Lessons Learned in the De-Inventory Process for the Alpha Gamma Hot Cell Facility at Argonne National Laboratory - 11115

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ABSTRACT

One of the major activities in the Nuclear Operations Deactivation Program at Argonne National Laboratory is preparing nuclear material for final disposition from the Argonne Alpha Gamma Hot Cell Facility (AGHCF), and shipping the material to either Idaho National Laboratory (INL) or to the Waste Isolation Pilot Plant (WIPP). The AGHCF is a non-reactor nuclear facility that is being transitioned from a programmatic, research and development (R&D) mission to a radioactive material handling, management, storage, and disposition mission. In the course of this conversion, inventory discrepancies are occasionally discovered. These differences can be due, in part, to entry errors, inconsistencies, or under-documentation in material databases. Another cause of differences can be chemical or physical changes in the nuclear material itself (often decades old) due to degradation, decomposition, oxidation, morphology changes, fracture, abrasion, or other mechanisms. A small percentage of nuclear material can be, at least temporarily, unidentified, under-identified, or misidentified.[1] This talk discusses some of the methods employed for reconciling and resolving inventory discrepancies, as well as some of those that have been suggested during a January 2010 Workshop at Argonne sponsored by The Department of Energy and The Office of Health, Safety, and Security (DOE/HSS) on the analysis of nuclear inventory discrepancies.[2]

INTRODUCTION

The Alpha-Gamma Hot Cell Facility (AGHCF) at Argonne National Laboratory has been in operation since 1964. Historically, AGHCF operations were focused on destructive and non-destructive examination of irradiated materials. It was originally designed to examine plutonium bearing fuel elements from ANL West's Experimental Breeder Reactor (EBR II). Since then, the source of materials was expanded to include the destructive examination of specimens from other reactors as well as some specimens (e.g., structural) that do not contain fuel bearing material, which are essentially beta - gamma emitters from activation products. The destructive examination activities supported research in metallurgy, fission product yields, structural analysis, loss of cooling scenarios, and reduced uranium enrichment studies. The contents include samples from many of the Idaho reactors (EBR-II, ATR, MTR, ETR and TREAT) in addition to materials from reactors at other DOE sites (Hanford, Savannah River, Oak Ridge), as well as commercial reactor facilities (Three Mile Island, North Anna, HB Robinson, Surry, Limmerick, and Canadian & European facilities).[3]

During the 53 years of operations in the AGHCF, a significant volume of waste has accumulated inside the hot cell. This waste includes items such as broken equipment, swarf (metal fines, chips, and turnings from cutting or working metal and related items), small residual pieces from sample preparation, and items that cannot be processed economically to recover useful material. The primary operations in the AGHCF are presently focused on waste packaging, de-inventory, and routine maintenance.

The AGHCF includes the hot cell itself and the surrounding offices, labs, and work areas in the resident building. The facility is a reinforced concrete structure, with zinc bromide filled shielding windows at each workstation, and is capable of mega-curie source handling. The hot cell is divided into six criticality control areas. Prior to termination of programmatic operations, **Area 1** was an operating area where fuel specimens were nondestructively and destructively examined, e.g., by visual inspection and metallography. **Area 2** was a fissionable material storage zone below the floor level, and included the air space above the top of the storage holes. **Area 3** was primarily used for nondestructive testing of fuel elements, although some destructive experiments on fissile and non-fissile materials were also performed there. **Area 4** was a moderator-unlimited control area consisting of all areas of the AGHCF on the main floor external to the hot cell and the decontamination and repair area (DRA), which was used for wet decontamination of equipment and repair of equipment from the AGHC. **Area 6** was connected to the AGHC through a shield door and a seal door. **Area 7** was a general criticality control area consisting of all rooms on the second floor within the boundary of the AGHCF. There is no **Area 5** as it is a passageway and has been included in **Area 4**.[4]

There's a colorful history (literally!) to the record keeping of the inventory of accountable materials since Argonne began work with nuclear materials. Records originally were kept by manual entries on colored index cards, 4" X 6" in size, with one color representing fissile material, another color indicating metallographic (met) mounts (a combination of Bakelite and copper diallyl phthalate powders pressed into a solid disk with ~ 1 gram of fissile material)[4], and yet another color representing non-fissile/non-accountable material. This color-coding scheme is maintained, even to this day, in the modern computerized inventory system. All information regarding the material, from its receipt, to experimental work, to movement within the AGHCF, could be found on these cards. They were carefully controlled and checked on several levels.[5]

As time progressed and computer use became more widespread, the hand-entered inventory system was converted to a proto-Fissile Inventory Management System (FIMS) program. This was the first attempt at utilizing computers for maintaining information on the inventory in the AGHCF. The conversion from hand entry to computer record keeping was not without its difficulties, as has been the case elsewhere with other conversions, but over time the computerized system won out over the hand entry system because of its ability to formalize and expedite record keeping activities and conduct automated searches.

Computer-based recording-keeping was implemented at an opportune time, just as the AGHCF and Argonne began an intensive period of research on nuclear fuel types and the manner in which they behaved in different experimental reactors. Soon, the demands on the computer recording keeping required more capabilities than were originally available. Thus, the proto-FIMS database was upgraded using ACCESS (http://office.microsoft.com/en-us/access/default.aspx?ofcresset=1), with tables, queries, reports, and forms that met the needs of this extremely busy time. It is this resulting database that is currently in use to de-inventory the AGHCF.

CURRENT SITUATION

Recently, as a result of the Laboratory's Mission Realignment, Argonne has made the reduction of its "Nuclear Footprint" a priority, and has dedicated resources to inventory and deactivation of the majority of its Nuclear Facilities. The AGHCF falls into this category, and as a result of the American Reinvestment & Recovery Act (ARRA) funding provided to The Department of Energy (DOE), the deactivation process has begun in earnest.

Two major pathways for disposing of all the nuclear material were established during the project planning. One pathway ("sodium bonded") directed the disposition of sodium-bonded experimental fuel and the other (Remote Handled Transuranic - RH/TRU) focused on the balance of the remaining material. According to the Waste Acceptance Criteria for the Waste Isolation Pilot Plant (WIPP), no reactive sodium may be present in any of the acceptable waste forms. The pathway for disposition of the sodium bonded fuels must include the removal of the sodium hazard, and then, the resultant waste may be a candidate for shipment to WIPP. Hence, the intermediate stop for this fuel will be at Idaho National Laboratory (INL), where it may be processed to remove the sodium hazard, and then potentially shipped to WIPP as waste.

The other pathway, called the Fuel Examination Waste (FEW) pathway, involves a direct shipment to WIPP, as all the rest of the material meets the Waste Acceptance Criteria. This material, analyzed at Argonne, does not contain any reactive sodium bonding material. This "FEW" is a subset of the RH/TRU Waste inventory in the hot cell. The radiological characteristics of this FEW material create the need for As Low As Reasonably Achievable (ALARA) shielding for handling, as well as additional data gathering requirements to support characterization processes.

The process of identification, sorting, and repackaging was initiated with the sodium bonded fuel inventory. At first, it seemed like a simple process to identify sodium-bonded fuels that were examined at Argonne, package them, and send them out. However, because the fissile material database was only set up to track fissile material, no information regarding the chemical makeup of the fuels or the reactor type used to irradiate the fuel was recorded in the database.

Another difficulty arose when it was discovered that some experimental fuels were run in two different reactors, each a different type (light water vs. fast breeder, water coolant vs. liquid metal sodium). This information was not recorded in the database, nor was there a pedigree of the reactors in which the fuel had been tested—the only one listed for any given material was the last reactor in which it had been run. INL requires packaging based upon the reactor the fuel was run in, as it impacts the future handling of the material.

More problems surfaced when it was discovered that sodium-bonded fuel could not be processed in the electro-refining process at INL if it was oxidized. Information regarding oxidation of fuel was never included in the database.

Just as these difficulties were discovered, materials comprising the FEW portion of the RH/TRU inventory were just started to be sorted and evaluated for packaging. At first glance, the sodium-bonded problems appeared to be far more difficult to resolve that those for the FEW effort. And, indeed, few FEW difficulties were encountered at the onset. However, complications quickly arose.

These included duplicate numbers assigned to met mounts, material found in cans but not identified, mis-marked met mounts, cans containing only ash, cans found with an assortment of waste material other than fissile material, material that had been accepted with shipper information that may be incorrect, incomplete record keeping of non-fissile material, and a host of other yet to be fully identified difficulties.

The following is a summary list of difficulties encountered so far:

A. Record keeping – not sufficient for de-inventory needs
B. Incorrect shipper information – creates difficulty for planning packaging
C. Unexpected material found and not listed in the database – what to do?
D. Duplicate and mis-marked material – which is which?
E. Composition of fuel – how to find out?
F. Unmarked items – how to resolve?
G. Condition of fuel – not compatible with existing INL processes
H. Other problems – still being discovered

The result of all these problems is that the de-inventory process for the AGHCF is not going to be straightforward. Record keepers from the onset of nuclear fuel experimental work at Argonne, and even up to a few years ago, never anticipated the possibility of a de-inventory process, nor all the future issues that might arise. Their efforts were highly focused on the intake and processing for experimental work, and they did an admirable job of it. But we have many problems to overcome to complete the de-inventory process.

PROBLEM SOLVING

In general, any and all discrepancies from the FIMS database are processed in the same manner. The discrepant item is immediately segregated from the other conforming items, a Material Discrepancy Investigation Form (MDIF) is completed, and photographs are taken. The information is then conveyed to the AGHCF MC&A personnel to record and resolve. Once the discrepancy has been resolved, the MDIF is closed, and the material is released for packaging.

Much of the following discussion addresses our in-house solutions to discrepancies the FIMS database. But since FIMS is the AGHCF link to the Local Area Network Material Accounting System (LANMAS), the overall fissile material tracking system at Argonne, it is vital that the information FIMS provides be as accurate as possible. So far, there have been no deviations from the LANMAS inventory, with the exception of a few rounding errors that have been successfully rectified.

A. RECORD KEEPING

To address the need for accurate information on fuel composition for packaging and ultimate disposition (i.e., identifying which pathway to follow – sodium bonded or FEW), the database is thoroughly searched to find any and all information related to the items in question. The notes section of the database often reveals some useful facts. Sometimes, searching for samples with similar histories provides relevant information. When that avenue is exhausted, a search of the hard copy records for each item is conducted. Fortunately, some of the information on the items has been retained in binders for historical purposes and perhaps future research. More often than not, though, more questions are raised than are answered. That means we must then contact the researchers—some still at Argonne and others retired—who actually worked with the material. This turns out to be extremely helpful in many cases. They are surprisingly familiar with the experimental material they worked with a number of years in the past. They can identify and verify chemical compositions of the experimental fuels, lengths, which reactors the fuel had been placed, subassembly information, element numbers, and other pertinent information to assist with the correct identification of the material. Often they can point to their research papers for further documentation support.

B. INCORRECT SHIPPER INFORMATION

Usually when material was received at Argonne, the shipper's information on the material was accepted without further testing or verification of any portion of that information. The information was then recorded in the database.[5] However, as pieces are being sectioned for packaging, physical verification of some reactor fuel lengths contradicts the database information. Sometimes the fuel is longer; other times it is shorter. This impacts the fissile distribution within the fuel rods.

Our solution to this problem is to recalculate the correct fissile quantities for the corrected lengths. The process involves determining the correct fuel rod length and calculating the fissile amount per inch for each sectioned piece. The total fissile content numbers remain the same, but the individual pieces have changed values. It only impacts the FIMS data and not LANMAS.

C. UNEXPECTED MATERIAL

Even with all the documentation, resources, and records available, occasionally surprises happen. Containers are opened, a physical inventory is done, and there are several marked pieces that were not expected to be in that container. An "in-house discrepancy" (MDIF) is written on each item, pictures are taken of the piece, and the item is set aside in a discrepancy container. Research in FIMS takes place first, then, hard copy records are investigated.

Most of the items that fall into this category are identified as non-fissile/non-accountable material. The information often is found in the sectioning slips records. Towards the end of work in the AGHCF, if the material was non-fissile/non-accountable, it was not entered into FIMS. The solution now is to enter it into FIMS with zero fissile quantity values. If the material happens to be fissile, the original sectioned piece is "re-sectioned" to include the piece not recorded. The fissile material is then entered correctly in the database.

D. DUPLICATE AND MISMARKED MATERIAL

One of the most challenging problems has been working through mis-marked and duplicated numbers on materials. Over the years, many cuts of material have been made. Currently there are more than 7000 pieces in FIMS. At this point in the de-inventory process, nearly 50 items have been identified as possessing a duplicate number or being mis-marked. That works out to a 0.7% rate, which is remarkably low, considering all the complex work done in AGHCF over the years. In spite of that, resolution of these items must take place. Investigation into FIMS is done. Many times there is a record in the notes section that the technician mis-marked an item, and the correct ID is provided. If not, a further review of the photographs is undertaken. This often clarifies the details to confirm the true identity of the item. Currently, at least 25 items remain to be clarified and are segregated with others whose resolutions have not yet been determined.

E. Composition of fuel

The FIMS database often included the fissile fuel type, but did not note if it was sodium bonded in its preparation or if sodium was used in the reactor. Moreover, FIMS does not regularly identify whether the fuel was oxide, carbide, or other. The differentiation is extremely important because existing processes at INL cannot handle oxides. The segregation of fuel samples had to be documented through an item-by-item identification of each sample. It has been possible to segregate, with researchers input, the “metal” fuels (sodium bonded) from the oxide and carbide fuels (generally helium bonded), and was the first required action taken to establish inventories for both types.

F. Unmarked items

What should be done when a container is opened and many of the items have lost their identification numbers? Over time, the material can become abraded, oxidized, fractured, and any number of things that could cause the identification numbers to separate from the material. The FIMS database was of little to no help, other than to supply the container number the items were in and the numbers that were originally placed into the container. A search of the original logbooks usually confirmed what was listed in the FIMS database.

One solution was to take pictures of the items in question. When these pictures were shown to the researchers, they could often identify the type of material from pictures of the items. In one case, for example, a researcher looked at photographs of two different types of unidentified material from one container. From the different sizes and shapes of the fuel, he immediately identified the fuel types, which reactors they had been run in, and other information enabling the packaging of sodium bonded fuel to proceed.[6]

Another solution for unknown material involves the process of elimination. If there are two unidentifiable pieces in a container, and the logbook and FIMS both confirm that the two items not already identified are indeed in the container, then by the process of elimination, these two items must be those items identified in the database, even though their numbers are not readable. This method works particularly well when the listing in FIMS identifies both pieces as from the same batch.

G. Condition of Fuel

More surprises awaited in the AGHCF. Several samples bound for the sodium-bonded pathway had degraded over time from solid pieces to nothing but oxidized powder. Since this was experimental fuel, no studies had ever been conducted on the longevity of the fuel in a solid form. This was a completely unexpected condition, and an unacceptable one for INL processing operations. Moreover, FIMS was never set up to predict or track degradation of fuel, an important piece of information for packaging. Currently, INL will accept the oxidized material as long as it is packaged separately. Ultimately, a separate process will need to be developed to handle the oxidized sodium bonded fuel.

H. Other Problems

Each day brings a new difficulty for the de-inventory process that has not been encountered before. We do not know what to expect, other than to expect something new. One of the lingering problems is what will we find when we check the floor of the AGHCF? For instance, because of restrictive manipulator capabilities, mishaps occur. Some pieces may be so small that the manipulator has difficulty in holding onto the piece. The piece might have been dropped. Or the pressure of the manipulator might cause a piece to come loose and fly across the room. Both of the incidents are recorded in FIMS, but we don't know how many others might have had the same events occur.

LESSONS LEARNED

We have come to realize that the de-inventory process is not straightforward. The lessons we have learned during Argonne's de-inventory process may have applicability to other de-inventory programs elsewhere. The advice and observations we would offer include the following:

Dealing with Limited information

It's important to recognize that the information in your database will probably be, at best, incomplete. In some cases, it will be inaccurate or misidentify material. You should begin with that premise, and proceed forward. It is important to read all the notes in the notes section, wherever they may be found. Look for similar items, even though they might be identified with different numbers, as they might be able to shed light on what needs to be resolved. Search the archives for any and all information that might be able to support decisions about uncertainties. It is also important not to forget the original researchers. They carry information and expertise that can be invaluable for sorting out the de-inventory process.

Time demands

When difficulties arise, the process to resolve them will be very time consuming, and one that should be done correctly, not in haste. It is important to recognize that accurate reconstruction of events that happened 30 or more years ago is not something that can always be completed quickly. Sometimes, there is an easy answer, but be prepared to deal mostly with "not so easy answer" scenarios.

The most helpful tool

Because of the nature of the material and its location, it is impossible to physically inspect the material in question up close. Instead, the items must typically be viewed through zinc bromide filled shielding windows, making clarity for identification of the material problematic. Through several iterations of types of digital cameras and the use of a professional photographer, we discovered that better pictures could be taken through the hot cell window to provide clear views of the items with questionable identities, and use it to confirm identifications. This led us to purchase a better camera. The model we currently use in the AGHCF is Canon EOS Rebel XS.

Expect the unexpected

No matter how carefully a database may have been created and maintained, there will always be surprises. Experimental fuels are just that—experimental. Who knows what will happen to them 30 years after they were irradiated? That was not part of the original research, but it is part of the equation to be dealt with now. And, it can make a difference in the packing of material for shipment.

IT'S OK TO HAVE AN INVENTORY GAIN

If more material is found than originally thought, that is ok. There is a paperwork trail to follow, but it is not arduous. In general, it is better to have more than less.[2]

CONCLUSIONS

Changing the focus of the Alpha-Gamma Hot Cell Facility (AGHCF) at Argonne National Laboratory AGHCF from research to a de-inventory process is challenging. De-inventory turns out to be a much different process than preparing and tracking material for research purposes.[1] This is a new area of work, uncharted, and we learn as we go. The approach to resolving these issues often leads us into new territory, gathering further information about the material, and often learning historical information not recorded elsewhere. Careful analysis, detective work, and logical reasoning are the best methodologies to help solve de-inventory problems.

Individuals and organizations who are going through their own de-inventory process are welcome to contact the author to discuss details.

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REFERENCES

1. Lovett, James E., 1974, Nuclear Materials: Accountability Management Safeguards, ANS Monograph, The American Nuclear Society.
2. U.S. Department of Energy, *Proceedings of the Workshop on the Analysis of Inventory Differences*, Argonne National Laboratory, January 25-26, 2010.
3. Personal communication with Daniel Pancake, Argonne National Laboratory, May, 2010.
4. Nuclear Operations Deactivation, Decommissioning, and Demolition Program, *Nuclear Criticality Safety Evaluation for Operations with Fissionable Materials in the Alpha-Gamma Hot Cell Facility: NOD-AGHCF-035*, January 12, 2010.
5. Personal communication with Terri Shearer-Bray, Argonne National Laboratory, May 2010.
6. Personal communication with Jim Holland, Argonne National Laboratory, April, 2010