, the peer review process, and some onsite presentations. It appears that any funding for training or conference attendance must come from organizations other than the holdup or NDA personnel's organizations. Research collaboration within, or external to, the site has been nearly nonexistent in recent years.

The separation of NDA personnel into different organizations is detrimental to the development of site knowledge. This is especially disadvantageous given the small number of individuals practicing NDA. There are two waste facility personnel, two NDA laboratory personnel, 14 NDA field measurement personnel, and a measurements group within NMC&A.

## Quality Assurance (QA)

### *Program Management*

The responsibility for the QA program resides within the NDA Engineering Group. Field NDA engineers initiate response actions to out-of-control conditions. The NDA Field QA Lead within the NDA organization compiles and interprets measurement control data. The QA plan is described in the Y-12 document Y/DK-2145, *Measurement Control for Y-12 Uranium Holdup Measurements*. Further detail is described in multiple procedures.

Measurement control is an inherent function of the HMS-series software used to collect and analyze data. The automation capabilities of the HMS($x$) system allow for a rigorous measurement control scheme. A uranium cup standard is measured once every 20 measurements. In addition, an americium (Am)-241 source is attached to the front of the detector. This signal is analyzed with every measurement. Quality measurement performance is ensured through these features, in conjunction with yearly training and regular procedure reviews.

Annotated control charts are attached to each measurement report and are available to all data users. The MC&A organization reviews the data to ensure that it meets the stringent requirements of the DOE Orders. Detection levels are typically less than one gram in low-background areas, and this is generally adequate for criticality safety as well as MC&A.

When practical, holdup measurements are compared to cleanout values. As needed, these feedback data are used to adjust models and measurement approaches.

### *Documentation and Calibration*

Measurement data and analysis results are maintained in a centralized file cabinet. Hard-copy files can be associated with locations and process equipment within the facility. In the near future, it is planned to upgrade the measurement system to HMS4, which includes a central electronic database.

Calibration records are kept both electronically and in a paper file. Instrument manuals and logbooks are kept for each instrument. Investigations of out-of-control situations are tracked by physically writing on the control charts. Reports are tracked by control number.

Instrument calibrations are performed in a low-background area in a separate building that does not contain holdup. High-quality standards are used to perform calibrations, although only in the last month have line and area sources been available to verify calibrations.

Operationally, the limits of the instrument calibration are in terms of areal density ($g/cm^2$), and not the overall gram quantity of the item. The practical calibration limit is where the item has a sufficient areal density so that it appears infinitely thick. Infinite thickness checks are incorporated into the measurement program. Measurements are validated by comparisons to cleanout data and by comparisons to other measurement techniques (high-resolution spectroscopy). These comparisons are used to help ensure that the measurement range is valid.

For the qualitative measurements, each radiological survey meter is calibrated to read the same count-rate on similar sources. The survey meters are calibrated each day in which a survey is conducted. Action limits for the survey are set by evaluating the variability of each data point. Those points that exceed the action limit are investigated and normally remeasured.

Calibrations for the quantitative instruments are valid for one year. This timeframe was initially set by observing spectral degradation over time. Detectors that cannot meet quality assurance checks within one year are removed from service. Calibrations are validated with a uranium standard every 20 measurements and validated against an americium source attached to the detector with every measurement. The calibration status of equipment is controlled through procedure and by software. A full recalibration is required after any maintenance, except for cable replacement.

### *Nuclear Material Calibration Standards*

Nuclear material standards were prepared at Y-12. They were prepared to the same exacting standards as would be used in uranium parts. They are high-integrity standards that are well-characterized. The standards used for quality control were made with New Brunswick Laboratory-certified reference material and fabricated at Y-12. The standard used for calibration is a working reference standard. The material used for the calibration standard was characterized by the Y-12 plant laboratory and the standard was fabricated at Y-12. The documentation for this standard was captured in report Y/DK-2145, *Measurement Control for Y-12 Uranium Holdup Measurements.*

### *Check Sources and Control Charts*

The control standard is a uranium cup standard that fits over the collimator. A second standard is an Am-241 seed attached to the detector endcap. Control parameters are contained within each instrument to alert the operator of an out-of-control situation. If the uranium control standard fails, the system does not let the operator continue with data collection without rectifying the situation. If the instrument is out of control, the operator has an opportunity to move to a lower background area or to clean the detector. If the instrument is out of control after multiple attempts, the operator is trained to stop all data collection until a more thorough review has been performed.

The NMC&A organization routinely reviews the measurement control program and reviews the measurement control data that are issued as part of the quantitative reports produced per system measured. This program has also been reviewed during routine external reviews, including the 2008 Office of Independent Assessment inspection.

### *Validating Measurement Results*

Validation of NDA measurement results against cleanout data is performed when practical, although opportunities are rare. In some situations, parallel measurements are made by peers using alternate measurement techniques. Additionally, a comparison of NDA measurements of a system over time is tracked through the IAPP and TJIV programs. These opportunities are used to help better define measurement uncertainties and changes in holdup deposits. HMS, HMS3, and HMS4 software has been maintained, verified, and tested in accordance with Y-12 Software QA programs. Input values are double-checked through peer review.

## Oversight

In general, oversight activities involve both internally- and externally-initiated reviews to determine the extent to which programs and personnel are performing work activities in compliance with specific requirements. The application of particular review criteria for the purpose of assessment is effective for readiness reviews, performance analyses, and demonstration of adherence to policies and programmatic or operational procedures. This method is also effective for identification of deficiencies and opportunities for improvement, and for enhancement through self-assessment and independent oversight.

NDA may be implemented to support various requirements for compliance involving several site-level programs or functional areas. These areas typically include material control and accountability, criticality safety, safeguards and security, and waste characterization programs. Therefore, oversight performed on these programs may demand demonstration of compliance of NDA performance and identify deficient or noteworthy conditions as well as lessons learned. Often, oversight reviews will concentrate on performance objectives and criteria, broken down into specific LOIs, that are directed according to a high or low level of focus within a program or organization.

The LOIs established for the Oversight section of this review were directed toward determining what, when, and how oversight is performed and how the results are applied to NDA assessments and improvements, with a focus on criticality safety. Oversight reviews at Y-12 involve both internal (onsite) reviews and external reviews, typically directed by DOE. Internal oversight of NDA practices are routinely performed by the CSE, CSO, NMC&A, and site nuclear criticality safety committee organizations. The Y-12 NDA Manager noted that the NDA support required for recent external oversight has impacted the resources available for internal reviews; in particular, self-assessments. Typically, assessments involve reviewing the two NDA programs implemented for the uranium processing systems within Buildings 9212 and 9215: the UHSP and the IAPP.

The UHSP requires the coordination of NDA Technical Support, CSE, CSO, NMC&A, and the UHSP Lead for concurrence and approval. Quantitative holdup measurements are performed by procedure Y17-69-418 at locations requiring mass values for the periodic inventory or due to high point survey results. The results are issued in a UHSP high-alarm gram quantity report, a TJIV report, or similar holdup report as appropriate. Each report undergoes a technical review. UHSP results are distributed to several NDA customer organizations that provide a review of results, including facility managers, CSE/CSO, and NMC&A. These reports are excellent documentation of NDA measurements within the UHSP for any oversight reviews. NDA holdup measurements and analyses are not reviewed by individuals outside of NDA Engineering. Such an external review, if implemented, could provide a more comprehensive understanding of the advantages and difficulties of NDA capabilities.

Several criticality safety evaluations credit the UHSP for equipment holdup monitoring in the Administratively Controlled Limits and Requirements sections. The controls may also include requirements for engineered features or periodic cleanouts of system equipment. The bases for the survey action values are recorded in a UHSP survey basis report. However, there does not seem to be documentation that provides a calculation link between an individual survey action limit for a defined assay configuration and the corresponding criticality safety limit. The survey frequency is set to detect and track the assumed slow accumulation of uranium deposits and allow for CSE guidance. A Technical Deviation or Clarification (TDC) report is issued by CSE to document the guidance, or as requested for support.

The CSE may request an IAPP review for a particular need as deemed necessary during development of a criticality safety evaluation. Several program assessments are required by the IAPP procedure (Y70-162). These oversight assessments are performed according to the Y-12 nuclear criticality safety committee, the nuclear criticality safety review program procedure (Y70-66-002), the management assessment procedure (Y15-902), or independent assessment procedure (Y15-903).

Oversight assessments are routinely performed by several internal organizations with respect to the UHSP and IAPP, involving the implementation of criticality safety practices and NDA measurements. External oversight includes expert individuals recruited for particular reviews as well as larger site evaluations that include NDA program elements. The IAPP, by definition of its scope, provides an oversight function of NDA implementation for criticality safety because systems are analyzed, issues are identified, and corrective actions are recommended. While all of the individuals interviewed for this portion of the TSG review were knowledgeable of the UHSP and IAPP, several were not familiar with the documented safety analysis or authorization basis documents applicable to the processing facilities, Buildings 9212 and 9215.

A significant annual review of selected elements of the Y-12 criticality safety program is conducted by a broad team of site experts, including selected *ad-hoc* members external to Y-12. The Y-12 nuclear criticality safety committee conducts its annual review according to an assessment plan developed according to input from various sources. These sources include defined review criteria as LOIs, previous oversight issues, assessment databases, and potential customer concerns. Typically, the review will focus on a specific interest area or concern. As an example, an annual review report contained criteria specific to assessing the corrective actions in response to a filter investigation. Committee recommendations of findings, observations, or opportunities for improvement are considered by a review board for selection of prioritized corrective actions and tracking in the site issues management system (IMS) database. The committee performs a review of the IAPP on a three-year schedule.

The Y-12 Site Office (YSO) approves the corrective actions in IMS that are given higher priority than others. Site Office personnel perform quarterly assessments according to selected criteria or concerns or to follow up on previous oversight concerns and record the results in a dedicated, DOE-owned database, Pegasus. Both the IMS and Pegasus databases interface with read-only capability, allowing for excellent communication between the contractor and DOE as well as YSO oversight of identified issues.

Annual process reviews of fissile systems are performed by CSE personnel according to established LOIs. Similarly, CSE performs program reviews per industry administrative requirements (i.e., the American National Standards Institute (ANSI)/ANS-8.19 Standard). The LOI sections include UHSP, IAPP, inventory control, and large-geometry exclusion areas. Monthly meetings are used to discuss lessons learned, deficiencies or noncompliance items, and corresponding performance metrics. The CSE point of contact serves as the interface with the NDA organization to review monthly holdup reports and facilitate resolution of high survey results for Buildings 9212 and 9215. This CSE position is instrumental to the efficient communication between the criticality safety and NDA organizations and to the integration of both programs. CSE personnel are frequently in view of fissile material operations. However, holdup surveys and quantitative NDA measurements are seldom observed by CSE personnel, but would provide a valuable input for the CSE self-assessments. Self-assessments, which include NDA holdup criteria, are also periodically performed by NMC&A personnel.

Criticality safety self-assessments are also performed by the CSO for each fissile material process. A surveillance database requires the CSO to perform periodic reviews of the validation, implementation, and annual surveillance of criticality safety requirements. The surveillances are conducted according to a checklist of general criteria that includes a review of NDA controls from criticality safety documents. An "unsatisfactory" result requires that a supervisor be notified to determine further disposition, including the recording and tracking of corrective actions in the surveillance database. In general, the CSO functions as a vital, expert asset for coordinating NDA requirements for criticality safety with process operations via the UHSP and IAPP. Inclusion of the CSO and CSE findings and corrective actions in the Y-12 IMS database could better drive continuous improvement. The IMS is a more formal database that ensures an adequate, consistent review of issues for proper identification of corrective actions and their tracking to completion. In addition, the IMS provides a central point for calculation of various performance metrics and a source of review data for various oversight needs.

General self-assessments are not performed by NDA personnel because of limited staffing resources. Within NDA Engineering, blind standards are issued by the lead engineer for assay to determine proper identification and quantification. The NDA Engineering Manager stated that recently NDA personnel were expected to support a number of external oversight queries, which limits NDA support beyond the UHSP duties. Occasionally, the NDA Engineering organization relies on the technical review and support of an NDA expert from ORNL. This type of external technical review should be used on a regular basis to provide a fresh view of NDA methods, potential improvements, or overlooked problems.

## Roles and Responsibilities

The contractor roles and responsibilities for the UHSP program are adequately defined in procedures Y15-014 and Y70-162. Federal roles and responsibilities for overseeing elements of the UHSP related to nuclear criticality safety are described in YSO-5.9. The UHSP program resides within both the NDA group, which is part of the Engineering Organization, and within Production. The NDA group is composed of staff having technical expertise ranging from senior technical specialists to technicians. The UHSP Manager, who is concurrently the NDA Group Manager, is responsible for identifying funding needs. Funding is project-based, and is negotiated with the Operations organization. Included in this funding is contingency planning to account for unexpected resource expenditures such as unplanned quantitative measurements and emergent work. Additional funding needs are quantified by the NDA Group Manager and submitted to the Vice-President for Engineering for further disposition. These roles and responsibilities are clearly defined in procedures Y15-014 and Y70-162.

Procedure Y15-014 assigns overall responsibility for the conduct of uranium holdup surveys and coordination of activities of applicable support organizations such as criticality safety and NMC&A. Procedure Y70-162 implements the multiorganizational IAPP to address geometrically unsafe areas within fissile material activity systems. This procedure defines roles and responsibilities for the Engineering, Quality and Manufacturing organization, Operations organization, and Deputy Manager. Together, these procedures provide for clear and effective communications between interfacing organizations.

Procedures Y15-014 and Y70-162 also define the functions, assignments, responsibilities, and reporting relationships necessary to support line management control of safety. Discussions and presentations by the CSO regarding the IAPP demonstrated effective interfaces between the Operations organization, which is responsible for the UHSP; and NCS, which is responsible for promulgating the guidance necessary for ensuring continued safe operation of processes and equipment having the potential for enriched uranium holdup. The IAPP, which serves to validate the potential for holdup, has been designed to document the potential for holdup, and identify best methods or technologies for minimizing such potential. This program includes a mechanism with technical recommendations that require funding for implementation, which may be brought to line management attention for further resolution and disposition. Several corrective actions stemming from completion of IAPP activities were assigned as capital items requiring Plant Manager approval for the release of funding.

The UHSP is implemented by NDA technical support staff and by Production staff. Procedure Y15-014 defines the roles and responsibilities for the following NDA and holdup measurement personnel: Survey Coordinator (Production); Qualitative Measurement Survey Team (Production); and NDA Technical Support (Engineering). Per Procedure Y15-014, the Survey Coordinator oversees the routine qualitative surveys in an assigned area. The Survey Coordinator is alerted to surveillance due dates, ensures that the surveys are completed within the required time period, and is responsible for transferring the data results to the central UHSP database. The Survey Coordinator is also responsible for preparing holdup survey equipment to be used by the Qualitative Measurement Survey Team. Technical support for operation of the holdup survey equipment, including calibration, modifications, repair, maintenance, equipment specifications, and for the purchase of survey equipment, is provided by the NDA Technical Support group. This group also performs routine follow-up qualitative and quantitative measurements in response to qualitative results exceeding defined action thresholds.

SEPARATION

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# Technical Support Group State-of-the-Practice Review of the Nondestructive Assay *in-situ* Holdup Program at the Hanford Plutonium Finishing Plant (PFP)

**September 22 – 24, 2009**


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## Executive Summary

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 Recommendation 2007-01), dated October 24, 2007. The Implementation Plan outlines a process to be carried out by a Technical Support Group (TSG) to address the issues raised in Recommendation 2007-01. A 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). This document reports the results of a TSG state-of-the-practice review of the nondestructive assay *in-situ* holdup program at the Hanford Plutonium Finishing Plant (PFP).

Nearly all *in-situ* NDA measurements are quantitative. The equipment used for *in-situ* measurements is all commercially available and relatively new. The data quality objective (DQO) measurement process is the cornerstone of the Hanford *in-situ* measurement program and, when combined with rigorous calibration methodology, quality control (QC) fixtures, and adherence to procedures, the quality of the final assay result, and the ability of that result to meet customer needs, is quite high. There are good controls on procedures; only the latest versions are used to perform work. A notable requirements document is PRC-RD-EN-10484, *Nondestructive Assay Management Program*, which contains a compressive description of the site-wide NDA program requirements. The DQO process integrates the involvement of NDA and holdup personnel at the earliest stages of project definition and during the design review process. Criticality safety reviews of the NDA reports do not extend beyond the DQOs. The assessments performed by criticality safety personnel could be expanded to include the NDA measurements and analysis methodology for criticality safety compliance verification. PFP also uses well-produced nuclear material calibration standards. However, any further loss of nuclear material standards will severely hinder *in-situ* NDA efforts. The use of nuclear material, in conjunction with the QC fixtures, demonstrates a best practice for QC checks on detector performance. Final measurement results are rigorously reviewed. The implementation of PFP's Generalized Geometry Holdup (GGH) database measurement system is a best practice within the complex. The database system includes corrections and checks for infinite thickness and finite source effects for point and line models. Currently, NDA scientists are performing input into the modeling of the measurement and results. It is important to note the PFP-GGH database Measurement System could become a worst practice if the input into the system is performed by less qualified individuals

Since PFP is undergoing decontamination and decommissioning (D&D), there are few opportunities for new equipment design, research and development, and formal advanced, offsite, and continuing training of new scientists. The lack of continuing training is a concern. The site has a good process in place for waste assay and makes effective use of existing gloveboxes for D&D activities. Project execution and design

appear to include minimizing the generation of dusts and materials that could lead to holdup accumulations.

The Material Control and Accountability (MC&A) statistician performs quarterly reviews of the calibration and measurement control results. The criticality safety organization uses worksheets for self-assessments, quarterly reports, and annual assessments. There are no scheduled self-assessments specific to NDA. NDA is not specifically included in the integrated evaluation plan. Facility representatives communicate well with appropriate organizations. Having one manager over the NDA, criticality safety, and quality assurance organizations should strengthen communications between them. The unusually large number of separately employed and managed measurement staff appears to be a barrier to effective communication within the NDA organization.

## ACRONYMS

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|---|---|
| ARRA | American Recovery and Reinvestment Act of 2009 |
| ASTM | American Society for Testing and Materials |
| BNFL | British Nuclear Fuels Limited |
| CHPRC | CH2MHill Plateau Remediation Company |
| CRRS | Condition Reporting and Resolution System |
| Cs | Cesium |
| CSE | Criticality Safety Engineer |
| CSER | Criticality Safety Evaluation Report |
| CSO | Criticality Safety Officer |
| CSR | Criticality Safety Representative |
| D&D | Decontamination and Decommissioning |
| DA | Destructive Analysis |
| DNFSB | Defense Nuclear Facilities Safety Board |
| DOE | Department of Energy |
| DQO | Data Quality Objective |
| EM | Office of Environmental Management |
| FMEF | Fuel Material Examination Facility |
| FWHM | Full width at half maximum |
| GGH | Generalized Geometry Holdup |
| HEPA | High-efficiency particulate air |
| HILLS | Hanford Information Lessons-Learned Sharing |
| IEP | Integrated Evaluation Plan |
| ISOCS | *In-Situ* Object Counting System |
| ISSF | Internal Secure Storage Facility |
| JPM | Job Performance Matrix |
| LANL | Los Alamos National Laboratory |
| LLW | Low-level waste |
| LOIs | Lines of Inquiry |
| MC&A | Material Control and Accountability |
| MDA | Minimum Detectable Activity |
| MSA | Mission Support Alliance, LLC |
| MT | Metric ton |
| NaI | Sodium iodide |
| NCS | Nuclear Criticality Safety |
| NDA | Nondestructive Assay |
| NMC&A | Nuclear Material Control and Accountability |
| NNSA | National Nuclear Security Administration |
| OJT | On-the-Job Training |
| ORNL | Oak Ridge National Laboratory |
| OSU | Outdoor Storage Unit |
| PDF | Portable Document Format |
| PFP | Plutonium Finishing Plant |
| POC | Point of Contact |
| PRF | Plutonium Reclamation Facility |

| | |
|---|---|
| Pu | Plutonium |
| QA | Quality assurance |
| QC | Quality control |
| R&D | Research and development |
| RL | Richland Operations Office |
| ROI | Region of Interest |
| SGRP | Second Generation Retrieval Project |
| SGS | Segmented Gamma Scanner |
| SME | Subject Matter Expert |
| SMP | Safety Management Program |
| SWB | Standard Waste Box |
| TSG | Technical Support Group |
| WIPP | Waste Isolation and Pilot Plant |
| WRAP | Waste Receiving and Packaging |

## 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 Recommendation 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 Hanford Plutonium Finishing Plant (PFP) 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. PFP is in an advanced stage of deactivation and decommissioning. The majority of the facility's inventory has been shipped offsite. The remaining inventory consists primarily of legacy holdup. The site review was not an assessment; any conclusions contained in this report are included for PFP to use at its own discretion. The final report submitted to DNFSB after the completion of all site reviews will not tie information to individual sites.

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 Hanford before the site visit. Eight topical areas were reviewed, seven of which 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.

Observations occurred during the TSG organizational visit to Hanford in August 2008 and during the September 2009 site visit. Reviews of documents and observations of the performance of holdup measurements occurred during the two site visits. TSG members toured the following facilities and observed the activities listed below:

- PFP glovebox holdup measurement (August 2008);
- *In-situ* measurement system calibration (August 2008);
- Demonstration of the PFP Generalized Geometry Holdup (GGH) database system;
- Waste measurement process; and
- Tour of the Plutonium Reclamation Facility (PRF).

Two overview presentations were made to the TSG: the NDA technical expert presented recent changes to the holdup measurement program, and a criticality safety engineer (CSE) discussed the Nuclear Criticality Safety (NCS) organization's use of holdup measurement results.

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

- NDA Scientist
- Chemical Technician
- NDA Manager
- Training Group Personnel
- Criticality Safety Engineer
- Criticality Safety Representative
- Quality Assurance and Assessments
- Project Manager
- Central NDA
- Mid-Level Manager (Criticality, Nuclear Safety, Quality Assurance (QA), and NDA)
- DOE Criticality Safety Subject Matter Expert
- Senior Engineer
- Decontamination and decommissioning (D&D) Managers
- Material Control and Accountability (MC&A) personnel
- DOE Senior Manager
- Richland Operations Office (RL) SME (Subject Matter Expert)
- RL Facility Representatives

The following eight sections contain the results from the state-of-the-practice review at PFP. The majority of the information was obtained during interviews covering the lines of inquiry (LOIs). Other sources of information included document reviews, tours, work practice observations, follow-up questions, and PFP presentations.

## Training and Selection of *in-situ* NDA Holdup Measurement Personnel

Now that the Hanford PFP facility is in its final D&D phase, the working environment has a great deal of influence on the selection, training, and qualification of personnel involved with *in-situ* NDA holdup measurements. The field NDA group has attempted to rapidly increase in size to accommodate the D&D plan. In 2004, the group ramped up to consist of 10 scientists and 22 technicians; but, following a shift in funding in 2005 through 2007, the holdup staff was reduced to two scientists and six technicians. Using funding obtained primarily through the American Recovery and Reinvestment Act of 2009 (ARRA), Hanford now has a goal of decommissioning the PFP processing plant in two years. The Hanford holdup measurement group has hired two and one-half new scientists (one scientist is sharing part of his time with the WRAP facility) and five new technicians this past year in response to the ARRA funding requirement of creating new jobs by hiring from outside. The current holdup staffing consists of 5 scientists and 12 technicians. The result of this D&D staffing means that 40 percent of the group is new to Hanford and new to *in-situ* NDA holdup measurements, with a need for rapid training and development. Of particular concern is the fact that Hanford has just lost its senior scientist, who was heavily relied upon to provide technical training.

Another large influence on the makeup and development of holdup personnel at the Hanford site is the fact that technicians and operators are unionized, while the scientists are nonunion. The labor union causes the work duties to be clearly delineated and subdivided. The technicians are responsible for performing field measurements, instrument calibrations, and data entry into spreadsheets. Operators are responsible for handling instruments and all positioning of detectors. Scientists are responsible for measurement planning, modeling, analyzing, and reporting. This division of roles does not allow overlapping of responsibilities, making all the phases of a holdup measurement highly compartmentalized.

The selection of technicians to fill openings in the group is controlled by the labor union. Technicians are allowed to transfer into the group based on seniority. Technicians who have been previously laid off have an opportunity to return. Only then may remaining openings be filled by interviewing candidates. This union-influenced work structure causes a demand for a great deal of communication, planning, and formality to accomplish a measurement, and causes the need for highly specific procedures and training.

In response to its work environment, Hanford has developed several very good training and qualification practices. All members of the measurement team who were interviewed had relevant experience in NDA measurements, typically in using fixed NDA laboratory systems, prior to joining the holdup group. This experience is invaluable in standing up a holdup measurement team for the D&D phase. The training of the holdup measurement group consists of both formal classroom training and on-the-job training (OJT). Roughly 10 to 20 percent of the group had received formal training in NDA measurements through the Los Alamos National Laboratory (LANL) holdup training program. All other training has been accomplished in-house.

Because of both the size of the group and its short-term mission, management intends to rely on in-house training to develop its current workforce. In 2004, Hanford, in conjunction with the Radiochemistry Society, developed a two-week training course in fundamentals of gamma spectroscopy and holdup measurements and provided the training to all interested parties. The course was abbreviated and repeated in 2009. All members of the holdup measurement group have attended this course. All members have also been given training in the use of the software relied on for measurements. Technicians were given procedure-level training on the newly developed PFP-GGH database system software that is being used to acquire and transfer field data. Scientists were given the opportunity to learn the new PFP-GGH database software by participating in the validation and testing phase required for software quality assurance. Scientists have also been provided vendor training sessions in other field NDA software in use, *in-situ* Object Counting System (ISOCS) by Canberra.

The qualifications necessary for each category of personnel in the NDA holdup group have been well developed in the Hanford training program. The skills necessary to perform the duties of each category are clearly captured in the qualification cards, and the formal OJT program ensures that each new employee is given exposure to all identified job tasks. It typically takes from six to twelve months for a new employee to complete all required qualifications. For the technicians, job performance measures (JPMs) are established for each procedure used by the group. The JPMs include performing actual measurements and oral questioning to test mastery of measurement setup and instrument operation. Checklists are used to document performance and training records and track proficiencies as they are obtained, and include trainer and manager approvals and dates. However, the OJT program and the JPMs for NDA technicians are conducted without input from or review by the scientific staff.

For the scientists, the qualification card consists of an extensive list of required readings, but it is up to the NDA manager to decide when proficiency in assigned tasks has been achieved. OJT for newly hired scientists is accomplished through intensive one-on-one training sessions with the senior scientist. No tests are given to the scientist to objectively assess in-depth knowledge. Since management has relied on the senior scientist for evaluation of proficiency, the loss of this individual may make this evaluation difficult to make. Attendance of a formal, offsite training course by the manager and new scientists could be valuable in ensuring that the team has the training needed for the accelerated schedule.

The NCS group at Hanford has no formal requirements to learn about NDA holdup measurements, although some members clearly had many years of experience in working with NDA measurement groups. The NCS engineers are largely self-taught in this area. Personnel within the NCS group did not complete the 2004 Hanford course when it was available. A mutual understanding of holdup measurement needs and limitations is conveyed in Data Quality Objective (DQO) meetings held prior to each system measured. The NCS group holds to the policy that it is the sole responsibility of the NDA group to provide a mass estimate that represents the upper 95 percent confidence interval for the measurement.

The following table lists the Hanford NDA holdup measurement group personnel identified in accordance with the standard categories in American Society for Testing and Materials (ASTM) International C1490–04, *Standard Guide for the Selection, Training and Qualification of Nondestructive Assay (NDA) Personnel.*

**Table 1: Summary of NDA Expertise in Holdup Measurement Group at Hanford**

| Senior NDA Professional | NDA Professional | NDA Technical Specialist | NDA Qualified Instrument Operator |
|---|---|---|---|
| 0 | 2[1] | 3 | 12 |

A summary of the current training and qualification program for *in situ* NDA holdup measurement personnel at Hanford is provided in Table 2.

[1] At the time of the Hanford interviews, one of the two NDA professionals in the group had announced his intention to take a new job outside of the NDA Holdup Group.

**Table 2: Summary of Holdup Training and Qualification Status at Hanford**

| | |
|---|---|
| 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 | No |
| 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 to onsite |
| Tests in place to demonstrate knowledge adequacy | Technicians: Yes<br>Scientists: No |
| Qualification program in place for each level of NDA measurement personnel in group | Yes |
| Appropriate manpower in place at each level of expertise to maintain a balanced program | No, more scientists are currently needed |
| Formal oversight of less experienced or qualified individuals performing measurements | Yes |
| NDA program manager is knowledgeable about NDA | Limited |
| NDA professionals are knowledgeable about NDA | Yes |
| Understanding of holdup measurement uncertainty and limitations evident in customers using the data: NCS, MC&A | Limited |

As mentioned, both the significant changes in staff personnel and the short-term mission raise concerns regarding the ongoing training offered to holdup measurement staff at PFP. Further suggestions and training needs are listed below.

- It would be useful to have a way to recognize deficiencies and weaknesses in understanding through a standardized testing program for scientists.

- Some NDA holdup cross-training with NCS personnel would help strengthen the mutual understanding of each of these disciplines.

- A heavy reliance on in-house training can result in a narrow approach to measurements and propagation of errors. Offsite training would provide an influx of new ideas, up-to-date techniques, and the opportunity to interact with peers from other facilities to share strategies and articulate needs.

## Design Requirements for New Facilities and Equipment

### *Design Process*

The PFP is undergoing D&D activities and is slated to be totally decommissioned in about four years, so very little new processing equipment is being designed or installed. However, several projects are underway to support D&D activities that interact with NDA and holdup measurement activities. Several other projects elsewhere on the Hanford Site either have been or are involved with NDA and holdup measurement activities that may also provide some insight into Hanford Site best practices in this area.

Five facility construction projects were discussed with the ARRA Program Manager for D&D, providing useful information to the TSG on design and construction issues relating to NDA and holdup. The first was the Fuel Material Examination Facility (FMEF), but this project primarily dealt with assembled fuel and did not lead to significant dust or finely divided material that would require holdup measurements.

The second project was the PFP Thermal Stabilization and Packaging Project that prepared 20 metric tons of Pu for disposition. This involved processing plutonium materials through precipitation and drying processes as well as thermal treatment of oxides and metal prior to packaging in 3013 containers for disposition. The project used existing gloveboxes and one new glovebox and employed additional containerization of materials between each processing step even inside the gloveboxes to minimize the spread of dusts and powders that would lead to additional holdup. The holdup was characterized before, during, and after the processing campaigns. A screw-top convenience can was used instead of the normal open-topped "ice cream" containers that were traditionally used. Apparently, the initial design provided by British Nuclear Fuels Limited (BNFL) involved a lot of remote-handling equipment and did not consider holdup issues; for this and other reasons, this initial design was rejected. This indicated an awareness of the need to consider holdup and holdup measurement early in a project design phase.

The third project discussed was the Legacy Plutonium Holdup Removal Project that involved the management of items remaining in PFP after the stabilization and packaging project discussed above. This project took place in 2005 and used NDA data to determine whether safeguards controls were required. The NDA and holdup measurements ensured that safeguards controls were not required for the remaining materials except in the vaults. During this campaign, approximately 35 kg of plutonium (Pu) were removed from the facility into about ten 3013 containers, about half of which required blending prior to shipment to the Waste Isolation Pilot Plant (WIPP) for final disposition. Administrative procedures were used to ensure compliance with safeguards and security, criticality safety, and other requirements. Holdup measurements were indirectly required via criticality safety and safeguards requirements. One lesson learned from Rocky Flats Plant experience was that it was important to decontaminate equipment to levels that comply with low-level waste (LLW) packaging requirements to minimize worker exposures during the "slice–and-dice" operations. This required updating of the NDA and holdup data prior to intrusive work. The Program Manager for D&D commented that the NCS group relies totally on NDA and holdup measurement as a basis for decisionmaking on mass limits for processed items. There is little or no analytical laboratory destructive analysis (DA) support for NCS or project purposes and that NDA and holdup measurements are relied upon to meet measurement needs.

The fourth project was the Security Enhancement Project – Internal Secure Storage Facility (ISSF). This was a $200 million project that has been terminated. It was a design facility for the management of approximately 10 metric tons (MT) of Pu that was removed from the processing facilities. It involved subgrade 3013 container storage facilities. Container measurements involved fixed NDA equipment and involved little or no holdup measurements.

The fifth project discussed was the under-construction Outdoor Storage Unit (OSU) that will house six casks of slightly irradiated fuel that is currently being stored at PFP. Previously, Hanford had nine protected areas and has reduced this number to just one: the PFP. The OSUs will allow the closure of the PFP protected area. The OSU, a truncated pyramidal unit with a 20-ton lid, is not planned to be re-entered until the final disposition of the casks and material is executed. Several confirmatory measurements were considered for periodic measurement or for confirming the presence of the material within the OSUs, including NDA measurements, but the current decision was to use a pair of load cells with remote reporting.

General lessons learned included the need to minimize nooks and crannies and sharp bends in equipment where material could accumulate. Both PFP and Hanford had relatively mature design processes to address holdup and could predict where holdup might be a concern. The interviewed personnel held the opinion that NCS was more conservative about holdup measurement and values than was the Safeguards or MC&A discipline.

The MC&A Representative interviewed is employed by MSA (Mission Support Alliance) LLC, which is a different company than CH2MHill Plateau Remediation Company (CHPRC), which manages the operations and D&D activities. MSA provides measurement oversight and measurement statistics. It was reported that an approximate 10 percent error was found between NDA and cleanout measurements with no reported bias. Some bias has been noticed between different fixed NDA instrumental techniques; e.g., between neutron and calorimetric techniques. Recent holdup and cleanout measurement comparison data were available in the PRF cleanout effort, where 3 of 15 catchpan segments were measured and cleaned, and the cleanout materials measured. The difference was approximately 8 percent, with one catchpan reporting low and two higher removals than NDA values. The Safeguards organization is involved in the beginning of the process and relies on NDA and holdup measurement as the only tool they have. Also, data collected in 1998 using NDA and a crane compared well with data taken recently. Uncertainties assigned to holdup measurements are used to compute the accountability limits during processing, but limits of error on the inventory differences are not calculated during D&D activities since these are considered processing.

The Safeguards organization uses a variety of tools to ensure that the data provided are those requested. Examples of these tools include photographs, stickers, spreadsheet data and comparisons, the fact that NDA scientists are in charge, verification of the data by a second scientist, QC checks on the equipment, and procedures. The NDA scientists are very good at resolving background issues. One lesson learned was that initially an assumption was made that most of the holdup was on the floor of the gloveboxes, but measurements indicated that the whole glovebox (walls and ceiling) needed to be measured and cleaned to address the entirety of glovebox holdup. The safeguards statistician reported that she has not seen drastic movement of material within the air handling and ventilation systems as a result of the D&D activities. As-built drawings are "for the most part" available.

An NDA scientist at the Waste Remediation and Packaging (WRAP) facility who is also the acting site SME for NDA measurements was also interviewed. His role primarily consists of overseeing NDA activities in central NDA to ensure consistency. He pointed to procedure HNF-10484 as the governing document for NDA measurements. He cited the Second Generation Retrieval Project (SGRP) that involves digging up waste burial trenches at the Hanford Site and measuring materials for either reburial or repackaging for shipment to WIPP. A drum shredder procurement is underway that will use a commercially designed and fabricated drum shredder. The facility management plan to use the ISOCS NDA software program for holdup measurement of the drum shredder equipment. The WRAP system has a high-efficiency particulate air (HEPA) filter at the exit of the repackaging glovebox and another filter prior to discharge to the atmosphere, but the NDA scientists did not know whether measurements have been made on the ductwork between the two filters. Holdup in the gloveboxes is measured using ISOCS with a 60-gram Pu start-of-year limit.

The next interviewee was a project engineer for the Removal of PRF Project, who has previously served as an Engineering Design Authority and as a DA team leader. The PRF Removal Project involves removing the pencil tanks and associated hardware from the PRF. The project team plans to use the crane to move the tanks, one by one, to the maintenance cell inside the PRF, where they will be measured by NDA. The information collected from the NDA activities will then be used to prepare the cutup plan. The crane will then lay the tank down in the canyon and a specialized, not yet designed or procured shear/saw will dissect the tank into pieces that fit within the standard waste box (SWB) and are sized to meet the WIPP loading criteria. A new building will be constructed outside the existing PRF structure to permit the SWBs to be moved out via an airlock. The SWBs will then be measured using fixed NDA equipment (neutron and gamma-metric) prior to movement outside the building. No new confinement systems are planned.

The procedure PRC-PRO-EN-8258, *Functional Design Criteria*, requires the involvement of NDA and holdup disciplines (although not specifically called out by name) in the preparation of the project functions, project inputs, and design criteria. Nuclear and System Safety and Safeguards and Security are called out by name in Appendix C, *Review Guidelines,* and may or may not ensure the involvement of the NDA and Holdup personnel. This process is intended to ensure involvement of all the project participants and customers up front. The only national consensus standard cited that has potential holdup relevancy is ASTM C852, *Standard Guide for Design Criteria for Plutonium Gloveboxes*. A similar procedure, PRC-PRO-EN-2001, *Facility Modification Package*, is intended to ensure the same level of involvement in the change control process for facility and equipment modifications after initial design and construction. PRC-PRO-EN-8336, *Design Verification,* is used to verify that the design requirements are appropriately incorporated into the project design. The catchpan floor will be cleaned up with a vacuum cleaner after the shearing/sawing operations, and follow-up NDA/holdup will be performed to support safeguards and the Criticality Safety Evaluation Report (CSER) requirements. The Project Engineer indicated that a NDA scientist and criticality safety representative (CSR) or CSE were both consulted in the preparation of the design and operations proposed for this project.

## Standards for Conducting NDA Holdup Measurements

### *Measurement Program*

Nearly all in-situ NDA surveillances in support of criticality safety are quantitative using sodium iodide (NaI) detectors and the GGH method or, when necessary, a high-resolution germanium detector and the Canberra ISOCS method. The backbone of the *in-situ* holdup measurement program is the DQO process. A measurement is initiated by a customer request for NDA services. The first question asked by the NDA scientist is, "Is there a standing DQO for the requested measurement?" If the DQO already exists, the measurement will be made following that plan; if not, a DQO meeting is scheduled. All stakeholders (i.e. criticality safety, customer, MC&A, NDA Scientist) attend the DQO meeting. A scientist and measurement technician perform a walkdown of the required assay, referred to as a shot. Each shot typically requires multiple individual holdup measurements. During the walkdown, parameters that could affect the results of assay are noted and pictures are taken. Discussions with other NDA scientists may or may not be necessary, depending on the complexity of the shot. Once the measurement requirements are fully understood, a shot PFP-GGH database system spreadsheet is generated by the NDA scientist and shot stickers are placed at the measurement locations. The shot stickers contain shot number and distance information. After completion of the shot measurements, the gram values are calculated using the shot spreadsheet, results and the entire shot setup are reviewed, and a letter is issued documenting the results.

Management, QA, operations, and NDA personnel are all involved in the procedure review and approval process. Most of the *in-situ* NDA documentation is written by NDA scientists. The review process includes a field review of the document by measurement technicians. The overarching document for NDA measurements is PRC-RD-EN-10484, *Nondestructive Assay Management Program.* This requirements document records requirements, implementation, and expectations for the NDA measurement program onsite. PRC-RD-EN-10484 has significant references to DOE Orders and regulations and to consensus standards. PRC-RD-EN-10484 is a noteworthy implementation plan with regard to usefulness and breadth of coverage. There are five analytical procedures that cover a majority of the *in-situ* measurement activities. These documents are ZA-948-349, *Portable Non-Destructive Assay (NDA)*, ZA-948-350, *Mass Based Calibration of Portable Non-Destructive Assay (NDA) Equipment*, ZA-948-395, *Mass Based Calibration Data Package for Portable Non-Destructive Assay (NDA) Equipment*, ZA-948-401, *Portable Non-Destructive Assay (NDA) using the PFP-PFP-GGH database System*, and ZA-503-303, In-Situ *Object Counting System (ISOCS) Gamma Spectroscopy.* Training requirements are included in the NDA Assay Management Plan. The Plan requires only initial training but not retraining or continuing training. The initial training requirements for technicians may be lacking in breadth.

All measurements are performed according to approved procedures. Measurement procedures contain the appropriate level of specificity and are higher-level in nature, describing the process to make a measurement, not how each individual measurement is made. The PFP-PFP-GGH database system contains some guidance on how various measurement specifics might be decided. All of these parameters are evaluated during the DQO process before measurements commence. The fractionation of assay tasks is a weakness of the Hanford program. Personnel from three bargaining units and two subcontractors are involved in each measurement. The instrument operator is the individual that holds and points the detector at the measurement position. The chemical technician runs the computer, performs QA and QC checks on the instrument system, and saves the data. An NDA scientist, who may or may not be in the field during the measurement, prepares the PFP-GGH database spreadsheet, calculates the results, and documents the results in a letter. While there have been past significant issues, the peer and management review process appears to be an effective method for producing good results, improving technical capabilities, and increasing confidence that procedures are being followed.

Hanford does not appear to have a shortage of *in-situ* NaI and germanium NDA equipment to meet anticipated measurement needs; and, unlike other sites, the equipment is of modern vintage, and includes ISOCS systems. Other fixed NDA instrumentation includes calorimeters, small and large table Segmented Gamma Scanners (SGSs), low-level passive neutron counters, two isotopics stations, neutron slab detectors, and a super high-efficiency neutron counter in the WRAP facility. A high-efficiency neutron counter and tomographic gamma scanner are onsite, but have not been set up for use.

***Changes to Procedures***

Document reviews are required every two years. Revisions to documents are made when needed. NDA scientists modify and write nearly all of the *in situ* NDA-related documents, which can lead to resource-loading issues. The procedures group does a portion of the documentation process in the areas that do not require an SME. All of the site-wide operations documentation was recently reviewed when the new operating contractor took over management of Hanford. The DQO process also plays a part in identifying needed changes to documentation. Technicians are a part of the procedure change process by performing field checks of the new documents. Technicians are also encouraged to provide feedback on documents that are not currently being revised. A noteworthy practice with regard to procedures is the removal of obsolete or unneeded documents. A system is in place that allows a previously unneeded document to be reinstated after the proper review process in an efficient manner.

Strict procedure version controls are in place via the requirement that any procedure to be used that day must first be checked for updates. It is also required that personnel read new or revised procedures that are related to work activities they perform. Only the current version of a document is available on the document server. When a new procedure is fielded, the manager notifies the NDA staff, and e-mails are sent out to notify all site personnel when documents have been revised. Many of the NDA staff would be involved in the process of generating a new procedure alerting them to the fact that a new procedure will be available in the future. There is also a requirement that procedures be checked against the most recent version on web site before work is begun. It is also required to read new or revised procedures that are related to work activities performed.

***Results and Calculations***

Calculations are made using the PFP-GGH database system, which was observed by the TSG to be a very useful tool for *in-situ* NDA measurements. The database system software appears to have undergone a rigorous validation and verification process; however, version control of the software is not as rigorous as it could be; for example, although input parameters were changed, a new version was not generated. Included in the database system are checklists for the contributions to uncertainty. The database system not only calculates estimated gram quantities, but also provides an uncertainty estimate. Ancillary measurement information is maintained with the results as a hard-copy data file package that is scanned into Portable Document Format (PDF) and uploaded to the shared server.

The peer review of results is very comprehensive. The primary NDA scientist—the one who set up the spreadsheet—checks the results, and a second NDA scientist reviews everything in the spreadsheet. A customer review of the letter results is performed either by e-mail or with a pre-letter meeting. The letter result is reviewed and signed by an NDA Manager and a NDA scientist.

## 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 the Hanford PFP to support compliance with the NCS limits.

Organizationally, salaried holdup measurement personnel titled NDA scientists reside within the same organization, but are employed by multiple companies. Adding further complexity to the performance of holdup measurements is the fact that scientists are not allowed to perform holdup measurements at Hanford. Instead, two labor-unit employees who reside within two different bargaining units are required for every holdup measurement. Delays due to the least available member of each measurement team are a concern, as is the assurance that personnel with the required physics-based training provide necessary input to measurement performance and reporting quality.

While holdup measurement staff have historically been moved between several organizations, currently the NDA, NCS, Nuclear Safety, and Quality Assurance organizations report to the same manager. This is due to a recent reorganization and has the potential to increase communications between these organizations.

Interviews provided consistent details concerning the implementation of holdup measurements at Hanford. LOIs were used to evaluate the holdup measurement program and the interaction between the holdup measurement program and organizations that need measurement results.

The holdup measurement staff has recently added scientists and chemical technicians. Given the complexity of combining new and experienced staff in both scientist and labor union personnel, clear assurance that qualified scientists perform the technically challenging tasks, including establishing modeling parameters and calculating gram quantities and associated uncertainties will be essential. The facility conducts DQO meetings for all nonroutine measurements. Stakeholders in the measurement results attend and communicate measure requirements prior to and during the development of the planning and conduct of measurements. Holdup measurements are performed to support MC&A, NCS, waste management, and D&D activities. A work request system is used in conjunction with the DQO and Plan of the Day meetings. An NDA representative is included in the Technical Response Team when issues arise involving nuclear materials.

Holdup measurements are performed using the GGH method, based on a LANL peer review recommendation, primarily to support NCS, MC&A, and measurements required to support waste removal. Additional measurements are performed primarily to meet waste requirements using a vendor-developed modeling technique. This technique has been approved for MC&A and NCS purposes. The GGH method uses low-resolution detectors, which are quite portable, while the ISOCS method uses high-resolution detectors that are heavier and bulkier. These two modeling techniques combine to increase the ability to meet DQOs. Individuals interviewed are confident that at least 90 percent of holdup at the site has been measured, including most of the identified high-risk locations. Accelerated D&D efforts are reducing unidentified locations. The majority of measurements are performed based on process knowledge and engineering drawings. Isotopic characterization is based primarily on NDA of removed materials.

Hanford has developed a software application, the PFP-GGH database system, for data storage, detector control, and guidance during data collection. The system is currently in use for some, but not all, holdup measurements. The database creates a unique record for each assay performed and stores each measurement configuration with assay results and uncertainty calculations. The system has been reviewed by the NCS organization. The operating procedure includes Criticality Prevention Specifications controlling operation. Benefits of the use of this system include reduction in human error in data entry since it is automated, a well-documented permanent record of the measurements and result, and the fact that no additional equipment is required. Also, the system includes algorithms to correct for finite-source and self-attenuation errors. Possible concerns include a lack of assurance that personnel performing physics-based modeling may not be qualified for these tasks. Additionally, the data review may not be as thorough since the results are automatically calculated.

The Hanford holdup staff has investigated minimum detectable activity (MDA) calculations at selected locations, but does not routinely report MDA values for each result. Identification of high background locations and other interferences are documented and identified through training. Observed field measurements indicated that holdup measurement personnel were well-trained on detector positioning to minimize interferences. Also, each measurement spectrum is examined to check for possible interferences. Background measurements are performed on adjacent locations, if possible, or by use of a lead shield when low background measurements are not possible. Tripods are routinely used to keep the detector in the optimal position. Dead-time limits are proceduralized to ensure measurement quality. During data analysis and reporting, high attenuation locations are reviewed. Correction factors for shielding are calculated based on engineering drawings and ultrasonic testing. Transmission corrections are measured for high attenuation cases and are used to confirm or correct matrix density calculations. The use of commercial software and high-purity germanium detectors (ISOCS) is often used as a second but not totally independent method to investigate high or unexpected readings that challenge criticality safety limits.

Equipment in use at the site is in good condition and well-maintained. The current measurement systems are approximately five years old, and new systems for GGH and ISOCS have been ordered. The NDA group owns, but does not routinely use, neutron slab counters for holdup measurements. Holdup measurement systems are routinely in locked rooms within the protected area. Reports are stored in accordance with records management requirements, but individual spectra are not stored as records because the file format does not match the requirements for archival. They are maintained by the measurement group in the nonstandard format.

Hanford uses a combination of error propagation equations based on consensus standards and error propagation terms developed at the site. For example, one error term applicable to point and line models estimates the uncertainty introduced if the detector is not aimed directly at the object being measured. The propagation of error calculations has been incorporated into the PFP-GGH database based on the input parameters and is reviewed during data analysis and reporting. Error estimates are further reviewed at the time of reporting quantification results. The MC&A statistician supports analysis of error propagation and reviews comparison results between holdup and fixed NDA measurement systems.

In summary, the Hanford holdup measurement program appears to be a technically sound program in the area of implementation of standards. The DQO meeting process is one method for ensuring individual measurement-level communications between NDA, NCS, operations, and other stakeholders in the measurement results. Additional coordinated, routine communication between NDA and NCS should be considered. The routine comparison between holdup results with NDA neutron assay results is commendable, and this practice should be continued.

Upgrading the holdup measurement systems and automating the acquisition and storage database are program strengths. However, simplifying the data entry process does not reduce the technical challenges associated with performing holdup measurement modeling, spectral analysis, and quantity and uncertainty reporting. The fundamentals training offered to chemical technicians is of value, but cannot replace a detailed knowledge and understanding of physics. The loss of trained measurement staff is an issue at Hanford, as well as across the DOE complex.

## Research and Development

The LOIs for this section evaluated 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.

The TSG generally observed that R&D needs were currently very limited due to site decommissioning. Some GGH model improvements are needed for non-right-angle measurements and improved modeling calculations for attenuation corrections. Some difficult measurement needs may arise in the future once the routine measurements in support of the shutdown end and D&D work begins. The DQO process is used to identify new technology needs. Currently, there are no *in-situ* holdup technology needs. The NDA holdup equipment used at Hanford is all commercially available and relatively new when compared to other sites. Most of the equipment is about five years old, and new equipment is purchased when necessary. The reliability of NDA holdup equipment is not an issue on site, likely due to the relatively new equipment.

The site-developed PFP-GGH database system with the built-in uncertainty calculations could be useful to other sites due to the system's flexibility, which lends itself to a wide range of applicability. With the site's imminent closure, the lack of R&D, collaborations, and publications is expected.

The site had adequate calibration sources available on site. Recently, a number of the calibration sources were disposed of to meet deinventorying goals. The potential negative effect of losing the calibration sources would most likely affect the fixed NDA instrumentation and not the *in-situ* holdup measurements. The current level of standards is now at a minimum to meet the site's *in-situ* measurement needs. It would be unwise to dispose of any further calibration sources until all of the criticality safety, waste, and NMC&A measurements have been completed. Three new plutonium metal foil standards (1, 3, and 7 grams) were received about five years ago, are beneficial to the *in-situ* measurement program.

## Quality Assurance

### *Program Management*

The management responsibility for the NDA QA and QC programs at PFP resides with the site NDA professionals and scientists. Multiple individuals (e.g., NDA technicians, MC&A personnel) review the instrument measurement control data for specific out-of-control conditions and to initiate response actions.

Besides the measurement control data being reviewed by a minimum of two (sometimes three) scientists, the MC data are also reviewed quarterly by MC&A personnel. To avoid a potential conflict of interest, MC&A is a different organization—with contractors from a different company—from the NDA measurement and operations organizations. Of all the site requirements for QA and QC, the MC&A requirements are the most stringent.

To help ensure the quality of measurement performance, steps are incorporated into procedures, the NDA training program, and the measurement personnel qualification cards that address the QA and QC aspects of the operations of each instrument. There is one manager over NDA and Criticality Safety programs, which should improve organizational communication.

The DQO measurement process established at PFP is a benefit to the QA program. DQO meetings between all the appropriate organizations are conducted before new specific measurements are performed. There are also DQOs established to cover measurements of similar or routine items. All aspects of a measurement and the measurement process (e.g., MC, data expectations, potential problems, analysis requirements) are discussed and documented before any measurements are performed.

The PFP-GGH database system spreadsheet package developed and used at PFP deserves recognition for helping to simplify the operation and management of the NDA holdup program. The automated features of this package, from modeling the item being measured to the actual field measurement itself, help minimize the chances of human error and enhance QA and QC.

*Documentation and Calibration*

Several internal reviews are performed on the NDA field data, and all documentation is appropriately filed, both hard-copy and electronically. After measurements are performed, the individual NDA draft reports are reviewed by CSR, MC&A, and DOE-RL Facility Representatives, specific to the DQOs. As for external reviews, MC&A performs a quarterly review of all calibrations and measurement control data. There are no scheduled self-assessments specific to the NDA field measurement group.

As mentioned earlier, PFP has adopted the PFP-GGH database system spreadsheet package to automate, improve, and simplify *in-situ* measurements. The package has inherent MC functions that aid in the collection and analysis of data and allow for a rigorous measurement control scheme with less chance of human error.

At PFP, NDA calibrations are performed on demand. If the rigorous measurement control checks are satisfactory, no calibration is performed. A set frequency (e.g., once every year or every other year) should be considered for calibrations. This would at least allow for a close examination and evaluation of the instrument and its complete performance. All calibrations and measurement control data are given identification numbers and filed with a prescribed retention schedule. Operations logbooks are also kept on the instrument and system to supplement the calibration and measurement control data.

*Nuclear Material Calibration Standards*

The number of representative standards specifically designed for *in-situ* measurements is extremely limited. Of the available standards, the best-characterized is the Sheet (or area) Standards. These standards are very well designed, have well-documented traceable analysis with uncertainties, and have been reviewed and approved by the MC&A organization. Another excellent standard available at PFP are the foils fabricated at Los Alamos. Because of the limited number of standards, any further loss (requested disposition) of nuclear material standards would severely hinder NDA efforts at PFP (*in situ* and fixed instruments).

At PFP, a rigorous calibration methodology was observed during the TSG's 2008 visit. This included the well-produced nuclear material (Sheet) standards. The site NDA scientists have used these to meet the calibration and verification needs of their particular measurement scheme. The TSG also noted that PFP follows the good practice of storing the standards in a secure location and that tamper-indicating devices are applied where applicable.

### *Check Sources and Control Charts*

It should first be noted that PFP has fabricated a very good QC fixture for their MC measurements. The fixture helps to eliminate human error by reproducing the geometry of the Pu and cesium (Cs) standards used. The Pu standard is used in direct line of the detector, and the Cs standard is off line from the detector. A simultaneous measurement of the off line source provides an excellent method for monitoring changes to the detector, shield, and collimator. The placement of the Cs standard in the fixture is such that it is at the very sensitive, full-width-at-half-maximum (FWHM) position of the detector/collimator radial response curve. Even the slightest movement of the detector would be noted.

There are good daily MC checks to monitor detector performance. These are done with the QC fixture before and after each set of measurements. A Pu and Cs source are both used and peak count-rates, centroids, and FWHM data (on Cs) are monitored. There is also a Cs source that is measured intermittently during the day's operations for additional MC monitoring.

PFP uses control charts with limits to track specified MC values for each measurement system. The limits are posted on the instrument itself as well as in the control charts and database. An out-of-control situation is usually identified quickly, and procedures are in place that dictate the appropriate steps to follow. The NDA scientists and MC&A personnel review the data on a regular basis. All of the limits used in the MC programs were established by valid statistical methods and approved by the MC&A organization.

### *Miscellaneous (Validating Measurement Results)*

Validation of *in-situ* holdup measurement results is extremely difficult. When practical, holdup measurements are compared to cleanout values as a means of validating the *in situ* holdup result. Cleanout comparisons are extremely difficult, expensive, and time-consuming and not routinely performed. Even validation by alternate (i.e., NDA) methods is not routinely performed around the complex.

At PFP, data are available that can help support and validate measurement methodologies and uncertainties used. Since the site is in D&D mode, there are opportunities for measuring items before and after they are removed and packaged for future shipment. This second measurement could be performed by the field NDA group (via GGH or perhaps ISOCS), but is often performed by the fixed NDA instrument group (i.e., by SGS). If time permits, this verification opportunity should be pursued. There is little chance of doing this type of verification in an operating facility.

## Oversight

In general, oversight activities involve both internally- and externally-initiated reviews to determine the extent to which programs and personnel are performing work activities in compliance with specific requirements. The application of particular review criteria for the purpose of assessment is effective for readiness reviews, performance analyses, and demonstration of adherence to policies and programmatic or operational procedures. This method is also effective for identification of deficiencies and opportunities for improvement, and for enhancement through self-assessment and independent oversight.

NDA may be implemented to support various requirements involving several site-level programs or functional areas. These areas typically include MC&A, criticality safety, safeguards and security, and waste characterization programs. Therefore, oversight performed on these programs may demand demonstration of compliance of NDA performance and identify deficient or noteworthy conditions as well as lessons learned. Often, oversight reviews concentrate on performance objectives and criteria, broken down into specific LOIs, that are directed according to a high or low level of focus within a program or organization.

The LOIs established for this section of the state-of-the-practice review were directed toward determining what, when, and how oversight is performed, and how the results are applied to NDA assessments and improvements, with a focus on criticality safety. Oversight reviews at PFP involve both onsite reviews and external reviews, typically directed by DOE or by special request. Internal oversight of NDA practices are routinely performed by CSE, NMC&A, and DOE-RL personnel.

The Hanford NDA Management Program Requirements Document (PRC-RD-EN-10484) provides the site-level guidance for NDA activities. The requirements involve personnel training, QA, documentation, DQOs, software development, data analysis, and management reviews. Some specific criteria related to oversight include a review of training status, implementation of corrective actions, control chart review, data validation and verification, technical review, and management assessments that focus on identification of strengths and weaknesses of an NDA program by procedure (PRC-PRO-QA-246). This Requirements Document is the primary guidance for the PFP D&D NDA Measurement Plan (HNF-20866). The Measurement Plan claims that the PFP NDA program complies with the Requirements Document using a graded approach, as audited, although management assessments are not specifically listed among the Plan sections. The DQO section defines the PFP DQO process as "...a systematic planning process based on a common-sense, graded approach to ensure the type, quantity and quality of the data collected is commensurate with the importance and intended application for the data, resulting in decisions that are technically and scientifically sound and legally defensible." Several LOIs assessed by CSEs address the adequacy of NDA performance according to the DQOs. Some data review procedures that address oversight practices are identified in the PFP Administration Manual (FSP-PFP-5-8, Vol. 2) as the following:

17.4, *Review of Portable NDA Result*s
17.5, *NDA Data Process*

Procedure 17.5 states that "NDA data is not considered final until reviewed by a NDA scientist." Also, the Laboratory Quality Control Procedure (ZQ-150-301) specifically requires that control charts be maintained and available for auditors.

The Hanford Process Description for Safety Management Program Implementation Verification (HNF-22632) is the site-level approach and method for performing verification of safety management programs (SMPs). Several SMPs are required by a general Technical Safety Requirement (TSR). SMP descriptions are listed in the CHPRC Safety Management Programs document (HNF-11724), which identifies key attributes of each SMP relied upon to support facility nuclear safety. One such SMP is the Prevention of Inadvertent Criticality, as directed by the Criticality Safety Program (CSP) document (HNF-7098). Section 1.3.4 of the CSP document lists guidance according to the Criticality Safety Program Assessment Plan (PRC-MP-NS-40104). This guidance includes facility inspections and independent assessments involving NDA for implementation of criticality safety requirements. The PFP Standard Practices for Criticality Safety Internal Inspection procedure (ZSP-008) lists specific NDA criteria for self-assessments according to LOIs performed monthly, quarterly, semiannually, and annually.

Another important feature of the SMP Implementation Verification document is the CHPRC Assessment Plan (PRC-MP-QA-40092), which guides the site-level Integrated Evaluation Plan (IEP) database. The IEP receives assessment schedule inputs from many projects and functions requiring performance assessments, and it is the database that drives many assessments across the site. Individual Management Assessment Plans are derived from the IEP and conducted according to the Management Assessment procedure (PRC-PRO-QA-246).

Issues identified by all types of oversight are recorded and tracked to completion through the site-level Condition Reporting and Resolution System (CRRS), as guided by Issues Management procedure (PRC-PRO-QA-052). The procedure requires the independent screening and evaluation of each issue to identify its significance category and corrective actions, if any. The categorization determines the severity of the issue and whether the issue is reportable, requires a root-cause analysis, or requires DOE-RL approval for closure. The CRRS allows for attachment of closure documentation. The TSG did not examine the CRRS during this review.

It is interesting to note that two rather noteworthy NDA practices seem to have been bolstered by internal and external oversight of NDA performance. Approximately six years ago in September 2003, a dedicated surveillance by DOE NDA and criticality safety SMEs identified several findings and recommendations for improvements to the PFP NDA program. A subsequent QA assessment of the NDA management program in February 2004 identified issues with the DQO implementation and software management for NDA. Soon afterward, a comprehensive external assessment by SMEs from across the DOE complex gave several recommendations involving the DQO process and the GGH method with total measurement uncertainty treatment. These recommendations, along with additional DOE-RL and management assessments, led to the exemplary implementation and refinement of these programs currently in practice at PFP.

By far, the most recent and frequent assessments that involve NDA were performed by the criticality safety personnel according to the LOIs listed in procedure ZSP-008. The CSE, CSR, and fissile material handlers each perform these assessments involving NDA rooms, measurement method uncertainties, and compliance with the established DQOs, criticality safety mass limits, and technical reviews of NDA reports. The CSR reviews NDA reports prior to issuance, primarily for DQO compliance. Lessons learned are reviewed in weekly incident reports for Hanford and complex-wide relevance to NDA and criticality safety. Each applicable area of PFP is assessed by criticality safety personnel at least once per year. The semiannual assessments performed according to the four LOIs from Table 3 of procedure ZSP-008 could be expanded to include some of the NDA methodology and its proper implementation for criticality safety compliance verification. In general, as criticality safety personnel come to better understand the NDA methods, their independent oversight can provide a fresh or unbiased assessment of NDA performance.

Daily operational awareness reviews are performed and recorded by the DOE-RL Facility Representative, some of which may involve NDA performance for criticality safety. The Facility Representative sometimes attends NDA DQO meetings and reviews NDA reports as informal contractor oversight. These reviews are shared with the appropriate facility personnel, and may result in a finding, an opportunity for improvement, or a good practice. More formal contractual oversight is performed as surveillances according to a management oversight plan and reported at least quarterly. However, the LOIs (or other assessment guidance) are typically not specific to NDA. Such surveillances may be shared among the DOE-RL Facility Representative, DOE-RL SME, or other DOE personnel. The content of a surveillance report will likely contain input from the operational awareness reviews and their appropriate metrics. Conference calls between DOE sites are sometime used to communicate lessons learned applicable to NDA and criticality safety.

MC&A personnel periodically review and concur with the results of the control charts for the individual NDA measurement systems that support PFP operations. MC&A reviews also include NDA oversight as reviews of calibration reports for uncertainty analysis and reports that record material removal versus NDA comparisons. Sometimes MC&A oversight involves evaluating the NDA systems that support material inventory or safeguards implementation.

NDA self-assessments by NDA personnel are not performed with an established frequency. The IEP database does not normally receive management input for NDA assessments. If a particular project requires an NDA assessment, a request is entered into the IEP database. The DQO process provides an excellent means of establishing an NDA task. Participants in the weekly DQO meetings include personnel from NDA, CSEs and CSRs, MC&A, Operations, and NDA technician functions. The Portable NDA Request Form is used to initiate the request and identify the necessary information for an NDA need. The form includes a section where any criticality safety limits of concern can be indicated. Similarly, the NDA Data Review Checklist provides a formal means for ensuring that an NDA task was performed properly, which includes the DQO items.

A recent NDA self-assessment by a senior NDA scientist involved an evaluation of the effectiveness of portable NDA techniques on specific PFP gloveboxes over a three-year period. The self-assessment was conducted very well. TSG members highly encourage NDA personnel to include more of these self-assessments, preferably scheduled through the IEP database. NDA scientists perform technical reviews of data, analyses, software applications, and equipment.

NDA scientists also perform comparisons of NDA data to the removal of material from gloveboxes or other processing equipment. These comparisons provide a means of NDA oversight by self-assessment. Lessons learned involving NDA are communicated within the NDA organization through the Hanford Information Lessons Learned Sharing (HILLS) database.

All of the interviewees indicated that the NDA staff demonstrates full knowledge of their assigned tasks and that each member conducts the NDA operations in a safe and effective manner.

## Roles and Responsibilities

The procedure PRC-RD-EN-10484 establishes minimum requirements for CHPRC NDA activities. This procedure is applied in a graded manner across the various projects under CHPRC purview, such as PFP. CHPRC projects, in turn, have developed project-specific program procedures, such as HNF-20866 for the PFP. Project program procedures implement the requirements specified by the higher-level requirements procedure, and have been audited for compliance with those requirements.

The CHPRC NDA Management Program maintains and revises Requirements Document PRC-RD-EN-10484. The NDA Management Program is chartered by CHPRC senior management with the objective of providing technical and quality leadership of all CHPRC NDA applications while maintaining authority and responsibility for execution of NDA. The appendices of PRC-RD-EN-10484 include guidance for NDA staffing qualifications as well as the DQO process. This information is implemented at the project level via HNF-20866.

HNF-20866 identifies and defines customer requirements pertaining to customer data use. NDA data use includes the control and accountability of nuclear materials, maintenance of nuclear criticality safety, and D&D decision making. Per HNF-20866, customers specify the data quality requirements of the NDA measurements. Section 2.2 of HNF-20866 concerns NDA interfaces with the PFP nuclear criticality safety program. This section, however, does not articulate how this interface is to be implemented. The TSG's review of CHPRC nuclear criticality safety program procedure HNF-7098, and the project-specific nuclear criticality safety program manual, FSP-PFP-5-8 Volume 1, indicates a similar lack of specificity with regards to NDA program interfaces.

Section 3.0 of HNF-20866 describes the organization, functional responsibilities, levels of authority, and interfaces for those managing and performing work for the PFP D&D NDA operations. According to the version of HNF-20866 that was reviewed, the NDA program still resided within the PFP Analytical Laboratory organization. Due to recent organizational changes, the NDA program, along with nuclear criticality safety, currently reports to the same manager. Revisions to HNF-20866 describing the new organization were not reviewed during the site visit. The NDA group is composed of technical expertise ranging from senior technical specialists to statisticians and technicians. Under the revision of HNF-20866 reviewed during the site visit, the PFP Analytical Laboratory Manager's responsibilities included:

- Overall management of the technical and operations staff;
- Program-specific coordination and interfaces between the PFP NDA program and other customers; and
- Establishing priorities and coordinating conflicting activities.

The NDA Technical Lead reports to the PFP Analytical Laboratory Manager. The Technical Lead's responsibilities included technical direction and oversight of the NDA program to ensure continued compliance with PRC-RD-EN-10484. The roles and responsibilities of the NDA Scientists, Team Lead, Technical Specialist, and Instrument Operators were also defined in the revision of HNF-20866 reviewed during the site visit.