LA-UR-15-28900
November 2015
Revision A

# Engineering Options Assessment Report: Nitrate Salt Waste Stream Processing

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## EXECUTIVE SUMMARY


This report examines and assesses the available systems and facilities considered for carrying out remediation activities on remediated nitrate salt (RNS) and unremediated nitrate salt (UNS) waste containers at Los Alamos National Laboratory (LANL). The assessment includes a review of the waste streams consisting of 60 RNS, 29 aboveground UNS, and 79 candidate belowground UNS containers that may need remediation. The waste stream characteristics were examined along with the proposed treatment options identified in the Options Assessment Report[1]. Two primary approaches were identified in the five candidate treatment options discussed in the Options Assessment Report: zeolite blending and cementation. Systems that could be used at LANL were examined for housing processing operations to remediate the RNS and UNS containers and for their viability to provide repackaging support for remaining LANL legacy waste.

The waste streams for RNS and UNS differ not only in the presence of organic kitty litter found in the RNS drums but also in the amount of and type of debris as well as the free liquid content. RNS drums contain significant volume percentage of debris waste while the UNS waste is relatively free of debris. Conversely, RNS drums are nearly free of free liquids while the UNS drums all can be expected to contain free liquids. These differences, along with the related radiological makeup, were considered when assessing the treatment process and associated containment systems.

The preferred treatment option is blending the waste with zeolite (although the efficacy of this option needs to be confirmed early with ignitability [D001] testing). Blending with zeolite was the top remediation option identified in both the Options Assessment Report[1] and was originally proposed as the best option for remediation by Clark and Funk in their report, Chemical Reactivity and Recommended Remediation Strategy for Los Alamos Remediated Nitrate Salt (RNS) Wastes[2]. It would also be the least complex to install and implement in the available glovebox systems. Blending requires little or no modification to the glovebox, is operationally simple, and has been shown to be effective at treating nitrate salt surrogates to remove the ignitability (D001) characteristic[3]. Two approaches were considered: batch blending (1) using 3- to 5-gallon blenders to batch blend nitrate salt waste with zeolite in the glovebox or (2) adding salt waste directly to drums preloaded with zeolite and bulk blending in the drum using a drum tumbler. Bulk blending in the drum is the preferred option but will require extensive proof testing. This option, if effective, is less complicated and reduces the radiation dose to operators. The fall-back option would be batch blending in the glovebox.

Cementation is more complex to install, is operationally more complicated, and adds additional risks. The cementation process requires repulping the salt/Swheat in water, adjusting the pH, transferring cement, mixing cement, and curing the product. Accommodating these operations requires installing equipment, modifying the glovebox and the facility, and adding complexity to the operations. Additionally, the cementation process is not reversible, is time dependent, and generates heat—all of which add risk.


[1] Options Assessment Report: Treatment of Nitrate Salt Waste at Los Alamos National Laboratory (B.A. Robinson, P.A. Stevens)

[2] Reactivity and Recommended Remediation Strategy for Los Alamos Remediated Nitrate Salt (RNS) Wastes (D.L. Clark, D.J. Funk: LA-UR-15-22393)

[3] Results of Oxidizing Solids Testing (Energetic Materials Research and Training Center Report FR 10-13) (G. Walsh, New Mexico Institute of Mining & Technology, Socorro, NM; March 2010)

Six processing/repackaging systems were examined and assessed for their applicability to support zeolite blending and cementation of RNS and UNS waste streams. These systems options were as follows:

- Waste Characterization Reduction and Repackaging Facility (WCRRF) glovebox
- Mobile Visual Examination and Repackaging (MOVER) trailer
- Mobile Repackaging (MORK) system
- Modification of available on-site gloveboxes for placement in 231 Perma-Con®
- Fabrication of a new glovebox
- Relocation of the WCRRF glovebox

The preferred processing/repackaging system is the WCRRF glovebox because it provides the least risk, least equipment and facility modifications, least authorization basis (AB) modification, adequate flexibility, and likely the optimal path to remediating the nitrate salt drums. The glovebox is well configured to accommodate blending with zeolite but is less amenable to supporting cementation, especially cementing in the glovebox because of space limitations and material-handling requirements associated with the cementation process. The WCRRF Basis for Interim Operation is already in place, and updating to allow for nitrate salt processing should be straightforward because similar operations have been performed at WCRRF, although not with the same hazards. The infrastructure is in place and has been well tested for the last 20 years. Transporting the waste and refrigerating it at WCRRF are negative aspects of this option because they introduce additional cost, safety concerns, and coordination difficulties. The reliability of a proven, tested, and operating glovebox that is approved for 800 equivalent combustible plutonium-equivalent curies (ECPE-Ci), compared with modifying or relocating competing systems that may require modification, have no operating record, and have no current LANL AB, make WCRRF the best choice for the short term to handle the nitrate waste streams.

Installing a glovebox in a Perma-Con® in Building 231 (a fabric-covered dome) to support nitrate waste repackaging and the remaining LANL legacy waste could provide added flexibility and may be a relatively inexpensive option to augment repackaging, depending upon AB requirements. Two issues need to be resolved for this option: (1) the necessity to provide a Safety Significant glovebox for worker protection and (2) the allowable ECPE-Ci for any drum in process. These are both AB issues that should be analyzed to determine if they can easily be resolved before moving forward with this option. The safety basis control will impact the specifics of the glovebox that may be utilized, the design and fabrication/modification requirements, and ultimately, the operating requirements. The flexibility to configure a new glovebox for drum repackaging and locate it in an open floor plan like a Perma-Con® room is an attractive option for a large subset (~3900 drums) of legacy waste that contain less than 18 ECPE-Ci.

If an additional capability is desired at Technical Area 54 for higher content plutonium-equivalent curie (PE-Ci) legacy waste containers, WCRRF can be utilized until a new system is installed, configured, tested, and approved for use. This ensures a repackaging capability is available and mitigates schedule risk that may be associated with initiating a new system. MORK, the only other system evaluated that is designed to handle more than 18 ECPE-Ci, has hurdles that must be overcome, including decontamination, transportation, and siting to meet seismic requirements. Maintaining the WCRRF glovebox operation ensures a viable capability until an alternate system can be approved, installed, tested, and brought online.

A concern that remains unresolved is the path forward for debris found in the RNS and UNS waste containers. It is unclear if the debris stream should be considered D001 and requires treatment. Early surrogate testing to determine if debris waste separated from the RNS or UNS drums is ignitable (D001) should be initiated. Transuranic debris waste that is D001 cannot be sent to the Waste Isolation Pilot Plant unless the D001 characteristic is removed. Results from surrogate testing will drive handling and processing this waste stream after it is separated from the salt wastes.

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**Acronyms and Abbreviations**

| | |
|---|---|
| AB | authorization basis |
| ALARA | as low as reasonably achievable |
| BIO | basis for interim operation |
| CAM | continuous air monitoring |
| CC | contributing causes |
| CCP | Central Characterization Project |
| CFR | Code of Federal Regulations |
| CMR | Chemistry and Metallurgy Research (facility) |
| DOT | Department of Transportation (U.S.) |
| dpm | disintegrations per minute |
| DSA | documented safety analysis |
| ED | electrostatic discharge |
| ECPE-Ci | equivalent combustible plutonium–equivalent curies |
| EMRTC | Energetic Materials Research and Training Center |
| EPA | Environmental Protection Agency (U.S.) |
| FGE | fissile gram equivalent |
| FOD | Facilities Operation Division |

| | |
|---|---|
| GBE | walk in glovebox |
| HEPA | high-efficiency particulate arresting |
| hp | horsepower |
| HVAC | heating, ventilation, and air conditioning |
| JON | judgement of need |
| LANL | Los Alamos National Laboratory |
| LLNL | Lawrence Livermore National Laboratory |
| LLW | low-level waste |
| LTA | |
| MAR | material at risk |
| MLLW | mixed low-level waste |
| MORK | Mobile Repackaging (system) |
| MOVER | Mobile Visual Examination and Repackaging |
| MSA | management self-assessment |
| MU | modular unit |
| NEPA | National Environment Policy Act |
| NMED | New Mexico Environment Department |
| ORR | operational readiness review |
| PAAA | Price-Anderson Amendments Act |
| PC | performance category |
| PDSA | Preliminary Documented Safety Analyses |
| PE-Ci | plutonium-equivalent curie |
| POC | pipe overpack |
| PPE | personal protective equipment |
| QA | quality assurance |
| RC | root cause |
| RD&D | research development and demonstration |
| RLW | Radioactive Liquid Waste (facility) |
| RNS | remediated nitrate salt |
| RTR | real-time radiography |
| SCO | surface contaminated object |
| SME | subject matter expert |
| SRS | Savannah River Site |
| SSC | safety significant component |
| SSSR | sort segregate, size reduction, and repackaging |
| SWB | standard waste box |
| TA | technical area |
| TSR | technical safety requirement |

| | |
|---|---|
| TRU | transuranic |
| UNS | unremediated nitrate salt |
| WAC | waste acceptance criteria |
| WCRRF | Waste Characterization Reduction and Repackaging Facility |
| WCS | Waste Control Specialists, LLC |
| WIPP | Waste Isolation Pilot Plant |

# 1.0 INTRODUCTION

## 1.1 Objective

This white paper examines the possible options related to repackaging the nitrated salt waste streams that currently exists at Los Alamos National Laboratory (LANL) for shipment to the Waste Isolation Pilot Plant (WIPP). More specifically the goal is to:

> *identify and assess the options for processing/repackaging the LANL waste drums containing reactive nitrate salts (both Remediated with Swheat and Unremediated) as well as other below grade drums that have yet to be removed for shipment to WIPP. Solutions that could accommodate drums at other locations or could be duplicated at other locations are of interest.*

The primary goal is to treat and repackage the remediated nitrate salt (RNS) drums and unremediated nitrate salt (UNS) drums that remain at LANL for WIPP acceptance. RNS drums are those that were repackaged from UNS drums with organic kitty litter (Swheat) with an intention to meet the WIPP waste acceptance criteria (WAC).

## 1.2 Background

The focus of this paper is on evaluating the available systems—gloveboxes and facilities—that may be used for processing and repackaging the RNS and UNS drums. Previous studies are used as guidance and a basis for selecting and evaluating candidate systems. These studies include the following:

- Chemical Reactivity and Recommended Remediation Strategy for Los Alamos Remediated Nitrate Salt (RNS) Wastes (D.L. Clark, D.J. Funk: LA-UR-15-22393)
- Options Assessment Report: Treatment of Nitrate Salt Waste at Los Alamos National Laboratory (Bruce Robinson)
- Results of Oxidizing Solids Testing (Energetic Materials Research and Training Center [EMRTC] Report FR 10-13)
- Amount of Zeolite Required to Meet the Constraints Established by EMRTC (LANL-Carlsbad Office Difficult Waste Team: LA-UR-14-26860)
- Cementation study notes of surrogate nitrate salts and Swheat from Robert Wingo

The RNS drums that remain at LANL include 60 identified drums, of which 57 were repackaged with an organic kitty litter and 3 were repackaged with Waste Lock-770. The organic kitty litter, primarily a wheat-based product called Swheat Scoop, was added to the UNS during repackaging to absorb free liquids and remediate the ignitability characteristic of the nitrate salts. The resulting mixture was repackaged in daughter drums that became the RNS waste stream.

Swheat was found to increase the hazard associated with the UNS waste by creating a potential for exothermic chemical reactions[1]. After a release at WIPP from a stored LANL RNS drum containing Swheat, LANL initiated steps to isolate all remaining RNS waste drums located at LANL. The drums were overpacked in standard waste boxes (SWB) and placed in a Perma-Con®, in Dome 375, at Area G

[1] Options Assessment Report: Treatment of Nitrate Salt Waste at Los Alamos National Laboratory (B.A. Robinson, P.A. Stevens)

located in Technical Area 54 (TA-54). The RNS drums are being stored in a temperature-controlled environment to mitigate the oxidizing behavior of the waste in the drums. LANL also designated all remaining RNS drums at LANL as "ignitable," assigning U.S. Environmental Protection Agency (EPA) Hazardous Waste Number D001 after independent reactivity testing on surrogate samples containing Swheat and sodium nitrate salt[2]. Those drums containing free liquid have also been assigned D002 (corrosive) waste code.

The UNS drums remaining at LANL include 29 aboveground drums stored in a Perma-Con® in Dome 231 at Area G at TA-54 and approximately 79 candidate drums remaining belowground in Pit 9 and Trenches A, C and D. The 29 aboveground UNS drums were designated "ignitable" and those with identified liquid were deemed "corrosive," as defined by EPA Hazardous Waste Numbers D001 and D002, respectively. The waste is considered ignitable because of the nitrate salt content and corrosive because of the presence of free acidic and nitrate salt–bearing liquids.

An Options Assessment Report was prepared to evaluate various treatment options for the RNS and UNS waste streams to allow removal of their hazardous characteristics and in response to a New Mexico Environment Department– (NMED-) issued Administrative Order. This assessment identified five candidate treatment options for remediation of both RNS and UNS drums at LANL. The preferred options included dry blending with zeolite and cementation as the primary unit operations for remediating the drums. This evaluation provides a review and assessment of the available process approaches and associated gloveboxes and facilities for implementing the remediation.

## 2.0 APPROACH

To effectively evaluate the available and potential systems that could be used for processing and repackaging RNS and UNS waste the following steps were utilized: characterizing the waste stream, evaluating treatment options, reviewing processing and repackaging systems, and assessing treatment options.

### 2.1 Waste Stream Characterization

Processes modify or alter feed stocks to meet product requirements. Understanding the feed stream characteristics and the product requirements ensures that the operations, process conditions, and equipment selection are based upon pertinent information. The feed stream for this study is limited to the RNS and UNS waste drums at LANL. Available information on these drums was collected and evaluated to properly characterize the feed stream that will be processed and repackaged.

### 2.2 Treatment Options Evaluation

The recently completed options assessment report, Options Assessment Report: Treatment of Nitrate Salt Waste at Los Alamos, identifies five candidate process alternatives. The highest-ranked alternative is the blending of zeolite with RNS or UNS salts. The other four options include a cementation step:

1. Zeolite addition without cementation
2. Zeolite addition with cementation

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[2] Reactivity and Recommended Remediation Strategy for Los Alamos Remediated Nitrate Salt (RNS) Wastes (D.L. Clark, D.J. Funk: LA-UR-15-22393)

3. Dry process and cementation without zeolite
4. Wet Process and cementation without zeolite addition
5. Salt dissolution with cementation

Dry blending with zeolite and cementation were investigated as two different processing options for remediating the RNS and UNS drums, although the results are easily transferrable to the three remaining options.

### 2.3 Processing/Repackaging Systems

A review of the options available for remediating and repackaging the nitrated salt streams (RNS, UNS, and belowgrade) are presented. It is anticipated that the system will be used to process the nitrated salt waste streams using either blending or cementation, as described in Section 4. The repackaging systems examined include the following:

- existing on-site systems Waste Characterization Reduction and Repackaging Facility (WCRRF) glovebox and Mobile Visual Examination and Repackaging (MOVER)
- Mobile Repackaging ([MORK] a mobile, modular system at Savannah River Site [SRS])
- existing gloveboxes that would require modification
- fabrication of a new glovebox
- relocation of the WCRRF glovebox to TA-54

Processing the drums at TA-55 or at Chemistry and Metallurgy Research (CMR) was considered and investigated but excluded because the systems do not have the ability to accept waste drums as parent drums for bagging on to remove the waste stream for processing. The addition of this stream would likely require significant changes to the TA-55 and CMR safety basis as well, further reducing the attractiveness of this option.

### 2.4 Assessment of Treatment and System Options

Each system is evaluated against the following:

- supporting blending or cementation processing
- remediating and repackaging the various nitrated salt drums at LANL
- accommodating remediating and repackaging drums at other location
- providing capability for legacy drum repackaging operations
- addressing the complexity and risks associated with implementation

## 3.0 WASTE STREAM CHARACTERISTICS

The complete inventory of nitrate salt waste drums that require repackaging are as follows:

- 60 RNS drums in storage at LANL
- 114 RNS drums at Waste Control Specialists, LLC (WCS) in Texas[3]
- 29 UNS aboveground drums at LANL
- 79 UNS drums belowgrade at LANL

Presently, temperature control is used to maintain the aboveground RNS drums in a safe configuration and will be used before and during processing of the drums. Also, 114 drums at the low-level waste facility in Andrews, Texas, are managed by WCS in shallow underground storage that is effectively temperature controlled.

Developing an effective process and selecting a system to handle the process start with understanding the characteristics of the feed stream. For this effort, the initial feed streams are the RNS and UNS salt drums. Appendixes A through D highlight the RNS, UNS, belowgrade, and WCS drum information examined for this effort. Available information relating to these waste streams provides the following overview of the waste to be processed.

### 3.1 Waste Composition

#### 3.1.1 UNS Waste Drums

Typically, the nitrate salt wastes were recovered from an evaporation process at TA-55 that was fed by either ion-exchange effluent or oxalate-precipitation filtrate. The salts, contaminated mostly with plutonium and americium, were packaged in bags and placed in drums. The real-time radiography (RTR) results from the aboveground drums are available and provide the composition characteristics of the waste. All the drums contain lead liners, and most contain plastic liners in which the bags or cans of salt were placed. The UNS aboveground drums are all over packed in 85-gallon drums.

Belowgrade candidate drums do not yet have RTR documentation but do have limited information-relating to the drum contents. The belowground drums appear to contain a more diverse suite of salts, leached solids, crucibles, ash, NaOH pellets, resin, hydroxide cake, etc., based upon the generator notes.

#### 3.1.2 RNS Waste Drums

The RNS wastes were created from the UNS waste stream by mixing absorbents and/or neutralizers with the UNS wastes. The blended waste was placed in a fiberboard-insert liner that was placed inside a plastic bag in the 55-gallon drum. The salt/Swheat blend was placed directly into the fiberboard liner without any protective plastic around the waste, as was the case in the UNS drums. Debris waste was also often placed into the drum with the salt/Swheat mixture. Although the debris was typically placed atop the salt/Swheat blend, frequently the debris is intermingled rather than layered in the drum. Thirteen RNS drums are estimated to contain over 50 volume-percent debris and 23 RNS contain 20 volume-percent or more debris waste. The oxidizer and cardboard liner provide unique concerns not associated with the UNS drums. Twelve 12 RNS containers consist of 12-inch pipe overpacks (POCs).

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[3] The same processing capability could treat the LA-CIN01 drums at WCS, if required.

### 3.2 Liquid

Free liquid can be identified utilizing RTR. All but four of the RTR videos of the RNS drums were taken between September 2013 and April 2014. The other four RTR records are of the POCs taken in 2011 and 2012. Five RNS drums (at that time) were reported to contain liquid: three contain less than 100 milliliters and two POCs contain about 2 liters located outside the containment bag in the POC.

Free liquids are found in nearly all of the UNS drums, typically in the 1- to 5-gallon range, with one drum containing 15 gallons. The liquid is either in the bags containing the salt waste or located on the bottom of the internal plastic liner.

### 3.3 Material at Risk

The current material at risk (MAR) limit for operations in the 231 and 375 Perma-Cons® is 18 Equivalent combustible plutonium-equivalent curies (ECPE-Ci) of material in process, with an additional 18 staged. For RNS waste, the current plutonium-equivalent curies (PE-Ci) values are assumed to be the actual ECPE-Ci since the waste is considered combustible. Based upon the current drum information:

Fifteen of the known RNS, UNS, and belowgrade drums exceed the 18 ECPE-Ci limit.

- 60 RNS Drums — 9 drums exceed 18 PE-Ci
- 29 UNS Drums — 0 drums exceed 18 ECPE-Ci
- 79 Belowgrade UNS Drums — 6 drums exceed 18 ECPE-Ci (31 exceed 18 PE-Ci)

Ten drums appear to have Hazard Category 2 levels of radionuclides.

- 60 RNS — 0 exceed Haz Cat 3 levels
- 29 UNS — 0 exceed Haz Cat 3 levels
- 79 Belowgrade UNS — 10 exceed Haz Cat 3 levels

The current Area G technical safety requirements (TSR) limit sort, segregate, size-reduction, and repackaging activities to 18 ECPE-Ci in process and 18 ECPE-Ci in container storage in the area of processing. It may be possible to utilize the entire 36 ECPE-Ci (18 for process and 18 for storage) for drum repackaging/remediation operations. If this were possible, then only one RNS drum exceeds 36 ECPE-Ci and it contains 39.1 ECPE-Ci.

All the drums contain less than 200 plutonium-239 fissile gram equivalent (FGE), and it does not appear this will be an issue for the nitrate salt drums. This is the FGE limit that any one drum can have for shipment to WIPP, but the WIPP limit includes two times the measurement uncertainty, and this information is only available for containers that have been assayed recently.

# 4.0 REMEDIATION PROCESS OPTIONS

The recently completed options assessment report (Options Assessment Report: Treatment of Nitrate Salt Waste at Los Alamos) identifies five candidate process alternatives. The highest ranked alternative is the addition and blending of zeolite with the RNS or UNS salts. The other four options include a cementation step. The report predicts that the following number of RNS daughter drums (includes parent drums and debris drums) will be produced with each option (assuming 57 RNS drums):

- Zeolite addition without cementation 399
- Zeolite addition with cementation 798
- Dry process and cementation without zeolite 285
- Wet process and cementation without zeolite addition 342
- Salt dissolution with cementation 285

The exact number of daughter drums can better be estimated once the process option and the process operating conditions are resolved. However, this estimate provides some indication of the number of drums that are expected to be generated.

Four candidate processing approaches are presented as part of this review for the salt or salt/Swheat wastes. These approaches include two blending options and two cementation options. For each approach, a recipe is identified and a daughter drum count estimated. The daughter drum estimate is based upon the recipe and the drum information found in Appendixes A and B.

The debris stream is examined separately because it is not as homogenous, presents a different set of challenges, and will require different processing.

## 4.1 Impact of Process Option on Glovebox/System Selection

The process treatment option that is selected will impact how and where the processing will be carried out and present requirements for the confinement system. The dry-blending process, blending of the salt with zeolite, will be easier to process with the readily available repackaging system options. Cementation, a wet process, may require modifications or additional capability in addition to the available glovebox systems or may require a new glovebox. Cementation requires dissolution, pH adjustment, addition of cement, and agitation or blending of a heavy viscous paste.

## 4.2 Zeolite Blending

It is envisioned that dry blending with zeolite will require the following unit operations:

- Recovery or separation of the salt/Swheat matrix from debris waste
- Collection and absorption of free liquids in zeolite (expected to be minimal for RNS drums)
- Weighing of the salt/Swheat matrix or absorbed liquid/zeolite and zeolite components
- Blending of the salt/Swheat matrix and zeolite streams
- Processing of the debris waste—possibly washing or wiping and repackaging

These operations can be handled in typical repackaging gloveboxes. Two approaches to achieve a blended product include

1. small-scale batches that are then dumped into the daughter drum or
2. batching the appropriate ratio of zeolite and salt/Swheat into a drum and blending the entire contents.

Batch-blending operation can be achieved using a small drum blender or a conventional Hobart-type mixer, as shown in Figure 1. The mixer can be located in the glovebox at each daughter drum station. Selection of the size and type of blender will be based upon surrogate testing and size constraints of the glovebox.

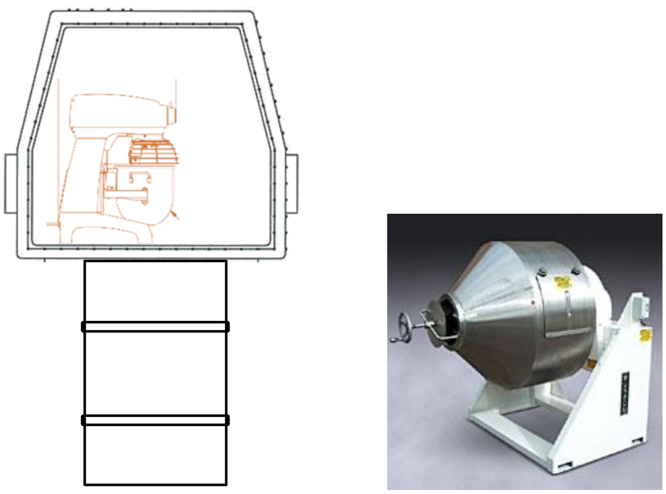

***Figure 1 Glovebox end view showing Hobart blender for batch blending and picture of a drum blender***

A second blending alternative uses the daughter drum to achieve blending of the salt/Swheat and zeolite. Dry blending is frequently performed in drums with lifters using a tumbling action. Bulk blending using the daughter drum after components are combined is achieved by using a drum tumbler or drum roller as those shown in Figure 2. Bulk blending using a drum tumbler or drum roller would likely require a drum insert with baffles to aid in the blending process. The optimal approach would be determined by conducting tests with surrogates. Drum tumblers are readily available and Radioactive Liquid Waste (RLW) facility uses a unit for cementation.

***Figure 2 Drum blending options: Drum tumbler and drum roller***

Blending is a dry process and may provide safety (and resulting safety basis) concerns related to sparking or electrostatic discharges (ED) during blending. The sensitivity of dry material may need to be examined to better understand these potential issues. Effective mitigation may be achieved through materials of construction and proper grounding of blending equipment.

#### 4.2.1 Zeolite Blending Recipe

The recipe for blending RNS and UNS waste assumes a 3:1 volume ratio of zeolite-to-salt waste[1]. Free liquids (mainly in the UNS stream) are first absorbed with zeolite and then the resulting wet zeolite is blended at the same 3:1 ratio. This ratio is identified in the Options Assessment Report. For operational efficiency, a 2:1 ratio was recommended by the LANL-Carlsbad Difficult Waste Team from data provided by testing at EMRTC.[4] The more conservative 3:1 ratio is used for estimating purposes in this assessment.

Zeolite has the following characteristics[5]:

- Water absorption per pound of Bear River (BR) zeolite 0.55 lb
- Bulk density of dry BR zeolite 55 lb/ft$^3$
- Bulk Density of wet BR zeolite 85 lb/ft$^3$

Salt waste and blended salt/Swheat exhibited the following characteristics during formulation for cementation tests performed by Robert Wingo:

- Bulk density of surrogate salts for cementation 100 lb/ft$^3$
- Bulk density of surrogate salt/Swheat blend 57 lb/ft$^3$

Based upon the zeolite characteristics and the expected salt and salt/Swheat bulk densities, the following recipes are expected for blending. The number of daughter drums produced based upon these recipes and the waste stream information are also shown.

<u>RNS Drum Blending Information</u>

- Small-batch blending (fill drum 90%):
  - ❖ Salt/Swheat 12.5 gal. (96 lb)
  - ❖ Zeolite: 37.5 gal. (278 lb)
  - ❖ **132 blended daughter drums**
- Bulk blending in a drum (fill to 60~~5~~%):
  - ❖ Salt/Swheat: 8.5 gal. (65 lb)
  - ❖ Zeolite: 25 gal. (185 lb)
  - ❖ **178 blended daughter drums**

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[4] Zeolite Required to Meet the Constraints Established by EMRTC (LANL-Carlsbad Office Difficult Waste Team: LA-UR-14-26860). Requirement was 1.2:1 but was rounded up to 2:1 for operational efficiency and provided additional conservatism.

[5] Specification from Bear River (BR) Zeolite, Preston, Idaho

UNS Drum Blending Information

- Small-batch blending (fill drum 90%):
  - Salt: 12.5 gal (168 lb)
  - Zeolite: 37.5 gal (278 lb)
  - **73 blended daughter drums**
- Bulk blending in a drum (fill to 60~~5~~%):
  - Salt: 8.5 gal (114 lb)
  - Zeolite: 25 gal (185 lb)
  - **99 blended daughter drums**

The UNS stream has significant free liquids. It is assumed the free liquids are absorbed directly with zeolite before blending with more zeolite. Therefore, every gallon of free liquid (8.4 pounds) will require approximately 16 pounds of zeolite. The zeolite with absorbed free liquids is then further blended with 3 more equivalent volumes of zeolite. This is accounted for in the drum estimation calculation.

### 4.2.2 Implementing Small-Batch Blending for Nitrated Salt Waste Streams

Batch blending includes combining the salt or salt/Swheat mixture and free liquids with zeolite. Zeolite comes in a variety of particle sizes. The optimal size for blending is likely to be a 14 × 40 mesh that is equivalent to a 1.4~~-~~ × 0.4-mm particle size. Most of the RNS drums do not appear to contain free liquids based on RTR evaluations, and this is likely the case for the WCS drums. Most of the UNS drums contain liquids (see Appendix B), and belowgrade drums are also likely to contain free liquids. Free liquids will first need to be absorbed with zeolite. The salt/Swheat or absorbed liquid/zeolite are then blended with zeolite in a 3 parts zeolite to 1 part salt/Swheat volumetric ratio (may be adjusted after treatability testing).

The waste drum (salt, Swheat, free liquids) is introduced into the box via the waste drum bag on port. Zeolite can be introduced via the daughter drum in bags that are removed and placed in the glovebox or via screw feeder through the side or top of the box. The parent drum is opened and any free liquid collected and mixed with zeolite to absorb the free liquid. The salt (UNS) or salt/Swheat (RNS) and the absorbed liquid on zeolite are then blended with zeolite.

Batch blending also provides flexibility for handling a range of salt/Swheat forms, from wet sloppy material to dry clumpy material. Most of the surrogate work has focused on a friable product, which is typically found when blending the nitrate salts with Swheat in a 3-to-1 volume ratio. However, it is possible that a more difficult physical form may be encountered, such as a wet “liquidy” consistency or a drier bread-like consistency. Batch processing provides the opportunity to add water or additional zeolite to get a proper consistency and mix regardless of the form obtained from the parent drum. Mixing the salt/Swheat with water before mixing it with zeolite also provides an opportunity to dilute the nitrate salt concentration found in the Swheat and allows the nitrates to report to the zeolite where it is of less concern.

A number of batch-blending systems can effectively provide the blending. The more homogeneous the feed stream, the easier it will be to blend. Large hard chunks of salt or excessively wet viscous material will be more difficult or require an approach that is less sensitive to particle size and viscosity. Initial candidate systems include a drum blender or a common Hobart blender used in the baking industry. Inserting the mixer can be achieved by bagging the blender into the box through the daughter or waste drum bag-on opening. Other blenders—drum or paddle—may be difficult to set in contaminated boxes because they are larger and heavier. The batch approach allows for verification of product quality before drum loading. However, the process rate is slow because of the batch size, typically 3 to 5 gallons. Three gallons of a 3-to-1 volumetric zeolite-to-salt mixture weighs about 20 pounds (depending upon the moisture content). Approximately 17 batches will fill a daughter drum.

**Challenges to Implementing Batch Blending in a Glovebox**

- *Batch size.* Blending equipment typically used for blending moist solids and dry solids is of a size that is not easily loaded into an existing glovebox. It may be possible to get a 5-gallon unit into a glovebox through the daughter drum port, but it will be very tight and the unit weighs 190 pounds. Therefore, smaller more conventional equipment, such as a Hobart blender may be required. The result is a more time-consuming operation that requires numerous batches to fill a daughter drum.
- *Testing.* Blending equipment will need to be tested to ensure the unit will handle the variability in the waste streams; salt/Swheat (RNS) and the salt (UNS) and that potential ED and spark sensitivities are not realized.
- *As low as reasonably achievable (ALARA).* Operation is slower and requires multiple batches increasing the dose that operators receive from the waste. Previous repackaging of this waste stream resulted in short duration (less than an hour) shifts by operators from radiation exposure.

**Benefits to Batch-Blending Approach**

- *Process is simple.* Process requires combining preset volumes of two ingredients into a set volume blender, mixing and dumping into the drum. Multiple units could be used in the glovebox to increase throughput.
- *No modifications required to the glovebox.* Equipment can be loaded into the glovebox via the daughter drum or the parent drum for set up. Zeolite can be introduced through the daughter drum. Although it is possible to use an augur to feed zeolite through the glovebox side or top, this would require modifying the glovebox.
- *Product quality is verifiable.* The blended product can be examined visually to ensure it has been well mixed before adding to the daughter drum.
- *Maximizes drum volume utilization.* The full drum volume can be utilized because the product quality is independent of drum utilization or drum weight.

### 4.2.3 Implementing Drum Blending for Nitrated Salt Waste Streams

A second alternative is to use the drum as the container for blending. As shown in Figure 3, an insert is placed in the daughter drum before bagging the daughter drum to the glovebox. The insert has baffles to aid in blending. Zeolite is placed in the insert before bagging the drum on to the glovebox. Salt/Swheat is then weighed and placed in the drum once it is bagged onto the glovebox. A top is secured to the insert, and the drum is then bagged off, covered, and placed in a drum tumbler for mixing (Figure 2).

Developing an insert that will improve blending will be important to achieving a well-blended product. Surrogate testing will provide insight into the effectiveness of this approach.

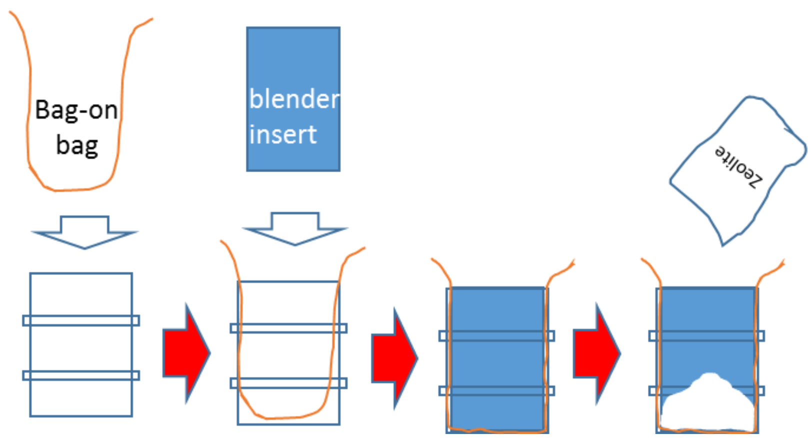


***Figure 3 Preparation of a daughter drum for drum blending using a drum tumbler***

**Challenges to Implementing Drum Blending**

- *Developing an insert to improve mixing performance.* Commercial blenders called "drum blenders" are used to blend ingredients in a number of industries. These are fixed units with a drum designed to fold and mix ingredients. The blenders have baffles and internal ribs that aid in mixing. Developing an insert that could be used with a drum roller or a drum tumbler may allow for batching ingredients into the drum and then mixing the contents after the drum is removed from the glovebox in a drum tumbler or drum roller.
- *Verification testing.* The product would be blended after the drum is closed. Testing would be required to verify the process effectively blends the zeolite and salt waste. RTR evaluations during testing may be effective at verifying blending performance and may provide a means of verification during processing.
- *Drum volume utilization.* To allow for mixing, the drum can only be partially filled, resulting in more daughter drums. For estimating purposes, a 60% fill volume was used. This resulted in an additional 46 RNS and 26 UNS daughter drums compared with filling the drum to 50 gallons.
- *Facility floor space.* The use of a drum tumbler requires availability of additional floor space. The system requires a space of about 8 feet × 10 feet.

**Benefits to Implementing Drum Blending**

- *Simple process.* Requires only that a preset volume of salt/Swheat be added to the drum. The drum is then removed and mixed via a drum tumbler or drum roller.
- *ALARA.* This option is very fast because it requires only the operator to measure out a volume of salt and add it to the drum, thus minimizing the amount of time dealing with the waste stream.
- *No modifications required to the glovebox.* No equipment is required inside the glovebox, making the best use of available space for handling debris and salt waste.
- *Available glovebox floor space.* Since no equipment is required inside the glovebox, the entire box is available for handling debris waste.

### 4.3 Cementation

Cementation of the salt or salt/Swheat waste streams can be achieved by mixing with an agitator in the glovebox (similar to TA-55 salt waste line) or drum tumbling in a containment box exterior to the glovebox (similar to RLW cementation process). In either case, the salt needs to be dissolved and pH adjusted before cementation takes place. This will likely require a tank or possibly a daughter drum for dissolution. Once the salt is dissolved, it can be pH-adjusted using a base solution such as sodium hydroxide. This operation can be thought of as a four-step process:

- Weighing of the salt/Swheat matrix or absorbed liquid/zeolite and zeolite components
- Dissolution of the salt/Swheat matrix and free liquids
- Adjusting the pH of the mixture
- Cementation of the mixture

The two cementation operations examined (TA-55 and RLW) do not include salt dissolution. The TA-55 cementation operation includes a pH adjustment followed by cementation and the RLW operation is just the cementation step.

A set of laboratory-scale cementation tests was completed by Robert Wingo using a blend of surrogate nitrate salts and Swheat. The salt/Swheat blend was pulped in water, the pH adjusted, and the blend cemented. Cementation was performed using an agitator and a roller. The cement made with the agitator was more homogeneous and stronger than the rolled product (from a qualitative perspective), although both were effective in removing the liquid. The 2-gallon monoliths are shown in Figure 4.


***Figure 4 Comparison of cement made with agitation and via rolling "tumble"***

One observation noted during the dissolution phase was the presence of gas formation before the pH for solutions that sat for extended periods (more than a week) was adjusted. However, no such gas generation was observed for mixtures pH adjusted with caustic to precipitate the metals (pH of 9 to12). This was likely the result of biotic activity that was suppressed at high pH (and ionic strength).

### 4.3.1 TA-55 Salt Solution Cementation Process

The TA-55 nitrate salt waste line utilizes the daughter drum for mixing cement into the pH-adjusted solution. The intent is to prepare drums of monolithic concrete that have 150 to 200 $^{239}$Pu FGE. The drum has a plastic insert to protect the bag-on bag from the processing operation. A total of 125 liters (33 gallons) of salt solution is mixed with approximately 25 liters (7 gallons) of 9-molar sodium hydroxide solution in the plastic insert to adjust the pH and precipitate metals. Once the solution has been pH adjusted to between 9 and 11.5, cement is metered into the drum while the solution is being agitated. The cement is stored outside the building in a large hopper and is batched into an inside hopper, which is then metered into the glovebox through the glovebox wall. A variable-speed mixer that can be raised or lowered via linear rails is used to blend the cement into the solution. The process recipe calls for approximately 300 pounds of cement. This results in a water-to-cement ratio of about 1:1 (which is very high), creating a soupy type of texture. The daughter drum rests on a scale to verify the amounts of material being added to the process. After mixing, the impeller is raised and cleaned off.

The glovebox is configured with two systems capable of preparing two drums. Figure 5 shows the cementation box at TA-55. The box has a height of about 12 feet to allow for raising and lowering the impeller shaft into the drum. The agitator is a variable speed Lightnin AJ350 and has dual impellers and 3.5-horsepower (hp) motor using 230-V three-phase power. After the cement is mixed, it is allowed to set for 2 days before it is bagged off. This set time allows for verification of the mix and time for the drum to cool.

***Figure 5 Cementation glovebox operation at TA-55***

The pH adjustment and the cementation process are both exothermic and generate heat. Drum heating has been noticed by the operators at TA-55, at the RLW facility and during processing cemented drums at the Dual Axis Radiologic Hydrodynamic Test Vessel Preparation Building. The TA-55 cementation process exhibits the following exothermic heating:

- Approximately 3500 kilocalories are generated during the strong acid/base reaction (pH adjustment) using 30 liters of 9-molar sodium hydroxide (270 moles of $OH^-$). This raises the 150-liter solution approximately 23°C.

- Type II Portland cement exhibits a heat of hydration of about 80 calories per gram typically over a 7-day period. The heat of hydration of cement will generate a concrete temperature rise of about 10°F (5.5°C) to 15°F (8°C) per 100 pounds of cement per cubic yard of concrete.[6]

The associated temperature rise with pH adjustment and hydration of Portland cement may be important considering the components in the waste may be heat sensitive, although the dissolution of the salts are likely to mitigate this sensitivity. Alternatives for cooling the drum or controlling the process rate may be considered to control temperature changes in the cemented waste. Reduced heat cements are available and should be evaluated if cementation is used[7].

### 4.3.2 RLW Waste Cementation Process

The RM-60 waste sludge stream at the RLW facility is cemented for final disposition. The waste stream contains precipitated hydroxides and oxides from pH adjustment related to water treatment. The waste feed is collected in a batch tank that holds 22 gallons of solution. A 55-gallon drum is loaded with 3 bags (280 pounds) of Portland cement (Type IV) and 2.5 gallons of sodium silicate, and the lid is installed and secured. The drum is then placed in a Morse Drum Tumbler, which is enclosed inside a high-efficiency particulate arresting (HEPA) filter ventilated containment box as shown in Figure 6. The 22 gallons of RM-60 sludge solution is gravity fed from the holding batch tank directly into the drum through the large bung in the drum lid. The bung is then tightened, the door to the box enclosure is closed, and the drum is tumbled for 20 minutes. After tumbling is complete, the door is opened and the large bung is removed with a rag covering the bung to relieve any pressure and open the drum to avoid pressurization during setting as the drum heats up. Finally a one-half cup of waste lock is added to absorb any free liquid that may weep out.


***Figure 6 RLW drum tumbler and containment box***

The recipe used for this operation is roughly 0.65 water-to-cement ratio, which is lower than the ratio used at TA-55 (1:1). The RLW recipe produces a drier, more viscous mix. It should be possible to design a

[6] Concrete Technology Today, Volume 18/Number 2, July 1997

[7] Concrete Technology Today, Volume 18/Number 2, July 1997

bung that could be vented to a pipe for HEPA filtering before the bung is removed to mitigate the "burp" associated with pressure build up during tumbling and to ensure it is handled in a controlled manner.

### 4.4 Implementing Cementation for Nitrated Salt Waste Streams

Two approaches are proposed for implementing cementation.

1. *Cementing inside the glovebox using a sacrificial agitator.* Salt dissolution, pH adjustment, and cementation are performed in a daughter drum, simulating the TA-55 process approach. The daughter drum requires a bag-on bag and an insert to accommodate agitation.
2. *Cementing outside the glovebox using a drum tumbler housed in a containment box.* Salt dissolution and pH adjustment are performed in a permanent daughter drum. The pH-adjusted solution is pumped from the glovebox to a drum for mixing similar to the RLW approach.

#### 4.4.1 Cementation Recipe

Cementation tests completed by Robert Wingo[8] to evaluate the effectiveness of "grouting" RNS waste provide some guidance on a possible cementation recipe. A surrogate RNS waste was produced in the laboratory using nitrate, chloride and sulfate salts, oxalic and nitric acids, and Swheat. Figure 7 shows the surrogate mixture of salt/Swheat mixed with water.

***Figure 7 Mixture of nitrate salt, Swheat, and water before cementation***

The mixture was pH adjusted to 9 and mixed with type II Portland cement. The final recipe for the cemented product is as follows:

- Volumetric ratio of Swheat-to-nitrate salt mixture 3:1
- Equivalent-mass ratio of Swheat to nitrate salt mixture 1:1

[8] Notes from Cementation Tests, Robert Wingo

- Mass ratio of water to dry Swheat 3.5:1 (after pH adjustment)
- Moles of NaOH used per kg salt 3 (120 g)
- Equivalent mass water to cement ratio 0.65:1
- Ratio of cement to salt 5.2:1

The cemented product is shown in Figure 8. It was blended using a mixer, and the product was very homogenous and the Swheat well distributed throughout the matrix. For the period observed, no dewatering was observed.

***Figure 8 Cut specimen of cemented surrogate nitrate salt/Swheat***

A proposed recipe for cementing the RNS and UNS is shown below (Tables 1 and 2). Two changes were made to the laboratory recipe. The amount of water used per unit of Swheat was increased to ensure the resulting slurry would mix and pump. The 3.5:1 ratio of water to Swheat was increased to 4:1. Also water to cement ratio was increased from 0.6 to 0.75 to produce a lower-viscosity mixture that could be more easily mixed by agitator or drum tumbler. It is not clear if all of the water is available for wetting the cement, something further testing can clarify. The recipe used by TA-55 calls for a 1:1 ratio of water to cement. The recipe for mixing RNS waste starts with 28 gallons while the drum tumbling recipe starts with 20 gallons to keep the volume in the drum at 60% to aid in mixing during tumbling.

***Table 1***
***Cementing Recipe for RNS Waste (60 Parent Drums)***

| Ingredient | Agitator (114 drums) | Tumbling (141 drums) |
|---|---|---|
| Water | 28 gal. (235 lb) | 20 gal. (168 lb) |
| Salt/SWheat | 118 lb | 84 lb |
| NaOH Soln* | 3 gal. | 2 gal. |
| Cement | 325 lb | 242 lb |

***Table 2***
***Cementing Recipe for UNS Waste (29 Parent Drums)***

| Ingredient | Agitator (68 drums) | Tumbling (95 drums) |
|---|---|---|
| Water | 28 gal. (235 lb) | 20 gal. (168 lb) |
| Salt | 125 lb | 88 lb |
| NaOH Soln* | 4 gal. | 4 gal. |
| Cement | 340 lb | 242 lb |

*9-molar concentration.

The UNS recipe calls for more nitrate salt because the Swheat is not available to soak up the water before cementation. Based upon these recipes, the number of cemented RNS daughter drums is expected to be 114 when using a mixer and 141 when using a drum tumbler. The number of cemented UNS daughter drums from the aboveground UNS drums is expected to be 81 if a mixer is used and 95 if a drum tumbler is used.

### 4.4.2 Cementing Nitrated Salt Waste in Daughter Drums in the Glovebox

To cement in the glovebox, the daughter drum must be prepared for the process. The daughter drum requires a bag-on bag and an insert before bagging onto the glovebox. The insert provides a hard surface to contain the monolith and protect the bag during processing. Since most candidate gloveboxes do not have enough height to lift the agitator out of the drum, a sacrificial agitator is inserted into the drum before bag-on. The agitator will be inserted into the drive after bagging on the daughter drum and then removed after processing is complete. The steps are shown in Figure 9.

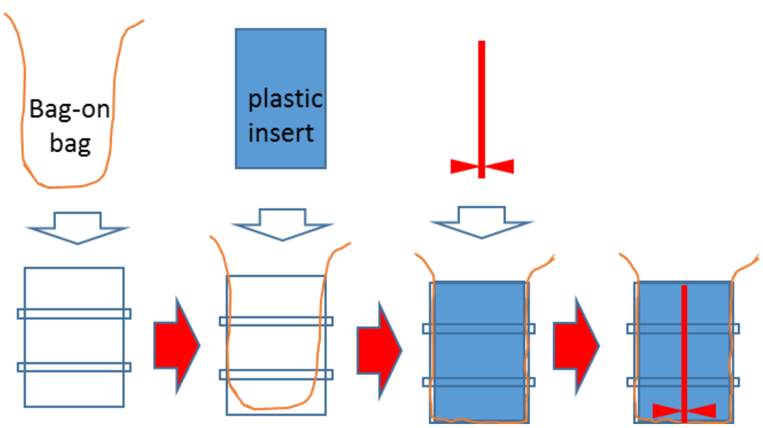


***Figure 9 Drum preparation for pH adjustment and cement addition in glovebox***

After the daughter drum is in place and the agitator is inserted into the drive, water is added to the drum and salt can be dissolved in water. Once the cement addition is complete, the agitator is removed and placed into the cement mix. The daughter drum is removed from the glovebox and allowed to cure. A general configuration of the equipment is shown in Figure 10.

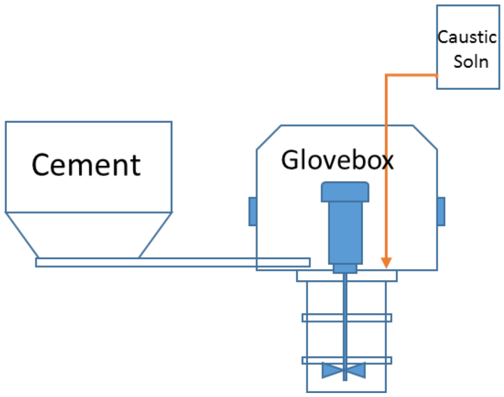


***Figure 10 Glovebox cementation configuration***

**Challenges to Implementing Cementation via Mixing in the Glovebox**

- *Glovebox modifications/design for agitator use.* The agitator at TA-55 is set in a glovebox with enough headroom to allow the mixer to raise and lower. Either (1) a box with more headroom needs to be selected or (2) the impeller/shaft may be used and sacrificed as part of the drum monolith. This would require a sacrificial impeller/shaft for each drum of waste. The agitator drive can be affixed to the box floor, the impeller and shaft introduced with the daughter drum, and the shaft installed into the drive before mixing and then removed and pushed into the monolith after mixing. Installation in a contaminated glovebox will be more challenging. A Lightnin I Series fixed mount 3-hp Type Q is similar to the system used by TA-55.

***Figure 11 Lightnin Type Q drive to locate inside glovebox***

An engineering review will be required to verify the unit (89 pounds) can be properly secured and the box credited-safety function is not compromised.

- *Ingredient introduction.* Introduction of caustic for pH adjustment and the addition of cement will require bringing these streams into the box through the top or side of the glovebox. This could be a challenge to retrofit for "hot" gloveboxes. It will likely include bulk transfer systems located outside the box and piped into the box for metering. Measurement of the drum weight or a predetermined volume could be used to ensure the proper recipe is achieved.
- *Throughput.* At TA-55, the daughter drum is allowed to cure for at least 2 days to ensure a proper set and no weeping of water from the mix. This process could significantly reduce the waste drum processing rate. A long cure time is not necessarily required, but bagging off the cement once mixed and before curing would require puncturing the plastic bag to allow for venting of hot gases

from the drum during curing. The addition of an absorbent above the cement may provide insurance for any weeping.

- *Box floor space.* The mixing equipment and cement delivery system will reduce available box space for handling debris waste.

**Benefits to Implementing Cementation via Mixing in the Glovebox**

- *Hazard mitigation.* Salt dissolution mitigates the potential of a fire from the oxidizer in the glovebox by immediately wetting the salt/Swheat mixture and dissolving the nitrate salts (although the liquid may still retain the oxidizer characteristic at that time). Wetting and cementation provide an added "comfort value" since cementation is widely accepted as a treatment process.
- *Single location.* Cementing in the glovebox eliminates the need to take the drum to another location to cement. Dissolution, pH adjustment, and cementation are done in a "one-stop" process, and the daughter drum is ready for disposal once curing is complete.
- *Verifiable product quality.* The cemented product can be examined visually to ensure it has been well mixed before the drum is removed.
- *Maximize drum volume utilization.* More drum volume can be utilized since the product quality is dependent upon mixing with an agitator and the entire drum volume can be utilized.

### 4.4.3 Cementing the Nitrated Salt Outside the Glovebox

To simulate the cementation process used by RLW, an exterior HEPA-filtered containment box is used to enclose the cementation operation. Dissolution and pH adjustment are carried out in the glovebox and then pumped to an exterior drum for cementation. The daughter drum becomes a permanent container used to dissolve the salts and adjust the solution pH. Dissolution can be achieved by adding water to a permanent daughter drum and dissolving the salt in the drum. A fixed mixer or a recycle pump is used for agitation during dissolution and pH adjustment. Caustic is pumped into the box and controlled via pH. Once the solution is ready for cementation, it is pumped to a holding tank or directly to the drum for cementing. The drum is located in a separate enclosure housing the drum tumbler and the drum. Figure 12 shows the configuration for mixing exterior to the glovebox.

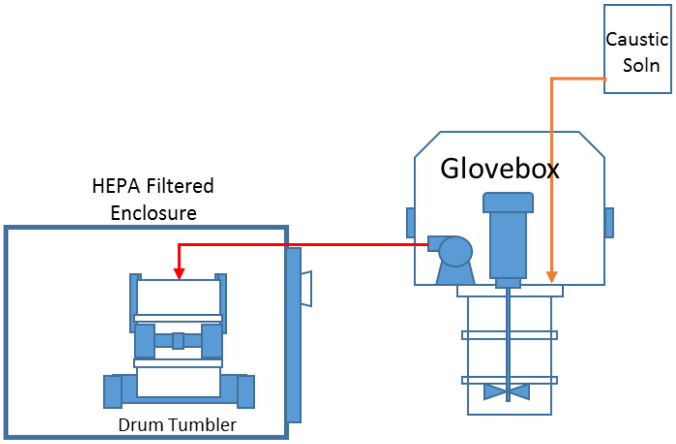


***Figure 12 Cementation using a drum tumbler***

**Challenges to Cementing Using a Drum Tumbler**

- *Verifying cementation effectiveness.* Unlike using a mixer with open access to the drum contents, it is difficult to verify the mix in the drum is adequate when using a drum tumbler. Mix quality will have to be thoroughly tested to ensure an adequate recipe and mix time are achieved. A bag or insert is unnecessary for this operation, so it is possible to preload baffling into the drum to improve mixing effectiveness. RTR evaluations during testing may be effective at verifying blending performance and may be a means of verification during processing.
- *Glovebox modifications.* Caustic addition and delivering the waste slurry to the drum will require piping through the glovebox.
- *Venting, post-cementation.* During tumbling (20 minutes), a cement-and-water mixture will likely heat the contents, including the gases, and will expand in the drum. After tumbling, the bung is removed and this is typically accompanied by a release of internal pressure as the bung is unscrewed from the lid. Using a bung with a valve should allow for a controlled release of pressure and for directing the gas to a HEPA filter for discharge.
- *Pumping.* Pumping the slurry will require a positive displacement pump that is capable of handling the repulped and pH-adjusted slurry.
- *Daughter drums.* For the drum tumbler to be effective, the daughter drum contents are kept below 60% to aid in mixing. This results in additional cemented daughter drums and in an estimated additional 27 RNS and 27 UNS daughter drums compared with mixing inside the glovebox.

**Benefits to Cementing Using a Drum Tumbler**

- *Hazard mitigation.* Salt dissolution mitigates the potential of a fire from the oxidizer in the glovebox by immediately wetting the salt/Swheat mixture and dissolving the nitrate salts (although the liquid may still retain the oxidizer characteristic at that time). Wetting and cementation provide an added “comfort value” since cementation is widely accepted as a treatment process.
- *Simplified glovebox operation.* The operations inside the glovebox only include dissolution of the salts and pH adjustment. Cementation is done externally so mixing and cement addition is not required inside the glovebox. This provides more room for waste handling and reduces the complexity of the processing in the glovebox.
- *Reduced bag-on operations.* The daughter drums are those that are exterior to the glovebox for cementation. Therefore, no daughter drum bag-ons required for cementation, only for debris waste.
- *Ease of cement addition.* Cement can be added to the drum before adding the salt/Swheat solution.
- *Production rate.* Reducing the operations in the glovebox will expedite processing. Daughter drums are concreted exterior to the glovebox, so bag-on operations for daughter drums are eliminated.

### 4.5 Processing Debris Waste

The RNS and UNS waste drums contain debris waste that is comingled with, and is assumed to be contaminated with, the salt (UNS) or the salt/Swheat (RNS). Adding organic debris waste to the daughter drums with the remediated salt (UNS) or salt/Swheat (RNS) is not allowed (compatibility). There is no guidance currently on a path forward for treating transuranic (TRU) D001 debris waste (if it carries the characteristic).

The generator is required to validate that the debris waste is either not TRU (D001 mixed low-level waste [MLLW] can be shipped off-site for treatment) or is not ignitable, or mitigate the characteristic, if it is ignitable. For TRU debris waste, this would require implementing a mitigation approach and verifying that the mitigation resulted in eliminating the D001 characteristic.

#### 4.5.1 RNS Debris Waste

Each RNS drum was configured with an outer bag and a cardboard liner inside the outer bag. The salt waste was blended with Swheat using the stub-out bag and included horsetail remnants from the parent or daughter drum bag-on. The horsetail or bag was then placed in the daughter drum with the salt/Swheat.

Debris waste from the RNS drums also includes items that were placed in the drum along with the salt/Swheat. The items found in the drum typically include the following:

- plastic bag horsetails from bag-on process
- metal objects such as 30-gallon drum, lids, cans, hardware
- lead liners
- gloves
- cardboard liners
- cans
- cut-up plastic bottles (e.g., Spilfyter Kolorsafe containers)

Review of the RTR indicates the items are located throughout the salt/Swheat matrix. Typically, the lead is found on top of the last daughter drum derived from the parent.

Five containers contain free liquids. Two of these are POCs, and the liquid is found at the bottom of the pipe component. In the other three drums, the liquid is found in the creases of the plastic bags in amounts of about 10 milliliters.

The type and location of the debris waste suggests that the debris waste will be contaminated with the salt/Swheat stream. The fact that there is no free liquids, except for small amounts, indicates the contamination will be dry or moist but not overly wet.

The debris waste, once repackaged back into the parent drum, could meet low-level waste (LLW) requirements. It may be possible to clean the debris waste, place it back into the parent drum, and meet the 100 nano-curie/gram LLW limit. This would eliminate the WIPP requirement to treat debris waste. Estimates based upon drum information presented in Appendixes A and B provide insight into the maximum amount of salt/Swheat waste that could remain on the debris waste placed back in the parent drum. Table 3 values assume the radioactive contamination is well mixed among the salt/Swheat material, including that remaining on the debris. Table 3 groups the drums according to the amount of salt/Swheat that could report back into the parent drum and still meet the 100 nano-curie/gram LLW limit.

***Table 3***
***Estimated Maximum Mass of Salt Waste Allowable in Parent Drum to Meet LLW Limit***

| Type of Waste | Less than 10 g | 10 g–20 g | 20 g–50 g | 50 g–100 g | Over 100 g |
|---|---|---|---|---|---|
| RNS | 1 drum | 3 drums | 26 drums | 17 drums | 13 drums |
| UNS | 0 drums | 0 drums | 1 drums | 2 drums | 26 drums |

Debris can be washed or soaked in the glovebox with water to remove as much salt or Swheat as possible. The resulting liquid can be used in the blending process and absorbed or cemented depending upon the treatment process. The washed debris is replaced into the parent drum. Finally, it would be beneficial to add 100 pounds of zeolite to the parent drum to ensure any salt solution remaining is absorbed and there are no free liquids. Zeolite has been shown to be an effective means to remove the D001 characteristic.

It will be worthwhile to test surrogate, cardboard, and plastics contaminated with nitrate salt to determine if they are a D001 waste. For this assessment, it is assumed the RNS debris waste will be washed and returned to the parent drum along with 100 pounds of zeolite to ensure any salt solution remaining is absorbed and there are no free liquids. The debris drum will then be evaluated to determine if it is LLW or TRU waste.

### 4.5.2 UNS Debris Waste

The UNS drums contain lead liners and plastic liners to protect the drum. The salt waste stream is packaged in plastic bags or cans and placed in the plastic liner. The liquid has leaked out of the packages (degradation of plastic over time) in many cases and is on the bottom of the drum and contained by the plastic liner. Other debris is not typically found in these drums. The amount of material that can remain in the parent drum and maintain the LLW criteria is typically more than in the RNS waste stream, as shown in Table 3.

For this assessment, it is assumed the UNS debris waste will be washed/soaked and returned to the parent drum along with 100 pounds of zeolite similar to the RNs approach. The debris drum will then be evaluated to determine if it is LLW or TRU waste.

## 4.6 Resource Conservation and Recovery Act Requirements

Regardless which process is selected for UNS drums, RNS drums, and debris waste, a Resource Conservations and Recovery (RCRA) permit will be required for any treatment effort. WCRRF and various units at Area G, including 231, 375 and 412, are currently permitted for storage but not for the treatment options considered in this report for RNS and UNS waste. There are three levels of RCRA permit modification: Class 1, 2, and 3. Class 1 can be obtained within 120 days of application. Class 2 allows authorization for construction as early as 60 days, and temporary authorization for activities can be provided within 120 days of application for a period of 180 days. Class 3 authorization is likely to require a year just to get a response from NMED. NMED could also choose to initiate a compliance order to remediate the nitrated wastes, which would likely be more expeditious. The current planning basis assumes that a Class 2 or 3 permit will be required to stand up nitrate salt processing.

Another option is a research development and demonstration RD&D permit. An RD&D permit may be issued by the EPA administrator (or an authorized representative) to a facility that proposes to utilize an innovative and experimental hazardous waste treatment technology or process for which permit standards have not been promulgated [40 Code of Federal Regulations (CFR) 270.65(a)]. With RD&D permits, the responsible regulatory agency may expedite the permitting process by modifying or waiving the standard RCRA permit application and issuance procedures specified in 40 CFR Parts 124 and 270. Operation of an experimental unit under a RD&D permit is limited to 1 year, unless the permit is renewed before the end of its term. Renewal can occur up to three times, but as with the term of the original RD&D permit, each renewal period is limited to no more than 1 year [40 CFR 270.65(d)].

## 5.0 REMEDIATION/REPACKAGING SYSTEM OPTIONS

A review of the options available for remediating and repackaging the nitrated salt streams (RNS, UNS, and belowgrade) are presented herein. It is assumed that the system will be employed to process the nitrate salt waste streams using either blending or cementation as described in Section 4. The repackaging systems examined include the following:

- existing on-site systems: WCRRF glovebox and MOVER
- MORK (a mobile, modular system at SRS)
- existing gloveboxes that would require modification
- fabrication of a new glovebox
- relocation of the WCRRF glovebox to TA-54

Each system is evaluated against the following:

- ability to support blending or cementation processing
- remediating and repackaging the various nitrated salt drums at LANL
- accommodating remediation and repackaging drums at another location
- providing capability for legacy drum repackaging operations
- complexity to implement

### 5.1 Glovebox at WCRRF

Located at TA-50 Building 0069, the WCRRF glovebox was used to repackage a large number of TRU waste drums including drums containing nitrate salts. The WCRRF building is a Hazard Category 2 nuclear facility that meets Performance Category (PC) 2. (Hazard Category 2 is defined as a facility that can exceed the threshold quantities of radionuclide identified in DOE-STD-1027-92 for Category 2 Nuclear Facilities. For plutonium-239 that is 900 grams or 56 curies.) The MAR limit for WCRRF is currently 800 ECPE-Ci waste and 1800 PE-Ci total as specified under the current TSRs [ABD-WFM-006, R.2.1, Technical Safety Requirements (TSRs) for Waste Characterization Reduction and Repackaging Facility (WCRRF)]. These limits are well above the MAR inventory for the RNS-bearing waste drums and the estimated highest MAR drum in the belowground inventory that may be subject to future retrieval.

The current WCRRF Basis for Interim Operation (BIO) does not evaluate the treatment or “processing” of TRU waste drums containing oxidizers. Hence, since RNS has been designated as ignitable (D001), a change to the WCRRF BIO and TSRs will be required to allow for processing of RNS waste in the WCRRF glovebox. Additional BIO/TSR changes would also be required for using the drum tumbling option, glovebox modifications, and new processes to incorporate the proposed cooling control for RNS-bearing waste drums.

The floor plan for WCRRF is shown in Figure 13. Two airlock rooms (103 and 104) are located in front of the nuclear operations area Room 102. The glovebox is highlighted in red in Room 102. A second walk-in glovebox is shown in Room 102. This walk-in box glovebox (GBE) is currently not in use and not identified for use in the WCRRF BIO.

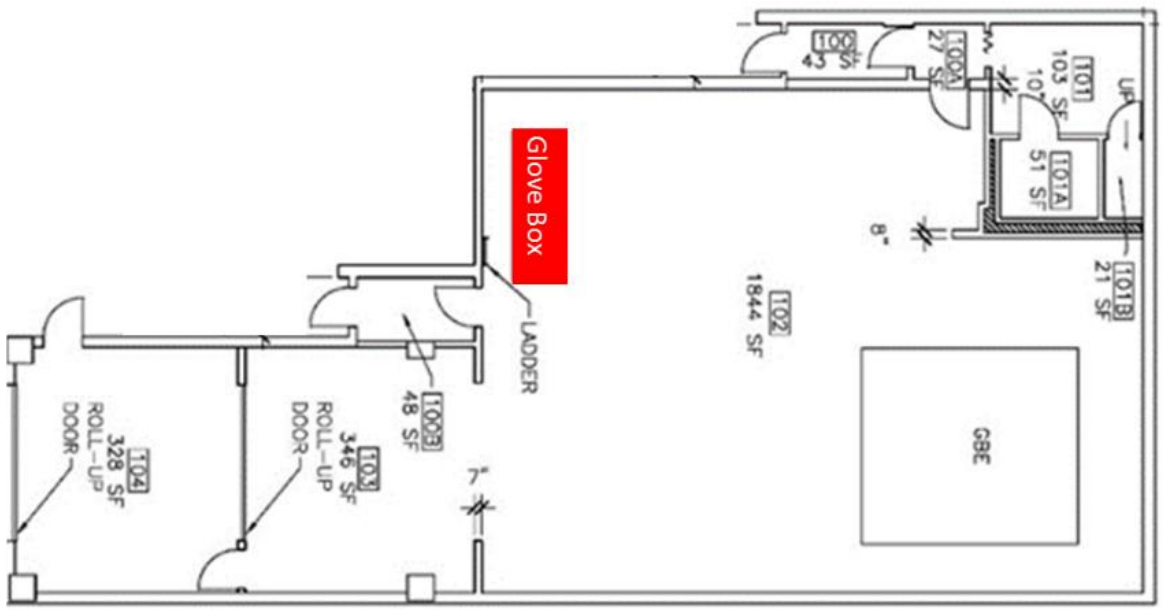


***Figure 13 WCRRF floor plan***

The WCRRF glovebox, shown in Figures 14 and 15, was designed in 1989 and installed in the early 1990s. It has two 55-gallon daughter drum bag-out ports, a 30-gallon daughter drum bag-out, and a single 55-gallon drum waste bag-on port. The box is 11 feet long, 3 feet wide, and 30 inches high. The box has seven work stations, three on the front side and four on the back. The waste drum is attached straight on from the front side of the glovebox and accessed from the back of the box. A liquid catch basin is located below the parent bag-on port to collect liquid from the parent drum. It is equipped with a water fire sprinkler for fire suppression. Ventilation for the glovebox is pulled in from the room and exhuasted through HEPA filters on the glovebox and then through facility HEPA filters. Access to the box is tight from both the back side and the back end.

The WCRRF glovebox is a credited Safety Significant system located inside a Hazard Category 2 nuclear facility that can accommodate 800 PE-Ci of MAR. The glovebox protects the worker and the collocated worker from airborne contamination and reduces radiation exposure to the worker. The associated fire suppression system helps mitigate the potential impact of fires inside the glovebox, thereby protecting the worker. The WCRRF glovebox has been used successfully for repackaging waste for over 20 years, and the allowable MAR limit provides for processing and repackaging all expected LANL legacy waste drums in inventory above or belowgrade.

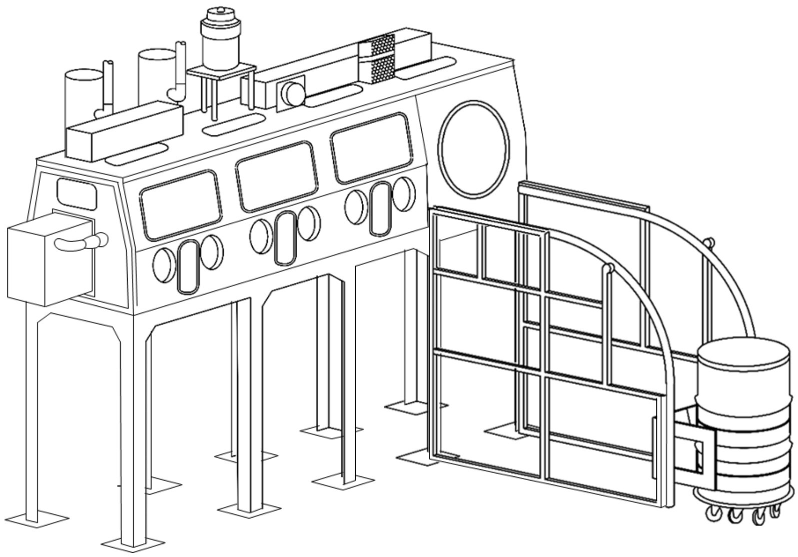

***Figure 14 WCRRF glovebox isometric***

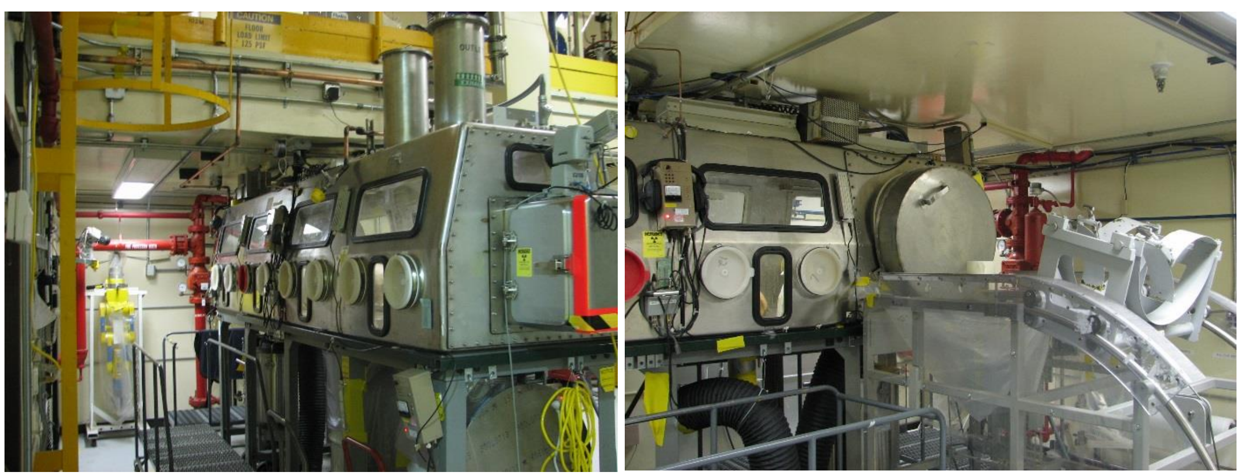

***Figure 15 Photos of the WCRRF glovebox***

### 5.1.1 WCRRF Evaluation

**Positives**

- The glovebox is configured, in place, and operational. No design, fabrication, or modifications are required to operate unless cement or zeolite needs to be delivered into the box.
- The WCRRF glovebox has been used effectively for 20 years on a wide variety of waste streams, including plutonium-238.
- The WCRRF MAR will accept all RNS, UNS, and belowgrade nitrate salt drums as well as any remaining legacy drums belowgrade (which are estimated to range to over 600 PE-Ci).
- The glovebox is located in a Hazard Category 2 facility, providing protection to the public for potential accidents. The facility has Safety Significant protections for the worker, allowing operations to proceed without workers continually wearing respirators.

- WCRRF has a BIO in place so most accident scenarios have already been evaluated, and appropriate TSRs are in place for safe operation. The review and update of the WCRRF BIO for processing D001 and D002 waste should be the less complicated and faster than options that include new equipment in new locations.
- WCRRF currently has National Environment Policy Act (NEPA) coverage in place.
- The configuration of the WCRRF glovebox has two salient features that assist with drum repackaging: (1) the side parent drum bag-on location and (2) the liquid collection basin. The parent bag-on port is the preferred location because it allows for direct viewing and access of the drum from the opposite side, and a work station on the end of the box also allows for accessing the lid and bolt for removal of the lid. The liquid collection basin will contain the free liquid often found in drums, making it easier to process.

**Challenges**

- WCRRF BIO modifications are required for processing material with D001 and D002 codes and for any needed glovebox or equipment changes.
- Use of WCRRF glovebox requires relocation of drums from Area G to WCRRF. This requires transport over road that would not be associated with a system located at TA-54.
- A refrigerator for maintaining drum cooling may be needed at or near WCRRF to ensure drums are properly cooled when processing begins to maximize operational time. Drum storage at WCRRF is described in the WCRRF BIO and managed with TSRs. This aspect of the BIO and TSRs would need to be modified for use of the WCRRF glovebox.
- Modifications to the facility and/or the glovebox for cementation at WCRRF would be required. The glovebox is contaminated and may need decontamination before any modifications are made. Either (1) a mixer and cement delivery system needs to be installed in the glovebox for cementing inside the glovebox or (2)a drum tumbler needs to be installed in the WCRRF glovebox room for mixing outside the glovebox.

**Zeolite Blending**

Zeolite addition can be readily accomodated within the WCRRF glovebox. Blending can be achieved using blenders loaded into place via the bag-out ports. Zeolite can be introduced into the box using the daughter drums loaded with bags of zeolite, or a zeolite addition system could be added to augur material into the box. Both daughter drum ports can be utilized for blending in either batch or drum processing.

**Cementation**

The WCRRF glovebox can accommodate cementation using a sacrificial agitator for in-box mixing or a containment box to house a drum tumbler. The glovebox and the facility require modifications for (1) delivering caustic solution for pH adjustment, (2) storage and delivery of cement, and (3) installation of an agitator drive. Modifications to the glovebox may be difficult because the glovebox is contaminated.

If a drum tumbler is found to be an acceptable cementation approach, then glovebox modifications are reduced and cement bulk storage and delivery to the glovebox are unnecessary.

For either cementation option, the process of designing glovebox and facility modifications and making the modifications will take time and add to the overall schedule.

**Debris Waste**

There is limited room to handle debris waste in the WCRRF glovebox. Removal, storage, and handling the debris during processing of the salt may be tight, with limited space to store the debris before it is placed back in the parent drum. Using water will require a means to introduce and use water for washing the debris waste.

**RNS Drums Processing**

All drums should be acceptable for processing once WCRRF BIO modifications are in place for operations. All RNS drums have MAR well below 800 ECPE-Ci and 1800 PE-Ci

**UNS Drums Processing**

All drums should be acceptable for processing once BIO modifications are in place for processing. All UNS drums have MAR well below 800 ECPE-Ci and 1800 PE-Ci. Most UNS drums have liquid and will require a means to collect, contain, and absorb the liquid. The glovebox has a collection reservoir.

**Belowgrade Drums**

All drums should be acceptable for processing once BIO modifications are in place for processing. All belowgrade drums have MAR well below 800 ECPE-Ci and 1800 PE-Ci.

**WCS Drums Processing**

No WCS drums will be allowed to be shipped off-site from the WCS facility.

**Legacy Waste—Future Capability**

WCRRF safety basis currently allows for the characterization and repackaging of all belowgrade drums based upon the known drum curie content. Other constituents in belowgrade drums may not be allowed at WCRRF without a Safety Basis change.

### 5.1.2 WCRRF Path Forward

Currently, WCRRF is in cold stand-by mode. To restart operations in the glovebox, the following steps are expected:

- Select nitrate salt process, select process-specific equipment, and develop procedures
- Identify glovebox and facility-related modifications to accommodate process option and initiate design effort
- Modify the WCRRF BIO, update the TSRs, and get approval to process a waste stream that contains an oxidizer and a corrosive in the WCRRF glovebox and make necessary facility/glovebox modifications
- Initiate RCRA permit modification or receive NMED order
- Implement needed facility or glovebox modifications

- Install a refrigerator at WCRRF for storing drums
- Implement BIO changes and conduct appropriate Readiness Assessments

### 5.2 MOVER

The MOVER system is a glovebox contained in a Type-A transportainer. MOVER is shown in Figure 16. The transportainer is a 40-foot-long qualified U.S. Department of Transportation (DOT) 7A Type-A container capable of highway transportation and designed to be located inside or outside, typically in a Hazard Category 2 facility. The system is meant to set and connect to existing building utilities. Generally, setup requires leveling the container, direct connecting to the building power with a simple plug, and, in some cases, connecting to the building compressed air or vacuum. MOVER has its own ventilation blower and the exhaust can be connected to a building's HEPA system but is not necessary. The module is designed to be self-sufficient and to handle risks posed by waste material fed to the glovebox. Typically, a facility safety analysis report or BIO can be structured to allow for the siting of the unit.

***Figure 16 MOVER before deployment to Argonne East***

MOVER was deployed to Argonne East in June 2001, during which time approximately 400 drums were processed for shipment to WIPP. The unit was operated by Central Characterization Project (CCP) of Washington Group International. Waste processing was completed in May 2003. The system was decontaminated and readied for redeployment to Lawrence Livermore National Laboratory (LLNL). Radiological work at LLNL began in April 2004.

On August 19, 2004, a radiological release occurred in the MOVER during bag-out operations. A complete listing of the root causes, contributing causes, and judgments of need (JONs) for the incident are included in Appendix E. Most of these deal with methods used to bag the parent drum onto the glovebox. A Price-Anderson Amendments Act (PAAA) Enforcements investigation of the MOVER radiological uptakes followed and resulted in proposed civil penalties to Washington TRU Solutions and LLNL. Violations included safety basis, work process, design and design basis documentation, and quality improvement violations for Washington TRU Solutions and as ALARA, radiological monitoring and work process violations for LLNL. MOVER operations were suspended after the incident, and the system was returned to LANL where it has resided since.

The general configuration of MOVER is shown in Figure 17. The facility has three rooms: a control room, a receiving room, and an operations room with a glovebox.

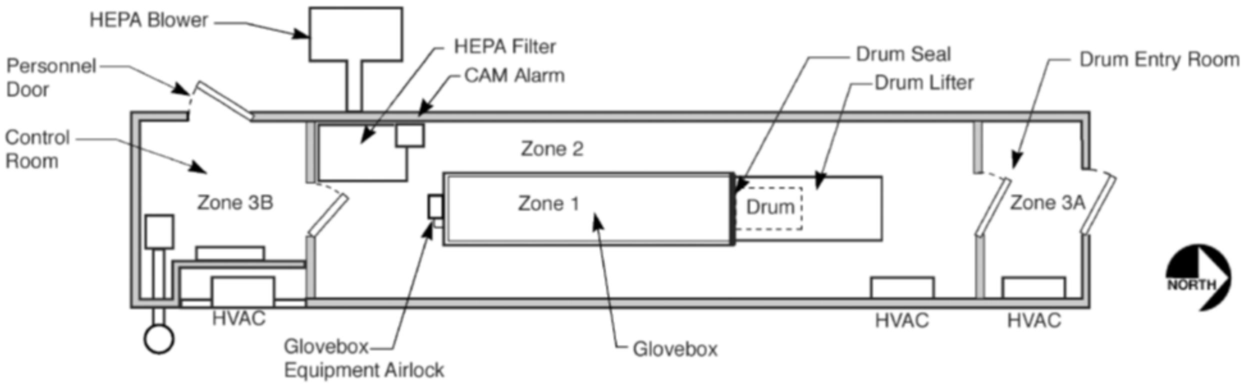


***Figure 17 MOVER general configuration***

Ventilation is pulled through HEPA filters in the side of the transportainer into Zone 2 (or the glovebox work area) and then into the glovebox (Zone 1) and out through a testable HEPA filter. The ventilation blower is staged outside. The control room, drum entry room, and the general work area all have an independent heating, ventilation, and air conditioning (HVAC) system that recirculate room air.

The drum entry room is located at one end of the trailer. This room provides space for four standard 55-gallon drums on transport dollies. Typically, only one drum is characterized in this process and placed in the airlock for testing each day.

Doors between each section isolate each room and are kept closed during glovebox operations to maintain negative pressure in the unit. Air-flow direction is maintained so the air flows from areas of low contamination to areas of potentially higher contamination before it is exhausted through the HEPA ventilation system.

Exterior doors are provided at each end of the trailer. A flashing light next to the exterior doors to the MOVER is lit if the continuous air monitoring (CAM) sounds. Exterior doors have a handle that can be locked when the MOVER is unattended. Radiological and warning postings signs are provided at each door entrance point in accordance with Environment, Safety, and Health protocols.

Once operators unlock the exterior doors (i.e., one at the drum entry room end and the other at the control room), the keys are removed and controlled by the operator. This precludes locking the doors while operations are ongoing.

The MOVER structure is classified as a Type II structure per National Fire Protection Association 220, Standard on Types of Building Construction. Its interior walls were constructed as double-walled for contamination purposes, with sealed and polished stainless-steel interior for ease of decontamination. The MOVER can be transported on public roads without special escort. The outside walls of the MOVER are constructed of carbon steel. The walls are insulated with cellulose, which is manufactured under Consumer Product Safety Commission performance criteria mandating fire standards. The insulation has a flame spread rate of 20 and smoke development rate of 5. Acceptable levels for a Class 1, flame spread rate are less than 25. The interior and exterior of the MOVER are nonflammable metal with steel stud construction. All electrical systems were designed to the National Electrical Code.

The glovebox, shown in Figure 18, is of similar design to the WCRRF glovebox with two significant exceptions:

- The drum on port is on the end of the box
- The box has one 55-gallon daughter drum and one 30-gallon daughter drum bag-out port

The MOVER glovebox is 12 feet long, 2.75 feet high, and 3 feet wide at the work area.The ventilation system provides 16 airchanges per hour and maintains a flow of 25 cubic feet per minute, which provides 125-feet-per-minute face velocity if a window or glove opening is compromised. The blower is capable of twice the normal operating flow.

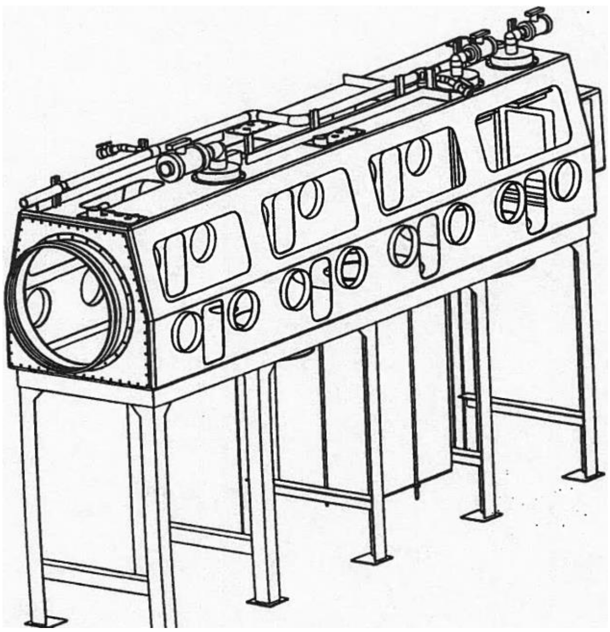

***Figure 18 MOVER Glovebox***

Working platforms are positioned on each side of the glovebox and are approximately 16 inches above the floor level. One step is required to access the working platforms. The platforms are hinged to the outside wall of the 7A Container and remain in the up position until used. In the down position, the platforms rest on pieces of angle iron welded to the glovebox feet (upright legs). Drums of characterized waste must be moved into and out from under the glovebox by lifting the section of the platform in the travel path of the drum.

MOVER could be located outside or inside a dome, preferably near the waste storage at the 231 or 375 dome, making access very easy and eliminating the need to transport waste for remediation.

### 5.2.1 MOVER Evaluation

**Positives**

- MOVER is very simple to set up and initiate operation, requiring only power.
- MOVER can be located at TA-54 close to the waste drums, thus eliminating the need to transport drums from TA-54 for remediation and processing.
- MOVER is mobile and can be relocated to other locations.

**Challenges**

- MOVER has not been used since 2004. It will require decontamination and resolution of those items identified by the PAAA investigation. Most of these relate to the parent drum bag-on approach and should be relatively easy to resolve.
- Necessary PAAA and JON issues should be resolved before restart.
- MOVER only has one 55-gallon daughter drum port.
- It is not known what MAR limit would be allowed in MOVER; however, it should be acceptable for the 18 ECPE-Ci if located inside either the 231 or 375 dome near the waste storage.
- MOVER reputation suffers from the LLNL event.
- It is unclear how much MAR MOVER would be allowed to house during operations and may limit its use on drums that contain higher amounts, especially legacy waste.
- Moving drums into and out of MOVER is slow as the elevated floor sections have to be lifted out of the way for each movement.

**Zeolite Blending**

Zeolite addition can be accomodated in the MOVER glovebox. Blending can be achieved using a blender loaded into place via the bag-out port. Zeolite can be introduced into the box using the daughter drum loaded with bags of zeolite. Blending the loaded drum in a drum tumbler located outside MOVER after filling would also be accomodated by MOVER.

**Cementation**

MOVER will complicate the cementation option as the addition of caustic and cement will need to be fed through the transportainer and into the glovebox. The box could be configured to accommodate cementation using a sacrificial agitator for in-box mixing.

As with blending the cement in a drum tumbler, the pH-adjusted solution would have to be pumped through the glovebox and the transportainer shell to an exterior drum tumbler enclosure.

If a drum tumbler is found to be an acceptable cementation approach, then glovebox modifications are reduced and cement bulk storage and delivery to the glovebox is unnecessary.

**Debris Waste**

MOVER has room on the back end of the box for handling debris waste. This may require manuvering around blending or mixing equipment. There is room for washing the debris. Water-supply issues will have to be resolved to accomdate washing the debris.

**RNS Drums Processing**

It is unclear what ECPE-Ci or PE-Ci limitations may be required for MOVER. MOVER would likely be allowed to process the RNS and UNS drums if located in the 231 or 375 dome.

**UNS Drums Processing**

It is unclear what ECPE-Ci or PE-Ci limitations may be required for MOVER. MOVER would likely be allowed to process the RNS and UNS drums if located at the 231 or 375 dome. Most UNS drums have liquid and will require a means to collect, contain, and absorb the liquid. The glovebox does not have a collection reservoir, and a basin will need to be added for this stream.

**Belowgrade Nitrate Salt Drum**

It is unclear what ECPE-Ci or PE-Ci limitations may be required for MOVER. MOVER would likely be allowed to process all the belowgrade nitrate salt drums, except the 10 that exceed Hazard Category 2 levels.

**WCS Drums Processing**

MOVER can be relocated and operated at other sites. It can move over the public roads as a Type A container. WCS would have to evaluate the MOVER and determine if operation is allowable.

**Legacy Waste—Future Capability**

MOVER may be capable of a limited role for handling low MAR waste for repackaging located at Area G. It is unclear what MAR would be allowed once the PAAA issues are addressed. It is likely the MAR would be above the 18 ECPE-Ci because the Type-A container provides a credited confinement.

### 5.2.2 MOVER Path Forward

Currently, the MOVER is shuttered and in need of maintenance and improvements to resolve PAAA and JON requirements. To restart operations in the glovebox, the following steps are expected:

- Select nitrate salt process and develop process-specific equipment and procedures (blending or cementing using a drum tumbler is preferred)
- Perform a readiness evaluation on the MOVER and its systems
- Prepare a list of maintenance, repair and PAAA and JON changes that will bring the MOVER in to operational readiness
- Identify a location to set MOVER for operation

- Update the Area G BIO and receive approval to process a waste stream that carries the D001 and D002 charactersitics in the MOVER glovebox to allow removal of these characterisitics (prohibited under the WIPP WAC).
- Initiate RCRA permit modification or receive NMED order
- Relocate MOVER for maintenance and upgrade work
- Initiate MOVER modifications and required TA-54 facility modifications
- Evaluate against NEPA requirements

### 5.3 MORK

MORK is a modular container that houses two repackaging gloveboxes.

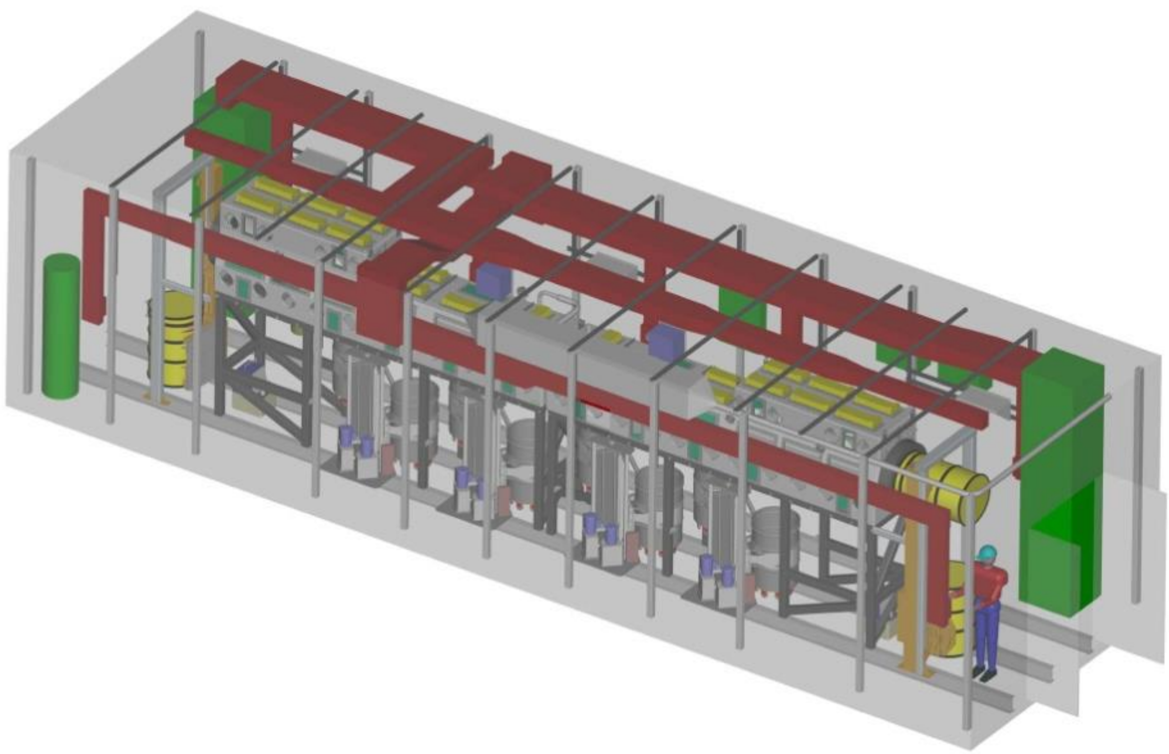

***Figure 19 MORK Isometric Drawing***

In 2004, at the request of Carlsbad Field Office, LANL completed the design of a set of mobile and modular nuclear facilities that could be used to process waste streams for packaging and shipment to WIPP. Two designs were completed in parallel: a Hazard Category 2 PC-2 design for deployment to SRS and a Hazard Category 2 PC-3 design for use at LANL. The SRS modular units (MUs) were built and deployed to SRS for use in repackaging drums for WIPP. The LANL design was completed, including all of the necessary documentation (construction designs, system design description, design criteria, functional and operating requirements, management level (ML) determinations, codes and standards, and preliminary detailed safety analyses (PDSA), to submit to DOE for approval. Figure 20 is a drawing of the nuclear-rated transportainer shell in which operations equipment is configured, and Figure 21 shows photos of the shell during construction.

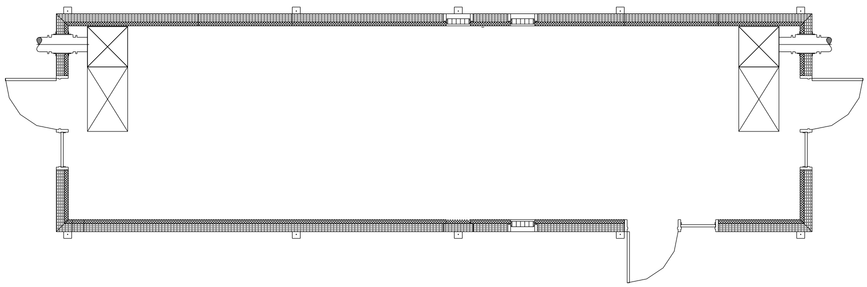

***Figure 21   Nuclear transportainer shell drawing***

***Figure 21   Photos of the nuclear transportainer shell during construction***

### 5.3.1 Transportainer

The mobile modular concept takes advantage of a standardized Hazard Category 2 nuclear transportainer shell that can be used to house nuclear operations and is mobile. The transportainer can be outfitted with equipment that performs functions necessary to meet mission objectives, in this case repackaging waste for shipment to WIPP. The transportainer is standardized to minimize fabrication costs and is self-sufficient. The shell is 47 feet long and 14 feet wide, capable of being moved over road, and connectable to other modules.

Transportainer internal dimensions are 12 feet wide by 11 feet high and 45 feet 6 inches long. Walls and ceilings are approximately 4 inches thick. Floors are approximately 6 inches thick. The framework is made entirely of metal. Transportainers are insulated with noncombustible insulation, and the inside (ceiling, walls, roof) is lined with 16-gauge stainless steel, which provides a radioactive material release barrier that can readily be decontaminated. All stainless-steel seams are sealed. The transportainers are equipped with fusible linked dampers to cover the HEPA filter penetrations. This provides complete isolation of the transportainer in the event of a fire. Transportainers must meet PC-3 criteria for LANL natural phenomena hazard events.

Transportainers have one exterior door opening at each end and two door openings on each side. Doors not in use can be sealed with a blind plate. All doors open to the outside and provide a tight seal. Exterior doors, panels, and frames are stainless-sheet steel and insulated with an R-value of 10. They are SDI-100, Grade III, extra heavy-duty, Model 2, minimum 16-gauge faces, insulated fire-rated B-label. Closed top and bottom edges of exterior doors are integral parts of door construction or by addition of minimum 16-gauge inverted steel channels.

Frames, concealed stiffeners, reinforcement, edge channels, louvers, and moldings are from either cold-rolled or hot-rolled stainless steel. Frames are a minimum of 16-gauge cold-rolled stainless steel. They are designed with mitered and welded corners. Door silencers are drilled to receive three silencers on strike jambs of single doorframes and two silencers on heads of frames with pairs of doors.

Penetrations through the exterior walls include ductwork, electrical conduit, and personnel doors. All transportainer penetrations, such as for ventilation and exhaust system ducts, pipes, and conduits, are sealed. Pipes, ducts, and valves are weld-type or flanged when it is not possible to weld such components.

The transportainer when equipped with process equipment becomes an MU. The MU equipped with two gloveboxes is called a MORK. Figure 22 shows the layout of a MORK with two gloveboxes for repackaging. MORK can be used to visually examine waste, retrieve prohibited items, or divide waste that exceeds radioactive limits for transportation for WIPP acceptance. MORK contains two 16-foot-long gloveboxes.

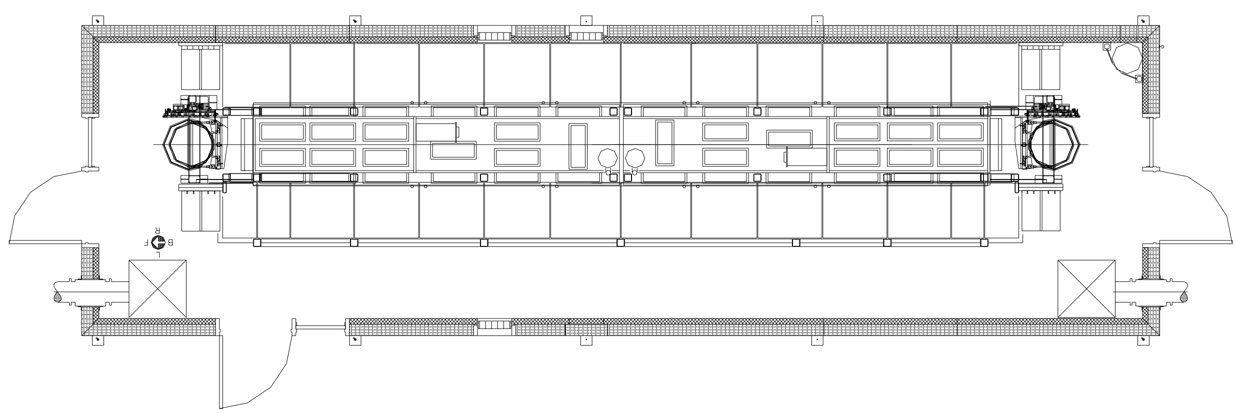

***Figure 22 MORK floor plan with two gloveboxes***

The MORK is self-sufficient and does not require other MUs to operate; however, it can attach to other MUs via a spool, allowing movement between MUs. The parent waste drum on ports for the gloveboxes is located at each end of the transportainer. Each end of the transportainer has a door and can be mated to a spool for access to other transportainers or to a receiving unit.

Each MU can be connected to other MUs—nuclear or nonnuclear—allowing for multiple functions, command and control, or increasing capacity. Figure 22 shows a configuration of four transportainers, two MORKs, a Command Operations Unit, and a drums storage/headspace gas unit connected via a spool as well as three receiving units also connected via a spool. This configuration is one of many possible with MUs.

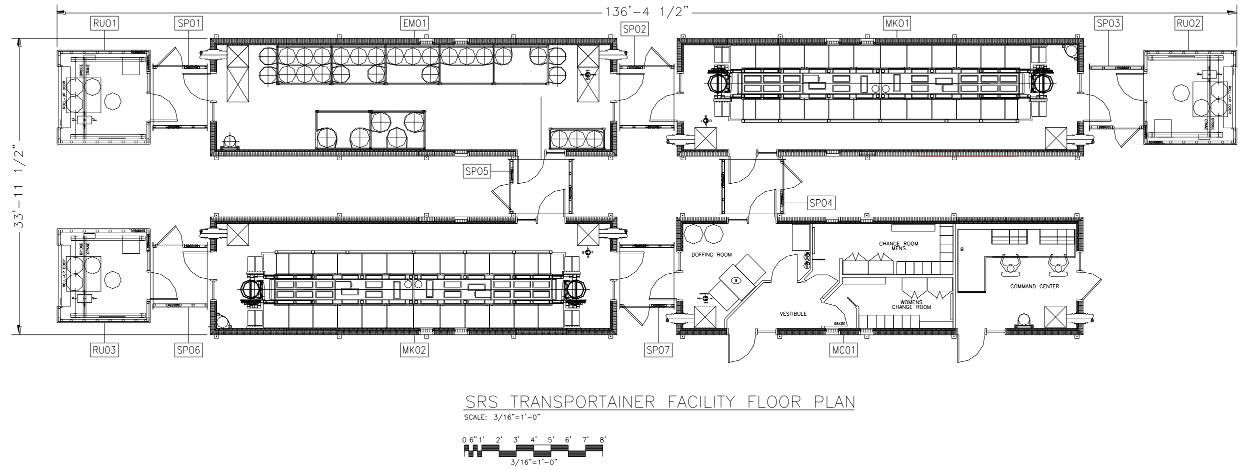


***Figure 23  Mobile system facility configuration***

The MAR for an MU is set at 2000 PE-Ci (32,160 plutonium-equivalent gram [PE-g]) because this limit provides a reasonable level for hot operations. Similarly, a single waste container, most often a drum, is limited to 1000 PE-Ci (16,080 PE-g). Based on operations, points of entry for the waste drums, and planned connection of the various MUs, the maximum MAR available for release is limited to the MAR of one MORK and is set at 2000 PE-Ci (32,160 PE-g).

The HVAC system for an MU is mounted on a concrete slab external to the MU. Major components of the system include supply fan, air filter, evaporator coil, hermetic compressor, condenser coil, and operating controls. The supply fan is a forward-curved centrifugal type, mounted with a V-belt drive, and an isolated high-efficiency motor. The air inlet filters are made of 2-inch-thick glass fiber disposable media in metal frames with 60% efficiency.

A concrete mounting pad is an integral safety feature included in the design of the MORK. The concrete mounting pad is identified as the key safety control to protect the off-site individual  from a natural phenomenon event. A stable platform for the MORK transportainer to prevent loss of radioactive material is critical to meet PC-3. The safety function of the concrete mounting pad is to provide a stable platform that will be able to survive a seismic event. This, in turn, allows the MORK transportainer to maintain structural integrity and confinement before, during, and after a natural phenomenon event.

### 5.3.2 MORK Glovebox

The general dimensions for each MORK glovebox are 40 inches wide by 48 inches tall, by 16 feet long. Five workstations are on each side as shown in Figure 24. Each glovebox has the following features:

- glovebox windows made of leaded glass;
- inerting gas supplied to the glovebox interior to prevent fires;
- a tray to collect free liquids from the parent drum located under the parent drum port mouth;
- five stations on each side, one bag-on port for parent drums located on the vertical end face and designed for both 55-gallon and 85-gallon overpack waste drum, and four bag-out ports for 55-gallon daughter drums on the underside;
- a trolley to lower objects weighing up to 500 pounds into a daughter drum;

- a high-purity Germanium counter located on the underside to measure the amount of radioactive material;
- electrical connections for tools;
- internal covers for bag-out ports not in use;
- seismically designed stand;
- external covers for all ports to protect the plastic bag stub during maintenance, extended shutdowns, and transportation;
- fire detection, fire suppression (FM-200), and fire alarm systems;
- fusible link dampers on intake and exhaust of ventilation system; and
- an oxygen monitor.

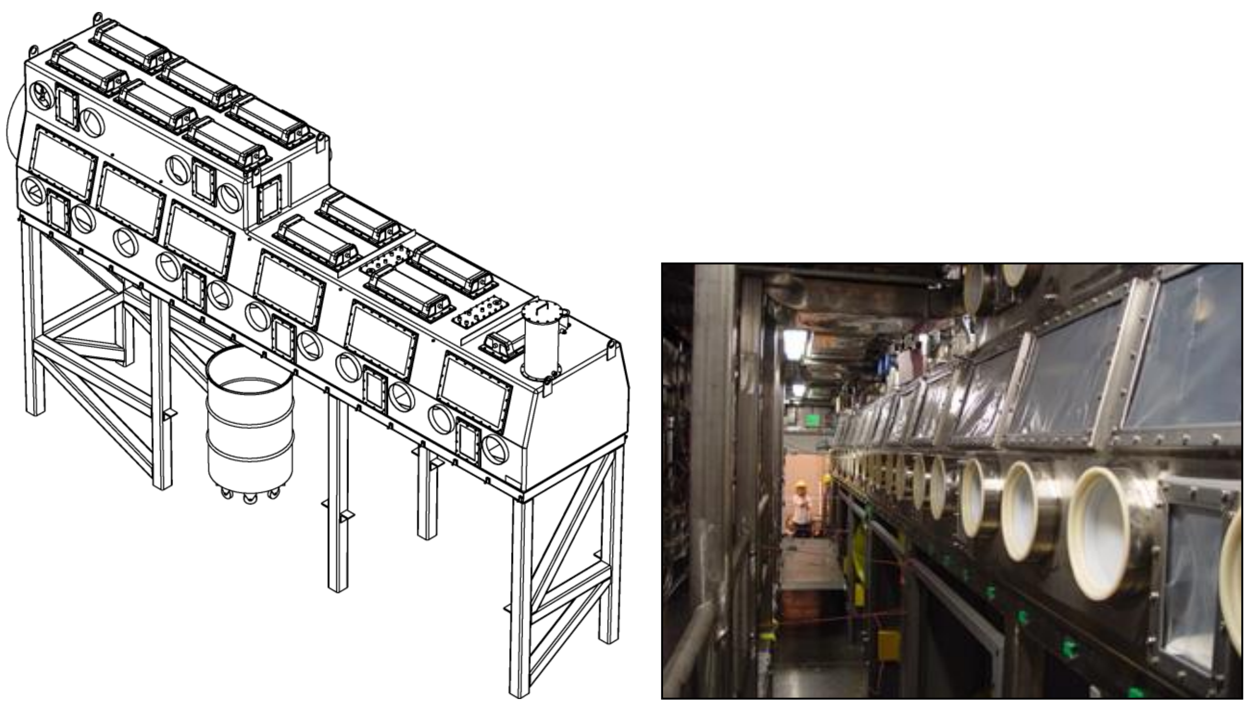

***Figure 24 Isometeric drawing of MORK glovebox and picture of gloveboxes in SRS MORK***

Waste containers that are 85 gallon or 55 gallon and weigh up to 1000 pounds can be bagged on to each glovebox for repackaging into four 55-gallon daughter drums. Drum lifts are provided for the waste drums and the daughter drums. The glovebox and the lifts are seismically designed and shown in Figure 25.

***Figure 25 Daughter drum and waste drum lifts for MORK***

#### 5.3.3 SRS MORK

In 2004, the Carlsbad Field Office sent a set of MUs to SRS to assist with the repackaging of waste for shipment to WIPP. The MUs were fabricated in Carlsbad by Washington TRU Solutions via funding from the Carlsbad Field Office. Siting of the MUs at SRS required that the MORK meet Hazard Category 2 and PC-2 because the location was about 1 mile from the site boundary. The system configured at SRS includes a MORK, two spools, a receiving unit, and a control MU as well as the HVAC system. The system was placed inside a “RUB,” a fabric dome similar to those at Area G. The layout of this system is shown in Figure 26.

***Figure 26 Configuration of modular units at SRS***

The SRS system (referred to as the MRS) was installed, successfully started up, and processed approximately 750 drums. Most of the operations was repackaging of legacy waste drums. These drums contained americium-241, plutonium-239, and plutonium-238 isotopes. No major problems were encountered with the operation of the system. Drum movement was noted to be tight (which was expected and was reflected in the design). HEPA filter change out was also noted to be difficult. However, the system performed well, and the legacy waste destined for repackaging was processed and sent to WIPP.

The system was shut down in 2009 after the legacy waste was repackaged and sent to WIPP. The system was then put into "lock down." Currently, SRS no longer uses these MUs and is contemplating salvaging them. The ventilation system has been shut down and the MORK was shuttered to allow for no ventilation. Phone discussions with Lee Fox, Deputy Director of Solid Waste Management at SRS, confirmed the site has no plans to use the MUs and is open to the possibility of relocating the system.

The glovebox contains contamination and will require decontamination before relocation to meet DOT requirements. Discussions with LANL Transportation representatives concluded that the best alternative is to transport MORK as a Surface Contaminated Object (SCO). SCO exists in two phases ACO-I and SCO-II. LANL Transportation believes the MORK would meet the SCO-II container requirements:

**SCO-II:** A solid object on which the limits for **SCO-I** are exceeded and on which:

(i) The non-fixed contamination on the accessible surface averaged over 300 $cm^2$ (or the area of the surface if less than 300 $cm^2$) does not exceed 400 $Bq/cm^2$ (24,000 disintegrations per minute [dpm]) for beta and gamma and low toxicity alpha emitters, or 40 $Bq/cm^2$ (2,400 dpm) for all other alpha emitters;

(ii) The fixed contamination on the accessible surface averaged over 300 $cm^2$ (or the area of the surface if less than 300 $cm^2$) does not exceed 8 × 105 $Bq/cm^2$ (4 × $10^7$ dpm) for beta and gamma and low-toxicity alpha emitters, or 8 × 104 $Bq/cm^2$ (4 × $10^8$ dpm) for all other alpha emitters; and

(iii) The non-fixed contamination plus the fixed contamination on the inaccessible surface averaged over 300 $cm^2$ (or the area of the surface if less than 300 $cm^2$) does not exceed 8 × 105 $Bq/cm^2$) (4 × $10^7$ dpm) for beta and gamma and low-toxicity alpha emitters, or 8 × 104 $Bq/cm^2$ (4 × $10^6$ dpm) for all other alpha emitters.

### 5.3.4 MORK Siting at LANL

To maintain the PC rating and, in turn, maximize the amount of MAR allowance, a suitable foundation and location must be available to set MORK. The concrete mounting pad provides a stable platform that will be able to withstand a PC-3 seismic event and prevent the transportainer from toppling. Based on the analysis, the transportainer concrete mounting pad and tie down hardware are designated as safety class. The concrete mounting pad cannot be placed above any of the previously used pits or underground storage locations.

Locations in Area G are limited for siting MORK because nearly all the existing buildings and most of the property sits above underground storage locations. A large area in the center of Area G is a drainage area and is not considered for siting. Dome 33 is one building that is not above a waste storage area and it is covered by an existing RCRA permit. Dome 33 currently has a mission for venting legacy drums for processing. It is unclear if the existing pad would meet seismic requirements. Another location in Area G (proposed in 2004 for siting MORK) is west of Pit 38 and it is not covered by a RCRA permit. Dome 33 and the area west of Pit 38 are outlined in red in Figure 27.

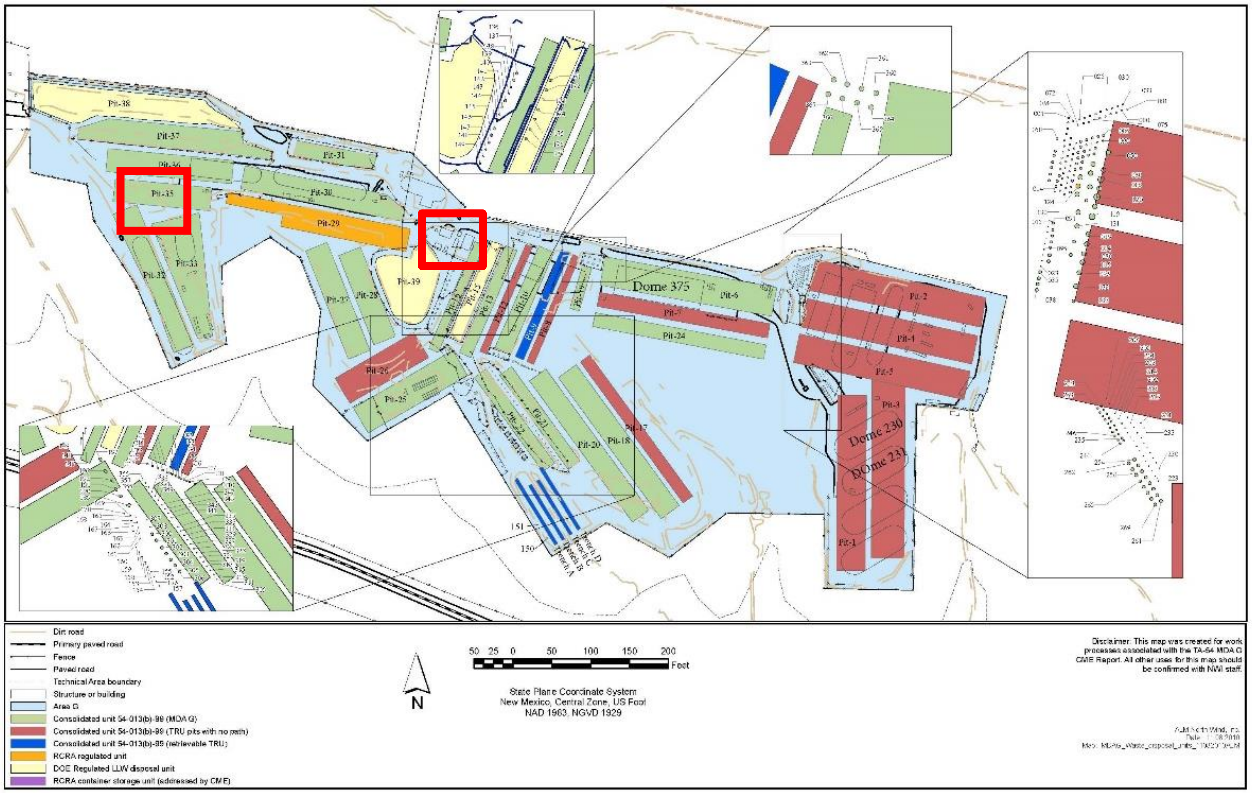


***Figure 27   Area G Map showing possible MORK siting locations***

Benefits are associated with locating MORK outside Area G. The R-56 pad in Zone 4 is located close to Area G and is in an area that could be configured to house MORK. Locating MORK next to Area G enables repackaging and remediation within Area G, thus minimizing operational impacts. However, this location does not benefit from having the Area G BIO or RCRA permit and would require a documented safety analysis (DSA) and RCRA Class 3 application permit to operate. This impacts cost and schedule for this option but provides a longer-term solution for legacy drums that could replace WCRRF.

Siting MORK at Area G or R-56 will require providing a seismic pad to maintain the Safety Class performance of the transportainer. Power and weather protection would be additional requirements and costs associated with siting MORK. While MORK could be located outside, it is not preferable for drum operations in the winter or during poor weather (although a dome or Perma-Con® surrounding MORK could be constructed).

### 5.3.5 MORK Evaluation

**Positives**

- MORK is designed for 1000 PE-Ci/drum and 2000 PE-Ci/MORK. This will accommodate all legacy drums, including the high PE-Ci drums containing plutonium-238 waste stored in Trenches A–D.
- MORK was and can be operated as a Hazard Category 2 nuclear facility.
- MORK operated effectively at SRS, processing approximately 750 drums including plutonium-238 waste.

- MORK has two gloveboxes each with four daughter drum ports, enabling faster processing of the waste if both boxes are used simultaneously.
- MORK can be relocated.
- Locating MORK at Area G is close to the drums, thus eliminating the need for off-site drum movement

**Challenges**

- MORK has not been used since 2009. Systems will need to be examined and assessed. It is likely maintenance will need to be performed to bring systems up.
- MORK will require decontamination to relocate to LANL. Deconatmination will require the support of SRS and must meet SCO-II levels. Contamination includes plutonium-238.
- Transporting MORK will require preparing the internal systems for transportation, including bracing the glovebox and ventilation ducting.
- MORK may require special siting to meet seismic requirements that may include the installation of a concrete slab.
- TA-54 BIO modification or a new DSA will be required depending upon its location for MORK to operate.
- Locating MORK at TA-54 will require utilities to run the HVAC, ventilation, lighting, and controls.
- A Class 3 RCRA permit application will likely be required for locating MORK in a location not already covered by a RCRA permit.

**Zeolite Blending**

Zeolite addition can be accomodated in the MORK glovebox. Blending can be achieved using a blender loaded into place via the bag-out port. Zeolite can be introduced into the box using the daughter drums loaded with bags of zeolite. Drums can also be preloaded with zeolite and tumbled after the salt is added to the drum. Use of a drum tumbler will require a location outside the MORK.

**Cementation**

MORK will complicate the cementation option because the addition of caustic and cement will need to be fed through the transportainer and into the glovebox. The box could be configured to accommodate cementation using a sacrificial agitator for in-box mixing.

Similarly, for blending the cement in a drum tumbler, the pH-adjusted solution would have to be pumped through the glovebox and the transportainer shell to an exterior located drum tumbler enclosure.

If a drum tumbler is found to be an acceptable cementation approach, then glovebox modifications are reduced and cement bulk storage and delivery to the glovebox is unnecessary.

**RNS Drums Processing**

The MORK is expected to handle all of the RNS drums since it is designed for 1000 PE-Ci/drum. Having four daughter drum bag-on ports makes the MORK versatile in providing multiple blending stations as well as providing space for debris issues.

**UNS Drums Processing**

The MORK is expected to handle all of the UNS drums because it is designed for 1000 PE-Ci/drum. Most UNS drums have liquid and MORK has a collection reservoir for liquids.

**Belowgrade Nitrate Salt Drum**

The MORK is expected to handle all of the belowgrade nitrate salt drums because it is designed for 1000 PE-Ci/drum.

**WCS Drums Processing**

MORK can be relocated and operated at other sites. Moving MORK requires decontamination of the glovebox to acceptable SCO levels.

**Legacy Waste—Future Capability**

The MORK is expected to handle all LANL legacy waste drums because it is designed for 1000 PE-Ci/drum. MORK has two gloveboxes each with four daughter drum bag-on ports. This should provide excellent remediation and processing capability.

### 5.3.6 MORK Path Forward

Relocation of the SRS system to LANL will require the following path forward:

- *Approval from SRS to relocate.* SRS (via Lee Fox) has indicated it does not intend to use MORK and is considering decontamination and demolition. It is amenable to supporting a LANL effort to decontaminate and relocate MORK.
- *Verification that MORK can be moved if the glovebox meets SCO-II levels.* Initial discussions with LANL Transportation representatives indicate that MORK could be transported if the glovebox is decontaminated to meet SCO-II levels
- *Verification that MORK glovebox can be decontaminated down to a level that meet SCO-II levels.* Initial indications with LANL decontamination subject matter experts (SMEs) indicate the MORK glovebox could be decontaminated to meet SCO-II requirements. A better judgment can be made once the current MORK glovebox contamination levels are analyzed.
- *Walkdown and evaluation of system at SRS by LANL SMEs.* Relocation of MORK will require a concerted effort by a range of SMEs at LANL. An initial review and visit to SRS by engineering, Facilities Operation Division (FOD) and AB SMEs are recommended to ensure the system can be relocated to LANL and deployed successfully. This review and evaluation will provide a more accurate determination of the effort, cost, and schedule required.
- Approval to use at LANL
    - ❖ *Identify a siting location.* The original design (2004) called for the MU facility to be PC-3 and located at the west end of TA-54. Two potential sites were identified: one west of Pit 38, and the other southeast of former Building TA-54-281. Based upon the waste to be processed and the MAR the facility must house, the need for seismic performance may be reduced, especially if the intent is to remediate only the RNS and UNS waste streams. A longer-term strategy for using the MORK as a Hazard Category 2 facility to

process additional legacy waste may require meeting more stringent mounting requirements and an alternate location.

- *Identify concrete mounting pad requirements.* As with the MUs, the concrete pad must meet PC-3 criteria for LANL natural phenomena hazard events. The MUs must be anchored to a concrete mounting pad. The concrete mounting pad design must have sufficient length and width to support and anchor the MUs. Based upon the waste to be processed and the MAR the facility must house, the need for seismic performance may be reduced and siting requirement related to the concrete pad relaxed. Handling the RNS and UNS and most of the belowgrade nitrate salt waste, of which only nine drums exceed 18 ECPE-Ci, may be acceptable without significant concrete pad requirements.
- *Identify the RCRA and NEPA requirements for the siting location.* Either a new permit will be required or an existing permit may need to be modified.
- *Identify AB requirements for use.* Verify LANL can obtain DOE approval to relocate and use MORK based upon siting location and intended usage plans. Identify what siting requirements would be imposed.

- *Decontaminate glovebox to levels that meet SCO-II.* Coordinate with SRS to decontaminate the MORK glovebox with SRS. Preferable option is to provide funding if necessary to SRS for decontamination services.
- Initiate AB efforts to adjust AB for using MORK
- Initiate planning to decontaminate and relocate MORK to LANL

### 5.4 Glovebox Located at Area G

Four gloveboxes are considered as candidates for installation at Area G. Two gloveboxes are in storage at Area G. They were obtained from sources within the LANL. Both have some level of pedigree but would likely not meet all the requirements for a credited system providing a safety significant function. Both will require some additional modifications to become operational and useful for this effort. The third glovebox is the MORK glovebox. The MORK-type glovebox would have to be fabricated. It is considered because (1) it has a complete design package, (2) the design is for use in a Hazard Category 2 facility to withstand PC-3 seismic events, and (3) the box includes four daughter drums ports. Finally, relocating the WCRRF glovebox is considered because it is a credited glovebox and has demonstrated that it can be an effective repackaging system.

Benefits are associated with having a repackaging capability at Area G. The current repackaging glovebox is located at TA-50 and requires transportation and storage of waste to and from WCRRF to repackage drums. Transportation impacts schedule, adds to cost, and increases coordination complexity. Additionally, operating a remote Hazard Category 2 facility requires additional maintenance, operations personnel, and operating cost. However, WCRRF TSRs allow for 800 ECPE-Ci and 1800 PE-Ci, providing a location to repackage any legacy drum on-site at LANL.

At a maximum, the current Area G TSRs allow for 18 ECPE-Ci of MAR in process and 18 ECPE-Ci of MAR in storage where SSSR is taking place. Nine RNS drums exceed 18 ECPE-Ci, *assuming all the contained MAR is now considered combustible*. All the aboveground UNS drums have less than 18 PE-Ci. It may be possible to receive approval to process a drum containing 36 ECPE-Ci if during sort, segregate, size reduction and repackaging (SSSR) operations no MAR is stored in the building. Only 1 RNS and 26 belowgrade drums exceed 36 PE-Ci. Therefore, it may be possible to repackage 141 of the 168 known LANL RNS, UNS, and belowgrade nitrate salt drums in a glovebox located within Area G.

A glovebox located within Area G could also be used after completing the nitrate salt waste stream for limited combustible PE-Ci drums. Approximately 3900 remaining legacy drums have less than 18 PE-Ci and are candidate drums for repackaging in a glovebox at Area G. Processing higher MAR drums will likely require systems such as WCRRF or MORK that has credited systems in place and can handle higher MAR.

Currently, three locations are considered for housing a glovebox for repackaging operations: the Perma-Cons® in Domes 375 and 231 and the enclosure at Building 412. There are competing priorities for these locations for the longer term, especially the two Perma-Cons®. This may limit the duration and long-term viability of maintaining a repackaging capability in the Perma-Cons®. Building 412 requires additional effort because the ventilation system requires attention to bring it up and to verify operation requirements; it has never been demonstrated to be nuclear capable.

### 5.4.1 Area G Glovebox Requirements

Fabrication or modification of available gloveboxes is an option that may be effective for the remediation of the RNS and UNS waste streams. It is unclear what level of rigor would be required for installing a glovebox at Area G. Typically, a glovebox is a credited system under safety basis to limit MAR dispersion and to protect workers.

The current Area G TSRs allow SSSR activities that are below 18 ECPE-Ci to be carried out in a glovebag at Building 412. A glovebag does not provide credited protection as a Safety Significant–rated glovebox does. The Area G BIO identifies training, fire watch, and separation distances as mitigating controls. It is unlikely that these administrative controls will be credited in future hazard analyses. Therefore, it is expected that any system employed to handle the UNS and RNS waste stream will likely require a glovebox that is Safety Significant and can act as a primary control to limit exposures to the worker. The glovebox/drum lift system

1. Provides confinement to potential airborne radioactive material, preventing release of radioactive material from the glovebox to working areas;
2. Attenuates the level of penetrating radiation to the work area;
3. Provides a stable platform for the waste container; and
4. Prevents embers from being entrained in the exhaust ventilation (fire screen) and HEPA system.

Similarly, a fire suppression system in the glovebox will also act as a Safety Significant system to control and limit the size of fire within the glovebox and mitigate the impact of the fire on the glovebox confinement (i.e. gloves).

A safety significant component (SSC) protecting the worker requires the requisite design, fabrication, installation, maintenance, and quality assurance (QA) to meet the SSC designation. The added formality and documentation ensure the glovebox can be credited to protect the worker during operation and will perform its intended preventive or mitigating function.

Schedule considerations for repackaging RNS drums may not allow for the design, fabrication, installation, and readiness activities associated with a new credited glovebox system at Area G. Discussions with Merrick suggest design may take 9 months to a year and fabrication an additional 9 months to a year. This would mean that a credited glovebox may not be available for 18 to 24 months. Alternate options are (1) qualifying an existing glovebox (with potential design/QA vulnerabilities) as a safety control for worker protection, or (2) accepting the use of an existing glovebox as defense-in-depth but requiring additional protection for the workers as determined by the Radiation Protection Program. This would mean the glovebox was performing a radiation-control function (not Safety Class).

Therefore, for this option, the glovebox is assumed to be a non-credited system but capable of handling the RNS and UNS drums containing less than 18 ECPE-Ci. The need for a gap analyses to bring it into compliance for Safety Significant credit and the associated qualification efforts will not be considered. The glovebox will be evaluated for its ability to support remediation and repackaging efforts.

### 5.4.2 Glovebox 1121

Glovebox 1121 is tall box with an open floor plan and is shown in Figure 28. The box has 8 stations around the base and 24 elevated stations. The box is 8 feet long, 7 feet high, 5 feet wide at the bottom, and 4.5 feet wide above the large viewing windows. Currently, it has no glass, gloves, or base. It also does not have any parent or daughter drum bag-on adapters.


***Figure 28 Glovebox 1121***

The large floor plan in this box provides adequate space for handling waste, blending operations, and cementation operations. The high ceiling will allow for installing agitators for cementation that could be raised and lowered. Space exists for at least three daughter drum ports. Two daughter drum ports could be used to process salt waste and the third for debris waste. Large blenders could be installed, thereby reducing the number of batches to fill a drum. A catch basin could also be installed to collect free liquids when parent drums are opened. Figure 29 shows a possible floor plan for the glovebox with three daughter drum ports, a collection basin, and a parent drum bagged on port, shown in red in the figure.

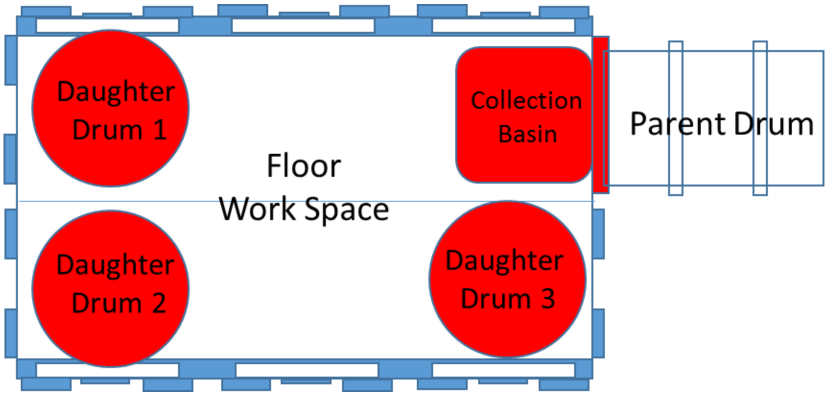


***Figure 29 Floor plan option for Glovebox 1121***

Significant design changes would be required to modify and qualify this glovebox for use. These would include the following:

- installing daughter drum bag-on ports
- installing parent drum bag-on port
- installing a collection basin
- covering many of the upper glove and window ports
- installing HEPA filter and ventilation ports
- installing a fire-suppression system
- modifying the base support for repackaging
- designing and fabricating a seismic stand
- providing lighting

The extensive design changes and modifications may be better achieved by designing a new box. Before initiating a redesign, it would be advisable to compare the time and cost of modifying versus starting new. The time to design and modify the glovebox for repackaging operations is estimated to be 12 to 18 months.

#### 5.4.2.1 Glovebox 1121 Evaluation

**Positives**

- Large floor space is available in the glovebox to add daughter drum bag-on ports and a collection basin and still have room for dealing with debris.
- The high ceiling could accommodate mixer or more and larger blending equipment.
- A new unused and uncontaminated glovebox will be easier to set up with processing equipment.
- A glovebox at Area G is close to the drums and eliminates the need for off-site drum movements.
- Setting the glovebox in a Perma-Con® or at Building 412 provides a large working space around the glovebox, allowing for easy access to drum tumbler and cement or zeolite delivery equipment.

**Challenges**

- Design and modifications could take over a year to complete.
- The glovebox would not be a credited system and may not be acceptable for use at Area G.
- Operators my have to wear respirators during operations because the glovebox is not a credited system.
- The TA-54 BIO will require modification for using the glovebox for D001 and D002 operations.

**Zeolite Blending**

Zeolite addition can be accomodated in the glovebox. Blending can be achieved using large blenders loaded into place before commissioning. Zeolite can be introduced into the box using the daughter drums loaded with bags of zeolite. The open floor plan in the Perma-Con® would also allow for auguring zeolite into the glovebox. Easy to locate a drum tumbler near the glovebox if setting up in a Perma-Con®.

**Cementation**

The glovebox can be modified to support cementation either in the glovebox or outside the glovebox. Necessary provisions can be made to install mixers for mixing in the glovebox or pumps to feed a drum tumbler. The glovebox could also be configured to direct free liquids to the cementation or dissolution drum.

**RNS Drums Processing**

All but nine RNS drums can be handled under the existing 18 ECPE-Ci TSR limit for SSSR at Area G. If 36 ECPE-Ci is allowed without drum storage, then all but one RNS drums could be processed in the glovebox. The larger glovebox floor space would allow for storing and handling debris waste associated with the RNS drums.

**UNS Drums Processing**

All UNS drums can be handled under the existing 18 ECPE-Ci TSR limit for SSSR at Area G. Installing a collection basin would aid in collecting or diverting and treating free liquids found in the UNS drums.

**Debris Waste**

The 1121 Glovebox would provide for the best configuration to collect and wash the debris waste. The glovebox has available floor space to handle and store as well as wash debris removed from RNS drums.

**Belowgrade Nitrate Salt Drum**

Six belowgrade nitrate salt drums cannot be handled under the existing 18 ECPE-Ci TSR limit for SSSR at Area G (assuming all radiological material is considered combustible). If 36 ECPE-Ci is allowed without drum storage, then four UNS drums exceed the limitation.

**WCS Drums Processing**

A similar glovebox (plus Perma-Con®) could be fabricated and located at WCS for RNS processing.

**Legacy Waste—Future Capability**

Gloveboxes located at Area G would likely be limited to the 18 ECPE-Ci limitation. There are approximately 3900 remaining legacy drums that contain less than 18 ECPE-Ci, but approximately 500 drums exceed this value.

### 5.4.3 Glovebox 412

Glovebox 412 is a more typical repackaging configured glovebox. It has limited space for remediation and waste handling and has only one daughter drum bag-on port. It was modified in 2014 to be used in the glovebag area for SSSR operations. The modifications were identified as “Defense-in-Depth” and included installing the daughter and parent drum bag-on ports, a support stand connected to a large steel plate, and piping for a water sprinkler system. The glovebox is intended to connect to the facility ventilation and fire protection systems and can be moved when needed.

***Figure 30 Glovebox 412***

A second daughter drum port could be added as well as a collection basin for free liquids. The limited work area in the glovebox would probably not allow for both. A collection basin and an area to handle debris waste are a higher priority than a second daughter drum port. The floor plan for Glovebox 412 is shown in Figure 31.

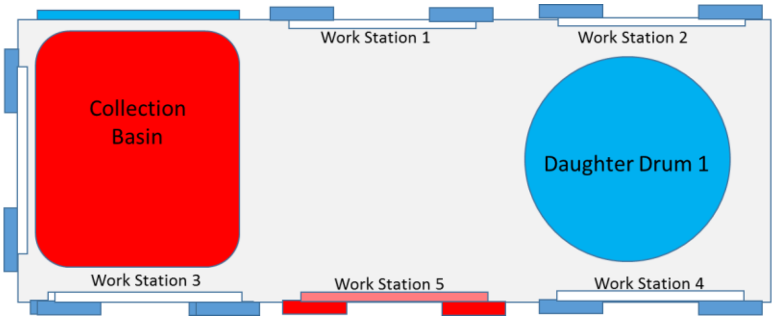


***Figure 31 Glovebox 412 proposed floor plan.***

Design and modifications would be required to modify and qualify this glovebox for use. These would include the following:

- installing collection basin
- installing HEPA filter and ventilation ports
- installing a fire suppression system
- providing lighting
- installing an extra work station

#### 5.4.3.1 Glovebox 412 Evaluation

**Positives**

- Minimal modifications are required for this glovebox.
- A new unused and uncontaminated glovebox will be easier to set up with processing equipment.
- A glovebox at Area G is close to the drums, thus eliminating the need for off-site drum movements.
- Setting the glovebox in a Perma-Con® or at Building 412 provides a large working space around the glovebox, allowing for easy access to a drum tumbler and cement or zeolite delivery equipment.
- The parent bag-on port is the preferred location because it allows for direct viewing and access of the drum from the opposite side, and a work station on the end of the box also allows for accessing the lid and bolt for removal of the lid.

**Challenges**

- Limited glovebox working floor space and one daughter drum will limit throughput.
- Design and modifications could take up to a year to complete.
- The glovebox may not be a credited system and may not be acceptable for use at Area G.
- Operators my have to wear respirators during operations.
- The TA-54 BIO will require modification for using the glovebox for D001 and D002 operations.

**Zeolite Blending**

Zeolite addition can be accomodated in the glovebox. Blending can be achieved using a large blender loaded in place before commissioning. Zeolite can be introduced into the box using the daughter drum loaded with bags of zeolite. The open floor plan in the Perma-Con® would also allow for auguring zeolite into the glovebox. A drum tumbler could easily be locatednear the glovebox if it is set up in a Perma-Con®.

**Cementation**

The glovebox can be modified to support cementation either in the glovebox or outside the glovebox. Necessary provisions can be made to install mixers in the glovebox or pumps to feed a drum tumbler. The glovebox could also be configured to direct free liquids to the cementation or dissolution drum.

**RNS Drums Processing**

All but nine RNS drums can be handled under the existing 18 ECPE-Ci TSR limit for SSSR at Area G. If 36 ECPE-Ci is allowed without drum storage, then all but one RNS drums could be processed in the glovebox. Limited floor space makes it difficiult to store and handle debris waste associated with the RNS drums.

**UNS Drums Processing**

All UNS drums can be handled under the existing 18 ECPE-Ci TSR limit for SSSR at Area G. Installing a collection basin would aid in collecting or diverting and treating free liquids found in the UNS drums.

**Debris Waste**

The glovebox has limited floor space to handle, store, and wash debris removed from RNS drums.

**Belowgrade Nitrate Salt Drum**

Six belowgrade nitrate salt drums cannot be handled under the existing 18 ECPE-Ci TSR limit for SSSR at Area G. If 36 ECPE-Ci is allowed without drum storage, then four UNS drums exceed the limitation.

**WCS Drums Processing**

A similar glovebox could be fabricated and located at WCS for RNS processing.

**Legacy Waste—Future Capability**

Gloveboxes located in a Perma-Con® at Area G would likely be limited to the 18 ECPE-Ci limitation. Approximately 3900 remaining legacy drums contain less than 18 PE-Ci, but approximately 500 drums exceed this value.

### 5.4.4 MORK-Type Glovebox

A completed design is available for the MORK-type glovebox shown in Figure 23. This design could reduce the time to get a credited glovebox fabricated by eliminating or greatly reducing the design time. The glovebox is described in Section 5.3.2. The system provides a Safety Significant design with four daughter drum bag-on ports and can handle a 1000-pound, 85-gallon parent drum. However, the Safety Significant design may not provide for accepting additional MAR if it is located in a facility at TA-54 unless the Safety Basis is increased above the current 36 ECPE-Ci.

A review of the current design should be performed to identify any gaps that may be present from changes in requirements for gloveboxes since the MORK glovebox design was completed (2004). This gap analysis, along with possible design adjustments, would take 3 to 6 months. Fabrication time for building a MORK-type glovebox is expected to be about 1 year, assuming the Safety Significant pedigree is required. A MORK glovebox could be operational within 2 years (including time associated with design verification, purchasing, contracting, fabrication, installation, and start-up). This system would provide a credited, robust capability for processing and repackaging.

#### 5.4.4.1 MORK-Type Glovebox Evaluation

**Positives**

- The design is complete.
- It provides Safety Class credit for worker safety.
- A new, unused, and uncontaminated glovebox will be easier to set up with processing equipment.
- A glovebox at Area G is close to the drums, thus eliminating the need for off-site drum movements.
- Setting the glovebox in a Perma-Con® or at Building 412 provides a large working space around the glovebox, allowing for easy access to drum tumbler and cement or zeolite delivery equipment.
- The MORK glovebox has four daughter drum bag-on ports and a free liquid collection reservoir

**Challenges**

- The design review and modifications could take 2 years.
- The TA-54 BIO will require modification for using the glovebox for D001 and D002 operations.
- Locating at 231 would impact demands for that space and may limit long-term use

**Zeolite Blending**

Zeolite addition can be accomodated in the glovebox. Blending can be achieved using large blenders loaded into place before commissioning. Zeolite can be introduced into the box using the daughter drum loaded with bags of zeolite. The open floor plan in the Perma-Con® would also allow for auguring zeolite into the glovebox. It would be easy to locate a drum tumbler near the glovebox, if setting up in a Perma-Con®.

**Cementation**

The glovebox can be modified to support cementation either in the glovebox or outside the glovebox. Necessary provisions can be made to install mixers for mixing in the glovebox or pumps added to feed a drum tumbler. The glovebox could also be configured to direct free liquids to the cementation or dissolution drum.

**RNS Drums Processing**

All but nine RNS drums can be handled under the existing 18 ECPE-Ci TSR limit for SSSR at Area G. If 36 ECPE-Ci is allowed without drum storage, then all but one RNS drums could be processed in the glovebox.

**UNS Drums Processing**

All UNS drums can be handled under the existing 18 ECPE-Ci TSR limit for SSSR at Area G. Installing a collection basin would aid in collecting or diverting and treating free liquids found in the UNS drums.

**Debris Waste**

The glovebox has four daughter drum ports and space for handling debris waste.

**Belowgrade Nitrate Salt Drum**

Six belowgrade nitrate salt drums cannot be handled under the existing 18 ECPE-Ci TSR limit for SSSR at Area G. If 36 ECPE-Ci is allowed without drum storage, then four UNS drums exceed the limitation.

**WCS Drums Processing**

A similar glovebox could be fabricated or relocated at WCS for RNS processing.

**Legacy Waste—Future Capability**

Gloveboxes located in a Perma-Con® at Area G would likely be limited to the 18 ECPE-Ci limitation. Approximately 3900 remaining legacy drums contain less than 18 ECPE-Ci, but approximately 500 drums exceed this value.

### 5.4.5 WCRRF Glovebox

Removing and relocating the WCRRF glovebox to Area G provides a ready glovebox that is credited. The glovebox is described in Section 5.1. This is a quick way to get an operating glovebox in an Area G space. No modifications or design work is required. The glovebox could be decontaminated, secured, and relocated for installation in a Perma-Con® or Building 412. The box has been proven in operation for over 20 years and is effective for repackaging operations. Removal and relocation could be accomplished in 6 months to a year. Removing the glovebox would eliminate the capability to handle drums with more than 18 ECPE-Ci at WCRRF.

**Positives**

- No design, fabrication or modifications required to operate unless cement or zeolite delvery into the box is added.
- The WCRRF glovebox has been used effectively for 20 years on a wide variety of waste streams, including plutonium-238.
- The WCRRF glovebox would act as a safety significant system
- The configuration of the WCRRF glovebox has two salient features that assist with drum repackaging: (1)the side parent drum bag-on location and (2) the liquid collection basin. The parent bag-on port is the preferred location because it allows for direct viewing and access of the drum from the opposite side; a work station on the end of the box also allows for accessing the lid and bolt to remove the lid. The liquid collection basin contains the free liquid often found in drums.

- Glovebox could be located at TA-54 close to the drums, thus eliminating the need for off-site drum movement
- Setting up in a Perma-Con® provides a large working space and allows for easy access to drum tumbler and cement or zeolite delivery equipment

**Challenges**

- Removing the glovebox from WCRRF eliminates the only existing location to handle drums with elevated MAR.
- The glovebox must be decontaminated and removed from WCRRF.
- The glovebox is contaminated and may need decontamination before any modifications can be made. Either (1) a mixer and cement delivery system needs to be installed in the glovebox for cementing inside the glovebox or (2) a drum tumbler needs to be installed in the WCRRF glovebox room for mixing outside the glovebox.

**Zeolite Blending**

Zeolite addition can be accomodated in the WCRRF glovebox. Blending can be achieved using blenders loaded into place via the bag-out ports. Zeolite can be introduced into the box using the daughter drums loaded with bags of zeolite or a zeolite addition system could be added to auger material into the box. Both daughter drum ports can be utilized for blending for either batch or drum loading.

**Cementation**

The WCRRF glovebox can accommodate cementation using a sacrificial agitator for in-box mixing or a containment box to house a drum tumbler. The glovebox requires modifications for (1) delivering caustic solution for pH adjustment, (2) storage and delivery of cement, and (3) installation of an agitator drive. Modifications to the glovebox may be difficult since the glovebox is contaminated.

If a drum tumbler is found to be an acceptable cementation approach, then glovebox modifications are reduced and cement bulk storage and delivery to the glovebox is unnecessary.

**Debris Waste**

There is limited room to handle debris waste in the WCRRF glovebox. Removal, storage, and handling the debris during processing of the salt may be tight, with limited space to store the debris before placing back in the parent drum. Rinsing with water will require a means to introduce and use water for washing the debris waste.

**RNS Drums Processing**

All but nine RNS drums can be handled under the existing 18 ECPE-Ci TSR limit for SSSR at Area G. If 36 ECPE-Ci is allowed without drum storage, then all but one RNS drums could be processed in the glovebox. Limited floor space makes it difficiult to store and handle debris waste associated with the RNS drums.

**UNS Drums Processing**

All UNS drums can be handled under the existing 18 ECPE-Ci TSR limit for SSSR at Area G. Most UNS drums have liquid and the WCRRF glovebox has a collection reservoir for liquids.

**Belowgrade Nitrate Salt Drum**

Six belowgrade nitrate salt drums cannot be handled under the existing 18 ECPE-Ci TSR limit for SSSR at Area G. If 36 ECPE-Ci is allowed without drum storage, then four UNS drums exceed the limitation.

**WCS Drums Processing**

The glovebox could be decontaminated and relocated (within a Perma-Con®) at WCS for RNS processing.

**Legacy Waste—Future Capability**

Gloveboxes located in a Perma-Con® at Area G would likely be limited to the 18 ECPE-Ci limitation. Approximately 3900 remaining legacy drums contain less than 18 ECPE-Ci but approximately 500 drums exceed this value.

## 6.0 OPTIONS ASSESSMENT

### 6.1 Nitrate Waste

1. Nine RNS drums contain more than 18 PE-Ci. The RNS waste drums have little or no free liquids, except for two POCs each containing approximately 2 liters, based on RTR evaluations. The waste is bulk loaded into a cardboard liner and debris is randomly placed in the salt/Swheat. The debris waste does not have a clear path forward if the debris is determined to be TRU and D001. The intent is to clean the debris of as much Swheat and salt as possible to meet LLW levels and/or conduct testing to demonstrate the debris is not D001. This could be difficult and time-consuming. A treatment approach may be required for this stream if it is considered D001 and contains TRU levels of contamination.

2. The UNS aboveground drums all contain less than 18 PE-Ci. Typically, the UNS drums have free liquids (up to 15 gallons), indicating the salt is very wet. Accommodations should be in place to collect the free liquids when the drums are opened and absorbing the liquid with zeolite. The salt is packaged in plastic bags but they may have broken open. There is less debris in these drums but it is likely more contaminated with salt solution. The moist texture and composition will likely provide a different remediation challenge compared with the RNS drums.

3. The UNS belowgrade drums are less well characterized. Approximately 6 exceed 18 ECPE-Ci and 31 exceed 18 PE-Ci. It is assumed they are similar to the aboveground UNS drums, although the composition and chemical makeup may be significantly different.

### 6.2 Nitrate Waste Process Options

1. The preferred option is drum blending with zeolite—if it can be proven to be effective and safe. Blending using a drum tumbler would be the easiest operationally and would be the fastest and have the least impact to operators from an ALARA perspective. This option can be handled by any of the available gloveboxes and would not require a complex zeolite delivery system. Zeolite could be added to the drum before bagging on to the glovebox. This approach results in the most daughter drums (178 RNS blended daughter drums and 99 UNS blended daughter drums) because the drums are only filled to 60% for purposes of optimal blending. This approach would have to be tested and proven to show that the resulting mix is well blended. The UNS stream will be the most difficult to effectively blend because it will be the wettest and least friable.

2. Batch blending zeolite is the second choice as it requires installing a system in the glovebox and extends the amount of time operators must spend processing waste. The process is simple, requiring only one operation: blending. All the gloveboxes would be capable of supporting this approach without modification. Zeolite addition could be accomplished using the daughter drum although an augur-type delivery system would be preferable. Less testing and verification are required for this option as the blended product is visually confirmed. It will produce an expected 132 RNS blended daughter drums and 73 UNS blended daughter drums.

3. Cementation using a drum tumbler is a more complex operation, requiring dissolution of the salt, pH adjustment, pumping, and drum tumbling. This method of cementation removes the cementing process from the glovebox reducing the complexity associated with delivering cement to the glovebox and would be the preferred cementation approach. Issues associated with achieving a reliable mix and incorporating the Swheat into the matrix as well as the heating associated with hydration of the cement will need to be addressed. As with drum blending, it would have to be tested and proven to show the resulting mix is well blended. The additional complexity and quality issues make this a less desirable approach. The MOVER and MORK would be the most difficult to employ this approach because of the tight quarters in the transportainer and the need to breach both the glovebox and the transportainer wall to move solution. A glovebox located in an open area like a Perma-Con® would be the best choice for this process option. This approach is expected to produce 141 RNS blended daughter drums and 95 UNS blended daughter drums.

4. Cementation in the glovebox is the most complex and not well accommodated by any of the gloveboxes, except Glovebox 1121. The limited box height, the need to deliver the cement to the glovebox, and the number of steps involved make it the least desirable option. It will require the most modifications and has the greatest chance for operational upsets that could impact operations. The approach will provide a well-mixed and remediated product and produces the least number of daughter drums, an expected 114 RNS blended daughter drums and 68 UNS blended daughter drums.

### 6.3 Nitrate Salt Remediation System Options

Seven system options were identified for implementing the blending or cementation processing approaches. The 7 options included using WCRRF as is, 2 modular systems (MOVER and MORK) that would be located at TA-54, and 4 glovebox options to be located either in a Perma-Con® or at Building 412. Consideration was also given to the usefulness of the system to repackage legacy waste after nitrate salt drums were completed. An initial evaluation was performed relating to 12 criteria. Each criterion was rated from 1 to 5, with 5 being better. The rating breakdown for each criterion is included in Appendix F. The criteria are as follows.

Amenable to installing process equipment and operating:

- **Blending:** Complexity and difficulty to configure for blending operations and performing blending for RNS and UNS waste drums.
- **Cementing:** Complexity and difficulty to configure for cementation operations and performing cementation for RNS and UNS waste drums
- **Debris Waste:** Complexity and difficulty to configure for debris waste cleanup and performing debris operations for RNS and UNS waste drums

Ability to handle waste streams:

- **RNS and UNS Drums**: Percentage of RNS and UNS drums the option will be able to process because of physical and AB-related limitations
- **Legacy Drums:** Percentage of legacy drums the option will be able to process because of physical and AB-related limitations

Permitting Issues:

- **AB Issues:** Number and complexity of issues and adjustments required for preparing and getting AB approval.
- **RCRA Issues:** Number and complexity of issues and adjustments required for RCRA permitting approval.

Physical Adaptation Requirements:

- **Fabrication:** Modifications to the system before installing or using for repackaging.
- **Installation:** Complexity related to installing the system for operation.

Project Impacts

- **Schedule:** Impact to schedule related to the options requirements to become operational
- **Regulatory/Public Acceptance:** Effectiveness and reliability of the approach/system

Table 4 provides the ratings for each of the system options discussed. The best option is to utilize WCRRF. The next two best options are installation of a glovebox in a Perma-Con® at Area G using one of the available gloveboxes. These two options are rated higher, based on the assumption that the gloveboxes would only be used as a non-credited glovebox and could not provide worker protection as a Safety Significant system. If the box were to be credited, nine drums exceed 18 EC-PE, and the ratings would be lower-impacting fabrication, installation, schedule, and cost.

**Table 4 System Options Evaluation Table**

| | Blending | Cementation | Debris Waste | RNS & UNS Drums | Legacy Drums | AB Issues | RCRA Issues | Installation | Fabrication | Regulatory/Public Acceptance | Operation | Schedule | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WCRRF | 4 | 3 | 4 | 5 | 5 | 4 | 3 | 4 | 5 | 3 | 3 | 4 | 47 |
| MOVER | 3 | 1 | 2 | 5 | 4 | 4 | 1 | 4 | 4 | 2 | 3 | 3 | 36 |
| MORK | 3 | 2 | 5 | 5 | 5 | 2 | 1 | 2 | 3 | 4 | 4 | 1 | 37 |
| GB 1121 | 5 | 5 | 5 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 4 | 3 | 40 |
| GB 412 | 4 | 4 | 2 | 3 | 3 | 3 | 2 | 3 | 4 | 2 | 4 | 4 | 38 |
| MORK GB | 4 | 4 | 4 | 3 | 3 | 4 | 2 | 3 | 1 | 3 | 5 | 2 | 38 |
| WCRRF GB | 4 | 3 | 4 | 3 | 3 | 4 | 1 | 2 | 3 | 2 | 4 | 4 | 37 |

1. The WCRRF glovebox provides the least risk, adequate flexibility, and (likely) the fastest path to remediating the nitrate salt drums. The glovebox is configured to accommodate blending with zeolite but is less amenable to supporting cementation, especially cementing within the glovebox. The WCRRF BIO is already in place, and updating to allow for nitrate salt processing should not be overly onerous because similar operations have been performed at WCRRF, although not with the same hazards. The infrastructure is in place and has been well tested for the last 20 years. Transporting the waste and potentially refrigerating it at WCRRF are negative aspects of this option because they introduce additional cost, safety concerns, and coordination difficulties. However, the reliability of an available proven and operating glovebox approved for 800 ECPE-Ci, compared with modifying or relocating systems that have no operating record and no current AB, makes WCRRF the best choice for the short term to handle the nitrate waste streams. The schedule required to bring WCRRF online for nitrate salt processing is better understood, more predictable, and less likely to be adversely impacted compared with other options.

   WCRRF can be utilized until a new system is configured, tested, and approved for use in TA-54. This ensures a repackaging capability is always available and mitigates being held hostage to schedule problems that may be associated with initiating a new system. MORK, the only other system that can handle more than 18 ECPE-Ci, has some hurdles that must be overcome, including decontamination, transportation, and siting to meet seismic requirements. These risks, along with the time it may take to relocate, set up, and obtain permission to operate, are significant to both success as well as schedule. Maintaining the WCRRF glovebox operation ensures a viable capability until an alternate system can be approved, installed, tested, and brought online.

2. Installing a glovebox at Area G for supporting nitrate waste repackaging and for supporting remaining LANL legacy waste could provide added flexibility and be a relatively inexpensive option to augment repackaging. Two issues need to be resolved for this option: (1) the necessity to provide a Safety Significant glovebox for worker protection and (2) the allowable ECPE-Ci for any drum in process. These are both AB issues that should be resolved before moving forward on this option. They will impact the choice of glovebox as well as design and

fabrication/modification requirements. The flexibility to configure a new glovebox for drum repackaging and locate it in an open floor plan like a Perma-Con® room is an attractive option for a large subset (~3900 drums) of legacy waste. The existing Perma-Cons® are used for other waste-processing operations that would be impacted if a glovebox is housed in an existing Perma-Con®.

### 6.3.1 Legacy Waste Repackaging System Options at TA-54

Two options for drums containing more than 18 ECPE-Ci are WCRRF glovebox and MORK. An estimated 470 legacy drums at Area G contain more than 18 PE-Ci. MORK provides a tested and robust capability for repackaging and remediation. Locating the SRS MORK at TA-54 would be a long-term solution for handling the remaining legacy waste at LANL. Relocating the SRS MORK requires resolving a number of issues, including

- Verifying MORK can transport SCO-II material over public roads,
- Decontaminating the glovebox to meet SCO-II levels,
- Transporting MORK to LANL without compromising the systems,
- Siting MORK to meet seismic requirements, and
- Repairing and reactivating MORK.

If these issues cannot be resolved, then LANL could have a MORK built for deployment at TA-54. The design for fabricating a new MORK exists and could be used, and the AB documentation exists. Until an alternate system that can handle MAR in excess of 18 ECPE-Ci is up and running, WCRRF should be maintained and operational.

## 6.4 Recommendations

1. *Initiate nitrate salt waste stream process development.* Begin testing equipment for blending zeolite with nitrate salt waste streams. Building 39 at Area L can be set up to begin equipment evaluation and testing using surrogate waste. Purchase a drum tumbler, drum roller, and batch blenders for evaluation and process development.

2. *Decide on a system for carrying out nitrate salt repackaging.* Identify which glovebox system will be utilized for nitrate salt repackaging to tailor the process, equipment, and operating procedures to the system. Focus AB efforts for addressing the processing of D001 waste and identify any restrictions or operating requirements that may impact processing operations.

3. *Determine if debris waste associated with nitrate waste steams is D001.* Initiate tests to determine if debris waste separated from the RNS or UNS drums is D001. TRU debris waste that is D001 cannot be sent to WIPP unless the D001 characteristic is removed. Use the results from surrogate testing to drive the handling and processing of this waste stream after separating from the salt waste.

4. *Resolve AB, RCRA, and NEPA issues associated with repackaging nitrate salt drums and for developing new capability at Area G.* Four AB issues need clarification:

    - Area G BIO issues for safeing and denesting the waste from the overpacked SWBs

- WCRRF TSRs that may be required for remediating and repackaging RNS and UNS waste considered D001 and D002
- Necessity of a credited Safety Significant glovebox for waste repackaging at Area G
- Determination of AB requirements to relocate MORK: if a PDSA is required or a major modification can be used for relocating MORK to Area G

4. *Visit the SRS site to obtain more information on MORK.* Relocation of MORK will require a concerted effort by a range of SMEs at LANL. An initial review and visit to SRS by engineering, operations, FOD, and AB SMEs is suggested to ensure the system can be relocated to LANL and deployed successfully. This review and evaluation will provide a more accurate determination of the effort, cost, and schedule required.

## APPENDIX A REMEDIATED NITRATE SALT DRUMS

**Remediated Nitrate Salt Drums**

| PKG_ID | ParentID | Waste Stream | Container Type | Gross Wt (lbs) | PECi | EC PECi | FGE | TOTAL DOSE | Drum Utiilzation (vol%) | Debris (vol%) | Hogeneous Solids (vol%) | Lead/Metal (kg) | Non-Metal (kg) | Salt/Swheat Matrix (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68408 | S842463 | MHD01 | 55-gallon | 205 | 0.4 | 3.7 | 18.9 | 10.5 | 50 | 60 | 40 | 25.0 | 6.0 | 29.1 |
| 68430 | S833846 | MIN02 | POC | 383 | 11.2 | 9.8 | 33.1 | 1.5 | 70 | 5 | 95 | 0.0 | 2.0 | 26.9 |
| 68507 | S853279 | MIN02 | POC | 353 | 4.8 | 4.2 | 36.6 | 0.9 | 50 | 5 | 95 | 0.0 | 2.0 | 13.4 |
| 68540 | S842181 | MHD01 | 55-gallon | 85 | 0.3 | 0.3 | 0.4 | 13.5 | 20 | 85 | 15 | 0.1 | 4.0 | 1.0 |
| 68553 | S842181 | MHD01 | 55-gallon | 118 | 1.9 | 1.6 | 2.8 | 33.5 | 45 | 50 | 50 | 1.2 | 6.0 | 13.8 |
| 68567 | S816837 | MHD01 | 55-gallon | 202 | 1.3 | 1.1 | 4.6 | 7.5 | 40 | 65 | 35 | 31.6 | 7.0 | 20.0 |
| 68624 | S824184 | MIN02 | 55-gallon | 152 | 0.9 | 0.8 | 10.6 | 38.5 | 40 | 25 | 75 | 0.0 | 7.0 | 28.6 |
| 68631 | S825810 | MIN02 | 55-gallon | 214 | 1.5 | 1.3 | 2.3 | 70.5 | 45 | 15 | 85 | 20.0 | 3.0 | 40.6 |
| 68638 | S825810 | MHD01 | 55-gallon | 85 | 0.4 | 0.4 | 0.5 | 14.5 | 25 | 90 | 10 | 0.0 | 4.0 | 1.1 |
| 68648 | S855139 | MIN02 | 55-gallon | 269 | 16.7 | 14.7 | 62.4 | 28 | 55 | 15 | 85 | 23.0 | 5.5 | 60.1 |
| 68665 | S853492 | MIN02 | 55-gallon | 372 | 10.1 | 8.9 | 47.1 | 17.5 | 85 | 15 | 85 | 13.0 | 7.0 | 115.6 |
| 68685 | S855793 | MIN02 | 55-gallon | 391 | 8.5 | 7.5 | 21.9 | 26.7 | 85 | 20 | 80 | 25.2 | 6.0 | 112.9 |
| 69013 | S870213 | MIN02 | POC | 349 | 0.7 | 0.6 | 3.6 | 1.5 | 50 | 5 | 95 | 0.0 | 2.0 | 11.4 |
| 69015 | S851418 | MIN02 | POC | 358 | 3.0 | 2.6 | 9.3 | 1.5 | 60 | 5 | 95 | 0.5 | 4.0 | 12.9 |
| 69036 | S873554 | MHD01 | 55-gallon | 175 | 10.3 | 9.1 | 22.0 | 31.3 | 50 | 80 | 20 | 33.4 | 4.2 | 8.5 |
| 69076 | S852530 | MIN02 | 55-gallon | 384 | 10.0 | 8.8 | 56.0 | 60.8 | 100 | 5 | 95 | 5.0 | 6.0 | 130.1 |
| 69079 | S901114 | MIN02 | 55-gallon | 402 | 21.1 | 18.6 | 58.3 | 70.5 | 75 | 10 | 90 | 7.8 | 6.1 | 134.7 |
| 69183 | S870478 | MIN02 | 55-gallon | 427 | 15.1 | 13.3 | 46.8 | 50.5 | 100 | 10 | 90 | 3.0 | 12.0 | 145.1 |
| 69208 | S851772 | MIN02 | 55-gallon | 507 | 39.1 | 34.4 | 157.4 | 82 | 95 | 10 | 90 | 10.0 | 2.0 | 184.1 |
| 69280 | S841251 | MIN02 | 55-gallon | 236 | 18.1 | 15.9 | 69.3 | 22.8 | 40 | 15 | 85 | 6.0 | 4.0 | 64.6 |
| 69298 | S841251 | MIN02 | 55-gallon | 448 | 23.2 | 20.4 | 122.4 | 46.5 | 95 | 10 | 90 | 5.0 | 4.1 | 160.5 |
| 69361 | S892963 | MIN02 | 55-gallon | 170 | 4.9 | 4.3 | 17.3 | 30.5 | 35 | 5 | 95 | 0.1 | 2.0 | 41.5 |
| 69445 | S823229 | MIN02 | 55-gallon | 366 | 5.1 | 4.5 | 57.6 | 31 | 75 | 15 | 85 | 15.0 | 6.0 | 110.6 |
| 69490 | S892963 | MIN02 | 55-gallon | 371 | 18.9 | 16.6 | 76.0 | 60.5 | 95 | 5 | 95 | 3.0 | 8.4 | 123.2 |
| 69491 | S891387 | MIN02 | 55-gallon | 330 | 12.1 | 10.6 | 14.4 | 60.5 | 85 | 5 | 95 | 5.1 | 6.0 | 105.0 |
| 69519 | S816768 | MIN02 | POC | 416 | 17.2 | 15.0 | 18.7 | 2.1 | 75 | 5 | 95 | 7.0 | 0.0 | 36.9 |
| 69520 | S813471 | MIN02 | POC | 344 | 5.1 | 4.4 | 2.1 | 2 | 65 | 40 | 60 | 0.0 | 2.0 | 9.4 |
| 69548 | S851416 | MIN02 | 55-gallon | 207 | 0.9 | 0.8 | 2.4 | 7.5 | 45 | 10 | 90 | 23.0 | 2.0 | 35.6 |
| 69553 | S841627 | MIN02 | 55-gallon | 227 | 12.5 | 10.8 | 61.7 | 29 | 50 | 10 | 90 | 5.0 | 2.0 | 62.6 |
| 69559 | S832148 | MIN02 | 55-gallon | 367 | 14.0 | 12.3 | 22.4 | 60.5 | 70 | 5 | 95 | 30.0 | 2.0 | 100.6 |
| 69568 | S825664 | MIN02 | 55-gallon | 248 | 4.5 | 1.1 | 5.2 | 10.5 | 95 | 60 | 40 | 0.1 | 6.0 | 33.0 |
| 69595 | 69090 | MIN02 | 55-gallon | 189 | 8.8 | 7.7 | 57.3 | 14.5 | 65 | 20 | 80 | 4.0 | 3.0 | 45.1 |
| 69598 | S793450 | MIN02 | POC | 349 | 2.0 | 1.8 | 0.3 | 1.5 | 45 | 5 | 95 | 0.1 | 2.0 | 11.3 |
| 69604 | S816768 | MIN02 | POC | 413 | 11.6 | 10.1 | 4.3 | 1.6 | 95 | 5 | 95 | 0.0 | 0.0 | 42.4 |
| 69615 | S843673 | MIN02 | 55-gallon | 285 | 13.3 | 11.6 | 85.6 | 60.9 | 75 | 15 | 85 | 23.0 | 0.0 | 73.1 |
| 69616 | S841627 | MIN02 | 55-gallon | 437 | 9.8 | 8.5 | 62.1 | 35.5 | 90 | 10 | 90 | 26.0 | 3.0 | 135.6 |
| 69618 | S818412 | MIN02 | 55-gallon | 373 | 4.1 | 3.6 | 3.6 | 20.5 | 75 | 20 | 80 | 23.0 | 7.0 | 106.1 |
| 69620 | S816768 | MIN02 | 55-gallon | 376 | 20.4 | 17.8 | 9.1 | 51.3 | 90 | 20 | 80 | 23.0 | 2.0 | 112.1 |
| 69630 | S843672 | MIN02 | 55-gallon | 437 | 20.4 | 17.8 | 74.2 | 28.6 | 95 | 10 | 90 | 5.0 | 5.0 | 155.1 |
| 69633 | S851418 | MIN02 | 55-gallon | 417 | 20.2 | 17.6 | 59.0 | 36.5 | 90 | 10 | 90 | 10.0 | 4.0 | 142.1 |
| 69634 | S851416 | MIN02 | 55-gallon | 501 | 11.0 | 9.5 | 35.1 | 25.5 | 95 | 5 | 95 | 10.0 | 0.0 | 183.6 |
| 69635 | S851418 | MIN02 | 55-gallon | 240 | 4.4 | 3.8 | 17.3 | 40.5 | 60 | 5 | 95 | 0.5 | 5.0 | 70.1 |
| 69636 | S843672 | MIN02 | 55-gallon | 209 | 15.1 | 13.1 | 50.2 | 16.8 | 65 | 15 | 85 | 5.0 | 6.0 | 50.6 |
| 69637 | S813471 | MIN02 | 55-gallon | 301 | 6.7 | 5.8 | 5.2 | 26.5 | 75 | 20 | 80 | 5.0 | 3.5 | 94.6 |
| 69638 | S822679 | MIN02 | 55-gallon | 331 | 8.1 | 7.1 | 5.9 | 43.5 | 70 | 5 | 95 | 0.0 | 5.0 | 111.6 |

**Remediated Nitrate Salt Drums**

| PKG_ID | ParentID | Waste Stream | Container Type | Gross Wt (lbs) | PECi | EC PECi | FGE | TOTAL DOSE | Drum Utiilzation (vol%) | Debris (vol%) | Hogeneous Solids (vol%) | Lead/Metal (kg) | Non-Metal (kg) | Salt/Swheat Matrix (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 69639 | S843673 | MIN02 | 55-gallon | 362 | 4.4 | 3.8 | 31.5 | 8.5 | 95 | 10 | 90 | 15.0 | 3.0 | 113.1 |
| 69641 | S813471 | MIN02 | 55-gallon | 323 | 9.1 | 7.9 | 5.1 | 75.5 | 70 | 10 | 90 | 15.1 | 5.0 | 92.5 |
| 69642 | S818412 | MIN02 | 55-gallon | 215 | 4.9 | 4.3 | 3.3 | 14.5 | 55 | 15 | 85 | 8.0 | 0.0 | 56.1 |
| 69644 | S793450 | MIN02 | 55-gallon | 510 | 9.3 | 8.1 | 4.2 | 30.5 | 100 | 5 | 95 | 8.1 | 7.0 | 183.0 |
| 69645 | S822679 | MIN02 | 55-gallon | 352 | 16.1 | 14.0 | 17.2 | 22.5 | 55 | 15 | 85 | 20.0 | 6.0 | 100.6 |
| 87823 | S864332 | MIN02 | POC | 376 | 0.9 | 0.1 | 10.4 | 0.65 | 95 | 30 | 70 | 0.0 | 2.0 | 54.0 |
| 87825 | S864332 | MIN02 | POC | 378 | 2.1 | 0.2 | 22.8 | 0.95 | 95 | 70 | 30 | 3.1 | 2.0 | 20.8 |
| 87826 | S864332 | MHD01 | POC | 392 | 0.9 | 0.2 | 10.4 | 1.2 | 95 | 90 | 10 | 0.0 | 25.3 | 10.0 |
| 87827 | S864332 | MHD01 | POC | 342 | 0.9 | 0.2 | 10.4 | 0.75 | 95 | 95 | 5 | 0.0 | 9.3 | 3.0 |
| 92459 | 90316 | MIN02 | 55-gallon | 247 | 2.0 | 0.5 | 9.6 | 30 | 90 | 30 | 70 | 12.0 | 12.0 | 54.6 |
| 92472 | 90317 | MHD01 | 55-gallon | 228 | 3.3 | 2.8 | 11.9 | 50.3 | 65 | 60 | 40 | 19.5 | 16.0 | 34.6 |
| 92669 | 90900 | MHD01 | 55-gallon | 250 | 2.0 | 1.8 | 8.6 | 12.3 | 85 | 55 | 45 | 28.0 | 16.0 | 36.1 |
| 93605 | S824541 | MIN02 | 55-gallon | 348 | 14.8 | 13.0 | 21.3 | 50.7 | 75 | 20 | 80 | 10.5 | 4.0 | 110.5 |
| 94068 | S851852 | CIN01 | 55-gallon | 398 | 29.0 | 0.2 | 173.2 | 81.3 | 80 | 15 | 85 | 12.0 | 4.0 | 131.1 |
| 94227 | S813475 | MHD01 | 55-gallon | 208 | 1.3 | 0.0 | 3.5 | 11.7 | 100 | 75 | 25 | 42.0 | 3.0 | 16.1 |

## APPENDIX B UNREMEDIATED NITRATE SALT DRUMS

**Unremediated Nitrate Salt Drums**

| PKG_ID | Waste Stream | EPA Codes | Container Type | Gross Wt (lb) | PECi | EC PECi | FGE | Total Dose | Liners | Liner wt. (kg) | Pb/Metal (kg) | Nonmetal (kg) | Water vol gal | Salt wt. (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S864213 | CIN01 | 1,2,7,8,9 | 85/55 gal | 434 | 5.5 | 0.0 | 61.1 | 8 | Rigid/Lead | 15 | 12 | 5.0 | 5 | 117 |
| S862888 | CIN01 | 1,2,7,8,9 | 85/55 gal | 373 | 1.8 | 0.0 | 19.4 | 2 | Lead | 12 | 12 | 3.0 | 3 | 90 |
| S853714 | CIN01 | 1,2,7,8,9 | 85/55 gal | 457 | 6.9 | 0.0 | 76.7 | 4 | Rigid/Lead | 15 | 12 | 4.0 | 3 | 136 |
| S842446 | CIN01 | 1,7,8,9 | 85/55 gal | 572 | 4.9 | 0.0 | 44.7 | 5 | Rigid/Lead | 15 | 12 | 0.0 | 0 | 100 |
| S825879 | CIN01 | 1,2,7,8,9 | 85/55 gal | 352 | 4.7 | 0.0 | 52.1 | 5 | Rigid/Lead | 15 | 12 | 0.5 | 1 | 51 |
| S825878 | CIN01 | 1,7,8,9 | 85/55 gal | 358 | 16.7 | 0.1 | 186.3 | 2 | Rigid/Lead | 15 | 12 | 0.0 | 0 | 88 |
| S823184 | CIN01 | 1,2,7,8,9 | 85/55 gal | 443 | 14.2 | 0.1 | 158.6 | 2 | Rigid/Lead | 15 | 12 | 5.0 | 5 | 128 |
| S823124 | CIN01 | 1,7,8,9 | 85/55 gal | 578 | 2.7 | 0.0 | 30.2 | 1 | Rigid/Lead | 15 | 12 | 0.0 | 0 | 159 |
| S822844 | CIN01 | 1,2,7,8,9 | 85/55 gal | 481 | 8.6 | 0.1 | 95.6 | 2 | Rigid/Lead | 15 | 12 | 15.0 | 15 | 147 |
| S822713 | CIN01 | 1,2,7,8,9 | 85/55 gal | 521 | 1.3 | 0.0 | 11.0 | 120 | Rigid/Lead | 15 | 12 | 5.0 | 5 | 114 |
| S822599 | CIN01 | 1,2,7,8,9 | 85/55 gal | 435 | 5.2 | 0.0 | 58.5 | 7 | Rigid/Lead | 15 | 12 | 4.0 | 4 | 124 |
| S818435 | CIN01 | 1,2,7,8,9 | 85 gal | 351 | 1.8 | 0.0 | 20.3 | 2 | Rigid/Lead | 15 | 12 | 5.0 | 5 | 92 |
| S816810 | CIN01 | 1,2,7,8,9 | 85/55 gal | 511 | 2.1 | 0.0 | 22.3 | 1 | Rigid/Lead | 15 | 12 | 5.0 | 5 | 133 |
| S816434 | CIN01 | 1,2,7,8,9 | 85 gal | 476 | 3.5 | 0.0 | 38.9 | 2 | Rigid/Lead | 15 | 12 | 1.0 | 1 | 150 |
| S813545 | CIN01 | 1,2,7,8,9 | 85/55 gal | 419 | 1.0 | 0.0 | 11.5 | 0 | Rigid/Lead | 15 | 12 | 4.0 | 4 | 79 |
| S813385 | CIN01 | 1,2,7,8,9 | 85 gal | 442 | 4.1 | 0.0 | 45.8 | 11 | Rigid/Lead | 15 | 12 | 1.0 | 1 | 104 |
| S805289 | CIN01 | 1,2,7,8,9 | 85/55 gal | 470 | 0.3 | 0.0 | 0.2 | 2 | Rigid/Lead | 15 | 12 | 3.0 | 3 | 140 |
| S805051 | CIN01 | 1,2,7,8,9 | 85 gal | 397 | 0.6 | 0.0 | 6.2 | 1 | Rigid/Lead | 15 | 12 | 2.0 | 2 | 112 |
| S804995 | CIN01 | 1,2,7,8,9 | 85/55 gal | 415 | 1.1 | 0.0 | 12.3 | 2 | Rigid/Lead | 15 | 12 | 2.0 | 2 | 115 |
| S804948 | CIN01 | 1,2,7,8,9 | 85/55 gal | 414 | 0.5 | 0.0 | 4.3 | 0 | Rigid/Lead | 15 | 12 | 2.0 | 2 | 101 |
| S803078 | CIN01 | 1,2,7,8,9 | 85/55 gal | 382 | 1.7 | 0.0 | 15.3 | 1 | Rigid/Lead | 15 | 12 | 3.0 | 3 | 101 |
| S802833 | CIN01 | 1,2,7,8,9 | 85/55 gal | 417 | 0.4 | 0.0 | 4.2 | 3 | Lead | 12 | 12 | 5.0 | 5 | 113 |
| S802739 | CIN01 | 1,2,7,8,9 | 85/55 gal | 407 | 0.6 | 0.0 | 6.0 | 1 | Rigid/Lead | 15 | 12 | 2.0 | 2 | 106 |
| S801676 | CIN01 | 1,2,7,8,9 | 85/55 gal | 421 | 1.2 | 0.0 | 11.3 | 2 | Rigid/Lead | 15 | 12 | 2.0 | 2 | 112 |
| S793724 | CIN01 | 1,2,7,8,9 | 85/55 gal | 365 | 1.4 | 0.0 | 9.5 | 2 | Rigid/Lead | 15 | 12 | 2.0 | 2 | 89 |
| 70072 | CIN01 | 1,2,7,8,9 | 85/55 gal | 490 | 4.7 | 0.0 | 49.6 | 11.3 | No Liners | 15 | 12 | 5.0 | 5 | 128 |
| 70069 | MIN02 | 1,2,7,8,9 | 85/55 gal | 464 | 0.6 | 0.5 | 5.4 | | Rigid/Lead | 15 | 12 | 0.5 | 1 | 102 |
| 69907 | MIN02 | 1,2,7,8,9 | 85/55 gal | 429 | 14.4 | 12.5 | 149.1 | 9 | Rigid/Lead | 15 | 12 | 5.0 | 5 | 100 |
| 69904 | MIN02 | 1,2,7,8,9 | 85/55 gal | 509 | 10.3 | 8.9 | 114.7 | 5.25 | Rigid/Lead | 15 | 12 | 0.5 | 1 | 151 |

## APPENDIX C BELOWGRADE POSSIBLE SALT DRUM CONTENT INFORMATION

**Belowgrade Nitrate Salt Drums**

| PKG_ID | Waste Code | Location | Container Type | Gross Wt (lb) | PECi | EC PECi | FGE | Total Dose |
|---|---|---|---|---|---|---|---|---|
| S790007 | 25 | Pit 9 | 55 gal | 247 | 6.7 | 0.0 | 70.3 | 5 |
| S790008 | 25 | Pit 9 | 55 gal | 255 | 15.3 | 0.1 | 171.1 | 8 |
| S790009 | 25 | Pit 9 | 55 gal | 290 | 7.3 | 0.0 | 81.7 | 0 |
| S790010 | 25 | Pit 9 | 55 gal | 168 | 11.2 | 0.1 | 117.3 | 6 |
| S790011 | 25 | Pit 9 | 55 gal | 33 | 1.4 | 0.0 | 16.1 | 1 |
| S790012 | 25 | Pit 9 | 55 gal | 67 | 1.6 | 0.0 | 17.9 | 1 |
| S790013 | 25 | Pit 9 | 55 gal | 58 | 4.1 | 0.0 | 35.4 | 1 |
| S790039 | 25 | Pit 9 | 55 gal | 213 | 19.5 | 0.1 | 98.7 | 10 |
| S790061 | 25 | Pit 9 | 55 gal | 130 | 3.4 | 0.0 | 31.6 | 0 |
| S790070 | 25 | Pit 9 | 55 gal | 256 | 75.5 | 0.5 | 13.8 | 3 |
| S790071 | 25 | Pit 9 | 55 gal | 251 | 2.3 | 0.0 | 16.1 | 2 |
| S790085 | 25 | Pit 9 | 55 gal | 246 | 6.2 | 0.0 | 69.9 | 0 |
| S790087 | 25 | Pit 9 | 55 gal | 139 | 54.2 | 0.3 | 155.5 | 0 |
| S790098 | 25 | Pit 9 | 55 gal | 210 | 15.2 | 0.1 | 121.8 | 0 |
| S791736 | 25 | Pit 9 | 55 gal | 152 | 15.5 | 0.1 | 171.7 | 2 |
| S791737 | 25 | Pit 9 | 55 gal | 115 | 0.2 | 0.0 | 2.0 | 1 |
| S791751 | 25 | Pit 9 | 55 gal | 336 | 29.8 | 0.2 | 39.2 | 8 |
| S791752 | 25 | Pit 9 | 55 gal | 433 | 1.2 | 0.0 | 11.1 | 1 |
| S791754 | 25 | Pit 9 | 55 gal | 255 | 4.1 | 0.0 | 44.6 | 2 |
| S791923 | 25 | Pit 9 | 55 gal | 262 | 0.0 | 0.0 | 0.0 | 0 |
| S791924 | 25 | Pit 9 | 55 gal | 290 | 2.6 | 0.0 | 20.3 | 1 |
| S791925 | 25 | Pit 9 | 55 gal | 361 | 4.2 | 0.0 | 29.7 | 2 |
| S791926 | 25 | Pit 9 | 55 gal | 346 | 0.7 | 0.0 | 5.5 | 2 |
| S791927 | 25 | Pit 9 | 55 gal | 373 | 0.8 | 0.0 | 5.6 | 1 |
| S791934 | 25 | Pit 9 | 55 gal | 375 | 1.2 | 0.0 | 10.2 | 2 |
| S791944 | 25 | Pit 9 | 55 gal | 376 | 1.4 | 0.0 | 11.7 | 2 |
| S791947 | 25 | Pit 9 | 55 gal | 84 | 3.5 | 0.0 | 38.7 | 3 |
| S791948 | 25 | Pit 9 | 55 gal | 410 | 0.4 | 0.0 | 3.5 | 1 |
| S791950 | 25 | Pit 9 | 55 gal | 448 | 0.5 | 0.0 | 3.8 | 1 |
| S791952 | 25 | Pit 9 | 55 gal | 220 | 7.6 | 0.0 | 58.9 | 1 |
| S793025 | 25 | Pit 9 | 55 gal | 186 | 8.0 | 0.0 | 59.2 | 0 |
| S793063 | 25 | Pit 9 | 55 gal | 241 | 25.9 | 0.2 | 96.0 | 3 |
| S793110 | 25 | Pit 9 | 55 gal | 381 | 1.6 | 0.0 | 12.8 | 1 |
| S793113 | 25 | Pit 9 | 55 gal | 191 | 13.2 | 0.1 | 134.0 | 2 |
| S793125 | 25 | Pit 9 | 55 gal | 174 | 37.8 | 0.2 | 176.6 | 10 |
| S793143 | 25 | Pit 9 | 55 gal | 423 | 2.3 | 0.0 | 15.8 | 2 |
| S793152 | 25 | Pit 9 | 55 gal | 148 | 0.2 | 0.0 | 1.1 | 2 |
| S793159 | 25 | Pit 9 | 55 gal | 241 | 31.8 | 0.2 | 187.2 | 40 |
| S793172 | 25 | Pit 9 | 55 gal | 143 | 11.4 | 0.1 | 98.4 | 4 |
| S793178 | 25 | Pit 9 | 55 gal | 125 | 26.6 | 0.2 | 158.8 | 4 |
| S793180 | 25 | Pit 9 | 55 gal | 125 | 0.1 | 0.0 | 0.9 | 2 |
| S793190 | 25 | Pit 9 | 55 gal | 138 | 40.5 | 0.3 | 159.2 | 8 |

| Belowgrade Nitrate Salt Drums | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PKG_ID | Waste Code | Location | Container Type | Gross Wt (lb) | PECi | EC PECi | FGE | Total Dose |
| S793194 | 25 | Pit 9 | 55 gal | 358 | 1.1 | 0.0 | 9.1 | 2 |
| S793196 | 25 | Pit 9 | 55 gal | 317 | 65.5 | 0.4 | 146.2 | 15 |
| S793204 | 25 | Pit 9 | 55 gal | 240 | 5.2 | 0.0 | 45.2 | 5 |
| S793212 | 25 | Pit 9 | 55 gal | 161 | 2.0 | 0.0 | 12.5 | 3 |
| S793216 | 25 | Pit 9 | 55 gal | 217 | 10.0 | 0.1 | 134.5 | 10 |
| S793219 | 25 | Pit 9 | 55 gal | 328 | 2.7 | 0.0 | 18.8 | 3 |
| S793220 | 25 | Pit 9 | 55 gal | 276 | 36.4 | 0.2 | 84.9 | 7 |
| S793244 | 25 | Pit 9 | 55 gal | 122 | 23.1 | 0.1 | 171.4 | 15 |
| S793250 | 25 | Pit 9 | 55 gal | 214 | 34.3 | 0.2 | 88.8 | 50 |
| S793276 | 25 | Pit 9 | 55 gal | 199 | 26.0 | 0.2 | 51.0 | 100 |
| S793279 | 25 | Pit 9 | 55 gal | 334 | 11.3 | 0.1 | 85.1 | 10 |
| S793292 | 25 | Pit 9 | 55 gal | 393 | 2.0 | 0.0 | 14.8 | 5 |
| S793404 | 25 | Pit 9 | 55 gal | 157 | 53.6 | 0.3 | 164.5 | 2 |
| S793410 | 25 | Pit 9 | 55 gal | 96 | 6.4 | 0.0 | 53.8 | 4 |
| S793411 | 25 | Pit 9 | 55 gal | 95 | 1.3 | 0.0 | 9.0 | 6 |
| S793429 | 25 | Pit 9 | 55 gal | 121 | 49.3 | 49.3 | 150.5 | 13 |
| S793443 | 25 | Pit 9 | 55 gal | 170 | 16.1 | 0.1 | 184.1 | 1 |
| S793451 | 25 | Pit 9 | 55 gal | 238 | 6.4 | 0.0 | 71.7 | 2 |
| S793455 | 25 | Pit 9 | 55 gal | 289 | 19.2 | 0.1 | 33.9 | 10 |
| S793475 | 25 | Pit 9 | 55 gal | 221 | 20.1 | 0.1 | 86.4 | 8 |
| S793490 | 25 | Pit 9 | 55 gal | 358 | 2.2 | 0.0 | 16.3 | 1 |
| S793706 | 25 | Pit 9 | 55 gal | 390 | 2.2 | 0.0 | 9.2 | 1 |
| S793707 | 25 | Trench OC | 55 gal | 386 | 0.7 | 0.0 | 4.9 | 1 |
| S793768 | 25 | Trench OC | 30 gal cask | 70 | 120.9 | 120.9 | 2.2 | 15 |
| S793769 | 25 | Trench OC | 30 gal cask | 55 | 14.5 | 14.5 | 3.1 | 1 |
| S802571 | 25 | Trench OC | 30 gal cask | 78 | 110.5 | 110.5 | 2.0 | 1 |
| S803091 | 25 | Trench OC | 30 gal cask | 64 | 29.9 | 29.9 | 0.6 | 2 |
| S816426 | 25 | Trench OC | 30 gal cask | 37 | 122.2 | 122.2 | 2.3 | 15 |
| S822540 | 25 | Trench 0D | 30 gal cask | 35 | 26.0 | 26.0 | 0.5 | 2 |
| S822560 | 25 | Trench 0D | 30 gal cask | 47 | 200.1 | 1.2 | 3.7 | 8 |
| S824154 | 25 | Trench 0D | 30 gal cask | 69 | 180.7 | 1.1 | 3.3 | 4 |
| S832274 | 25 | Trench 0A | 30 gal cask | 76 | 92.3 | 0.6 | 1.7 | 5 |
| S842188 | 25 | Trench 0D | 30 gal cask | 59 | 222.2 | 1.4 | 4.1 | 18 |
| S844290 | 25 | Trench 0D | 30 gal cask | 41 | 46.8 | 0.3 | 0.9 | 6 |
| S845076 | 25 | Trench 0D | 30 gal cask | 59 | 210.5 | 1.3 | 3.9 | 16 |
| S846104 | 25 | Trench 0A | 30 gal cask | 70 | 144.3 | 0.9 | 2.7 | 12 |
| S846105 | 25 | Trench 0D | 30 gal cask | 55 | 166.4 | 1.0 | 3.1 | 8 |

## APPENDIX D WASTE CONTROL SPECIALISTS, LLC, NITRATE SALT DRUM INFORMATION

**WCS Nitrate Salt Drums**

| PKG_ID | Waste Stream | Contnr Type | Gross Wt (lb) | PECi | EC PECi | FGE | Total Dose | Vol Util. (%) | Liner wt. (kg) | Metal (kg) | Nonmetal (kg) | Container (kg) | Salt wt. (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68311 | MIN02 | 55-GAL | 306 | 5.4 | 4.8 | 32.0 | 14.5 | 75 | 5.7 | 0.1 | 6.3 | 28 | 99 |
| 68313 | MIN02 | 55-GAL | 308 | 14.3 | 12.6 | 112.3 | 12.5 | 65 | 5.7 | 19 | 4 | 28 | 84 |
| 68314 | MIN02 | 55-GAL | 206 | 1.8 | 1.6 | 10.0 | 10.5 | 50 | 5.7 | 0 | 6.1 | 28 | 54 |
| 68315 | MIN02 | 55-GAL | 359 | 27.7 | 24.4 | 186.0 | 61.2 | 75 | 5.7 | 25 | 4 | 28 | 101 |
| 68325 | MIN02 | POC | 376 | 11.8 | 10.4 | 54.2 | 2.5 | 55 | 36.1 | 0 | 0 | 109 | 25 |
| 68341 | MIN02 | POC | 377 | 13.1 | 11.5 | 62.0 | 2.6 | 80 | 36.1 | 0.5 | 0 | 109 | 25 |
| 68342 | MIN02 | POC | 334 | 2.6 | 2.3 | 15.0 | 1 | 35 | 36.1 | 0 | 1 | 109 | 5 |
| 68347 | MIN02 | POC | 372 | 6.7 | 5.9 | 13.2 | 1.1 | 80 | 36.1 | 0 | 4 | 109 | 20 |
| 68350 | MIN02 | POC | 388 | 11.8 | 10.4 | 34.4 | 1.7 | 85 | 36.1 | 0 | 0 | 109 | 31 |
| 68396 | MHD01 | POC | 330 | 3.7 | 0.9 | 15.6 | 1 | 45 | 36.1 | 2.7 | 2.2 | 109 | |
| 68425 | MIN02 | POC | 386 | 2.9 | 2.5 | 0.7 | 1.5 | 80 | 36.1 | 0.3 | 0 | 109 | 29 |
| 68426 | MIN02 | POC | 347 | 15.5 | 13.6 | 147.1 | 1.5 | 50 | 36.1 | 0 | 1 | 109 | 12 |
| 68428 | MIN02 | POC | 380 | 6.7 | 5.9 | 9.4 | 1.5 | 85 | 36.1 | 0 | 2 | 109 | 25 |
| 68429 | MIN02 | POC | 396 | 4.2 | 3.7 | 9.7 | 1.5 | 90 | 36.1 | 0 | 0 | 109 | 34 |
| 68431 | MIN02 | POC | 362 | 12.3 | 10.7 | 45.3 | 1.8 | 70 | 36.1 | 0 | 4 | 109 | 15 |
| 68432 | MIN02 | POC | 337 | 0.3 | 0.3 | 2.3 | 1.5 | 30 | 36.1 | 0 | 1 | 109 | 7 |
| 68433 | MIN02 | POC | 351 | 1.0 | 0.9 | 9.0 | 0.8 | 40 | 36.1 | 0 | 1 | 109 | 13 |
| 68449 | MIN02 | 55-GAL | 429 | 13.1 | 11.5 | 68.0 | 40.5 | 90 | 5.7 | 20 | 4 | 28 | 138 |
| 68508 | MIN02 | POC | 398 | 7.9 | 6.9 | 35.8 | 1.5 | 95 | 36.1 | 0 | 0 | 109 | 35 |
| 68509 | MIN02 | POC | 370 | 5.5 | 4.9 | 14.2 | 1 | 75 | 36.1 | 0 | 0 | 109 | 22 |
| 68543 | MIN02 | 55-GAL | 358 | 8.4 | 7.3 | 46.7 | 25.5 | 85 | 5.7 | 6 | 2 | 28 | 121 |
| 68546 | MIN02 | 55-GAL | 415 | 47.4 | 41.7 | 146.6 | 72 | 85 | 5.7 | 10 | 1 | 28 | 144 |
| 68580 | MIN02 | 55-GAL | 465 | 4.5 | 3.9 | 11.3 | 8.5 | 90 | 5.7 | 20 | 11 | 28 | 147 |
| 68583 | MIN02 | POC | 382 | 5.7 | 5.0 | 2.1 | 2 | 75 | 36.1 | 0 | 0 | 109 | 29 |
| 68584 | MIN02 | POC | 361 | 1.5 | 1.3 | 16.2 | 0.9 | 50 | 36.1 | 0 | 2 | 109 | 17 |
| 68617 | MIN02 | POC | 341 | 2.5 | 2.2 | 28.9 | 0.8 | 50 | 36.1 | 0.3 | 0 | 109 | 10 |
| 68619 | MIN02 | POC | 392 | 4.6 | 4.0 | 35.3 | 0.9 | 75 | 36.1 | 0 | 0 | 109 | 32 |
| 68620 | MIN02 | POC | 403 | 0.9 | 0.8 | 10.6 | 1.2 | 75 | 36.1 | 0 | 2 | 109 | 35 |
| 68625 | MIN02 | 55-GAL | 295 | 2.0 | 1.8 | 22.7 | 52 | 50 | 5.7 | 7 | 4 | 28 | 89 |
| 68627 | MIN02 | 55-GAL | 357 | 0.3 | 0.3 | 2.3 | 30.5 | 85 | 5.7 | 35 | 8 | 28 | 86 |
| 68628 | MIN02 | 55-GAL | 370 | 0.9 | 0.8 | 10.6 | 70.5 | 80 | 5.7 | 8 | 4 | 28 | 123 |
| 68632 | MIN02 | 55-GAL | 342 | 2.5 | 2.2 | 28.8 | 60.5 | 80 | 5.7 | 6.5 | 4.2 | 28 | 111 |
| 68656 | MIN02 | 55-GAL | 461 | 34.4 | 30.3 | 160.1 | 51 | 95 | 5.7 | 5 | 21 | 28 | 150 |
| 68661 | MIN02 | 55-GAL | 309 | 3.2 | 2.8 | 16.5 | 18.5 | 65 | 5.7 | 5 | 7 | 28 | 94 |
| 68676 | MIN02 | 55-GAL | 473 | 6.0 | 5.2 | 4.2 | 18.5 | 100 | 5.7 | 6 | 6 | 28 | 169 |
| 68679 | MIN02 | 55-GAL | 507 | 18.8 | 16.5 | 35.6 | 20.5 | 100 | 5.7 | 5 | 4 | 28 | 187 |
| 68681 | MIN02 | 55-GAL | 374 | 11.3 | 10.0 | 78.2 | 35.5 | 80 | 5.7 | 2 | 1 | 28 | 133 |
| 68686 | MIN02 | 55-GAL | 367 | 9.0 | 7.9 | 43.7 | 50.5 | 75 | 5.7 | 10 | 6 | 28 | 117 |
| 69014 | MIN02 | POC | 352 | 3.6 | 3.2 | 11.8 | 1.1 | 70 | 36.1 | 0 | 2 | 109 | 12 |
| 69033 | MIN02 | 55-GAL | 262 | 13.4 | 11.7 | 30.5 | 60.5 | 65 | 5.7 | 10 | 1 | 28 | 75 |
| 69034 | MIN02 | 55-GAL | 303 | 11.4 | 10.0 | 43.4 | 100.5 | 75 | 5.7 | 2.5 | 4 | 28 | 97 |
| 69041 | MIN02 | 55-GAL | 444 | 12.2 | 10.8 | 33.9 | 16.5 | 85 | 5.7 | 38 | 0 | 28 | 130 |
| 69043 | MIN02 | 55-GAL | 420 | 11.3 | 9.9 | 78.8 | 40.5 | 90 | 5.7 | 0 | 6 | 28 | 151 |

| WCS Nitrate Salt Drums | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PKG_ID | Waste Stream | Contnr Type | Gross Wt (lb) | PECi | EC PECi | FGE | Total Dose | Vol Util. (%) | Liner wt. (kg) | Metal (kg) | Nonmetal (kg) | Container (kg) | Salt wt. (kg) |
| 69045 | MIN02 | 55-GAL | 288 | 9.0 | 7.9 | 83.3 | 12.5 | 80 | 5.7 | 20 | 6 | 28 | 72 |
| 69060 | MIN02 | 55-GAL | 210 | 11.8 | 10.4 | 68.8 | 85.8 | 50 | 5.7 | 0.2 | 5 | 28 | 56 |
| 69061 | MIN02 | 55-GAL | 256 | 12.3 | 10.8 | 70.9 | 15.6 | 50 | 5.7 | 20 | 2 | 28 | 61 |
| 69063 | MIN02 | 55-GAL | 350 | 14.4 | 12.7 | 102.9 | 37.5 | 80 | 5.7 | 2 | 7 | 28 | 117 |
| 69064 | MIN02 | 55-GAL | 334 | 6.1 | 5.4 | 34.0 | 32.5 | 80 | 5.7 | 10 | 9 | 28 | 99 |
| 69066 | MIN02 | 55-GAL | 379 | 15.2 | 13.4 | 107.0 | 20.5 | 90 | 5.7 | 20 | 4 | 28 | 115 |
| 69067 | MIN02 | 55-GAL | 246 | 17.0 | 15.0 | 107.8 | 60.9 | 50 | 5.7 | 10.1 | 2 | 28 | 66 |
| 69068 | MIN02 | 55-GAL | 244 | 2.3 | 2.0 | 11.8 | 18.5 | 75 | 5.7 | 0.1 | 9.5 | 28 | 68 |
| 69069 | MIN02 | 55-GAL | 227 | 3.0 | 2.7 | 19.1 | 16.5 | 50 | 5.7 | 10.1 | 6.5 | 28 | 53 |
| 69073 | MIN02 | 55-GAL | 256 | 13.6 | 12.0 | 63.0 | 38.8 | 75 | 5.7 | 5 | 6 | 28 | 72 |
| 69074 | MIN02 | 55-GAL | 229 | 11.2 | 9.9 | 95.8 | 16.8 | 55 | 5.7 | 3 | 2 | 28 | 66 |
| 69077 | MIN02 | 55-GAL | 294 | 1.3 | 1.1 | 9.0 | 5.5 | 85 | 5.7 | 27 | 6 | 28 | 67 |
| 69080 | MIN02 | 55-GAL | 295 | 6.1 | 5.4 | 19.9 | 50.5 | 75 | 5.7 | 16 | 3 | 28 | 81 |
| 69081 | MIN02 | 55-GAL | 191 | 18.2 | 16.0 | 118.6 | 87 | 50 | 5.7 | 5 | 2 | 28 | 47 |
| 69083 | MIN02 | 55-GAL | 431 | 10.7 | 9.4 | 57.5 | 28.5 | 95 | 5.7 | 12 | 8 | 28 | 142 |
| 69085 | MIN02 | POC | 346 | 6.4 | 5.7 | 47.7 | 1.5 | 50 | 36.1 | 0.5 | 2 | 109 | 9 |
| 69087 | MIN02 | POC | 382 | 9.8 | 8.6 | 68.6 | 1.5 | 90 | 36.1 | 3 | 0 | 109 | 25 |
| 69091 | MIN02 | 55-GAL | 268 | 9.2 | 8.1 | 32.1 | 37.5 | 65 | 5.7 | 0.5 | 2.5 | 28 | 85 |
| 69094 | MIN02 | 55-GAL | 416 | 9.6 | 8.5 | 7.3 | 70.5 | 55 | 5.7 | 0 | 6 | 28 | 82 |
| 69097 | MIN02 | 55-GAL | 415 | 11.3 | 9.9 | 92.4 | 25.5 | 100 | 5.7 | 24 | 6 | 28 | 123 |
| 69099 | MIN02 | 55-GAL | 235 | 14.5 | 12.7 | 65.6 | 48.8 | 40 | 5.7 | 0 | 2 | 28 | 72 |
| 69102 | MIN02 | POC | 348 | 3.8 | 3.3 | 20.2 | 0.9 | 50 | 36.1 | 0 | 2 | 109 | 11 |
| 69103 | MIN02 | POC | 375 | 7.9 | 7.0 | 65.7 | 1.5 | 85 | 36.1 | 0.5 | 2 | 109 | 22 |
| 69105 | MIN02 | POC | 425 | 4.2 | 3.7 | 19.5 | 1.5 | 70 | 36.1 | 1.5 | 0 | 109 | 18 |
| 69154 | MIN02 | 55-GAL | 134 | 1.7 | 1.5 | 9.9 | 7.5 | 25 | 5.7 | 10 | 2 | 28 | 16 |
| 69158 | MIN02 | 55-GAL | 182 | 19.4 | 17.0 | 90.2 | 50.5 | 40 | 5.7 | 19.5 | 2 | 28 | 28 |
| 69159 | MIN02 | 55-GAL | 457 | 26.3 | 23.1 | 97.4 | 71.5 | 95 | 5.7 | 23 | 6 | 28 | 144 |
| 69161 | MIN02 | 55-GAL | 370 | 5.1 | 4.5 | 8.0 | 18.5 | 85 | 5.7 | 0 | 8 | 28 | 126 |
| 69162 | MIN02 | 55-GAL | 339 | 7.9 | 7.0 | 35.3 | 27.5 | 85 | 5.7 | 5.2 | 6.1 | 28 | 109 |
| 69163 | MIN02 | 55-GAL | 414 | 8.3 | 7.3 | 30.6 | 36.8 | 95 | 5.7 | 0 | 6 | 28 | 148 |
| 69177 | MIN02 | 55-GAL | 279 | 2.9 | 2.6 | 9.8 | 15.5 | 70 | 5.7 | 0.1 | 6 | 28 | 95 |
| 69179 | MIN02 | 55-GAL | 384 | 9.9 | 8.7 | 79.1 | 20.5 | 95 | 5.7 | 5.2 | 6 | 28 | 129 |
| 69180 | MIN02 | 55-GAL | 337 | 31.8 | 28.0 | 137.0 | 51.5 | 70 | 5.7 | 8 | 4 | 28 | 108 |
| 69181 | MIN02 | 55-GAL | 213 | 2.2 | 1.9 | 13.9 | 10.5 | 55 | 5.7 | 0.5 | 4 | 28 | 59 |
| 69182 | MIN02 | 55-GAL | 252 | 8.5 | 7.5 | 52.5 | 34 | 60 | 5.7 | 5.1 | 4 | 28 | 72 |
| 69185 | MIN02 | POC | 381 | 1.9 | 1.7 | 5.0 | 0.9 | 85 | 36.1 | 0 | 2 | 109 | 25 |
| 69187 | MIN02 | POC | 378 | 6.1 | 5.4 | 20.1 | 1.5 | 65 | 36.1 | 0 | 2 | 109 | 24 |
| 69188 | MIN02 | POC | 382 | 4.1 | 3.6 | 15.9 | 1.5 | 80 | 36.1 | 0 | 2 | 109 | 26 |
| 69189 | MIN02 | POC | 343 | 2.3 | 2.0 | 11.0 | 1.5 | 60 | 36.1 | 0 | 2 | 109 | 8 |
| 69191 | MIN02 | POC | 393 | 6.4 | 5.6 | 8.8 | 1.2 | 75 | 36.1 | 0 | 2 | 109 | 31 |
| 69192 | MIN02 | POC | 342 | 3.1 | 2.7 | 21.8 | 1.5 | 55 | 36.1 | 0 | 1 | 109 | 9 |
| 69193 | MIN02 | 55-GAL | 332 | 8.3 | 7.3 | 47.9 | 30.5 | 75 | 5.7 | 0 | 9 | 28 | 108 |
| 69194 | MIN02 | 55-GAL | 248 | 0.4 | 0.3 | 1.4 | 3.7 | 65 | 5.7 | 2 | 8.5 | 28 | 69 |
| 69195 | MIN02 | 55-GAL | 265 | 11.9 | 10.5 | 52.8 | 17.5 | 55 | 5.7 | 35 | 0 | 28 | 52 |
| 69196 | MIN02 | 55-GAL | 115 | 2.1 | 1.8 | 5.8 | 25.5 | 40 | 5.7 | 0 | 5.1 | 28 | 14 |

**WCS Nitrate Salt Drums**

| PKG_ID | Waste Stream | Contnr Type | Gross Wt (lb) | PECi | EC PECi | FGE | Total Dose | Vol Util. (%) | Liner wt. (kg) | Metal (kg) | Nonmetal (kg) | Container (kg) | Salt wt. (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 69209 | MIN02 | 55-GAL | 532 | 43.3 | 38.1 | 93.1 | 70.5 | 95 | 5.7 | 25 | 5 | 28 | 178 |
| 69210 | MIN02 | 55-GAL | 288 | 3.2 | 2.8 | 6.6 | 10.5 | 55 | 5.7 | 15 | 4 | 28 | 78 |
| 69216 | MIN02 | 55-GAL | 232 | 10.9 | 9.5 | 85.0 | 32.8 | 60 | 5.7 | 0 | 2 | 28 | 50 |
| 69217 | MIN02 | 55-GAL | 305 | 10.0 | 8.8 | 17.0 | 29 | 75 | 5.7 | 23.3 | 4.2 | 28 | 78 |
| 69226 | MIN02 | 55-GAL | 300 | 20.8 | 18.3 | 100.6 | 46 | 60 | 5.7 | 5.5 | 7.2 | 28 | 90 |
| 69230 | CIN01 | 55-GAL | 349 | 6.4 | 6.4 | 31.9 | 10.5 | 95 | 5.7 | 1.5 | 0 | 28 | 123 |
| 69232 | MIN02 | 55-GAL | 383 | 4.0 | 0.5 | 44.2 | 15.5 | 95 | 5.7 | 16 | 0 | 28 | 127 |
| 69234 | MIN02 | 55-GAL | 347 | 2.9 | 2.6 | 9.3 | 11.5 | 80 | 5.7 | 1 | 7 | 28 | 116 |
| 69235 | MIN02 | 55-GAL | 265 | 1.0 | 0.1 | 11.2 | 15.5 | 60 | 5.7 | 5 | 2 | 28 | 80 |
| 69237 | MIN02 | 55-GAL | 383 | 12.9 | 11.3 | 55.2 | 45.5 | 80 | 5.7 | 18 | 0 | 28 | 122 |
| 69279 | MIN02 | 55-GAL | 385 | 28.2 | 24.8 | 102.4 | 80.9 | 70 | 5.7 | 6 | 4 | 28 | 132 |
| 69282 | MIN02 | 55-GAL | 354 | 12.7 | 11.1 | 71.4 | 50.5 | 80 | 5.7 | 5 | 4 | 28 | 118 |
| 69285 | MIN02 | 55-GAL | 287 | 13.9 | 12.2 | 93.1 | 91 | 60 | 5.7 | 8 | 5.5 | 28 | 83 |
| 69295 | MIN02 | 55-GAL | 317 | 3.0 | 2.6 | 6.0 | 21.5 | 100 | 5.7 | 10.1 | 8 | 28 | 93 |
| 69402 | MIN02 | 55-GAL | 390 | 5.2 | 4.5 | 57.6 | 32.5 | 90 | 5.7 | 6 | 8 | 28 | 129 |
| 69413 | MIN02 | 55-GAL | 293 | 4.1 | 3.6 | 19.3 | 7.5 | 65 | 5.7 | 5 | 2 | 28 | 93 |
| 69422 | MIN02 | 55-GAL | 253 | 10.1 | 8.9 | 4.4 | 23 | 50 | 5.7 | 10 | 0 | 28 | 72 |
| 69428 | MIN02 | 55-GAL | 385 | 11.4 | 10.0 | 4.4 | 32.5 | 80 | 5.7 | 0 | 8.3 | 28 | 133 |
| 69430 | MIN02 | 55-GAL | 419 | 3.9 | 3.4 | 41.7 | 17.7 | 90 | 5.7 | 1.5 | 4 | 28 | 151 |
| 69492 | MIN02 | 55-GAL | 352 | 1.2 | 1.1 | 13.8 | 14.5 | 75 | 5.7 | 0 | 8 | 28 | 119 |
| 69493 | MIN02 | 55-GAL | 375 | 18.4 | 16.2 | 63.0 | 31.2 | 80 | 5.7 | 12 | 8 | 28 | 116 |
| 69555 | MIN02 | 55-GAL | 375 | 27.1 | 23.9 | 70.3 | 80.5 | 90 | 5.7 | 15.1 | 1 | 28 | 121 |
| 69565 | MIN02 | 55-GAL | 315 | 24.5 | 21.3 | 144.4 | 28.9 | 80 | 5.7 | 23 | 3 | 28 | 84 |
| 92900 | MHD01 | 55-GAL | 283 | 6.3 | 1.6 | 20.5 | 32.6 | 80 | 5.7 | 23 | 12 | 28 | 60 |
| 94201 | CIN01 | 55-GAL | 503 | 24.4 | 0.2 | 124.3 | 49.9 | 100 | 5.7 | 0 | 11 | 28 | 182 |
| 94211 | CIN01 | POC | 405 | 17.2 | 0.1 | 100.2 | 1.9 | 95 | 36.1 | 0 | 0 | 109 | 39 |

# APPENDIX E MOVER INCIDENT ANALYSIS REPORT FINDINGS

## Root Causes (RC)

**RC 1**: Lawrence Livermore National Laboratory's (LLNL's) initial evaluation and formal acceptance testing of the Vendor's confinement system (design, technique, and procedures) were less than adequate.

**RC 2**: LLNL's ongoing evaluation of the Vendor's confinement system (design, technique, and procedures) was less than adequate for the bag-in and bag-out operation involving LLNL transuranic (TRU) waste drums.

## Contributing Causes (CC)

**CC 1:** The CCP/Los Alamos National Laboratory (LANL) initial design of glovebox drum port/bag interface, necessary to maintain the integrity of the seal when working with materials from LLNL drums. Specific supporting examples are as follows:

- The design of the retaining band was LTA and did not address performance specifications (e.g., torque, change-out frequency) for the band.
- The approach to establishing a seal at the drum ports was ineffective, including use of a retaining clamp on the ends of the internal O-ring of the bags, tape under the exterior retaining band, and lack of taping the end of the bag to the port.
- The design to achieve a wrinkle-free attachment of the bag around the full circumference of the drum port was LTA.

**CC 2:** LLNL's response to the National Nuclear Security Administration's/LSO's ORR comment on the Vendor's configuration management did not fully address the flow down of design intent and specifications, from a radiological control standpoint, to end users at LLNL.

**CC 3:** The Vendor's (CCP's) safety management of ongoing operations was LTA. Specific supporting examples are as follows:

- Communication to LLNL of previous MOVER (Mobile Visual Examination and Repackaging) operation experiences was not adequate. The full paper trail for exposure histories and airborne monitoring at all sites (Nevada Test Site, Argonne National Laboratory, LANL) where the MOVER had operated was not provided to LLNL by CCP.
- Changes to operations (addition of the bungee cord) to address emerging issues (low-level airborne contamination) were agreed to by LLNL and CCP project managers; however, CCP did not consider these to require procedure or design changes. As a result, these changes were not reviewed by the CCP safety organization. CCP did not seem inquisitive as to the safety implications of change or its need to conduct a safety review of the change. Rather, the main concern was if the change impacted the Waste Isolation Pilot Plant (WIPP) certification for the drums.

**CC 4:** Vendor's operational procedures did not include methods for recognizing and responding to changing conditions. Specific supporting examples are as follows:

- The approach and procedure for handling low-Ci and high-Ci drums in the glovebox were the same; consideration of implications of the change in drum activity and material form was LTA.
- Operators normalized events (low-vacuum alarms, elevated meter readings, and minor contaminations) and considered them minor nuisances.
- Identification of radiological hold points for out-of-normal conditions was LTA.

**CC 5:** LLNL's verification of the Vendor's quality assurance plan for the design and fabrication of the confinement system (design, technique, and procedures) was LTA.

**CC 6:** Communication of technical issues and operational problems up the LLNL and CCP line management systems was LTA.

**Judgments of Need (JONs)**

**JON 1:** LLNL needs to recommend to the Vendor that the seal between the bag and drum port needs to be redesigned to achieve an effective seal. This need includes, but is not limited to, recommending that the Vendor evaluate the current process against other, more effective interface-seal processes used in gloveboxes to seal the drum port/bag interface; modify its seal process based on its evaluation; evaluate the current drum port bags against other drum port bags; and provide an effective drum port/bag interface seal.

**JON 2:** LLNL needs to evaluate and revise, as necessary, its current ORR process to ensure that the adequacy of a subcontract's design data information and quality assurance (QA) plan/program are assessed as part of the ORR process to identify any gaps in the adequacy of a subcontract's design review for quality significant equipment.

**JON 3:** LLNL needs to review its process for using Vendor-supplied, quality-significant equipment in a nuclear facility to ensure the equipment is evaluated either through an LLNL design review or other adequate Vendor design review.

**JON 4:** LLNL needs to review and revise, as necessary, its processes for formal communication of the risks associated with Vendor-supplied, quality-significant equipment that has unverified design reviews to the cognizant approval authority.

**JON 5:** LLNL needs to formally communicate to the Vendor the safety management significance and importance of the Vendor providing historical operational information—involving Vendor-supplied, quality-significant equipment—to U.S. Department of Energy sites before the equipment is put to use.

**JON 6:** LLNL needs to formally communicate to the Vendor the safety management significance and importance of the Vendor reviewing site proposed process changes involving Vendor-supplied, quality-significant equipment for safety impacts relative to the initial design specifications and radiological control intent.

**JON 7:** LLNL needs to review and revise, as necessary, its current procedure review processes (contained in the Environment, Safety and Health manual) to ensure that hold points are assessed for their appropriateness and incorporated into procedures to proactively prevent out-of-control conditions from occurring, to allow management adequate time to evaluate areas of concern, and to render effective decisions to address the concerns.

**JON 8:** LLNL needs to issue a lessons learned document on the importance and process for effectively communicating technical issues, operational problems, safety concerns, and off-normal conditions to line management in a timely manner.

**JON 9:** LLNL needs to develop for submittal to DOE a lessons learned document on the issues identified in this Incident Analysis Report.

## APPENDIX F NITRATE SALT SYSTEM ASSESSMENT SCORING BASIS

**Blending**
5 = No radiological issues for set up, system holds multiple blenders, or holds larger capacity blender and can access drum tumbler easily
4 = Moderate to set up in glovebox (GB) (contamination), holds multiple blenders or larger capacity blender, access drum tumbler easily
3 = Moderate to set up in GB (contamination)—single blender—can access drum tumbler easily
2 = Moderate to set up in GB (contamination)—single blender—drum tumbler outside facility
1 = Difficult to insert blender—single blender

**Cementation**
5 = No radiological issues for set up—multiple mixers—can feed drum tumbler easily
4 = No radiological issues for set up—single mixer—can access drum tumbler easily
3 = Moderate to set up in GB (contamination—single mixer—access to tumbler inside
2 = Moderate to set up in GB (contamination)—single mixer—drum tumbler outside facility
1 = Difficult to insert blender-single mixer—drum tumbler outside facility

**Debris Waste**
5 = Space for handling waste and treating debris, free liquid reservoir
4 = Moderate space for handling waste, free liquid reservoir
3 = Moderate space for handling waste, no free liquid reservoir
2 = Little space for debris waste, free liquid reservoir
1 = Little space for debris waste

**Remediated Nitrate Salt (RNS) and Unremediated Nitrate Salt (UNS) Drums**
5 = Capable of handling all drums
4 =
3 = 18 Equivalent Combustible Pu-Equivalent Curies (ECPE-Ci)
2 =
1 = Few RNS and UNS

**Legacy Drums**
5 = All drums
4 = Hazard Category 3 levels
3 = 18 ECPE-Ci
2 =
1 = Few RNS and UNS

**Authorization Basis (AB) Issues**
5 = Page change
4 =
3 =
2 =
1 = New DSA

**Resource Conservation and Recovery Act (RCRA) Issues**
5 = No modification required/RD&D Permit
4 = Class I modification
3 = Class II modification
2 =
1 = Class III modification

**Installation**
5 = Minimal to no modifications for startup
4 = Facility utility-related modifications to accept capability
3 = Facility structural, ventilation, and foundation modifications
2 = Facility structural, ventilation, and some site modifications
1 = Significant facility and site modifications

**Fabrication**
5 = No fabrication
4 = Minimal fabrication or maintenance upgrades
3 = Design and fabrication requiring equipment installation
2 = Design and fabrication requiring equipment installation and facility modifications
1 = Significant equipment fabrication and facility modifications

**Regulatory/Public Acceptance**
5 = Facility and process well configured for remediation operation with historical operating record and all permitting in place
4 = Facility and process well configured for remediation operations and minimal permitting required for operations
3 = Facility has track record for safe, compliant operations. New permitting required for operations.
2 = Facility systems and infrastructure meet required performance, not all drums permitted for processing, some new permitting required
1 = Facility systems and infrastructure meet required performance, not all drums permitted for processing, all new permitting required

**Operation**
5 = Drums easily accessible, operators easy access to box and systems, limited personal protective equipment (PPE), as low as reasonably achievable (ALARA) impact, high drum process rate, low complexity to operate systems
4 = Drum accessible, operator access, limited PPE, ALARA impact, drum process rate, low complexity
3 = Drum accessible, operator access, limited PPE, ALARA impact, drum process rate, low complexity
2 = Drum accessible, operator access, limited PPE, ALARA impact, drum process rate, low complexity
1 = Drum accessible, operator access, limited PPE, ALARA impact, drum process rate, low complexity

**Schedule**
5 = Page change for AB issues only to start and Class II RCRA
4 = Resolve AB issues, minimal fabrication and installation
3 = Resolve AB issues, moderate fabrication and installation
2 = Resolve AB issues, Class III RCRA, significant fabrication and installation, off-site coordination and effort
1 = New documented safety analysis for AB issues, Class III RCRA, significant fabrication, off-site coordination and effort