INEL-95/0287

August 1995

Pilot Study Dismantlement of 20 Lead-Lined Shipping Casks

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Pilot Study Dismantlement of 20 Lead-Lined Shipping Casks

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Published August 1995

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**Prepared for the
U.S. Department of Energy
Assistant Secretary for Environmental Management
Under DOE Idaho Operations Office
Contract DE-AC07-94ID13223**

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ABSTRACT

This report describes a pilot study conducted at the INEL to dismantle lead-lined casks and shielding devices, separate the radiologically contaminated and hazardous materials, and recycle resultant scrap lead. The facility areas where the work was performed, dismantlement methods, and process equipment are described. Issues and results associated with recycling the lead as a free-released scrap metal are presented and discussed. Data and results from the pilot study are summarized and presented. The study concluded that cask dismantlement at the INEL can be performed as a legitimate recycling activity for scrap lead. Ninety-one percent of the lead recovered passed free-release criteria. The value of the 50,375 lb of recovered lead is approximately \$0.45/lb. Resultant waste streams can be satisfactorily treated and disposed. Only very low levels of bulk radiological contamination (47 picocuries/gram of ^{137}Cs and 3.2 picocuries/gram of ^{60}Co) were detected in the lead rejected for free release.

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ACRONYMS

AEA	Atomic Energy Act	TSF	Technical Support Facility
B&W	Babcock and Wilcox	WAC	Waste Acceptance Criteria
CFR	Code of Federal Regulations	WERF	Waste Experimental Reduction Facility
DEQ	Division of Environmental Quality	WROC	Waste Reduction Operations Complex
DOE	Department of Energy		
EDF	Engineering Design File		
EG&G	EG&G Idaho, Inc.		
FY	fiscal year		
HEPA	high-efficiency particulate air		
INEL	Idaho National Engineering Laboratory		
LDR	Land Disposal Restrictions		
MWSF	Mixed Waste Storage Facility		
NEPA	National Environmental Policy Act		
PCB	polychlorinated biphenyl		
RCRA	Resource Conservation and Recovery Act		
RCT	Radiological Control Technician		
RWMC	Radioactive Waste Management Complex		
SES	Special Equipment Service		
SMC	Specific Manufacturing Capability		
TAN	Test Area North		
TCLP	toxicity characterization leaching procedure		

Pilot Study Dismantlement of 20 Lead-Lined Shipping Casks

1. INTRODUCTION

This report was prepared for the Waste Reduction Operations Complex (WROC) Lead Management Project to document the process, results, and conclusions from a pilot study to dismantle 20 lead-lined shipping casks at the Idaho National Engineering Laboratory (INEL). An objective of the Lead Management Project is to recycle for free release as much scrap lead as reasonably possible. The successful separation of clean lead used as radiological shielding from radiologically contaminated shipping cask and shielding device structural materials allows for the disposition of the lead as a recyclable scrap metal and the disposal of the steel as a low-level waste. Without dismantlement and separation, the cask materials constitute a mixed waste and must be managed in compliance with Resource Conservation Recovery Act (RCRA) regulations.

A pilot study was conducted to determine the performance capability at two facility areas at the INEL's Test Area North (TAN). Babcock & Wilcox Idaho, Inc. performed dismantlement of three casks and/or devices in their TAN 607A facility, and EG&G Idaho, Inc. performed dismantlement of 17 casks in the TAN 607 Hot Shop area. Both areas and companies demonstrated successful cask dismantlement operations.

Dismantlement performance and cost effectiveness were not the only concerns or objectives of the pilot study. Compliance with NEPA and State of Idaho Air Permitting requirements were significant issues of concern. Other concerns included the control of radiological contamination, personnel safety and exposures to radiation and airborne lead particulate, secondary waste stream generation and treatment, surface and bulk surveys and analyses of the lead to verify compliance with DOE Hazardous Waste Shipping Moratorium criteria for free release, and conformance with the specific factors that would allow the lead to be considered a legitimate scrap metal recycling operation exempt from RCRA control and permitting.

This report presents selected detailed and summarized performance results from the cask dismantlement pilot-scale study. Conclusions based on an assessment of the results are presented and discussed.

2. BACKGROUND

2.1 History

Lead has proven to be an ideal material to shield personnel and equipment from the highly penetrating gamma rays that may emanate from some radioactive materials. Lead is the densest of the common metals except for gold and mercury,¹ is solid at normal temperatures, and is relatively inexpensive. Either a thick layer of a less dense material (like concrete), or a thinner layer of a very dense material (like lead) is often necessary to provide adequate shielding in the nuclear industry.

A several-inch-thick layer of lead is used as the shielding material in many INEL shipping casks. Shipping casks are containers used to safely transport and store radioactive materials. Examples of radioactive materials transported at the INEL in shipping casks are spent nuclear fuel rods (composed partially of unused uranium fuel and associated fission byproducts), and used high-efficiency particulate air (HEPA) filters on which radioactive particles are trapped.

For decades, the INEL has used lead-lined casks of various sizes and shapes to store and transfer radioactive materials from nuclear reactor operations. Many of the old casks have been declared waste and are currently in storage in controlled and permitted locations at the INEL. Rather than continuing to store these obsolete casks, the feasibility of recovering and reusing the lead within the casks was investigated. Lead is a valuable commercial product that could potentially be reused at the INEL or sold for off-Site use. Even if the recovered lead is radiologically contaminated, it could still be reused for shielding applications at the INEL.

Lead in the casks exists as a filler encased between steel liners. Until the late 1970s, casks were fabricated at the INEL CFA Lead Shop by pouring molten lead between previously positioned inner and outer steel vessels.² Therefore, cask design is such that the radioactive materials temporarily stored within the casks do not directly contact the lead. However, it was not known whether efforts to separate the lead from the contaminated steel liners would contaminate the lead. It was expected that the lead might be radiologically contaminated after dismantlement and would therefore require some surface decontamination before qualifying as radiologically clean.

2.2 Regulatory Benefits to Dismantlement

Previously used casks are required to be stored in controlled areas because they contain the following two materials: radiological contamination and the hazardous material lead. The inside steel liners of the used casks are considered radiologically contaminated because when the casks were in use, the liners may have directly contacted radioactive materials. Other portions of the casks, even parts that may not have contacted radioactive materials (such as the lead filling material), are also considered to be radiologically contaminated (unless proven otherwise, which is impossible to do as long as the casks are intact).

In addition, the material lead is an acute human toxin when ingested or inhaled. RCRA regulates lead as a hazardous material due to its toxicity.³ Because the casks are no longer being

used, they qualify as a waste. Because they exhibit contamination from both radionuclides and a RCRA-regulated hazardous material, they qualify as a mixed waste. Managing this type of waste poses special challenges, in part because all applicable requirements of both the Atomic Energy Act (AEA) and RCRA must be met.

The primary regulatory benefits to the INEL to successfully dismantling lead-lined casks and properly testing the resulting separated materials are the following:

- It was thought that the majority of the lead would be "clean" radiologically. Further, it was thought that the clean lead could be separated from the radiologically contaminated materials. This separation would enable the "mixed waste" classification to be removed from most of the cask material (the bulk of the cask weight is due to the lead filler material). This would reduce the amount of mixed waste in the INEL's inventory, in support of the Federal Facility Compliance Act of 1992.
- It was thought that the majority of the non-radiologically contaminated materials in the cask could probably be separated from the radiologically contaminated portions. This separation would reduce the total amount of AEA-regulated waste. In addition, it was thought that further waste minimization could be achieved by recycling the "clean" (i.e., non-radiologically-contaminated) steel rather than disposing it to a landfill.
- Cask dismantlement at the INEL was demonstrated to be a legitimate scrap metal recycling activity. Scrap metal recycling does not require permitting as a RCRA treatment operation. Moreover, as long as the legitimate recycling of casks continues, the casks previously declared mixed waste may be reclassified as recyclable scrap metals.⁴

2.3 Initial Cask Dismantlement Demonstration

In 1993, a joint effort by EG&G Idaho and Babcock and Wilcox (B&W) was undertaken to successfully demonstrate the feasibility of dismantling lead-shielded radioactive shipping casks to recover the lead for recycling purposes. A single cask was to be dismantled for the demonstration project. The project was intended to provide baseline information for future planning involving lead recovery from other obsolete INEL casks.

A cask identified as "HS-101" was chosen for this demonstration. Prior to the dismantlement, HS-101 weighed 5,857 lb and had a radiological reading of 5 mR on its external surface. The actual cask dismantlement process was completed within a 2-week period, concluding on September 1, 1993. The work took place at Test Area North, in the part of building TAN-607 referred to as TAN-607A.

A small amount of lead from the cask was found to be radiologically contaminated and was cut away from the clean lead and treated as mixed waste. Ninety percent of cask HS-101's original weight was ultimately recovered as recyclable, radiologically clean lead. This lead has been free-released to an off-site vendor, GNB Corp. of Los Angeles, CA, for manufacture into lead acid batteries.⁴ The wastes generated from the dismantlement process were identified, categorized, packaged, and were handled as required by applicable regulations.⁵

3. OBJECTIVE AND SCOPE

This report describes the FY 1994 pilot study project whereby 20 obsolete casks/devices were dismantled at the INEL. Based on the demonstration project described above, it was believed that a majority of lead from the project would not be contaminated and would meet "free-release" criteria. In order for the lead recovered from cask dismantlement to be suitable for release to a private sector lead recycler, the following requirements were established:

- a. The lead would have to be free from fixed or smearable radiological contamination. DOE Order 5400.5 criteria, as well as EG&G Idaho Radiation Control Manual requirements were to be met to allow release of the lead from the INEL. EG&G Idaho radiological survey and control experts were to certify that the materials to be released met the prescribed requirements. A RCRA Hazardous or TSCA Regulated Waste/Material Non-Radioactive Certification Form (EG&G-0919) was to be completed and signed. Free release criteria were developed and documented in WROC-EDF-237.⁶
- b. Originally, process knowledge on the operational history of the casks was considered adequate to substantiate that the lead recovered from the casks had never been volumetrically contaminated or exposed to activating beams or particles sufficient to cause radioactive activation. However, during the course of the cask dismantlement activities, it was discovered that the CFA Lead Shop had reportedly used slightly contaminated lead as a feedstock in the manufacture of some shipping casks.² At this point, practices that had been employed by the CFA Lead Shop to manufacture casks were investigated.² As a result of this investigation, it was concluded that process knowledge alone was not adequate to certify the lead from casks was free from volumetric radiological contamination or activation. The established requirement was that volumetric contamination of the lead must be ruled out based on representative samples analyzed with a highly sensitive technique.
- c. The lead was to be certified acceptable by the recycler, and was to be 99% pure lead.

B&W selected the casks to be dismantled for the study, and the selection was then reviewed and approved by EG&G Idaho. The 20 casks selected were typically cylindrical in shape and each had an opening into an internal cavity by which the fuel rods or other radioactive materials could be loaded or unloaded. A lid (end plug) covered each opening, and the lids, like the casks, were constructed of steel-covered lead. Most of the steel that cladded the lead was carbon steel, but some, especially the internal cavity linings, was of stainless steel. Figure 1 is a representation of a cask similar to some of those dismantled during the study.

Original weights of the casks ranged from approximately 330 to 14,000 lb, with the bulk of the weight attributable to the lead shielding. Most of the casks were known to be contaminated with low levels of fission products on their steel surfaces. The degree of radiological contamination on the lead was unknown prior to dismantlement.

The casks had previously been stored in a RCRA-permitted waste storage facility at building TAN-647. When all approvals had been obtained and all other preparations made, casks were loaded by forklift onto a truck and transported across the facility to building TAN-607 for the

Figure 1. Typical cask.

dismantlement. The pilot study dismantlement work was performed between February and September of 1994. Some casks were dismantled by each of the DOE contractors, B&W and EG&G Idaho, as described in this report.

Casks were to be dismantled in a manner so that the lead shielding could be recovered and certified clean for release to a scrap metals recycler for use in the private sector. Precautions were taken to prevent contaminating the lead with radionuclides that might originally have been confined to only a portion of the lead or to the steel shell only. Lead that was contaminated and could not be cleaned was planned to be returned to RCRA storage.

If this pilot-scale study demonstrated success in safely recovering a sufficient amount of clean lead for recycle, the identified processes were to be then considered for implementation on a production scale. Forty additional casks stored at TAN-647 had been identified as candidates for dismantlement and recycling.⁷ (At the time of this writing, the production scale dismantlement at TAN of these additional casks is ongoing.)

4. CASK DISMANTLEMENT BY B&W

4.1 Facility Description

The facility selected as the location for performing the cask dismantlement demonstration was TAN's Technical Support Facility (TSF), the same facility at which the casks were being stored. Figure 2 is a layout of the TSF facility. When all approvals had been obtained and personnel were prepared to start the work, casks were loaded by forklift from their storage location, TAN-647, onto a truck and transported across the TSF facility to the building described below.

The work was performed in a portion of building TAN-607 referred to as TAN-607A. TAN-607A was B&W's SMC Materials Development Facility. TAN-607A has large access doors into a high bay area equipped with 10- and 75-ton capacity overhead cranes. The building has a HEPA filter exhaust. The dismantlement work was performed in a high bay area in TAN-607A referred to as the Contaminated Manufacturing Area (room 152). Figure 3 shows the location of this area within TAN-607.

A temporary work enclosure was erected and installed in room 152 to contain any radionuclides and/or metal particles that might be freed from the casks during dismantlement. All machining and dismantlement work was performed within the confines of this enclosure, and the enclosure air was exhausted and filtered through the facility HEPA filter system. A radiation control area inside the temporary enclosure was set up to ensure radiation control of the machining and the dismantling activities. Safety procedures were implemented to enter/exit the enclosure.

4.2 NEPA Requirements and Permitting

Under the National Environmental Policy Act of 1969 (NEPA), an environmental assessment and/or an environmental impact statement must be prepared for many federal actions. A "categorical exclusion," however, would exempt the federal agency from these measures.⁸ It was thought that the proposed work was eligible for such a categorical exclusion.

A categorical exclusion for the proposed work scope as a pilot-scale study was solicited. B&W prepared the necessary NEPA documentation for this solicitation, which included completion of an Environmental Checklist. A NEPA categorical exclusion, ID-SMC-93005, for this cask dismantlement pilot project was approved by DOE-ID on December 3, 1993. The proposed action was therefore categorically excluded from further NEPA review and documentation.

Air permitting requirements associated with this dismantlement project were investigated and determined. The proposed work was then reviewed by the Idaho Department of Health and Welfare, Division of Environmental Quality (DEQ), and subsequently approved on March 4, 1994. The requirements that were imposed stated that the emissions from the temporary work enclosure could either be attached to the facility's existing HEPA filter system and exhausted to the ambient air, or exhausted into the work place if they met appropriate health and safety standards without substantial utilization of personal protective equipment on workers outside the enclosure. The work was done with the enclosure being exhausted into the facility HEPA system.⁹

Figure 2. Technical Support Facility (TSF) at Test Area North (TAN).

Figure 3. Floor Plan of building TAN-607.

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4.3 Dismantlement Equipment, Special Tools, Techniques, and Processes

Three casks/devices were dismantled by B&W for the pilot scale study. The work took place between February and June of 1994. The Transfer Bell Ring (TBR) was the only non-cask device dismantled in the pilot scale study. TBR was a ring-shaped lead-filled shielding device about 6 ft in diameter, covered with steel cladding. The two casks, HS-102 and HS-104, were similar in design and size to cask HS-101, which B&W had dismantled the previous year during the demonstration project. Both HS-102 and HS-104 had painted carbon steel outer shells and an inner cavity formed by 4-in. schedule 40 stainless steel pipes. Original weights of the devices ranged from about 2,300 to 5,600 lb. Table 1 in Section 8 contains a description for each cask.

Design drawings were available for the casks/devices dismantled, which greatly facilitated planning. However, some discrepancies between drawings and actual cask design were discovered during the dismantlement.

To ensure that personnel were protected from exposure to metal particles, fumes, and radionuclides that might be freed during machining, all work took place within the temporary enclosure. The milling machine was operated by machinists standing outside the enclosure, and no personnel were present inside the enclosure during machining. The milling machine was used for machining on all three devices. Some attachments used on this machine were a roughing end mill and a slitting saw.

Before placing any cuts into the casks, the lids (end plugs) were removed, and a urethane foam was sprayed into the internal cavity and allowed to dry to its hardened state. This foam fixed any removable radiological contamination, lessening chances that contamination would be released and spread upon cask dismantlement. B&W's Industrial Hygiene personnel had disallowed the use of hand tools, such as jack hammers and grinders, that might force excessive amounts of lead dust into the air inside the dismantlement enclosure. One machine tool, a band saw, was used inside the dismantlement enclosure to cut up the TBR only.

The first machining cuts made to each cask/device were performed to remove the welds on all lifting hooks and brackets. Next, cuts were made on each end of the cask at the weld locations that held the outer vessel to the inner vessel. The cask was then moved off the machining table to the floor within the enclosure. Here the outer steel shell was removed from the lead by use of a hydraulic jack and the aid of the crane. The cask, minus its outer steel shell, was then returned to the machining table where the lead lining was split lengthwise. The lead was then cut and pried away from the inner vessel (a stainless steel pipe) and the inner vessel removed.

As the larger pieces of metal were removed from the cask/device, they were radiologically surveyed and the lead was surface decontaminated if necessary. The pieces were then segregated according to whether they were surface clean or contaminated, and whether they were lead or steel. During the process, B&W collected and recorded numerous measurements such as airborne lead and radiation monitoring data, and weights of the various product and waste streams. Each device was completely dismantled before starting on the next device.

All swarf (metal chips, filings, and grit generated from machining operations) was collected. The swarf was a mixture of lead and steel. Since this material was known to be a mixed waste, it was kept separate from other non-mixed wastes. A few larger chunks of contaminated lead, also a mixed waste, that were removed during decontamination were added to the swarf. The swarf was included in with the swarf obtained from EG&G Idaho's work, and some of this was later used in a RCRA treatability study. The rest will undergo an appropriate RCRA treatment so that it can be properly disposed according to federal regulations.

4.4 Radiological Contamination and Worker Health and Safety Controls

All employees working within the enclosure were required to wear respirators to prevent inhalation exposure to radioactive or lead particles. In addition to the respirators, workers wore the standard protective clothing and dosimeters required by the area Radiological Control Technicians. The casks/devices had been previously characterized as containing only low levels of radiological contamination. Industrial hygiene concerns relevant to this pilot study were generally limited to potential worker exposure to lead.

Throughout the dismantlement activity, personnel were continuously monitored for potential lead exposure and radiological contamination. No radiation exposure to personnel, as verified by the EG&G Idaho analysis of dosimeter badges, was reported. The level of respiratory protection used during this work was commensurate with the airborne lead concentrations, and further verified as having been adequate by the negative, post-job blood/lead levels.

Due to lead's high density, sufficiently large chunks of lead may pose a lifting hazard to personnel. To move the larger pieces of lead and to reorient them during dismantlement, overhead cranes and a portable hydraulic lifting device were used.

As discussed above, a temporary work enclosure was constructed to ensure the safety of the workers. All machining and dismantlement work was performed within the confines of this enclosure. While the milling machine was operated, personnel were not present inside the machining enclosure. The air in the enclosure was filtered through HEPA filter systems. A radiation control area around the temporary enclosure was established to ensure radiation control of the machining and the dismantling activities, and safety procedures were implemented to enter/exit the enclosure. A change-out room was integrated into the enclosure to further prevent contamination spread.

B&W personnel were successful in controlling the spread of radioactive contamination. As mentioned above, radiological contamination inside each cask's internal cavity was secured by use of a urethane foam. Foam was sprayed inside each end of the internal vessel and allowed to dry before beginning dismantlement. The use of engineering control, conducting all activity on the devices within an enclosure, and constant monitoring contributed to the control of both radiological and airborne lead contamination.

4.5 Radiological Survey, Analyses, and Results

Prior to shipment to the RCRA storage facility, the casks/devices had been measured for loose contamination and found to be contaminated with low levels of radioactive cesium and cobalt isotopes. This contamination was found on the steel surfaces of the internal cavities of the casks, which were previously in contact with stored radioactive materials. The outside of the three casks/devices had previously also been checked with hand-held radiological survey instruments, and had exhibited readings of less than 1 mR/hr. Since the lead was not yet exposed at this time, the degree of radiological contamination of the lead was unknown. Table 1 in Section 8 lists the radiological readings of the casks prior to dismantlement.

Radiological readings were taken repeatedly during the dismantlement process. New readings were taken to check contamination levels as new materials were exposed. Radiological readings were recorded in the TAN Radiation Control log books at TAN-607. Lead that was determined to be radiologically surface clean was separated from that determined to be surface contaminated. Similarly, radiologically surface clean steel was segregated from surface contaminated steel.

Some of the lead removed from the devices was found to require some surface decontamination. Decontamination was accomplished in various ways, from wiping the surfaces with an oil-impregnated heavy duty cloth, to use of wire brushes and chisels, to actually machining off the portion of lead that could not be decontaminated. One cask, HS-104, had extensive surface contamination of the lead. Portions of the lead surface identified as contaminated were machined off until the remaining lead surface met clean surface requirements.

Potential volumetric contamination of the recovered lead identified as surface-clean, was investigated a few months later by EG&G Idaho after the cask work was transferred to EG&G Idaho. Core samples from each device were analyzed. One of the three devices, the TBR, was found to have measurable levels of polonium-210, which at the levels detected, was determined to be a naturally occurring isotope in lead, rather than evidence that the lead from this device was volumetrically contaminated.² All three devices were determined to not be volumetrically contaminated, which meant that the lead from these devices was eligible for recycle. Table 2 in Section 8 lists the radiological readings of the recovered lead, and Table 3 lists samples collected and analyzed.

4.6 Associated Costs

For the three casks/devices dismantled by B&W, (Transfer Bell Ring, HS-104, and HS-102), the total cost for the pilot study dismantlement was about \$188,700. B&W's costs on a per cask basis likely would have declined as more casks were dismantled and accumulated experience allowed streamlining of procedures. However, after B&W dismantled the first three devices, the work was turned over to another DOE contractor that was able to use many of B&W's lessons learned to efficiently dismantle the remaining 17 casks. In addition, since this was the first time such a project had been attempted, it was especially important toward the beginning of the study to gather data pertaining to contaminant levels and waste amounts. B&W therefore had more requirements in terms of monitoring and documentation than was necessary later on under the other contractor.

5. CASK DISMANTLEMENT BY EG&G IDAHO

5.1 Facility Description

It was initially planned that B&W would dismantle all 20 devices, but a labor dispute resulted in the work being turned over to EG&G Idaho after the first three devices had been dismantled by B&W. The cask dismantlement work under EG&G Idaho was performed in another part of the same building that had been occupied by B&W, and in which B&W had disassembled the previous casks. This was building TAN-607 at TAN's TSF facility.

The EG&G Idaho work was performed in the portion of building TAN-607 referred to as the TAN Hot Shop, which is a large shop with 7-ft thick walls originally designed to service and maintain nuclear experiment assemblies.¹⁰ The TAN Hot Shop has large access doors into a high bay area equipped with a 110-ton overhead bridge crane and a 10-ton hoist. The TAN Hot Shop has its own ventilation system and HEPA filter exhaust, and adequate space for safe conduct of the work. EG&G Idaho had performed similar work in the Hot Shop in the past, and the dismantlement activity was determined to be a routine operation for EG&G Idaho's TAN Operations Group in the TAN Hot Shop.

The dismantlement took place on the east end of the Hot Shop in a room called the Special Equipment Service (SES) Room. Figure 3 shows the relative locations of the rooms in TAN-607. The SES can be closed off by means of sliding radiological shielding doors. Its floor is approximately 16 ft above the Hot Shop's main floor level. The crane and manipulator can be moved into the SES room while other operations are being carried out in the main part of the Hot Shop. A control station for the SES room on the second floor of TAN-607 has a 6-ft thick window for viewing into the cell.¹⁰

After the lead had been removed from the casks in the TAN Hot Shop, the lead was transferred to the TAN Warm Shop, which is located immediately adjacent to the Hot Shop in building TAN-607. The Warm Shop is used for low-to-medium level radiological work. Here, in the Warm Shop, the lead was radiologically surveyed for surface contamination and spot-decontaminated if necessary. The TAN Warm Shop is one large open room and is equipped with large access doors and an overhead crane.

The surface-clean lead was then placed on pallets and temporarily stored at TAN-609 where it was core-sampled and analyzed for volumetric radiological contamination. This lead included the surface-clean lead generated from the three devices earlier dismantled by B&W. Building TAN-609 is an equipment maintenance shop located at TAN south of TAN-607.

The lead that was verified to be volumetrically clean (18 of the 20 casks) was then transferred to the Clean Lead Facility at the Power Burst Facility for temporary storage. In July 1995, the clean lead, 50,375 lbs, was shipped off-site to the GNB Corporation, a private sector recycler of scrap lead. The lead that was determined to contain volumetric contamination was sent to the Mixed Waste Storage Facility (MWSF) for interim storage as mixed waste.

5.2 NEPA Requirements and Permitting

As required by NEPA, an Environmental Checklist was prepared and submitted prior to initiation of any work. This Checklist describes the nature of the work, details surrounding the proposed activity, and identifies the environmental laws and regulations potentially applicable to the proposed activity. Since EG&G Idaho's proposed work was not significantly different from B&W's, EG&G Idaho's NEPA documentation was a modification of that previously submitted by B&W. A Categorical Exclusion for the pilot program was approved January 28, 1994, by DOE-ID.¹¹ A Categorical Exclusion has the effect of categorically excluding the proposed action from further NEPA review and documentation.

B&W had already received an air permit approval from the Idaho DEQ, and some discussion took place as to whether it was necessary to attempt to transfer B&W's air permit to operation in the Hot Shop. It was determined that it was not necessary because the proposed actions were consistent with activities that have been and can be routinely conducted within the TAN 607 Hot Shop.

5.3 Dismantlement Equipment, Special Tools, Techniques, and Processes

In all, 17 casks were dismantled in the TAN Hot Shop. This work was performed from July 12, 1994 to August 13, 1994. The casks were of various sizes, and their original weights varied from 330 to 14,000 lb. The thickness of their lead linings varied between about 1.5 and 8 in. The casks were all cylindrical in shape, except for HS Round Cask, which was spherical. Table 1 in Section 8 contains a brief description of each cask.

Although a considerable amount of information was obtained from B&W's previous work, some of EG&G Idaho's proposed processes were different than B&W's. It was decided to test EG&G Idaho's proposed processes by starting with one small cask and one large cask. During this initial test, Radiation Control personnel gathered sufficient data to accomplish an ALARA (as low as reasonably achievable) review and appropriately revise the Radiological Work Permit for the remaining 15 casks.¹¹ In addition, the most appropriate available metal working tools for disassembling the casks were identified: hand-held grinders and hand-held jackhammers (power chisels). These tools provided quick, clean cuts (with only small amounts of fines) of the outer steel shell and facilitated removal of the steel cladding from the lead.

The following is a step-by-step description of EG&G Idaho's process:¹¹

1. A sample was taken of each cask prior to dismantlement. This was accomplished by drilling into the cask 2 in. by 0.25 in. The sample was then counted by Radiation Control personnel with hand-held instruments.
2. The lid was then pulled from the cask and the cavity filled with a polyurethane foam, which was sprayed in. The purpose of the foam was to prevent any contamination from the inner vessel to spread to the lead during dismantling. The foam had a very short curing time, allowing the dismantlement to progress in a timely manner.

3. A hand-held grinder was used to grind out the weld at both ends of the cask to allow the removal of the end pieces of the shell.
4. The outer steel shell was then cut lengthwise using a grinder. Once the shell was cut the full length of the cask, the shell was split apart using crowbars. The outer shell was then removed and placed into a "hot" waste box for storage.
5. An electric jack hammer was then used to cut the lead away from the inner vessel's drain line.
6. Using the jack hammer, a v-cut was made into the lead all the way down the length of the cask to uncover the inner vessel. The lead in this v-cut was cut into small pieces for ease of removal. The inner vessel was then removed and placed into a "hot" waste box for storage.
7. Using the portable jackhammer, the lead was split in half for ease of handling for survey and storage.
8. The lead inside the lids was removed in much the same way. The outer steel shell was cut through and removed from the lead.
9. The dismantled lead from the casks and lids was bagged or covered in plastic to ensure it stayed clean, and placed in a storage box. The boxes were transferred to the Warm Shop.
10. Each piece of lead was then removed from the box and placed on a table to allow a survey to be performed. An inch-by-inch survey was performed by Radiation Control personnel on each piece of lead. Spot decontamination was performed as necessary. Of the 17 casks dismantled, only two casks were contaminated on essentially the entire external surface of the lead lining. The contaminated layer of lead on the outside surfaces of these casks was removed using power chisels during decontamination.
11. The clean lead was placed on pallets and put in storage to await final sampling and analysis. This lead included that previously recovered by B&W.
12. The lead, thus far identified as surface clean, was sampled a final time and analyzed by a highly sensitive analytical method to ensure that no cask lead was volumetrically contaminated. These samples were core samples rather than surface samples. Results of this testing showed that two casks and one cask lid were slightly volumetrically contaminated. The lead from these three devices was then segregated because it could not be recycled at this time, and instead would be stored as mixed waste.

5.4 Radiological Contamination and Worker Health and Safety Controls

All employees working on or near the devices were required to wear respirators to prevent inhalation exposure to lead or radioactive particles. In addition to the respirators, workers wore the standard protective clothing and dosimeters required by the area Radiological Control Technicians. The casks had been previously characterized as containing only low levels of radiological contamination. Industrial hygiene concerns relevant to this pilot study were generally limited to potential worker exposure to lead.

Throughout the dismantlement activity, personnel were continuously monitored for potential lead exposure and radiological contamination. No radiation exposure to personnel, as verified by the EG&G Idaho analysis of dosimeter badges, was reported. The level of respiratory protection used during this work was commensurate with the airborne lead concentrations, and further verified as having been adequate by the negative, post-job blood/lead levels.

Due to lead's high density, chunks of lead may pose a lifting hazard to personnel. Overhead cranes were used to move the larger pieces of lead and steel and to reorient them during dismantlement.

EG&G Idaho personnel were successful in controlling the spread of radioactive contamination. Radiological contamination inside each cask's internal cavity was secured by use of a urethane foam. The foam was sprayed inside each end of the internal vessel and allowed to dry and harden before beginning dismantlement. The use of engineering control and frequent monitoring contributed to the control of both radioactive and lead contamination.

5.5 Radiological Survey, Analyses, and Results

Prior to shipment to the RCRA storage facility, the 17 casks had been measured for loose contamination and found to be contaminated with low levels of fission or activation products (^{137}Cs , ^{60}Co , ^{134}Cs , ^{154}Eu , or ^{155}Eu), at least on the inside steel surfaces of the cask cavities. The outside of the 17 casks had previously also been checked with hand-held radiological survey instruments, and had exhibited readings that ranged from less than 1 to 20 mR/hr. Since the lead was not yet exposed, degree of radiological contamination of the lead was unknown. Table 1 in Section 8 contains a description of each cask, including original radiation readings and contamination levels.

Radiological readings were taken repeatedly during the dismantlement process. New readings were taken as new metal surfaces were exposed to check contamination levels and radiation readings. Table 3 lists samples collected and analyzed. Radiological readings were recorded in the Radiation Control log books at TAN-607. During dismantlement, surface contaminated lead and surface clean lead, and surface contaminated steel and clean steel were segregated from one another.

Following disassembly of the casks, all the external surfaces of the lead were carefully surveyed on all sides using hand-held radiation survey instrumentation. Varied amounts of surface

contamination were present on the lead ranging from non-detectable to 25,000 dpm/100 cm². Decontamination was performed on any areas that were above the beta/gamma release criteria, by wiping, chipping, or other means. Most of the lead either had no surface contamination or surface contamination in small, isolated areas only. However, two casks dismantled by EG&G Idaho had surface contamination distributed over the entire surface of the lead. These incidents of extensive surface contamination were apparently due to leaks that had developed in welds in the casks' steel shells. After decontamination, swipes were taken and at this point, each piece was certified to be below surface release standards.²

Next, activities were performed to test for volumetric radiological contamination in the lead that had passed the surface clean criteria. Representative core samples of the lead were collected. Each piece of lead was sampled by drilling 0.5 to 1 in. deep into the lead, withdrawing the drill, and transferring the ribbons of lead adhering to the drill bit, into the sample jar.² Lead sampled from various locations on each of the lead pieces was composited such that one sample from each cask and each lid was created.¹² These samples were collected from not only the casks dismantled by EG&G Idaho, but also from the three devices previously dismantled by B&W. The core samples were analyzed by a highly sensitive technique.

Table 2 in Section 8 lists the analytical results for the samples taken from the recovered, surface-decontaminated lead. The analytical results from these samples revealed that the samples taken from two of the casks, HS Round Cask and HS-301, and one of the cask lids were volumetrically contaminated. One possible cause of volumetric contamination would be that the materials were manufactured with slightly contaminated lead. The presence of contamination in the samples meant that the lead from these three devices would not be eligible for recycle at this time.²

An attempt was made to determine how the bulk contamination in the two casks was distributed and to verify contamination of the lid. Twelve more samples (plus two duplicate samples) collected from each of the casks and a duplicate sample previously collected of the lid were analyzed for man-made gamma-emitting radionuclides. Once again, ¹³⁷Cs and ⁶⁰Co were found in some of the samples, confirming that the three items were contaminated. However, the cask contamination did not appear to be evenly distributed over both casks, as had been expected, nor to follow a distribution pattern. Table 2 summarizes results of these confirmatory samples. The raw data for these samples can be found in the project files.

5.6 Associated Costs

The cost for dismantling 17 casks was \$231,369, which results in the cost per cask being about \$13,600. This was significantly less than B&W's per cask cost. However, it should be remembered that since B&W dismantled the first three casks, lessons about the task, on which there was previously very little data, were learned from B&W's prior work.

6. SECONDARY WASTES

6.1 B&W-Generated Secondary Wastes

Secondary wastes generated from the dismantlement and subsequent decontamination work performed by B&W were the following:

- Cask shells
- Lead and steel swarf
- Personal protective clothing
- Process materials (blotter paper, rags, HEPA filters).

The weight of the outer cask shells represented 7.4% of the original weight of the casks, on average. Inner vessels' weight (including that due to the urethane foam) represented 0.6% of the total original cask weight. The lead and steel swarf and contaminated lead chunks were combined, since they qualified as non-recyclable mixed waste. These contaminated chips and pieces represented 8.0% of the original weight of the casks. And the cables and cradle represented 2.1% of the original weight of the casks.¹³ Table 4 in Section 8 presents the various weights recorded by B&W for each device.

A sampling and analysis effort was performed to determine proper disposal location of the outer shells of the casks. The casks' outer shells were composed of carbon steel and had been painted with yellow paint. Appropriate analyses for this type of material would enable determination of whether the metal qualifies as a RCRA hazardous waste. Since the metals in steel most likely to fail the TCLP test are lead and chromium, these were the metals tested for. In addition, due to the age of the materials, it was necessary to determine whether the paint was a lead-based paint. Test results indicated that the TCLP metals concentrations in the painted steel shells are below regulatory limits, and the shells are therefore not a RCRA hazardous waste.¹⁴

The inner vessels of B&W's casks were made of a stainless steel 4-in. schedule 40 pipe around which molten lead had been poured and allowed to harden. Inner vessels were routinely disposed as "hot" waste during the dismantlement.

Because the dismantlement work was transferred to EG&G Idaho part way through the project, it was convenient to combine some of the product and waste streams generated by B&W with those generated by EG&G Idaho. Lead and steel swarf generated by B&W was combined with that generated by EG&G Idaho. A portion of this material has been used in a RCRA treatability study, as described in Section 8. Table 5 shows the contributions from B&W's work to some of the waste and product streams.

Amounts of secondary wastes in the form of personnel protective equipment and various process materials were not recorded.

6.2 EG&G Idaho-Generated Secondary Wastes

Secondary wastes that were generated from the dismantlement and subsequent decontamination work performed by EG&G Idaho were the following:

- Cask shells
- Lead and steel swarf
- Bulk (volumetric) contaminated lead
- Personal protective clothing
- Process materials (blotter paper, rags, HEPA filters).

Unlike B&W, EG&G Idaho did not weigh many of the individual casks' various components after dismantlement. It was important to gather that type of information at the beginning of the project, and B&W had therefore been required to record several weight measurements for each cask. However, after this information had been obtained for several casks, it was not necessary to continue to weigh individual cask components, so EG&G Idaho was not subject to this requirement.

One waste stream whose total weight was measured by EG&G Idaho was the lead and steel swarf generated from machining, combined with pieces of radiologically contaminated lead removed during decontamination. The measurement included material in this category that had been generated by both EG&G Idaho and B&W. For all 20 casks, the lead and steel swarf and the removed lead pieces (containing fixed radiological contamination) weighed about 2,300 lb. EG&G Idaho's contribution to this category of waste was 925 lb, 14% of which was swarf and 86% of which was lead chips and pieces that had been removed as part of decontamination.¹¹

Another waste stream whose total weight is known is the bulk contaminated lead. This category includes the two casks and one cask lid (end plug) that were determined to be volumetrically contaminated. The total weight of the bulk contaminated lead is about 4,950 lb. (As previously mentioned, none of the three casks dismantled by B&W were volumetrically contaminated, so the entire 4,950 lb originated from casks assigned to EG&G Idaho.)

Amounts of secondary wastes in the form of personnel protective equipment and various process materials were not recorded. Table 5 summarizes known waste amount data.

6.3 Treatment and Disposition of Secondary Wastes

The 2,300 lb of lead and steel swarf was known to be radiologically contaminated. Because of the radiological contamination and because of the presence of pieces of pure lead, the swarf was a mixed waste. It would have been impractical to attempt to separate the fine lead filings from the steel filings. RCRA requires the hazardous component of any waste to be treated to specified standards. Waste lead that cannot be recycled (such as the radiologically contaminated swarf)

must be macroencapsulated¹⁵ unless an alternative treatment technology is shown to be effective and is approved by the EPA.⁴ Macroencapsulation will produce a waste form that meets the treatment standard in RCRA's Land Disposal Restrictions (LDR), but the treatment residue must be disposed in a RCRA permitted Subtitle C landfill.

Some of the lead and steel swarf was used in a test called a treatability study. "Treatability study" is a term used in RCRA to refer to a study in which a hazardous waste is subjected to a treatment process to determine specified elements such as whether the waste is amenable to the process or the optimal process conditions.¹⁶ The treatment investigated in the treatability study was macroencapsulation. In this treatment, waste is completely encapsulated with a specified material type to prevent leaching of the hazardous components out of the waste form. 925 lbs of fines, chips, and lead pieces were used in the study.¹¹

The encapsulating medium chosen was an epoxy that included both a resin and a hardener. The resin was an epoxy marketed by Dow Chemical and the resin hardener was manufactured by Pacific Ancor/Air Products.¹⁷ Prior to the study, many bench scale tests were performed with various mold sizes and equipment adjustments to identify optimum parameters for macroencapsulation of cast iron chips. The cast iron chips served as surrogate swarf.

Then actual lead and steel swarf was used in the treatability study part of the research. The treatability study was performed in the temporary accumulation area located in the Warm Shop of TAN-607. Swarf was placed in a container that served as a mold. Epoxy resin was added to the swarf in the container. After the epoxy had hardened, the monolith was removed from the mold. A larger mold was then used to encapsulate several of these monoliths with more of the same epoxy resin. This ensured that all sides of the waste were completely covered by a sufficiently thick layer of resin. The waste was subjected to various vacuum levels during epoxy introduction to investigate the effect on the resulting monoliths' tensile and compressive strength.

The tests on the swarf yielded a product that met RCRA's LDR requirements, so the resultant macroencapsulated forms can be disposed in an approved Subtitle C landfill such as that operated by Envirocare in Utah. Offsite shipment of the treated waste is pending at the time of this writing.

The treatability study enabled a treatment to be designed for the remaining swarf (and for swarf to be produced later in more cask dismantlements). Macroencapsulation of the remaining swarf is scheduled to begin soon at TAN. Detailed operating procedures for the treatment process have been written and reviewed.

The majority of the cask shells were determined to be radiologically contaminated. Since analysis of the shells showed that they did not fail the TCLP test, the shells were not a hazardous waste, and contaminated shells were disposed/stored at the RWMC as low-level radiologically contaminated waste. No attempts were made to decontaminate the contaminated steel.

Bulk contaminated lead continues to qualify as mixed waste. Therefore, the lead from the two casks and one lid that were determined to be volumetrically radiologically contaminated was transferred to the MWSF. This 4,950 lb of lead will be stored at the MWSF until an appropriate treatment for it is identified.

7. RECYCLABLE MATERIALS

7.1 Lead

The total amount of clean lead recovered from the 20 casks was 50,375 lb. If the total original weight of all 20 casks was 65,700 lb (this value can not be verified because not all casks were weighed to verify database records, and some contradictory weight values appear in various reports), the recovered clean lead represents 77% of the total original cask weight. The percentage would have been even higher had lead from 2 of the 20 casks not been rejected as potentially volume contaminated.

If the weight of contaminated lead is considered to be the sum of the weight of the lead and steel swarf (2,300 lb), plus the weight of the volumetrically contaminated lead (4,950 lb), total amount of contaminated lead for the project weighed 7,250 lb. The relatively lightweight steel filings contribute little on a weight percent basis to the swarf. The weight ratio of recyclable clean lead to contaminated lead is then about 7:1.

Lifting hooks built into the casks had steel structural supports extending through the steel outer shell and embedded in the lead. Some of this steel was not entirely removed from the clean lead. A recycler requirement was that the lead must be 99% pure. This requirement was easily met, even with the small amount of steel that had been left in the lead.

Due to the DOE Hazardous Waste Shipping Moratorium, lead recovered from the casks cannot be allowed to be shipped off-Site for recycle in the private sector unless it can be proven that no radionuclides have been added to the lead from DOE operations. Lead can be shown to naturally contain measurable levels of certain radionuclides, provided the measurement is sufficiently precise. In addition, historical evidence was present that at least some of the casks could have been constructed at the INEL with slightly contaminated used lead.^{2,18} It was therefore necessary to show that any radionuclides that may be present in the lead were there when the lead was acquired by the INEL and had not been added at the INEL as a result of DOE activities.

First, an investigation was conducted to determine the radioactive background level in lead that is commercially available on the secondary recycled lead market. This population of lead is the best representation of lead used at the INEL.⁶ The study revealed that commercial lead is essentially free of radioactive material. Only ²¹⁰Pb was detected, but this isotope is a naturally occurring component of most lead ores at the very low levels observed, so does not qualify as a "DOE-added" radionuclide.² Free-release criteria for INEL lead were developed and documented in WROC-EDF-237.⁶

A second study was conducted to determine whether the lead recovered from the casks was as radiologically "clean" as the commercial lead. Core samples were drilled from the recovered lead pieces and subjected to the same radioassay techniques used to determine the background for commercial recycled lead. No true positive radionuclides were detected for 15 of the 20 casks and for 9 of the 10 cask lids (see Table 2). Three casks had true positive indications of ²¹⁰Po, but it was known that this isotope is a decay product of the naturally occurring isotope ²¹⁰Pb that is

present in most lead ores, so did not represent a "DOE-added" radionuclide.² However, true positive radionuclides were detected in the lead from two casks and one cask lid. These three items were therefore deemed volumetrically radiologically contaminated, and were recommended to be shipped to the MWSF to be stored as mixed waste.²

The 1991 DOE-imposed shipping moratorium at the INEL ordinarily prevents off-Site shipment of any RCRA or TSCA regulated materials that had been located in radiologically controlled areas. Requirements and criteria for the survey, radioassay, and release of such materials are specified in *Performance Objective for Certification of Non-Radioactive Hazardous Waste*. WROC-EDF-264² documents that the requirements in the above document have been met. The Lead Management Project requested that DOE approve a special case exemption to release the cask lead. The request was approved, and in July of 1995, 50,375 lb of clean lead was shipped off-Site to the designated recycler, GNB Corp. in California.

7.2 Steel

During dismantlement, a portion of the steel was determined to be radiologically clean and was placed in a "recycle box" at the point of generation. However, most of the steel was determined to be radiologically contaminated and was placed in a "hot" waste box as it was generated. Information presented by B&W (see Table 4) shows that for the three casks/devices dismantled by B&W, the steel shells (both outer shell and inner vessel) weighed 1,224 lb. The percentage of the steel designated as clean by B&W is not known. EG&G Idaho's dismantlement of 17 casks resulted in the generation of about 5,100 lb of contaminated steel and about 2,500 lb¹¹ of clean steel. The ratio of contaminated shell materials to recyclable clean shell materials for EG&G Idaho is then about 2:1.

For this study, radiological decontamination of steel was not attempted because steel represented only a small percentage of cask weight. Decontamination attempts have the potential to generate excessive waste, which often becomes RCRA-regulated waste. Contaminated steel from this project was sent to the RWMC for storage/disposal as a radiologically contaminated low-level waste. Potential exists for such low-level waste metals to be either decontaminated, or remelted and formed into new metal objects designed specifically for continued use by the DOE complex in radiation areas. Similar projects in the future may pursue an option other than designating steel as radiologically contaminated and disposing it as such at the RWMC.

8. RESULTS SUMMARY

8.1 Dismantlement Activities

The 20 casks targeted for the project each weighed less than 14,000 lb, exhibited less than 20 mR contact radiation, was of steel and lead construction, and was contaminated with low levels of some of the following fission and activation products: ^{60}Co , ^{137}Cs , ^{134}Cs , ^{154}Eu , and ^{155}Eu . Table 1 contains a description for each cask prior to dismantlement.

In three of the 20 casks, the entire outside surface of the lead was determined to be radiologically contaminated with fission products after dismantlement. This contamination is thought to have occurred through leaks that developed in the steel shells' welds. Loading or unloading casks in underwater nuclear fuel storage areas may have contributed to the deterioration of those welds and the subsequent leak-through of radionuclides to the surface of the lead. The other casks either had no surface contamination or were contaminated in isolated spots only. Contamination of the lead was not an obstacle to project completion because it was expected that at least some of the lead might be radiologically contaminated.

As planned, the contaminated areas were decontaminated, which usually involved mechanical removal from the bulk of the lead. Lead particles and chunks removed during decontamination were combined with the lead and steel swarf that had been generated from cutting operations. These materials continued to be classified as mixed waste. Some of this mixed waste underwent a RCRA treatability study, in which a treatment for the waste was investigated. The treatment studied was a macroencapsulation with a particular epoxy.¹⁷ Information and data gathered during the treatability study has been used to design the actual treatment to be effected on the remaining swarf.

After each piece of lead requiring decontamination was decontaminated, and each piece was certified to be surface-clean, one final radiological test remained. This final test was a highly sensitive technique performed to determine whether the lead from any cask was volumetrically contaminated. Of the 20 casks dismantled, two of them (and one cask lid) were determined to be slightly volumetrically contaminated. These three devices were therefore no longer candidates for recycle at this time, and were designated as mixed waste.

The lead from the other 18 casks (and nine lids) that was both surface-clean and volumetrically clean, was recommended to be recycled.² Because the casks had been used to transport radioactive materials, the 1991 DOE-imposed Hazardous Waste Shipping Moratorium would ordinarily prevent the lead from leaving the INEL. A special case exemption request was prepared and submitted to DOE by the Lead Management Project to allow the lead to be shipped off-Site to the recycler. When the request was approved, the lead that had been verified to be clean was sent to the designated recycler, GNB Corp. in California.

At the completion of the dismantlement and survey project, approximately 50,375 lb of clean lead was recovered and recycled. Recyclable clean lead represents about 77% of the total original weight of the casks. Also, approximately 2,500 lb of clean lead shells were ready for recycle as scrap steel. The clean steel represents about 4% of the total original weight of the casks.

Table 1. Cask descriptions.

Item #	Cask ID number	Original total weight (lb)	Outside dimensions: diameter × length (in.) ^a	Thickness of shield (in.) ^b	Radiological readings of the steel lining prior to cask dismantlement ^c	
					Internal smear for loose contamination (Ci)	Contact reading on cask outside for contamination (mR/hr)
1	HS-102	5,620 ^a , 5,801 ^d	20 × 47	8	¹³⁷ Cs: 2.27×10^{-4}	< 1
2	HS-104	5,300 ^a , 5,732 ^d	20 × 47	7.5	⁶⁰ Co: 3.42×10^{-5} , ¹³⁷ Cs: 1.01×10^{-4}	< 1
3	HS-151	2,500 ^a	18 × 32.5	?	⁶⁰ Co: 3.07×10^{-6} ; ¹³⁴ Cs: 3.10×10^{-6} ; ¹⁵⁴ Eu: 8.41×10^{-7} ; ¹³⁷ Cs: 2.07×10^{-4}	4
4	HS-153	2,500 ^a	18 × 32.5	?	⁶⁰ Co: 2.98×10^{-6} ; ¹³⁴ Cs: 2.33×10^{-6} ; ¹³⁷ Cs: 6.54×10^{-4} ; ¹⁵⁴ Eu: 5.56×10^{-6} ; ¹⁵⁵ Eu: 2.25×10^{-6}	20
5	HS-154	2,500 ^a	18 × 32.5	?	⁶⁰ Co: 1.12×10^{-6} ; ¹³⁷ Cs: 2.23×10^{-4}	2
6	HS-202	1,800 ^a , 1,880 ^e	16.5 × 21.5	8	⁶⁰ Co: 2.5×10^{-5} ; ¹³⁷ Cs: 1.37×10^{-4}	< 1
7	HS-301	3,150 ^a	21 × 28	6	⁶⁰ Co: 4.12×10^{-6} ; ¹³⁷ Cs: 2.12×10^{-4}	1.5
8	HS-309	3,020 ^a	20 × 28	4.5	⁶⁰ Co: 2.3×10^{-5} ; ¹³⁷ Cs: 3.7×10^{-4}	4
9	HS-352	5,900 ^a	26.5 × 31	8	⁶⁰ Co: 9.88×10^{-6} ; ¹³⁴ Cs: 3.38×10^{-6} ; ¹³⁷ Cs: 1.82×10^{-4}	6
10	PP-2	330 ^a	9.5 × 13.5	1.5	⁶⁰ Co: 1.05×10^{-4} ; ¹³⁷ Cs: 5.23×10^{-4}	5
11	PP-3	330 ^a	9.5 × 13.5	1.5	¹³⁷ Cs: 2.28×10^{-4}	---
12	PP-4	330 ^a	9.5 × 13.5	1.5	⁶⁰ Co: 4.5×10^{-5} ; ¹³⁷ Cs: 1.88×10^{-3}	5
13	PP-5	330 ^a	9.5 × 13.5	1.5	¹³⁷ Cs: 2.27×10^{-4}	< 1
14	XMTR-5	1,100 ^{a,f}	13 × 25	2	⁶⁰ Co: 1.29×10^{-5} ; ¹³⁴ Cs: 1.07×10^{-6} ; ¹³⁷ Cs: 1.77×10^{-4}	< 1
15	Transfer Bell Ring (TBR)	1200 ^a , 2,271 ^{d,g}	(70 ^g) (ring-shaped)	(7.5 ^g)	¹³⁷ Cs: 1.00×10^{-13}	< 1

Table 1. (continued).

Item #	Cask ID number	Original total weight (lb)	Outside dimensions: diameter × length (in.) ^a	Thickness of shield (in.) ^b	Radiological readings of the steel lining prior to cask dismantlement ^c	
					Internal smear for loose contamination (Ci)	Contact reading on cask outside for contamination (mR/hr)
16	AEC 720-1404	1,200 ^a	14 × 45	?	None detected	< 1
17	TRA-077	500 ^a	11 × 14.5	?	⁶⁰ Co: 4.87×10^{-6} ; ¹³⁷ Cs: 2.29×10^{-7}	< 1
18	HCA-001	9,000 ^a	26 × 51	6	¹³⁷ Cs: 2.27×10^{-4}	< 1
19	HS Round Cask (HSRC)	3,321 ^a	24 × N/A (spherical)	?	¹³⁷ Cs: 2.27×10^{-4}	< 1
20	CFA Cask (CFAC)	14,000 ^a	28 × 72	?	¹³⁷ Cs: 2.0×10^{-4}	2

a. Taken from predismantlement cask inventory records, e.g., May 1992 TAN-647 RCRA Storage Inventory.

b. Taken from drawings stored in the project files.

c. Taken from letter JRC-12-94.¹⁹

d. Taken from a facsimile report on which B&W personnel had recorded actual weights.¹³

e. Taken from a specifications sheet in the project files.

f. A specifications sheet in the project files implies that the "liner" was an additional 230 lb.

g. Actual weight; taken from letter JCS-35-94.⁹

Table 2. Recovered lead.

Cask ID number	DOE subcontractor that performed the dismantlement	Radiological analysis of the recovered, surface-cleaned lead (pCi/gram)		Recommended disposition for the lead ^a	Weight (lb)	
		Of one representative sample of each cask (to determine presence or absence of volumetric contamination) ^a	Of samples of those casks with positive indications of volumetric contamination (to attempt to determine contamination distribution) ^b		Original total cask weight	Lead ultimately recovered for recycling
HS-102	Babcock and Wilcox	ND ^c	N/A	Recycle	5620 ^d , 5801 ^e	4670 ^e
HS-104	Babcock and Wilcox	ND ^c	N/A	Recycle	5300 ^d , 5732 ^e	4527 ^e
HS-151	EG&G Idaho	ND ^c	N/A	Recycle	2500 ^d	f
HS-153	EG&G Idaho	ND ^c	N/A	Recycle	2500 ^d	f
HS-154	EG&G Idaho	ND ^c	N/A	Recycle	2500 ^d	f
HS-202	EG&G Idaho	ND ^c	N/A	Recycle	1800 ^d , 1880 ^g	f
HS-301	EG&G Idaho	¹³⁷ Cs: 0.38 +/- 0.09	12 locations were sampled. 7 of the samples contained radionuclides at levels above their detection limits. ¹³⁷ Cs: ranged from ND ^c to 9.4 +/- 0.8 ⁶⁰ Co: ranged from ND ^c to 3.2 +/- 0.3	Ship to MWSF ^h	3150 ^d	None
HS-309	EG&G Idaho	²¹⁰ Po: 0.24 +/- 0.06 ⁱ	N/A ⁱ	Recycle ⁱ	3020 ^d	f
HS-352	EG&G Idaho	ND ^c	N/A	Recycle	5900 ^d	f
PP-2	EG&G Idaho	ND ^c	N/A	Recycle	330 ^d	f
PP-3	EG&G Idaho	ND ^c	N/A	Recycle	330 ^d	f
PP-4	EG&G Idaho	ND ^c	N/A	Recycle	330 ^d	f
PP-5	EG&G Idaho	ND ^c	N/A	Recycle	330 ^d	f
XMTR-5	EG&G Idaho	ND ^{c,j}	N/A	Recycle	1100 ^{d,k}	f

Table 2. (continued).

Cask ID number	DOE subcontractor that performed the dismantlement	Radiological analysis of the recovered, surface-cleaned lead (pCi/gram)		Recommended disposition for the lead ^a	Weight (lb)	
		Of one representative sample of each cask (to determine presence or absence of volumetric contamination) ^a	Of samples of those casks with positive indications of volumetric contamination (to attempt to determine contamination distribution) ^b		Original total cask weight	Lead ultimately recovered for recycling
Transfer Bell Ring (TBR)	Babcock and Wilcox	²¹⁰ Po: 0.05 +/- 0.02 ⁱ	N/A ⁱ	Recycle ⁱ	1200 ^d 2271 ^{e,i}	1723 ^{e,i}
AEC 720-1404	EG&G Idaho	²¹⁰ Po: 0.49 +/- 0.01 ⁱ	N/A ⁱ	Recycle ⁱ	1200 ^d	f
TRA-077	EG&G Idaho	ND ^c	N/A	Recycle	500 ^d	f
HCA-001	EG&G Idaho	ND ^c	N/A	Recycle	9000 ^d	f
HS Round Cask (HSRC)	EG&G Idaho	⁶⁰ Co: 0.24 +/- 0.06; ¹³⁷ Cs: 8.0 +/- 1.3	12 locations were sampled. 2 of the samples contained radionuclides at levels above their detection limits. ¹³⁷ Cs: ranged from ND ^c to 47 +/- 4	Ship to MWSF ^h	3321 ^d	None
CFA Cask (CFAC)	EG&G Idaho	ND ^c	N/A	Recycle	14000 ^d	f

Table 2. (continued).

Note: A total of 10 cask lids were also disassembled for recovery of the lead within each of them. One of the cask lids (the individual cask to which it originally corresponded was not tracked) was contaminated with Cs-137 at 1.2 (+/- 0.2) pCi/gram. Its duplicate sample was then analyzed, which confirmed the presence of Cs-137 contamination. The resultant recommended disposition for this lid's lead was to ship it to the MWSF. No true positive radionuclides were detected on the other nine lids' lead, and the recommendation was to recycle the lead from these nine lids.²

- a. Taken from EDF-WROC-264.^{2, 20, 21}
 - b. Taken from data in project files.
 - c. ND means that no manmade true-positive radionuclides were detected.
 - d. Taken from predismantlement cask inventory records, e.g., May 1992 TAN-647 RCRA Storage Inventory.
 - e. Taken from a facsimile report on which B&W personnel had recorded actual weights.¹³
 - f. Values were not tracked on a per cask basis, but total amount of recovered lead for all 20 casks (and the recovered lids) was 50,375 lb.
 - g. Taken from a specifications sheet in the project files.
 - h. MWSF is the Mixed Waste Storage Facility, an INEL interim status storage facility for low-level mixed waste in compliance with RCRA requirements for hazardous and PCB wastes (40 CFR 261 and 40 CFR 761). Waste is stored at the facility until treatment and disposal, in compliance with RCRA regulations, can be accomplished.
 - i. ²¹⁰Po, at the indicated level, is a naturally occurring isotope in lead.
 - j. The lead from cask XMTR-5 was cut into small chunks during surface decontamination of the lead. The clean chunks from this cask were placed into a box with other chunks generated during disassembly and decontamination. This box of lead scrap pieces exhibited a radiological reading of Non Detectable.²
 - k. A specifications sheet in the project files implies that the "liner" was an additional 230 lb.
 - l. Actual weight: taken from letter JCS-35-94.⁹
-

The average cost to dismantle the 20 casks was approximately \$21,000 per cask (the 17 casks dismantled at the TAN Hot Shop had an average dismantlement cost of \$13,600). Post-dismantlement treatment and recycling activities amounted to about \$86,000. These post-dismantlement activities included analyses on the lead to meet all requirements to allow its off-site shipment and recycle (\$64,936), macroencapsulation of the lead and steel swarf (estimated at \$8/lb, so \$18,400 total), and recycle of non-lead scrap metal (\$2,673). The total cost per pound of clean lead recovered for recycle was \$6.77/lb. Although the value of scrap lead on the market is about \$0.45/lb, the success of this project is a significant achievement in terms of waste reduction. The amount of waste to remain in RCRA storage as mixed waste was reduced by about 29 tons.

8.2 Sampling and Analyses

Table 3 lists samples collected and analyzed for the cask dismantlement study. One type of sample ensured personnel were protected from exposure to hazardous materials. Another sample type ensured materials were properly characterized for recycling/disposal purposes.

8.3 Product and Waste Stream Disposition

Radiologically clean lead is the primary product from this project. This clean lead is to be sent to an off-Site recycler, GNB Corp., where it will be smelted and used in the manufacture of lead-acid batteries. A secondary product is the radiologically clean steel. This clean steel will also be sent to an off-Site recycler.

Waste streams consist of contaminated lead, contaminated steel, used personnel protective equipment such as disposable coveralls and gloves, and process material such as blotter paper and HEPA filters.

At EG&G Idaho's direction, B&W kept track of the weights of the various components from the casks that they dismantled, as shown in Table 4. Product and waste stream quantities and disposition are shown in Table 5.

Table 3. Sampling and analysis.

Sample and analysis type	Time frame	Taken by	Media or item sampled	Reason for the samples	Results
Internal smears and contact readings for contamination	Prior to cask storage at TAN-647	EG&G	Surface of the casks (the steel cladding was what was exposed at the time)	Determine level of radiological contamination to comply with WAC requirements of the RCRA storage facility, and to ensure proper controls were in place for shipment.	Most of the casks had measurable radiological contamination, but at low levels.
Survey for contamination: - at contact - at 1 m - smears for loose contamination	Prior to Demo. study on HS-101	B&W	Cask HS-101's outer surface (i.e., the carbon steel shell)	Determine if the cask is radiologically contaminated, either with loose or fixed contamination, and if so, to what extent.	No detectable radiation was found except at the front end plug/lid (1 mR/hr). Only very low levels of contamination were detected from smears, mostly near the front and rear end plugs.
Survey for background radiation and contamination	Prior to placing HS-101 in enclosure, and prior to removing its outer shell	B&W	Cask enclosure	Determine background levels for comparison purposes.	No detectable radiological contamination was found within the cask enclosure during either survey.
Analysis of special personnel dosimeter badges for radiation	During Demo. on HS-101	B&W	Thermoluminescent Dosimeter badge film	Measure the amount of ionizing radiation that workers' bodies may have been exposed to from this project alone.	No personnel doses were reported.
Air exiting portable HEPA filters for radionuclides	During Demo. on HS-101	B&W	Filtered air exiting the enclosure containing cask HS-101	Ensure no radionuclides were escaping the air filtration system.	No evidence of loss of containment was reported.
Smears for contamination on steel	During Demo. (after HS-101's end plugs were removed)	B&W	Inside surface of Cask HS-101's cavity	Determine contamination levels in the inner vessel.	No detectable levels of contamination.
Survey for contamination on steel	During Demo. (After removal of outer shell of cask HS-101)	B&W	Inner surface of HS-101's outer shell	Determine whether the inside of the outer shell was contaminated, and if so, to what extent.	No detectable radiological contamination on the inner surface of the outer steel shell.
Monitors on TAN Hot Shop emissions stack measure air samples for radionuclides	Whenever TAN-607 is operating	EG&G	Air exiting TAN-607 stack	Measures the release of radioactive halogens, noble gases, gross beta emitting particles from the stack.	No releases were reported.
Survey for contamination: - at contact - at 1 meter - smears for loose contamination	During Demo. on HS-101	B&W	Outer surface of Cask HS-101's lead before the lead had been halved lengthwise	Check for loose contamination on the lead once the steel shell had been removed.	No detectable radiation was found except at the front end plug/lid (1 mR/hr). Only very low levels of contamination were detected from smears, mostly near the front and rear end plugs. The lead was then decontaminated.

Table 3. (continued).

Sample and analysis type	Time frame	Taken by	Media or item sampled	Reason for the samples	Results
Survey for contamination	During Demo. on HS-101	B&W	Surfaces of HS-101's lead after it had been halved lengthwise	Ensure the newly exposed lead surface was radiologically clean.	Some minor contamination was initially detected, but the lead was subsequently decontaminated. Final surveys revealed no detectable contamination on the lead.
Painted carbon steel liner for TCLP metals (samples were cut into small pieces first)	After Demo. on HS-101, and after pilot dismantlement of B&W's casks	B&W	Casks' (painted) steel liners	Determine if the materials were RCRA-hazardous due to presence of possible lead-based paint and/or due to the metals composing the steel linings.	The paint and steel are not RCRA hazardous (i.e., the samples did not fail the TCLP test for heavy metals).
Lead (removed by drill) and analyzed by the recycler	Prior to Pilot Study dismantlement	B&W	Internal (not just surface) cask lead	Determine if lead purity was acceptable to the identified recycler.	Lead purity was well within bounds established by the recycler (99%).
Lead levels in workers' bloodstreams	Before, during, and after Pilot Study dismantlement	B&W and EG&G	Workers' blood	Verify that the workers had been adequately protected from lead entering their bodies.	The workers did not have elevated lead levels in their blood, verifying that they had been adequately protected.
Shavings of commercial lead for high accuracy alpha ^a and gamma ^c counting	Prior to Pilot Study dismantlement	EG&G	Shavings taken from commercial lead	Determine what radionuclides (and amounts of each) are ordinarily present in commercial lead.	Commercial lead is essentially free of radioactive material. Detected activity was from very low levels of Pb-210 (and its decay products), a naturally occurring component of lead.
Radiological screening with hand held instruments of lead extracted from the casks by drill bit	Prior to Pilot Study dismantlement	EG&G	Internal (not just surface) cask lead	Initial determination of internal contamination level of lead in each cask. If any cask's lead exhibited readings above background at this point with this method, the decision to dismantle it would have been re-evaluated. Also ensured that the lead shielding was in the form of a solid core rather than lead shot.	No readings above background were observed with this method. (This method would have resulted in readings above background only if contamination levels had been very high.) The lead was a solid core rather than being in the form of lead shot.
Core samples and external smears of HS-104's lead for radiological contamination	During Pilot Study dismantlement	B&W	Internal and external samples of the lead	Determine the extent of contamination on the lead, which was detected after the steel shell was removed.	Contamination was fixed ²² to the outside surface only of the lead. The contaminated outside surface was then decontaminated by being machined off.

Table 3. (continued).

Sample and analysis type	Time frame	Taken by	Media or item sampled	Reason for the samples	Results
Smears for loose contamination and direct-reading radiation survey measurements for fixed contamination (beta/gamma and alpha)	During Pilot Study dismantlement	B&W	All materials from the casks, particularly newly exposed metal surfaces	Locate potential hot spots as materials were newly exposed. Ensure high levels of radiation were not present in the materials. Ensure lead was not so highly contaminated so as to make efforts to keep it clean in vain. Ensure clean lead did not become contaminated. Determine if lead is contaminated on its surface with loose or fixed contamination (if it was, it was decontaminated and re-tested to verify adequacy of cleanup). Determine if recovered steel is radiologically clean.	No indications were present that dismantlement activities were contaminating previously clean lead. No high levels of radioactivity were detected. Some of the lead did have some surface contamination, which subsequently was removed by various methods such as wiping, chipping, slicing off contaminated portions with a saw blade on a machine tool. Clean or surface-decontaminated lead was retained as candidate for recycle. Steel determined to be "clean" was placed in a "recycle box" for steel.
Smears for loose contamination and direct-reading radiation survey measurements for fixed contamination (beta/gamma and alpha)	During Pilot Study dismantlement	EG&G	All materials from the casks, particularly newly exposed metal surfaces	Ensure lead was not so highly contaminated so as to make efforts to keep it clean in vain. Ensure clean lead did not become contaminated. Ensure high levels of radiation were not present in the materials. Determine if recovered steel is radiologically clean.	No indications were present that dismantlement activities were contaminating previously clean lead. No high levels of radioactivity were detected. Steel determined to be "clean" was placed in a "recycle box" for steel.
Personnel air sampling for airborne lead	During Pilot Study dismantlement	B&W and EG&G ^a	Air near the workers' faces while workers were in the enclosure with the cask materials	Although workers wore respirators, it was important to determine the levels of airborne lead to verify that respiratory protection used was adequate. Also determined what the workers' exposure might have been had respirators not been worn, or worn improperly.	During some activities the airborne lead levels exceeded the action level, but for most of the work, the airborne lead levels were low. The respiratory protection prescribed was appropriate and had been properly used.
Lead chips for radiological contamination	After Pilot Study dismantlement	B&W	Chips of lead that were generated during machining of casks HS-104 and HS-102	Determine level of contamination of the lead chips.	Inconclusive: no radionuclides were detected in any of the samples with the analytical technique used; however, B&W invalidated these results because hand-held friskers had detected measurable levels of radioactivity on outside of casks before dismantlement.

Table 3. (continued).

Sample and analysis type	Time frame	Taken by	Media or item sampled	Reason for the samples	Results
Direct-reading radiation survey measurements for fixed contamination (beta/gamma and alpha)	After Pilot Study dismantlement	EG&G	Surface of all pieces of lead from all 20 dismantled casks	Ensure each piece of lead was clean radiologically on its surface. Lead identified as being surface-contaminated was decontaminated. Lead deemed clean by this method was still a candidate for recycle and was identified to undergo a final test to verify absence of volumetric contamination.	Some of the lead did have some surface contamination, which subsequently was removed by various methods such as wiping, chipping, cutting off contaminated portions with electric hand tools. After decontamination, the majority of the lead from each cask was ultimately deemed surface-clean.
Core samples of surface-clean lead for high accuracy alpha and gamma counting	After Pilot Study dismantlement and after surface decontamination of all lead	EG&G	Internal (volumetric) samples from all pieces of lead from all 20 dismantled casks	Determine if the lead was volumetrically contaminated. At this point, since the lead had already been deemed surface-clean, the analytical results help determine final disposition of the lead.	The majority of the lead is not volumetrically contaminated, so it can be recycled. The lead from the 2 casks and one lid that <u>did</u> contain a small amount of volumetric contamination will continue to be classified as mixed waste.
Core samples of the 2 casks and 1 lid that had been determined to be volumetrically contaminated	After Pilot Study Dismantlement and after volumetric contamination was indicated via previous sample analyses	EG&G	Internal (volumetric) samples from all pieces of lead from the two casks and 1 lid that were determined to contain volumetric contamination	Determine distribution of the contamination throughout the cask lead (it was expected the contamination would be fairly evenly distributed). The lid was too small for such an objective, so instead, a duplicate lid sample was analyzed to confirm contamination.	The sample results showed that man-made gamma-emitting radionuclides were indeed present in cask HS-301's lead (found in 7 of the 12 samples). HSRC's contamination was not distributed as evenly (only 2 of the 12 sample locations had true-positive radionuclides). The duplicate lid sample confirmed contamination of the lid.

Note: Dismantlement of cask HS-101 was not part of the pilot study. Instead, HS-101 was dismantled earlier during the initial demonstration study in August 1993. Samples collected on/for it have been included to show greater sample frequency and type imposed for this first INEL cask dismantlement.

a. Analyzed by EG&G Idaho's Industrial Hygiene Department, using MSA Escort samplers at an average flow of 1.5 liters/min. Samples were collected on 37 mm, three piece, 0.8 μ m, MCE filters, with support pad (CLindstrand letter, CML-02-95).

b. Analyzed by Analytical Radiochemistry Laboratory for total spectrometric alpha analyses.

c. Analyzed by the Radiation Measurements Laboratory (RML) using standardized high resolution gamma-ray spectrometry techniques.

Table 4. Babcock and Wilcox cask component weights.

	Original weight of casks ^a	Clean lead recovered for recycle ^a	Contaminated lead chips and plugs ^a	Carbon steel outer shell ^a	Inner vessel including foam ^a	Cables and cradle ^a	% of lead available for recycle ^a	% of lead recycled per whole cask ^a
HS-101 ^b	5995.00 ^b	5300.00 ^b	200.00 ^b	312.00 ^b	45.00 ^b	138.00 ^b	96 ^b	88 ^b
TBR	2271.00	1723.00	20.00	528.00	0.00	0.00	99	76
HS-104	5732.50	4527.00	735.00	301.50	34.00	135.00	86	79
HS-102	5800.80	4670.00	628.30	319.50	41.50	141.50	88	81
Averages	4949.83	4055.00	395.83	365.25	40.17	138.17	92	81
Total weight	19,799.30	16,220.00	1583.30	1461.00	120.50	414.50	N/A	N/A

a. Taken from a facsimile report.¹³

b. Dismantlement of cask HS-101 was not part of the pilot study. Instead, HS-101 was dismantled during the initial demonstration project (August 1993). Weights of its components have been included in this report to show additional data points only.

Table 5. Product and waste stream quantities and dispositions.

Stream name	Stream type		Weight (lb)			Disposition
	Product	Waste	For B&W's three casks	For EG&G Idaho's 17 casks	For all 20 casks	
Recyclable clean lead	✓		10,920 ^a	39,455 ^b	50,375 ^c	To be shipped to an off-Site recycler to be used in the manufacture of lead acid batteries.
Lead volumetrically contaminated		✓	0	4,950	4,950 ^c	To be stored at the MWSF as a mixed waste until an appropriate treatment is identified.
Lead and steel swarf plus pieces of lead removed during decontamination		✓	1,383 ^a	925 ^d (14% swarf and 86% pieces from decon)	~2,300 ^c	To be treated and disposed at Envirocare. 925 lb was used in a RCRA treatability study. ^d The remainder is to undergo a macroencapsulation treatment.
Recyclable clean steel	✓		?	?	~2,500 ^d	To be combined with other clean scrap steel routinely generated at the INEL and routinely recycled off-Site.
Contaminated steel		✓	?	?	~5,100 ^c	To be stored at the RWMC as radiologically contaminated Low-level waste.
Personal protective equipment and process materials (blotter paper, rags, HEPA filters)		✓	?	?	?	To be sent to WERF for incineration as low-level waste, except for HEPA filters. HEPA filters will qualify as either a mixed or a low-level waste and will be disposed accordingly.

a. Taken from a facsimile report.¹³

b. The difference between the weight reported for all 20 casks and the weight reported for B&W-dismantled casks.

c. Recorded by EG&G Idaho's TAN Operations in May 1995.

d. Taken from Final Report for the 17 EG&G Idaho-dismantled casks.¹¹

8.4 Lessons Learned

- **Drawing accuracy/retrievability:** Some guess work was necessary regarding actual cask construction. Drawings that were available were sometimes not accurate. Several of the casks had old and inaccurate drawings or poorly defined diagrams or sketches. No drawings or sketches could be found for some casks.
- **Foaming of the inner vessel:** A method was devised to prevent the spread of potential contamination. A urethane foam was sprayed into the internal cavity of each cask after the lid was removed. After the foam hardened, the contamination was fixed and the openings were sealed. The lead was cut away from the internal vessel so that the internal vessel could be removed in one piece. This method of containing any potential spread of contamination to workers, equipment, or lead liners worked extremely well.
- **Radiation levels:** In almost every case, the radiation levels measured during dismantlement were significantly lower than was anticipated, based on information in the TAN-647 inventory database. Measurements for the inventory database had been taken prior to transporting the casks to TAN-647 for storage.
- **Removal of steel lining:** The steel lining on the outside of the cask was relatively easy to remove. However, the steel lining on the inside of the cask's cavity (the inner vessel) was not easily freed from the attached lead. This was thought to be due to the lead having contracted around the inner vessel as it cooled from its molten state. It was desirable to remove the inner vessel intact, since its inside surface had the greatest potential for being radiologically contaminated. This was accomplished, but after some trial and error. Initially, for a cask with two openings, B&W attempted to remove the inner vessel by pushing it out through the large plug end, using a pusher/puller device that had been fabricated for that purpose. This method was not successful, either due to shrinkage of the lead around the inner vessel or a drawing discrepancy that resulted in actual configuration of the small end plug opening being unknown. B&W eventually freed the lead by cutting it away from the inner vessel using a cutting blade on the milling machine. EG&G Idaho then initially attempted to do the same thing with saws. However, this method did not prove to be efficient, and EG&G Idaho ultimately resorted to use of the portable jack hammers to cut away the lead from the inner vessel. A "v" slot was cut the full length of the lead with jack hammers down to the inner vessel. The inner vessel could then be removed. This method worked well for EG&G Idaho and was used on the remaining casks.
- **Lead exposure:** No airborne lead exposure occurred to personnel and methods were developed to further reduce airborne lead. Airborne lead levels had been of concern to the Industrial Hygiene personnel because the activity had not been performed before at the INEL. In addition, it was known that some experimentation would be necessary to determine the best tools and methods to accomplish the task. The ventilation systems used, in combination with the fact that workers always wore appropriate respirators, ensured that personnel were adequately protected from exposure to lead at all times. A technique to reduce airborne lead was developed for future production scale

dismantlements. This highly successful technique involves spraying small amounts of soapy water on the materials while activities known to cause airborne lead are ongoing.

- Extensive radiological surface contamination: Despite the fact that cask lead is clad in steel, it can be extensively surface-contaminated with fixed contamination. On three of the 20 casks, surface contamination distributed over practically the entire outside surface of the lead was found. This contamination was removed by machining it off. The three cask surfaces had to be essentially "shaved" to remove all the outer surface contamination. This contamination was attributed to holes having formed in the shells' welds rather than by cross contamination from the dismantlement work. It was speculated that loading and unloading casks in under water storage pools may have contributed to weld failure and subsequent leakage of contaminated water into the cask between the outer steel shell and the outside surface of the lead.
- Volumetric contamination of lead: Process knowledge cannot be used as a basis to state that INEL cask lead is not volumetrically contaminated. Two of the 20 casks were found to contain volumetric contamination. These casks may have been constructed with slightly contaminated lead, the occasional practice of which was verified by retired former Lead Shop employees. The lead from these casks was no longer a candidate for recycle after volumetric contamination was detected, and this contaminated lead was transferred to the MWSF for storage as a mixed waste.
- Macroencapsulation of swarf: Swarf containing lead chips, filings, and chunks (which is a mixed waste in this case), can be adequately treated in accordance with RCRA regulations by double macroencapsulation in an epoxy resin, using the methods, equipment, and materials identified in the draft report, "Report and Analysis of the Treatability Study of Macroencapsulation of Lead and Steel Swarf".¹⁷

9. CONCLUSIONS

- Some cask lead has detectable levels of bulk DOE-Rad Added.
- Most surface contamination can be removed.
- Dismantlement can be conducted safely and efficiently in the TAN Hot Shop.
- Exposures of personnel to lead uptake can be controlled and limited within allowable concentrations by using personal protective equipment.
- No increased concentrations of lead in the blood of dismantlement workers was detected.
- Most of the lead retrieved from dismantlement activities can be certified to be in compliance with the release criteria for the DOE Hazardous Waste Shipping Moratorium, and can therefore be free-released for recycling.
- All secondary waste streams can be treated and disposed.
- Lead not passing free-release criteria can be reclassified as mixed waste and placed back into RCRA storage at the INEL.
- Cask steel shell materials that have low-level radiological contamination can be characterized and submitted to the RWMC for disposal as low-level waste. It is possible that the steel could be recycled using private sector provided technologies and facilities.
- Lead and steel swarf resulting from the dismantlement and decontamination activities can be macroencapsulated using epoxy.
- The macroencapsulation method will produce an encapsulation of lead and steel swarf that meets the RCRA criteria for encapsulation of a hazardous material and that can be characterized to meet current criteria for disposal in a RCRA Subtitle C landfill such as that provided by Envirocare in Utah.
- The average cost for macroencapsulation of lead and iron swarf generated from cask recycling was approximately \$8.00/lb of lead. This cost is the result of a treatability study. Continued macroencapsulation work could be accomplished at a lower cost.
- For this pilot scale study, the average cost for cask dismantlement was \$21,000/cask or \$6.77/lb of lead recycled.

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