Basis for Interim Operation (BIO) for the WIPP Mobile Characterization Units

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ACRONYMS AND ABBREVIATIONS

AAS	Add-A-Source
ACGLF	Adjustable Center of Gravity Lift Fixture
AED	aerodynamic equivalent diameter
AICC	adiabatic isochoric complete combustion
AK	Acceptable Knowledge
AMAD	activity median aerodynamic diameter
ARF	Airborne Release Fraction
BIO	Basis for Interim Operation
CAM	Continuous Air Monitor
CBAO	Carlsbad Area Office
CCP	Central Characterization Project
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CH	Contact-Handled
Ci	curie
DBA	Design Basis Accident
DBE	Design Basis Earthquake
DCF	Dose Conversion Factor
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DR	Damage Ratio
DSA	Documented Safety Analysis
DVS	Drum Venting System
EG	Evaluation Guideline
EPA	U.S. Environmental Protection Agency
ERPG	Emergency Response Planning Guideline
ES&H	Environment, Safety, and Health
FGE	Fissile Gram Equivalent
FID	Flame Ionization Detector
FM	Factor Mutual (Research Corporation)
GC	Gas Chromatograph
HAZOP	Hazard and Operability Analysis
HC	Hazard Category
HENC	High-Efficiency Passive Neutron Counter
HEPA	High-Efficiency Particulate Air
HSGS	Headspace Gas Sampling
HVAC	heating, ventilation and air conditioning
ICV	Inner Containment Vessel

IDLH	Immediately Dangerous to Life and Health
in. Hg	inches of mercury
in. WC	inches water column
IPAN/GEA	Integrated Gamma and Imaging Passive/Active Neutron/Gamma Energy Analysis
IPC	Industrial Process Controller
ISM	Integrated Safety Management
ISMS	Integrated Safety Management System
LFL	Lower Flammability Limit
LLW	Low Level Waste
LPF	Leak Path Factor
MAR	Material at Risk
MCS	Mobile Characterization Services
MCU	Mobile Characterization Unit
MDC	minimum detectable concentration
MDL	Method Detection Limit
MGA	Multi-Group Analysis
MLLW	Mixed Low Level Waste
MLU	Mobile Loader Unit
MOI	Maximally Exposed Offsite Individual
MOVER	Mobile Visual Examination and Repackaging
MS	Mass Spectrometer
MWCS	Mobile Waste Characterization Systems
NDA	Non-Destructive Assay
NDE	Non-Destructive Examination
NEC	National Electric Code
NPH	natural phenomena hazard
NRC	U.S. Nuclear Regulatory Commission
n/s	neutrons per second
OCA	Outer Containment Assembly
OCV	Outer Containment Vessel
OR	Occurrence Report
OS&IH	Occupational Safety and Industrial Hygiene
OSHA	Occupational Safety and Health Administration
PC	personal computer
PCB	polychlorinated biphenyl
PE-Ci	^{239}Pu-equivalent curies
PLC	Programmable Logic Controller
PPE	Personal Protective Equipment
ppm	parts per million
PrHA	Process Hazards Analysis
QA	Quality Assurance

QAP	Quality Assurance Program
RCRA	Resource Conservation and Recovery Act
RCT	Radiological Control Technician
RF	Respirable Fraction
RPP	Radiation Protection Program
RQ	Reportable Quantity
RTR	Real Time Radiography
SC	Safety Class
SGS	Segmented Gamma Scanner
SIH	Standard Industrial Hazard
SMP	Safety Management Program
SS	Safety Significant
SSCs	Structures, Systems, or and Components
ST	Source Term
SWB	Standard Waste Box
TCD	Thermal Conductivity Detector
TEDE	Total Effective Dose Equivalent
TEEL	Temporary Emergency Exposure Limit
TQ	Threshold Quantity
TRAMPAC	TRUPACT Authorized Methods for Payload Control
TRU	Transuranic
TRUPACT	Transuranic Package Transporter
TRUW	TRU Waste
TSR	Technical Safety Requirement
UL	Underwriters Laboratory
VE	Visual Examination
VOC	Volatile Organic Compound
WDR	Waste Disposal Requisition
WIPP	Waste Isolation Pilot Plant
WWIS	WIPP Waste Information System

EXECUTIVE SUMMARY

The purpose of this Basis for Interim Operation (BIO) is to establish an umbrella safety basis for the use of Waste Isolation Pilot Plant (WIPP) Central Characterization Project (CCP) Mobile Waste Characterization Units (MCU) to process Department of Energy (DOE) waste located at DOE or related sites. By meeting the requirements specified in this BIO and its associated Application Guide, a site can authorize TRU waste characterization without performing additional analysis.

This BIO authorizes the use of MCUs to characterize and prepare TRU wastes for shipment to WIPP. Each Mobile Unit is analyzed and administratively limited to an inventory of 100 ^{239}Pu-equivalent curies (PE-Ci), and therefore the facility is categorized in accordance with DOE-STD-1027-92 as Hazard Category 2. However, it is anticipated that the majority of sites using this BIO will handle waste containers with actual inventories well below this value.

The following MCUs will be deployed:

(1) Non-Destructive Examination:

- Real-Time Radiography Unit #1 (RTR-1)
- Real-Time Radiography Unit #2 (RTR-2)
- Real-Time Radiography Unit #4 (RTR-4)
- Real-Time Radiography Unit #5 (RTR-5)

(2) Non-Destructive Assay:

- Isotopic System (IQ3) Gamma Scanner
- Integrated Gamma and Imaging Passive/Active Neutron/Gamma Energy Analysis Mobile Waste System trailer (IPAN/GEA)
- Mobile Characterization Services (MCS) Segmented Gamma Scanner (SGS)
- High-Efficiency Passive Neutron Counter (HENC)

(3) Headspace Gas Sampling:

- Headspace Gas Sampling System Number IIA (HSGS-IIA)(Containerized)
- Headspace Gas Sampling System Number IIB (HSGS-IIB)(Equipment in Work Box)
- Drum Venting System #1 – Headspace Gas Sampling System (DVS-1)
- Drum Venting System #2 – Headspace Gas Sampling System (DVS-2)

(4) Visual Examination and Repackaging:

- Mobile Visual Examination and Repackaging (MOVER)

(5) Mobile TRUPACT Loader Unit (MLU)

These units have been evaluated to enable them to be located no closer than 200 meters from a site's boundary. Postulated Natural Phenomena Hazard (NPH) events, including lightning, wind, flood, wildfire, and earthquake, were considered. Specific controls were established for wind speeds, flood, and wildfire. No control is established to mitigate the consequences of an earthquake. These controls are specified below.

The equilibration process and transportation of waste to the units is evaluated in separate documents. The siting criteria requires evaluation of the placement and potential interaction with the activities authorized in the MCUs.

Summary of Controls

The following controls have been selected to ensure the activities performed in the MCUs are conducted in an efficient manner while protecting the public, worker and environment.

Design Features Requiring TSR Coverage

Control	**Safety Function/Importance to Safety**
TRU Waste Drum Integrity	DOT Certified Type A containers, or equivalent provide containment of radioactive materials and prevent release of radioactive material to the public and workers. Buildup of flammable gases within the drums is mitigated by the presence of carbon composite filters in place on vented TRU waste drums
MOVER Structural Integrity and Confinement	Prevent structural failure or damage during and following operational, natural phenomena, or external events. Requires that container be certified Type A container
MOVER glovebox (including HEPA Filtration)	Provide confinement to potential airborne radioactive material, thus preventing release of radioactive material from the glovebox to working areas and the public.
DVS Design- explosion-proof chamber	Provide blast confinement, protect operator from effects of detonation and pressure release.

Specific-Administrative Control TSR Coverage

Control	Safety Function/Importance to Safety
Radiological Inventory Limit	Reduce the consequences of a spill or fire by limiting the amount of radioactive material available for release. Inventory shall be maintained less than 100 PE-Ci for each MCU segment. Waste drum limits are 100 PE-Ci and 200 Pu-239 FGE.
Ignition Source Controls	Reduces possible initiators for fires within MOVER glovebox.
Prohibition on the use of diesel powered forklifts	Significantly reduces the likelihood of a significant drum breach and fire resulting from a forklift accident.
Requirement to use approved non-sparking, spark-resistant or spark-proof tools within MOVER glovebox and inspection of glovebox prior to use to verify that only approved tools are available.	Reduces the likelihood of a fire within the glovebox that could lead to a radiological material release.
Separation distances between MCUs	Maintains safe separation distances between MCU (siting criteria).
Vehicle Access Controls to prohibit potential impact of TRU waste drums being staged or handled	Defines measures (including physical barricades), policies, and actions to prevent or minimize occurrence of vehicle-elated accidents.
Requirement that a crane lift for TRUPACT-II loading is considered a critical lift and positioning of the crane such that it cannot impact material at risk in other nuclear segments.	Reduces the likelihood of payload drops and spills associated with TRUPACT-II loading operations.

Programmatic-Administrative Control TSR Coverage

Control	Safety Function/Importance to Safety
Container Inspection Program	Provides visual surveillance and inspection of drums to identify signs of pressurization or degradation that could challenge drum integrity
Emergency Response Program	Reduce the consequences of an accident through emergency response procedures, personnel communication systems, emergency drills, and other program elements that ensure effective evacuation.
Hazardous Material Protection Program	Reduce the likelihood of hazardous material accidents, such as fires or toxic releases, through a program that ensures proper handling of hazardous materials by procedures for their use and storage.
Maintenance, Testing, and Inspection Program	Reduce the likelihood of an accident resulting in release of radioactive material or worker injury caused by equipment failure, through programs requiring maintenance, testing, and inspection of equipment to confirm proper operation and continued reliability.
Quality Assurance Program	Reduce the likelihood and consequences of accidents though a program that ensures commitments made in the safety analysis are properly implemented.
Radiation Protection Program (RPP)	Reduce likelihood of worker exposure to radioactive material or radiation through a program that implements 10 CFR 835, Occupational Radiation Protection (CFR 2001e).
Training Program	Reduce the likelihood of an accident by ensuring that workers can successfully and safely execute actions defined by programs and supporting procedures. Training reduces the frequency of human error by improving awareness of hazards that could lead to worker injury or insults to radioactive waste.
Criticality Safety Program	Prevent the likelihood of a criticality by ensuring that the specified quantities of fissile material are not exceeded.
Fire Protection Program (Including Combustible Loading Control Programs)	Reduce the likelihood of fires by controlling the sources of ignition and reduce the spread and consequences of fires by limiting the quantities of combustibles and maintaining the operability of automatic fire suppression systems.

CHAPTER 1
INTRODUCTION

The purpose of this Basis for Interim Operation (BIO) is to establish an umbrella safety basis for the use of Waste Isolation Pilot Plant (WIPP) Central Characterization Project (CCP) Mobile Waste Characterization Units (MCU) to process Department of Energy (DOE) transuranic waste (TRU) located at DOE or related sites. By meeting the requirements specified in this BIO and the associated Application Guide (DOE 2003) a site can authorize TRU waste characterization without performing additional analysis.

This BIO is prepared in accordance with DOE-STD-3011-2002 (Ref. 1-2). Per 10 CFR 830.204(a) and Table 2 of Subpart B to Part 830 (Ref. 1-3), the contractor responsible for a DOE nuclear facility with a limited operational life may prepare its documented safety analyses using the method in DOE-STD-3011-94 (Ref. 1-4) or successor document. The use of MCUs at specific sites is expected for a limited amount of time, after which the equipment will be moved to another site. The hazard analysis methodology is consistent with that of DOE-STD-3009-94 (Ref. 1-5). Information is presented in six chapters, which follow the guidelines of DOE-STD-3009-94 for specific chapters as identified in DOE-STD-3011-2002.

- Chapter 1 -- Introduction
- Chapter 2 -- Facility Description
- Chapter 3 -- Hazard and Accident Analysis
- Chapter 4 -- Safety Structures, Systems and Components
- Chapter 5 -- Derivation of Technical Safety Requirements
- Chapter 6 -- Safety Management

1.1 Scope

The DOE has implemented a program to characterize and certify TRU waste for transportation and disposal at the WIPP in Carlsbad, New Mexico. The WIPP Resource Conservation and Recovery Act (RCRA) hazardous waste facility permit requires that TRU waste drums be examined to ensure they meet waste acceptance criteria before being shipped to WIPP. Legacy or “retrievably stored” TRU waste is currently required to undergo nondestructive examination, nondestructive assay, headspace gas sampling and analysis, and visual examination. As part of DOE’s complex wide strategy legacy waste at approximately 28 sites where limited amounts of TRU legacy waste is located will require the use of MCUs. The sites possess quantities of TRU waste ranging from just a few drums to several thousand drums, which need processing prior to shipment to WIPP. In addition, the characterization units may also process newly generated waste.

The TRU waste characterization process includes both non-intrusive and intrusive examination of the TRU waste drums. This examination takes place in CCP mobile facilities and vendor-owned support facilities. Each facility is considered to be an individual segment, unless multiple segments can be involved in a single accident, in which case the multiple units represent a segment. The following process units can be brought onsite for characterization and processing of TRU waste operated by the WIPP CCP:

- Real Time Radiography (non-intrusive)
- Non-Destructive Assay (non-intrusive)
- Headspace Gas Sampling (intrusive)
- Mobile Visual Examination and Repackaging (intrusive)
- Mobile TRUPACT Loading Unit (non-intrusive)

TRU waste that exceeds the WIPP WAC or TRUPACT Authorized Methods for Payload Control (TRAMPAC) requirements may be repackaged in the Mobile Visual Examination and Repackaging (MOVER) unit and later re-characterized. The principal exclusions that characterization seeks to preclude are:

- Liquid waste. (Containers shall be well drained and contain only residual liquids, and in all cases it must be less than 1 in. (2.5 cm) of liquid in the bottom of the container. In no case shall the total volume exceed 2 liters in a 55-gallon drum.)
- Sealed containers greater than 4 liters
- Ignitable, reactive or corrosive waste materials
- Waste containing flammable or compressed gases
- Waste containing greater than 50 ppm polychlorinated biphenyl (PCB) concentrations
- Waste containing nonradioactive pyrophoric materials
- Hazardous wastes not occurring as mixed TRU waste

Once the waste has been characterized and shown to meet the necessary requirements, it is loaded into TRUPACT-II Type-B casks for shipment offsite. The WIPP provides the TRUPACT-II casks, which hold 14 drums each. Up to three TRUPACT-II casks can be placed on a tractor-pulled trailer.

The waste characterization and TRUPACT-II loading equipment and activities are described in more detail in Chapter 2 of this document.

1.2 Reason for the Basis for Interim Operation

This BIO demonstrates that the MCUs can be safety deployed at sites that have a minimum of 200 meters from the sited components to the site boundary or public. Each unit is considered a Hazard Category 2 nuclear segment that is administratively limited to less than 100 ^{239}Pu-equivalent curies (PE-Ci) each. This BIO does not address waste transportation or thermal conditioning activities that will take place at sites where MCUs are deployed. These activities are evaluated in a separate document and depending upon the number of waste drums involved can be considered to be a Hazard Category 2 nuclear segment, which may require the establishment of additional controls.

The BIO demonstrates safety to onsite workers primarily through adherence to Safety Management Programs (SMPs). The required SMPs are a combination of CCP SMPs developed for use by the vendor operators of the MCUs and existing or developed site-specific SMPs. Integration of SMPs is further addressed in the Interface Document developed to support implementation of this BIO. In addition, the BIO demonstrates safety to onsite workers and the offsite public through identification of the safety envelope and presentation of the results of qualitative and semi-quantitative safety analysis. This BIO serves as the basis for operations for use of the MCU at compatible sites.

The Graded Approach is used as appropriate, as discussed below. Per 10 CFR §830.204(a) and Table 2 of Subpart B to Part 830 (Ref. 1-3), the contractor responsible for a DOE nuclear facility with a limited operational life may prepare its documented safety analyses using the method in DOE-STD-3011-94 (Ref. 1-4) or successor document. DOE expects a graded approach to be used in developing a BIO. The level of detail, analysis, and documentation will reflect the complexity and hazard associated with a particular facility. Thus, the BIO for a simple, low hazard facility may be relatively short and qualitative in nature. This BIO includes characterization and subsequent TRUPACT- II loading of TRU waste drums for a given campaign at any individual site and is considered to be a "short-lived" program. Upon acceptance of this BIO, the site-specific Unreviewed Safety Question (USQ) process will be used to maintain the safety basis current at all times. The USQ process will be performed in accordance with 10 CFR §830.203, *Unreviewed Safety Question Process*, and DOE G 424.1-1, *Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements* (Ref. 1-3, 1-6).

This BIO establishes the safety basis for the facility by summarizing and referencing existing information and, when necessary, by generating new information. The level of detail incorporated into the BIO is significantly dependent upon the level of complexity of the operations in the MCU segments.

This facility safety assurance depends more on a comprehensive understanding of the spectrum of worker hazards than on a focused evaluation of bounding hazards. Consequently, it emphasizes discussions of programs by which the facility needs to manage worker safety. Correspondingly, the safety analysis information presented in the BIO includes the facility hazard category and a discussion of identified vulnerabilities.

1.3 Past Relevant Operating History

The WIPP CCP certification practice is an established program and is currently being implemented at the DOE Savannah River Site, the Nevada Test Site, and Argonne National Laboratory – East. The WIPP TRU Waste Certification Program has an outstanding record of safety at these sites with only one recorded radiological release or worker-safety related accident. Similar waste characterization activities, using nondestructive assay and nondestructive examination units, have also been conducted at other remote locations in the past.

TRUPACT-II loading is also an established program that is currently being utilized at a number of DOE sites. In addition, a TRUPACT-II system has been deployed to additional sites where a set of exercises has been successfully carried out, including the loading of empty drums into the casks, and actual loading of TRU drums.

Further information on the past relevant operational history is provided in other chapters of this BIO where the information from previous deployments has formed the basis for this generic BIO.

1.4 MCU Siting

The hazard analysis and safety assessment made in this BIO has been performed independent of actual siting of the MCU segments. Due to the temporary nature of MCU placement the siting criteria for DOE non-reactor nuclear facilities are considered not to be applicable. Furthermore, the short-duration nature of the activity would suggest that a time-at-risk argument is applicable for the MCU processing. Significant siting considerations are addressed in the companion Application Guide (Ref. 1-1). Of main consideration is the avoidance of placing MCU segments within a potential flood plain, and use of tie downs in areas with high probability of high winds. MCU siting is considered for individual units that are placed in a manner that will preclude interaction between units such that they are considered individual

Hazard Category 2 segments. Accident analysis has been performed using a minimum site boundary distance of 200 meters from MCU segments.

1.5 Safety Analysis Conclusions

As a result of the hazard analysis and qualitative accident analysis, no specific design or operational safety improvement changes were identified. It is concluded that the overall risk to workers, the public, and the environment from activities and operations as evaluated is low. No generic issues require further resolution.

1.6 References

1-1. *Application Guide for Mobile Waste Characterization System Components in Support of the Mobile Operations Authorization Basis*. U.S. Department of Energy, Carlsbad Area Office, Carlsbad, NM, DRAFT, August 2003.

1-2. DOE-STD-3011-2002. *Guidance for Preparation of Basis for Interim Operation (BIO) Documents*. U.S. Department of Energy, Washington, DC, December 2002.

1-3. 10 CFR 830, *Nuclear Safety Management*. Code of Federal Regulations, U.S. Department of Energy, Washington, DC, January 2001.

1-4. DOE-STD-3011-94, *Guidance for Preparation for DOE 5480.22 (TSR) and DOE 5480.23 (SAR) Implementation Plans*. U.S. Department of Energy, Washington, DC, November 1994.

1-5. DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*. U.S. Department of Energy, Washington, DC, Change Notice 2, April 2002.

1-6. DOE-G-41-1, *Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements*. U.S. Department of Energy, Washington, DC, October 2001.

CHAPTER 2
FACILITY DESCRIPTION

This chapter provides information that satisfies the requirements of U.S. Department of Energy (DOE) Standard 3011-2002 (Ref. 2-1). The objective of this chapter is to provide a description of the mobile waste characterization units required to be temporarily located at DOE sites. A graded approach was established for this chapter by providing a typical description of the mobile waste characterization units that would allow an independent reader to develop an understanding of the mobile waste characterization units and process operations without extensive consultation of controlled references. The level of detail required in this description is based on the significance of preventive and mitigative features identified and the degree of unit complexity necessary to understand the operation and analyses. These equipment descriptions are intended as general reference for the BIO user. The MCUs perform both non-intrusive and intrusive examination and loading of Contact-Handled (CH) TRU waste for shipment to WIPP at various DOE sites. The MCUs are not standard in their design, layout, containment or processing methods, and in almost all cases were designed and built before the need for a certified waste characterization program. Therefore, various vendors were contracted to supply preexisting equipment to perform the waste characterization. The MCUs and equipment vary in shape and form but achieve the same process results.

The mission of the Central Characterization Project (CCP) MCUs is to perform onsite waste characterization of CH TRU legacy waste at DOE sites that is intended for shipment to WIPP. Many of the DOE sites do not have the necessary infrastructure and facilities to do onsite waste characterization. Without the infrastructure and the costly development of new waste characterization facilities, these sites are unable to reduce the risk of temporary waste storage above ground. The CCP mobile characterization equipment provides acceleration of waste processing with economies of scale. The MCUs are relocatable structures (i.e., semi-trailer trucks, containerized mobile laboratories, and skid-mounted equipment that are moved from site to site over the highways).

Overview

The CCP must comply with DOE/WIPP 02-3122, *Contact-Handled Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant* (Ref. 2-2). The WIPP CH-WAC establishes the specific physical, chemical, radiological, and packaging criteria for acceptance of defense TRU waste shipments at WIPP. The WIPP CH-WAC requirements are organized under six major categories: container properties, radiological properties, physical properties, chemical properties, gas generation properties, and data package contents. The MCUs enable the DOE site to perform onsite waste characterization in compliance with the WIPP CH-WAC.

This Chapter describes fourteen mobile characterization waste units that perform various functions, including nondestructive examination (NDE), non-destructive assay (NDA), headspace gas sampling (HSGS) and analysis, and visual examination (VE) and repackaging of TRU waste. All of the descriptions include as a minimum, the unit structure physical dimensions, major and supporting components and a description of the process flow of the waste through the unit. Figure 2-1 shows a typical flowpath for a drum of CH TRU waste through the MCUs, which are strategically placed within a controlled area on a DOE site. It should be noted that this flowpath is not always sequential (e.g., NDA may be performed before or after NDE) and may vary to support operational needs.

Typically, the drum begins the process flow in the NDE unit. The function of NDE is to verify that the physical form matches the waste stream description and that the waste matrix code assigned to the waste container is consistent with Acceptable Knowledge (AK) of the waste (i.e., based on process knowledge, operating and characterization records). The drum is then processed through the Non-Destructive Assay (NDA) unit. The function of NDA is to quantify the radionuclide composition of each waste container for purposes of tracking the inventory curie content. Following equilibration for not less than 72 hours at 18 °C, which is performed by the DOE site, the drum is then processed through the HSGS unit. The function of HSGS is to determine the types and concentrations of Volatile Organic Compounds (VOCs) in the void volume of waste containers. The CCP compares VOC constituents to those assigned by AK, and assigns Hazardous Waste Codes, as warranted. Following HSGS, approximately 10% of the drums are statistically selected for processing through the Visual Examination and Repackaging (VE) glovebox unit. The function of VE is to verify the physical form. A secondary function of the glovebox is to repackage when a container is not in compliance with the WIPP WAC.

The following MCUs are described in this chapter:

Non-Destructive Examination:

- Real-Time Radiography Unit #1 (RTR-1)
- Real-Time Radiography Unit #2 (RTR-2)
- Real-Time Radiography Unit #4 (RTR-4)
- Real-Time Radiography Unit #5 (RTR-5)

Non-Destructive Assay:

- Isotopic System (IQ3) Gamma Scanner
- Integrated Gamma and Imaging Passive/Active Neutron/Gamma Energy Analysis Mobile Waste System trailer (IPAN/GEA)
- Mobile Characterization Services (MCS) Segmented Gamma Scanner (SGS)
- High-Efficiency Passive Neutron Counter (HENC)

Headspace Gas Sampling:

- Headspace Gas Sampling System Number IIA (HSGS-IIA)(Containerized)
- Headspace Gas Sampling System Number IIB (HSGS-IIB)(Equipment in Work Box)
- Drum Venting System #1 – Headspace Gas Sampling System (DVS-1)
- Drum Venting System #2 – Headspace Gas Sampling System (DVS-2)

Visual Examination and Repackaging:

- Mobile Visual Examination and Repackaging (MOVER)

Mobile Loader Unit (MLU)

Figures that provide description of these units are presented the end of Chapter 2.

2.1 Non-Destructive Examination

The WIPP CCP uses four individual mobile units to perform NDE using radiography (i.e., RTR-1-, RTR-2, RTR-4 and RTR-5). Real-Time Radiography (RTR) is a nondestructive qualitative and semi-quantitative technique that utilizes X-rays to inspect waste drums and contents without opening the drums. All RTR units perform non-intrusive examination through X-ray without the need to open the 55-gallon drum. There are many similarities between the radiographic X-ray units from an operational standpoint, but some functional and structural differences that are further discussed in this section.

The process of NDE begins with visual inspection of drums staged outside of RTR units. A single pallet of candidate drums (4 drums) is positioned adjacent to the RTR by forklift. This staging area is normally 20 ft away from the load end of the trailer. Each drum is then visually inspected for processing. If an individual candidate drum is acceptable, it is loaded into the unit through one of various conveyor mechanisms (see Section 2.1.3.2). The RTR-1 unit has a scale, which is used to weigh the drum and average tare weight for the empty container (for repackaged drums, the measured gross and net weights are used). (The remaining RTR units are not equipped with load scales.) The drums are weighed by the site prior to or at delivery.

The drum then moves along the conveyor tracks into an X-ray vault. After the vault door is closed, the drum is X-rayed to determine content attributes. The high energy X-rays penetrate through the 55-gallon drum onto an image intensifier. A high-resolution camera then records the image from the intensifier onto magnetic tape and/or digital media. Digital imaging of 100% of the waste drums provides a non-intrusive method for inspecting packages containing TRU and mixed TRU waste. All RTR units are designed to characterize only one TRU waste drum at a time, but some units can accommodate up to four drums physically loaded into the unit at one time. A TRU waste drum must complete its radiography process before a new drum can be processed. Approximately 16 to 20 drums per day can be processed through each unit, with each drum taking approximately 30 minutes for examination.

Radiography is used to achieve the following objectives:

- Verify and document the physical form of the waste.
- Confirm that the physical form of the waste matches its waste stream description [i.e., homogeneous solids, soil/gravel, or debris waste (including non-categorized metals)].
- Verify that the waste matrix code assigned to the waste drum is consistent with the Waste Disposal Requisition (WDR), in accordance with the WIPP Waste Acceptance Criteria (WAC) (Ref. 2-2).
- Identify any prohibited waste in the drum.
- Estimate waste material parameter weights.

This technique can detect the presence of items such as liquid wastes and containerized gases, which are prohibited for disposal at the WIPP. The prohibition on liquids and containerized gases (WIPP WAC, Ref. 2-2) prevents the shipment of corrosive, ignitable, or reactive wastes to the WIPP. Minor residual liquids remaining in well-drained internal containers (e.g., bottles, cans) must not exceed 1 in. (2.5 cm) in the bottom of any container and the total liquid in the waste package must not exceed 1 vol%. Initially, AK is used to determine container contents. All radiography examinations are recorded on videotape. If the radiography indicates the presence of prohibited items or that the waste does not match the matrix performance category, then it is rejected, and the drum is dispositioned in accordance with the inventory management program requirements. Upon successful completion of radiography, the drum is unloaded from the RTR using the conveyors and a forklift, and containers are staged for the next step in the process, which typically includes NDA.

2.1.1 Real-Time Radiography Unit Description

All RTR units consists of the following components: X-ray-producing device; imaging system; an enclosure for radiation protection; a waste container handling system; an audio/visual recording system; and an operator control and data acquisition station. The radiography equipment has controls (or equivalent process) that allow the operator to control image quality for materials of varying density. On radiography systems, it is possible to vary the voltage, typically between 20kV to 240kV to provide an optimum degree of penetration through the waste. For example, high-density material is examined with the X-ray device set on the maximum voltage. This ensures maximum penetration through the waste container. Low-density material is examined at lower voltage settings to improve contrast and image definition. The imaging system utilizes a fluorescent screen, a low-light television camera, or X-ray detectors to generate the image.

The RTR units are commercial-grade trailers (DOT Class Code 10, Sub Code 6, Semi-Trailer), which provides for greater mobility of the equipment to remote locations. All RTR units are divided into three sections:

- Operator Control Room
- RTR Vault
- Loading Area

<u>RTR-1 Unit</u>. The RTR-1 layout is shown in Figure 2-2. Personnel access to the RTR-1 unit is through a personnel door into the Operator Control Room. There is one set of stairs for the personnel door to the Control Room. There is one set of stairs that provides temporary access to the drum loading area. Access to the Loading Area is at the end of the RTR-1 trailer through two normal semi-trailer steel door. The X-ray vault can be accessed through either the Operator Control Room or Drum Loading Area. Drums are directly loaded onto the inside loading conveyor system. The conveyor system is inside the physical boundaries of the trailer (no outside conveyor used in the process). The personnel access stairway extends out from the sides of the trailer approximately 3 ft 6 in.; therefore, the overall system width is approximately 13 ft with stairs in place. Overall physical dimensions of the RTR-1 unit are 46 ft in length, 8 ft in width, 13 ft in height, and 48,000 lbs in weight.

<u>RTR-2 Unit</u>. The RTR-2 layout is shown in Figure 2-3. Personnel access to the RTR-2 unit is through a personnel door into the Operator Control Room. There is also a door equipped with a crash bar for emergency exit only that is located on the opposite side of the trailer from the personnel access. There are three sets of stairs: one for the personnel door, one for the emergency exit door, and one for access to the Loading Area. Access to the Loading Area is at the end of the RTR-2 trailer through a roll up steel door. The Vault can be accessed through either the Operator Control Room or Loading Area. Drums are directly loaded onto the outside loading conveyor system, which is located between the roll–up door and the Vault. The stairways extend out from the sides of the trailer approximately 3 ft 6 in.; therefore, the overall system width is approximately 16 ft with both stairs in place. Overall physical dimensions of the RTR-2 unit are 48 ft in length, 8 ft in width, 12 ft in width, and 75,000 lbs in weight.

<u>RTR-4 Unit</u>. The radiation shielded, X-ray inspection system is housed in a 48-ft long x 8 ft 5 in. wide x 13 ft-6 in. tall semi-trailer with air suspension ride. During operations, shielded enclosures extend an additional 18 in. on one side and 36 in. on the opposition side. An elevated conveyor section extends an additional 13 ft to the rear of the trailer to facilitate the loading and unloading of 55-gallon drums with a forklift from one side of the extension conveyor. A rotating/turntable platform is incorporated into the transport mechanism that allows the waste drums to be turned 360 degrees on the platform to complete the X-ray inspection without the assistance of a forklift. The system can inspect waste boxes of 6-ft height and width, up to 10-ft length, and up to 7,000-pounds gross weight when set up to run boxes. Access to the exterior loading conveyor and drum loading area is at the end of the RTR-4 trailer through the rear double trailer doors. There is one personnel access from the control room located on the off street side of the trailer. The areas will require a minimum of 4 ft for the stairway. The overall side boundaries would require approximately 16 ft with body of the trailer, X-ray tube box and Image Intensifier extended. The RTR-4 layout is shown in Figure 2.-4.

RTR-5 Unit. The RTR-5 layout is shown in Figure 2-5. The Mobile RTR-5 is a stand-alone, self-contained system that is permanently attached to an 8 ft X 40 ft drop-deck lowboy trailer. Access to the loading platform on the RTR trailer is through a double door on the side of the trailer. Access area by forklift is a minimum of 20 ft from the side loading access door. Access to the unloading platform on the trailer is through a double door on the back of the trailer. Access area by forklift is a minimum of 20 ft from the rear unloading access door. There is one set of stairs for personnel to access the office space located on the opposite side of the trailer from the loading platform, and next to the fifth wheel section. All remaining access areas require a minimum of 3 ft 6 in. Overall physical dimensions of the RTR-5 unit are 48 ft in length, 8 ft in width, 12 ft in height and 75,000 lbs in weight.

2.1.2 RTR Unit Structural Classification

The RTR units are classified as Type V (000) structures per National Fire Protection Association (NFPA) 220, *Standard on Types of Building Construction* (Reference 2.1.4-3). NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials,* Section 3-5 (Ref. 2-4), requires buildings used to handle and store radioactive materials to have either a fire-resistive or noncombustible construction (Type I or Type II per NFPA 220). NFPA 801, Section 3-8, requires the interior finish of these buildings to be limited combustible. The interior finish on all four RTR units is combustible to some extent as discussed below.

The exterior walls of the unit are steel, over a steel stud frame of a standard trailer truck. The Operator Control Room walls in RTR-1, RTR-2 and RTR-5 units are covered by commercial grade carpet placed on plywood walls connected to the steel studs of the exterior walls. (Note there is no insulation on the trailer walls, ceiling, or floor). The Operator Control Room ceiling is composed of steel (shell of the trailer) with interior steel studs covered by vinyl. A drop plastic lighting panel system is connected to the steel studs of the roof of the trailer. The Operator Control Room floor is vinyl tile over a plywood subflooring, which is placed over the steel frame of the trailer structure. The Vault consists of a lead-lined steel-framed vault, which is connected to the steel floor of the trailer (the Vault is not part of the trailer structure walls, floor, or ceiling, but is positioned within the trailer). The Loading Area consists of vinyl-covered walls and ceiling over plywood connected to the steel studs of the outside walls of the trailer. The floor is covered with steel plates over the structural frame of the trailer.

The design of the RTR-4 trailer is almost all-steel construction with wood only present on the control room sub-floor. The floor is covered with Fire Retardant vinyl tile placed on a 3/4-in. plywood sub-floor that is connected directly to the structural steel trailer frame (no insulation under the floor). Walls and Ceiling are covered with Vinyl PYRO PanL-fire Retardant wall covering. The Vinyl PYRO Panels are connected directly onto the exterior steel braces of the trailer wall. Between the Vinyl PYRO Panels and the outer carbon steel surface of the trailer there is no insulation. The wall facing the X-ray vault is steel frame covered on the office side with 1/8-in. steel and then covered by Vinyl PYRO PanL-Fire Retardant wall cover. On the X-ray vault side, the wall is covered with 1/8-in. carbon steel and 1/8-in. lead liner.

The RTR units and associated equipment were not designed or built to DOE NPH standards. The associated equipment is not seismically qualified. The RTR structures do not perform an emergency function and are not Safety Significant or Safety Class.

2.1.3 RTR Unit Components

The RTR units are composed of the following major system components:

- X-ray System.
- Conveyor System
- Operator Control Room.

For additional details on system and process descriptions for the RTR units, see References 2-5 through 2-9.

2.1.3.1 X-Ray System

The X-ray systems consist of a lead-shielded X-ray tube (lead tube head box), which typically operates in the range of 20kV to 420kV (voltage to the tube), a shielded image intensifier box. The image Intensifier is an electronic device used to detect X-ray radiation and covert the energy into a visible light image viewable by the human eye. The X-ray tube and image intensifier box is located within a shielded X-ray Vault.

The X-ray enclosures incorporate dual safety switches on all Vault doors. The switch assembly is designed to meet the requirements of 21 CFR 1020.40 (Ref. 2-10), which requires such doors to have two interlocks, one of which must directly break the primary power circuit of the X-ray high voltage power supply.

A logic interlock prevents X-rays from being generated unless the doors are in the closed position. Upon a door opening, a conventional snap-action switch interrupts X-rays by removing a signal from the X-ray generator in its logic circuitry. This interruption of X-rays is achieved gently, as if the operator had initiated the stop button. This is called the logic interlock. The logic interlock gives no protection against failure of the switch internal mechanism, welding of the switch contacts, or malfunction of the X-ray generator.

A separate heavy-duty switch breaks the primary power circuit of the X-ray high-voltage power supply when the doors are in the opened position. This is called the primary interlock. Without primary power, the high voltage power supply cannot operate and no X-ray can be made while the door is open, regardless of any malfunction of the logic interlock switch or X-ray generator. The heavy-duty switch is designed as simply as possible, to minimize its risk of failure. A conductor is rigidly attached to the door by fixed hardware. When the door opens, the conductor is removed from the power circuit, preventing X-ray production. The interruption of X-rays by the primary interlock is less gentle, more like unplugging the unit while it is running at full power, but this rarely happens except when a malfunction exists in the logic interlock circuit.

Electronic vault doors open to allow drum loading. RTR-1 and RTR-5 each has one door, and RTR-2 and RTR-4 each has two doors. A personnel X-ray vault door is located one the other end of the vault facing the control room. The door is locked closed during operations. A leaded glass inspection sight glass window is in the door that allows viewing of the operating area. Personnel can access this area for maintenance.

Safeguards are also provided inside the X-ray Vault, enabling personnel to deactivate the X-ray unit in the unlikely event that the door was closed and the unit was started while a person was inside the Vault.

The Vault is a shielded lead lined vault with lead shielding varying from 1/2-in. to 3/4-in. of lead on walls, floor and ceiling. There are normally only minimum radiological restrictions on occupancy on the outside of the RTR units during X-ray operations. In order to keep personnel exposure levels As Low As Reasonably Achievable (ALARA), the mobile radiography system has been designed and constructed in accordance with ANSI 43.3 –1993 "exempt shielded installation" (Ref. 2-11). This class provides the highest degree of inherent safety because radiation protection does not depend on compliance with any opening limitations. The operator control station is fitted with closed-circuit television monitors that provide constant visual surveillance of the shielded enclosure, in-feed conveyor, and drum lifting and examination activities.

A coolant pump system located in the RTR –1 vault that provides coolant of the X-ray tube. The coolant is standard commercial grade automobile antifreeze. Other units rely on an oil-to-air cooler system that is located in the Operator Control Room or Vault, which provides coolant to the X-ray head.

The oil-to-air cooler system normally operates between 32˚F and 100˚F. The actual oil temperature depends on running time and energy at which the equipment operates. The normal operating pressure developed in the oil transfer lines is 90 psi, and the oil transfer lines that connect the system are rated at 200 psi. A pressure relief valve is installed in this system. These lines penetrate the vault wall into the Vault in RTR-2 and RTR-5. For RTR-1 and RTR-4, the oil cooling system is located within the Vault. The oil cooling system in the Operator Control Room, which includes the oil transfer lines and oil reserve tank, holds between 2 to 10 gallons of coolant oil. Because of the large size of the vault floor, any oil leak in the vault would be contained in the Vault. The amount of oil in the system that is actually in the transfer lines that go into the Vault is very small. The oil reserve tank in the Operator Control Room or Vault holds whatever is not in the transfer lines (the tank is not under pressure). An oil leak will be identified by a over-temperature sensor and the low oil flow alarm would sound during operations. The oil is not hazardous and can be cleaned up with paper towels and adsorbing materials. If an operator experiences a leak at any time, the system can be safety shutdown during operations with no safety impact.

The oil-to-air cooler has an over-temperature sensor, flow switch, pressure gauge, interlocks, low oil alarm and easy-view oil level indicator. The system has an over-temperature trip, which will shut down the X-ray unit if the coolant oil temperature reaches about 110˚F. An insulated box surrounds the oil-to-air cooler to reduce the noise levels produced by the equipment. Shell DIALA ® Oil AX used for coolant has a flash point of 295˚F and is a Class IIIB combustible liquid (any liquid that has a flashpoint at or above 200˚F) per NFPA 30, *Flammable and Combustible Liquids Code*, Section 1.7.3.1 (Reference 2-12).

2.1.3.2 Conveyor System

Various types of conveyor systems are deployed on the RTR units to transport drums from outside the units to vault for radiography.

2.1.3.2.1 RTR-1

A fitted conveyor track system is installed in the loading area that extends through and into the X-ray vault. An electrically driven drum carriage and drum turntable with a hydraulic lift table are used to transport drums into and out of the vault. The electrically driven drum carriage positions the drum and the turntable lifts the drum into position for X-ray. The turntable rotates the drum 360^0 during examination. Limit and trip switches are designed into the drum carriage, lift table and rotator table to guard against override.

2.1.3.2.2 RTR-2

There are two sets of metal conveyor rollers, which move the waste drum from the Loading Area into the X-ray Vault for inspection. The first conveyor is located inside the RTR-2 Vault (inside conveyor) and the second conveyor is located in the Loading Area at the end of the trailer (outside conveyor). The conveyor system is load rated at 10,000 lbs. Each conveyor operates independently of the other. The inside and outside conveyors are chain driven by individual electric motors. Cover plates are designed on the rollers to eliminate open spaces. Limit switches and sensors are installed at the end of each conveyor. The limit switches are designed to terminate conveyor operation to ensure that the waste drum does not over travel. Photo sensors are installed above the conveyors, which also stops the drum from traveling too far. An emergency pull line over the entire length of the inside conveyor provides an emergency stop of all mechanical movement of both conveyors. The operator must manually reset the emergency stop before restarting the conveyors.

The drum manipulator carriage consists of two sections:

- A wooden base frame of nominal 2 in. by 4 in. construction with a plywood cover (this base unit is in contact with the conveyor rollers).
- A top metal frame, which includes the drum manipulator turntable, bolted on top of the wooden base frame. The drum manipulator has two electrically driven turntables (turntables can be operated individually). Each turntable is load tested to 1100 lbs and turns at 6 rpm.

The carriage assembly moves along the conveyor to the Loading Area for drum loading/unloading and retracts back into the Vault for RTR.

2.1.3.2.3 RTR-4

There are two sets of conveyors. The inside conveyor is located inside the RTR-4 vault, which moves to match with the outside conveyor. The outside conveyor is located in the loading area and extends through and into the vault area at the rearmost end of the trailer. The outside conveyor is a fitted conveyor. Once the Drum Manipulator Carriage and Turntable has been positioned at the end most point of the conveyor, four drums are loaded one at a time onto the turntables by a forklift. Each turntable allows for the centering of the drum. Once loaded, the operator from the control panel initiates the electrical drive motor of the Drum Manipulator Carriage and turntable, which travels into the X-ray vault and onto the inside conveyor. Once loaded onto the inside conveyor the conveyor and Drum Manipulator Carriage move into position for X-ray of drums. One drum at a time is X-rayed.

The conveyor system is custom designed with a load rating of 10,000 lbs (4,500 kg) for each conveyor independent of the other. However, working levels are restricted to 7,000lbs. The inside is driven by individual electric motors. Limit switches and sensors are provided that ensures conveyors do not over travel. Emergency stops are located in the control room and vault area, which stop X-ray generation and all mechanical movement of both conveyors. The operator must manually reset the emergency stop before restarting. Limit switches are installed at the end of each conveyor that terminates the operations if the override occurs.

The drum manipulator carriage consists of two sections: a steel base frame and a top metal frame.

- The steel base frame is 9 ft x 4 ft and is covered by the turntable.
- A top metal frame includes the drum manipulator turntable, which is bolted on top of the base frame. The drum manipulator has four electrically driven turntables that are operated one at time.

The vertical movement of the turntable is hydraulically controlled, enabling the turntable to be lifted into position for the X-ray of the drums. The vertical scissors lift is limited to the lifting height by the equipment design (i.e. a drum can't be lifted higher than the equipment capacity). Limit switches are also provided that control lifting. The hydraulic equipment reservoir capacity is 10 gallons of hydraulic oil.

2.1.3.2.4 RTR-5

The conveyor system includes two hydraulically and remotely controlled conveyors of approximately 8 ft in length each, a free rolling conveyor of approximately 3 ft in length, a free rolling conveyor of approximately 1 ft in length and a chain driven (with an electric motor), remotely operated pusher bar. The conveyor system is used to remotely move the TRU waste drums through the X-ray system. A forklift is used to place the drums on the conveyor and remove them from the conveyor following the RTR examination.

The hydraulically controlled drum manipulator, located inside the vault, is remotely operated to allow movement of the entire drum through the X-ray field. The drum is pushed onto the drum manipulator by the pusher bar. The manipulator can rotate the drum 360 degrees clock wise and counter-clock wise, raise or lower the drum, shift the drum from side to side or tilt the drum 6 in.

The chain driven (with an electric motor), remotely operated pusher bar is used to move the drum from the entry 8 ft section of conveyor onto the 3 ft section of free rolling conveyor and then onto the drum manipulator for drum RTR examination. The pusher bar is deployed and retracted in a scissors fashion, and can only be operated when the X-ray vault doors have been completely opened. Following the drum RTR examination, and only after the X-ray vault doors have again completely opened, the pusher bar is remotely deployed to push the drum onto the 1 ft free rolling conveyor and then onto the exit 8 ft section of conveyor.

2.1.3.3 Operator Control Room

The Operator Control Room contains the following equipment:

- Operator's Console
- Audio/Video Subsystem. The Audio/Video subsystem is comprised of an image intensifier integrated CC digital camera, raw video monitor, digital image processor, precision video cassette recorder (VCR), process video monitor, and video printer. Additionally there is a CC video camera and dedicated monitor for surveillance of the X-ray Vault and Loading Area with the Vault doors open.

2.1.3.4 Other Unit Components

Other system components associated with RTR unit include the following, which are discussed further below:

- Heating, Ventilation and Air Conditioning (HVAC) System
- Emergency Shutdown Devices
- Warning Lights
- Electrical and Lighting System
- Communications
- Fire Detection System

2.1.3.4.1 Heating, Ventilation and Air Conditioning

HVAC units are provided on all RTR units strictly for the purpose of comfort of the operators, who are located in the Operator Control Room. There is no heating or cooling units provided for radiological operations in the X-ray Vault or Drum Loading Areas.

2.1.3.4.2 Emergency Shutdown Devices

RTR-1 and RTR-5 units are equipped with emergency shutdowns/overrides at the operator console (i.e., red mushroom button located on the Operator's Bench Board) and on the inside of X-ray vault. RTR-2 unit also has the emergency shutdown on the control panel, as well as one located at the main electrical panel. The RTR-2 and RTR-4 units are also equipped with a vault room cable that extends the length of the vault directly over the conveyor and several inches from the RTR units' ceiling. Once pulled, all systems stop, including any mechanical movement of the motorized conveyors (i.e., inside and outside of the conveyor).

2.1.3.4.3 Warning Lights

X-ray pre-warning alarm stack lights are located in the Vault and Loading Area. The amber beacon flashes 30 seconds before X-rays are produced, warning the operator that the system is about to energize. The red beacon flashes 10 seconds before the system energizes. Warning lights in the X-ray Vault and Loading Areas remain illuminated any time the X-ray generator is on.

2.1.3.4.4 Electrical and Lighting Systems

The RTR units are stand-alone, self-contained systems that require electrical power to operate. Electrical supply for RTR equipment is: RTR-1 and RTR-5 are 100 amp, single phase; RTR-4 is 200 amp, single phase; and RTR-2 is 100 amps, 3 phase. The electrical power feed panel is located on the outside wall of the RTR trailer. All RTR equipment is designed and installed in accordance with the minimum standards of the National Electric Code (NEC) and NFPA 70, *National Electrical Code* [e.g., enclosure power interlocks, 4-prong plugs, breakers, fuses, ground-fault circuit interrupt, etc.].

The distribution panel is mounted inside the Operator Control Room. A service disconnect is provided on the outside wall of the unit. Ground lugs are provided on the outside of the trailer.

There are fluorescent light fixtures controlled by light switches inside the Operator Control Room access door. In addition, batteries are provided for emergency lighting.

Illuminated EXIT signs are provided over the personnel access door. Battery backup is provided for these signs.

2.1.3.4.5 Communication Systems

A normal telephone line is connected to the RTR units to provide outside calling. This provides for communication from the site to the operator and from the operator to the site during normal operations and emergency conditions. An intercom system is also installed in the trailer that allows operators to communicate (e.g., one in the Loading Area and one at the control panel in the Operator Control Room).

2.1.3.4.6 Fire Detection System

The RTR units are equipped with several smoke detectors. These detectors can be linked to host site fire dispatch systems. Fire extinguishers are located in the Loading Area and Operator Control Room of the RTR units.

2.2 Non-Destructive Assay (NDA)

Radionuclide composition of each waste container must be quantified and reported for purpose of tracking the inventory curie content. Title 40 CFR, Sec. 194.24 (c) states that DOE shall specify the limiting values for waste components to be emplaced in the repository (Reference 2.2-1). The activities and masses of ^{241}Am, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{242}Pu, ^{233}U, ^{234}U, ^{238}U, ^{90}Sr, and ^{137}Cs must be established on a payload container basis for purposes of tracking their contributions to the total WIPP radionuclide inventory. All radionuclides other than the ten WIPP-tracked radionuclides (i.e., ^{241}Am, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{242}Pu, ^{233}U, ^{234}U, ^{238}U, ^{90}Sr, and ^{137}Cs) that contribute to 95% of the radioactive hazard for the payload container must be reported on the TRUPACT-II bill of lading or manifest in accordance with 49 CFR §172.203 and 49 CFR §173.433 (References 2-14, 2-15).

The activities and masses of these other radioisotopes must also be reported to the WIPP Waste Information System (WWIS) along with their associated TRU, expressed in terms of one standard deviation for each waste container (Reference 2-16). The NDA waste characterization equipment provide a direct measurement. The radio-assay equipment is qualified under the Performance Demonstration Program requirements. The WIPP CCP uses four individual MCUs to perform radioassay of CH TRU waste drums. These include the Isotopic System (IQ3) Gamma Scanner, the Integrated Gamma and Imaging Passive/Active Neutron/Gamma Energy Analysis Mobile Waste System trailer (IPAN/GEA), the Mobile Characterization Services (MCS) Segmented Gamma Scanner (SGS), and the High-Efficiency Passive Neutron Counter (HENC). There are similarities between the assay units from operational standpoint but functional and structural differences necessitate a complete description of each system and process for each of the units.

2.2.1 Isotopic System (IQ3) Gamma Scanner

The Gamma NDA and Isotopic System (IQ3) is a gamma spectroscopy based NDA system that determines the TRU content of bulk waste using low-energy germanium (LeGe) detectors. The IQ3 system can directly assay Pu-239, Pu-241, Am-241, U-233, U-235, U-238, Cs-137, as well as many other gamma emitting nuclides that may be present in the waste. In addition the IQ3 can measure the relative isotopic abundance of the plutonium isotopes Pu-238, Pu-239, Pu-240, Pu-241, Pu-242 as well as several other actinides including U-235, Am-241, Np-237, and Am-243 using the Multi Group Analysis (MGA) code. A similar code is used to calculate the isotopic ratios for the uranium isotopes U-234, U-235, and U-238. The isotopic ratios are then tied to the Pu-239 or U-235 mass values to provide direct assay values for all of the nuclides. The other nuclides such as Sr-90 can be inferred by assumed ratios to nuclides such as Cs-137. The standard assay output of the system quantifies the total fissile gram equivalent (FGE) of the drum and automatically calculates the minimum detectable concentration (MDC). Various performance tests and WIPP QAO reports have demonstrated that the system has the capability to assay down to the 10-nCi/g detection level. A demonstration project with the IQ3 system at Savannah River Site in 1996 demonstrated MDCs of 10 nCi/g for Pu-238 and Pu-239. A similar system is routinely used for low level counting keyed off the Am-241 nuclide to detection levels on the order of 1 nCi/g. WIPP Quality Assurance Office results also support detection levels of 10 nCi/g with a 30 minute throughput time. A Total Measurement Uncertainty (TMU) analysis, which has been audited and approved by DOE/CAO and the U.S. Environmental Protection Agency (EPA), is performed on all assay results with TMUs at the 95% confidence level.

The IQ3 system is optimized to assay 55-gallon and 85-gallon drums containing low level and TRU waste quickly and accurately. The IQ3 has a conveyor and loading system for automatically or manually moving 55-gallon or 85-gallon drums into the shield assay chamber and placing them on a turntable. The drum to be assayed is loaded onto the end of the conveyor at the first sensor location. The sample drum to be counted is automatically loaded, the shield door closes, the scanner turntable begins to rotate, and the drum is weighed. Shortly after this, acquisition begins and the Sample Information page will be displayed.

A sample loading conveyor is included with the IQ3, and can handle drums up to 322 L (85 gal.) in capacity and 455 kg (1000 lbs) in weight. Once the drum is placed on the conveyor, all motions, including sample loading and unloading, is under computer control, minimizing the need for operator interaction with the system. A forklift mechanism is attached to the counting chamber door, automatically moving the drum into and out of the chamber as the door is opened and closed.

A video camera is mounted in the equipment bay on the unload side interior wall of the trailer. This video camera allows the operator to view the inside the camber during loading and unloading operations until the chamber closes. Operator views this operation from the control panel monitor. This process is limited to a one-drum process by design. The throughput is approximately 30 minutes per drum. Approximately 16 to 20 drums per day can be processed through the IQ3 at this counting rate.

Once the assay is completed, the IQ3 automatically unloads the TRU waste drum to the unload conveyor. The TRU waste drum is then removed from the unload conveyor using a forklift.

2.2.1.1 IQ3 Unit Description

The IQ3 is a self-contained, stand-alone unit that requires only electrical power and bottled liquid nitrogen to operate. The IQ3 Mobile Trailer is a 54 ft long corrugated metal semi-trailer with a double axle and a fifth wheel, capable of being hauled by a diesel tractor-trailer. The unit is 15.5 ft high, eight ft wide, and weighs approximately 60,000 lbs (excluding conveyors). The structure can be transported over highways without any special provisions.

The trailer unit is divided into two sections that consists of a control room, located at one end of the trailer, and an equipment bay that houses the IQ3 scanner. Automated conveyor systems connect with the IQ3 scanner system for loading and loading drums. Access to the exterior loading conveyors and drum-loading area is at the sides of the IQ3 trailer through side doors. Access area by forklifts are conducted a minimum of 20 ft from the loading side of the exterior conveyor. One set of stairs: is provided for personnel access to the control room located on the off street side of the trailer for personnel access. A layout of IQ3 unit is shown in Figure 2-6. For additional details on system and process descriptions for the IQ3, see WSMS-TR-02-0017 (Ref. 2-17).

2.2.1.2 Structure Classification

The IQ3 structure is classified as a Type II (000) structure per NFPA 220 (Ref. 2-3). NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*, Section 3-5 (Ref. 2-4) requires buildings used to handle and store radioactive materials to have either a fire-resistive or noncombustible construction (Type I or Type II per NFPA 220). NFPA 801, Section 3-8 requires the interior finish of these buildings to be limited combustible.

The characterization units and associated equipment were not designed or built to DOE NPH standards. The associated equipment is not seismically qualified. The IQ3 structure does not perform an emergency function and is not Safety Significant or Safety Class.

2.2.1.3 Major Unit Components

- The IQ3 Scanning System
- Transmission Sources
- Conveyor System
- Compressed Gas Cylinders
- Computer

2.2.1.3.1 The IQ3 Scanning System

The IQ3 Scanning System consists of a counting chamber with three uncollimated coaxial germanium detectors that view the drum directly across from three transmission sources for determining matrix density. Measurements of individual radioisotope activities are made with and without transmission sources being exposed to the drum. Three are positioned at right angles to the transmission source-coaxial detector axis to determine isotopic ratios of plutonium and uranium in the waste container. The relative uncertainty will be highly dependent on the drum matrix density. High-density matrices will have higher uncertainties than low-density matrices

The counting chamber is comprised of a 15-cm (6-in.) thick shield, manufactured from low background steel to minimize the impact of background radiation and improve the Minimum Detectable Activity (MDA) of the system. The basic shield shell requires no maintenance. The interior of the shield is protected with a polyvinyl chloride (PVC) liner. The liner can be washed for decontamination purposes, and can be replaced if required.

The IQ3 has an automated shield door opening and door mounted loading system for moving 55-gallon or 85-gallon drums into the shield assay chamber and placing them on a turntable. Both systems are actuated by a synchronous motor drive, yielding 43 in. of horizontal door travel at approximately 2 in./second and 13.5 in. of vertical travel for the lifting device at approximately 0.83 in./second. Mechanical limiting switches are provided on both systems that provide signals to the PLC used in the motor control. An emergency stop condition (hard-wired) is initiated upon malfunction of the door or lifting device. An internal brake is also provided on each system for positive stopping, with a brake fail-stop operation and manual brake release.

The turntable is actuated by a permanent DC gear-motor with a rotation speed of the turntable during a measurement is set at 4 rpm. The rotation speed ramps down to 1.5 rpm when rotating to home position. Rotational position is determined by inductive proximity switches that sense a steel indictor bracket, providing input signals for the PLC. A torque protection/clutch system is mounted on the motor shaft and activates in case of an obstructed turntable or when stopping a rapidly rotating heavy load.

2.2.1.3.2 Transmission Sources

In order to determine the drum density, external radioactive line sources are located opposite three coaxial germanium detectors. These sources are stored in a shield and are raised into position by the actuator (solenoid assembly) only during the density measurements. When the solenoid is de-energized the sources fall into the shielded position.

The IQ3 has three radioactive transmission sources (Ba-133) installed in a lead and steel shield (no lead is exposed). A tungsten shutter attenuates gamma rays emitted from the source when the shutter is closed. The shutter is opened by an electrical solenoid and closes by gravity, thus it fails-safe if power is lost. Potential exposure from this source is possible when the shutter is open. Therefore, access to the equipment bay shall be controlled by the operator during normal operation and when performing maintenance and repairs.

Measurements of individual radioisotope activities are made with and without transmission sources being exposed to the drum. Three additional low-energy germanium (LeGe) detectors are positioned at right angles to the transmission source-coaxial detector axis to determine isotopic ratios of plutonium and uranium in the waste container.

Sealed Sources

P.O. Number	Manufacturer	Nuclide	Source No.	Activity	Ref. Date	Leak Tested
M13024	ISOTOPE Products Lab.	Ba-133	MM-301	10 mCi	15 Jul 98	Yes
M13024	ISOTOPE Products Lab	Ba-133	M13024	10 mCi	15 Jul 98	Yes
M13024	ISOTOPE Products Lab.	Ba-133	MM-302	10 mCi	15 Jul 98	Yes
Check Sources		Co-57		0.017-0.023 ngram		
		Co-60		0.13-0.18 ngram		
		Cs-137		1.7-2.3 ngram		

2.2.1.3.3 Conveyors

External loading and unloading conveyors can be set up in one of several configurations (i.e., lengths of 10 ft or 20 ft on both sides of the unit or just 10 ft on the load side). Each conveyor section is an individual 117 inch (2972 mm) long driven live roller conveyor. Each section is driven by a ¾ HP motor through a 60:1 gear box for a conveying speed of approximately 20 ft per minute (6 meters per minute). The effective conveying width of each section is 31 in. (787.4 mm). All rollers have 4.5 inch (114.3 mm) centers. All rollers are 2.5 in. (63.5mm) in diameter and composed of 11 gauge 11/16 inch (17.5mm) spring retained hex axles The conveyor height (from the ground to the top of the rollers) is adjustable from 65 in. (1651mm) +/- 12 in. (305mm). This height is based on the nominal 41 in. (1041.4 mm) ground to trailer deck height plus the 24.75 in. (628.7mm) trailer deck to rotator height. The support leg feet are designed to allow independent adjustment for leveling on uneven surfaces. The conveyor is mounted on single ended shear beam load cell assembly. The load cells are connected to high-resolution input modules on the PLC. Weighting results are sent to the computer through the RS-422 serial communication.

A middle conveyor section is located inside on both sides of the IQ3 scanner unit to transport drums from the external conveyor systems to/from the scanning system's door mounted lifting system. The middle conveyor is driven by a synchronous brake motor that drives a 45:1 gearbox, yielding a drum travel of approximately 20 ft/min.

Centering of the drum is sensed with photoelectric sensors located along the conveyor sides. Two pairs of sensors are used to accommodate various drum sizes. Both 85-gallon overpack drums and 55-gallon drums can be accommodated automatically. Drum size information is provided to the PLC from the host PC. A maximum of four drums can be accommodated at the load and unload sides.

Lateral centering of 85-gallon drums is achieved with guide rails. If the computer indicates that the drum size is 55-gallon, centering pins are raised to provide the proper lateral positioning. The two center pins are located on the channel between the rollers and are raised by energizing two solenoids attached under the center pins. The center pins, when raised, are approximately 1/2-in. above the rollers and guide a moving 55-gallon drum to its proper lateral position on the conveyor.

An operator interface to load drums onto the load conveyor and unload drums at the unload conveyor is provided at the end of each respective conveyor. The operator interface comes complete with 15 ft of cable so that the user may locate it as preferred.

2.2.1.3.4 Compressed Gases

Liquid nitrogen bottles are stored adjacent to the IQ3 unit on the load side of the conveyors. The bottles are secured to conveyor and trailer unit. There are six 7-liter Dewars that are involved in filling the Germanium Detectors with liquid nitrogen. Detectors are filled on a regular cycle (about every 4 days). The detectors take approximately 60 minutes to fill. The filling process is monitored on the Detector Fill display board. A blue light on the display board indicates which detector is currently being filled.

The Ge detector and the LeGe detector require liquid nitrogen cooling for proper operation. Routine filling of the detector Dewar ensures continuous operation of the detector. The extremely cold temperature of liquid nitrogen can cause severe burns to the skin. When filling the detector Dewars, protective gloves and a face shield should be worn. These items are kept in the equipment bay area.

2.2.1.4 Other Components

- HVAC System
- Emergency Shutdown Devices
- Warning Lights
- Electrical and Lighting
- Communications

2.2.1.4.1 Heating, Ventilation and Air Conditioning System

The HVAC system provides comfort control in the office area the office. The equipment is wall mounted on the exterior end of the trailer. The Equipment Bay has no HVAC.

2.2.1.4.2 Emergency Shutdown Devices

There are five emergency stops located as follows:

- Two in the equipment bay area,
- Two located on the conveyors, and
- One in the control room.

2.2.1.4.3 Warning Lights

The operator monitors the control tower lights in the control room during the load/unload process and acquisition.

- The YELLOW light is illuminated when there is any motion during the load or unload process.
- The WHITE light will be illuminated during the acquisition of the data.
- The RED light is illuminated when the transmission source shutter is open.

2.2.1.4.4 Electrical and Lighting

The system requires 208 VAC, 3 phase with neutral and ground. The unit has an Uninterruptible Power System (UPS).

If auxiliary power is required from diesel generators, the generators and diesel fuel tanks are installed and separated from important structures per the requirements of NFPA 30 (Ref. 2-12), which requires a minimum separation distance of 25 ft.

2.2.1.4.5 Communication

The MCU operations require one normal phone line and one Internet line. The phone box is located on the exterior front end of the trailer.

2.2.2 Integrated Gamma and Imaging Passive/Active Neutron/Gamma Energy Analysis Mobile Waste Assay System trailer (IPAN/GEA)

A single pallet of four drums is positioned adjacent to the IPAN/GEA Trailer for processing. A forklift loads one candidate drum for NDA with drum grabber into position onto the conveyor pallet centrally onto the powered roller. Following the correct positioning on the power roller, the remainder of the process is automated. The design of the system limits drum assay to one drum at a time.

All standard assay operations are performed and controlled by the assay system software. The shield door closes, the scanner turntable begins to rotate, and the drum is weighted. Three counts are made in the assay chamber that includes an active neutron assay, passive neutron assay, and passive gamma energy analysis (GEA) assay. The IPAN/GEA trailer uses High Purity Germanium (HPGe) detectors for gamma energy detection, shielded neutron flux detectors for passive neutron detection, and neutron generators with shielded neutron flux detectors for active neutron detection. The information from these detectors is used to determine the isotopic composition of TRU Waste

During the active neutron assays, the neutron generator inside the Moderator Assembly housing is fired, typically 10,000 to 40,000 times. Each neutron generator pulse produces approximately 10^6 14 MeV neutrons. After moderation, these interrogating neutrons induce fission in any fissile material present in the assay chamber. Measurements of the interrogating flux during and after moderation can be used to provide moderator and absorber matrix corrections to the observed signal neutron measurements. A typical assay chamber moderation time is 0.5 milliseconds. In current generation Project Sampling Coordinator IPAN™ systems, all signal detectors are of the cadmium-shielded type. Typical shielded detector fast neutron slow down time is 0.015 milliseconds. The terminology "differential die-away" is often used to describe this active neutron assay, because of the two very different slow down times.

During passive assay, the same shielding detectors are used to monitor neutron emissions from contaminated waste. The waste contains two sources of neutrons. One comes from spontaneous-fissile isotopes (e.g., Pu-240) another source comes from alpha, neutron (α, n) reactions in the light elements that are in close proximity to the alpha-emitting isotopes of plutonium, americium, curium, etc. (e.g., oxide and fluoride components of these elements). The spontaneous-fissile neutron is emitted in a cluster of two or more neutrons, and the neutron emission rate is proportional to the mass of the spontaneous-fissile isotopes present in the waste. These neutrons are detected within three to four times the detector response time, which is around 25 microseconds. The (α, n) neutron are a source of background that is taken into account when calculating the mass. Because these neutrons are not clustered, the multiplicity of the events (number of neutrons emitted) is used to differentiate between the two source types. Therefore, the multiplicity rate (events with more than one neutron) is directly present in the waste; the spontaneous-fissile mass is converted to a PU-239 mass. Knowing the ratio of the various isotopes present in the waste, where not only the isotopes are known but the chemical form is also known (e.g., oxide and how the oxide is mixed with other lighter elements), it is possible to obtain a Pu-239 mass and Pu-240 mass from the total neutron rate.

During passive GEA measurements, the detector (inside a fixed vertical slit collimator) surveys a drum. The drum rotates slowly, and one revolution takes place during the total gamma acquisition time. The passive GEA gamma measurements, after quantitative analysis, provide plutonium and other isotopes compositions of the waste. Approximately 16 to 20 drums per day can be processed through the IPAN/GEA, with each drum taking approximately 30 minutes for examination.

Once the drum has completed assay, the door automatically opens and the drum is automatically moved to the outer most part of the conveyor. A forklift is used to remove the drum from the conveyor. The drum is returned to storage or is processed through the next step in the characterization process.

2.2.2.1 IPAN Unit Description

The IPAN Mobile Waste Assay System is installed on a standard 40-ft tractor-trailer chassis that has been modified to function as an assay van. The trailer is 10 ft wide by 1.5 ft in height and weighs approximately 23,000 lbs. The interior is divided into two sections that include a control room and an assay room. The control room is furnished with equipment racks that house electronic, computer, and video components that support the control console. Telephone hook-up, power monitoring, electrical circuit breaker, and feed-through panels are also housed within the control room. The assay room contains a winch operated conveyor/door assembly, the assay vault, and two control cabinets housing the system control components. Fire extinguishers, smoke detectors, and emergency lighting are installed in both sections and meet all state fire code requirements at the time of manufacture. The layout of the IPAN/GEA unit is shown in Figure 2-7.

Automated conveyor systems connect with the assay vault for loading and loading drums. Conveyor systems include exterior conveyors on either side of the trailer that connect with another conveyor system that is located inside the unit. Conveyors enter through the middle section of the unit. Access to the conveyor by forklift is maintained at a minimum of 20 ft from the loading side of the trailer. Conveyor systems are shown in Figure 2-8.

The trailer provides three external personnel access doors, two in the assay room and one in the control room. There is one door between the two rooms. The control room exterior door is provided with emergency egress hardware in the event that evacuation is required. Access to the exterior loading conveyors and drum-loading area is at the sides of the IQ3 trailer through side doors. The exterior wall (left of conveyor) access panel houses the control panel and barcode reader. The structure can be transported over highways without any special provisions.

2.2.2.2 Structure Classification

The IPAN/GEA structure is classified as a Type II (000) structure per NFPA 220 (Ref. 2-3). NFPA 801, Section 3-5 (Ref. 2-4) requires buildings used to handle and store radioactive materials to have either a fire-resistive or noncombustible construction (Type I or Type II per NFPA 220). NFPA 801, Section 3-8 requires the interior finish of these buildings to be limited combustible. The entire trailer is fitted with a drop ceiling and vinyl flooring. The walls in the control room are carpeted and those in the assay room are fiberglass panels.

The characterization units and associated equipment were not designed or built to DOE NPH standards. The associated equipment is not seismically qualified. The IPAN structure does not perform an emergency function and is not Safety Significant or Safety Class.

2.2.2.3 Major Unit Components

Typical equipment for the IPAN consists of the following:

- WM-3100 passive neutron counter with sample rotator
- Transmission Source (Add-A-Source (AAS))
- Conveyor mechanism

For additional details on system and process descriptions for the IPAN/GEA, see SWD-TRU-2001-00001 (Ref. 2-18).

2.2.2.3.1 WM-3100 passive neutron counter with sample rotator

Canberra WM-3100 passive neutron counter applies to measurements of TRU and low level items whose total plutonium content ranges from mg to kg quantities. The total plutonium mass is derived from the plutonium isotopics, which are measured on Canberra gamma-based waste assay systems using Multi-Group Analysis (MGA) code, or that are declared based on process knowledge. An Add-A-Source (AAS) correction for matrix effects and multiplicity counting in addition to standard neutron coincidence counting is also used. The WM3100 series includes a multiple-position AAS with rotor for matrix corrections, automated conveyor for high throughput applications, two doors for pass through operations, and weighing mechanism. However, the IPAN currently uses only one door for loading and unloading drums. Three He detectors are positioned on all six sides of the sample cavity to maximize efficiency and provide a uniform response.

2.2.2.3.2 Transmission Sources (Add-A-Source)

A small ^{252}Cf neutron source (~50,000 n/s upon initial installation) for AAS matrix correction is installed in the system. The source is stored in a polyethylene shield located on the top of the system. During the AAS measurement, the source is moved into the counting chamber. The system is designed with safety interlocks that ensure that the source is returned to the storage shield if the door is opened minimizing exposure to the operator. The isotope ^{252}Cf has a half-life of 2.62 years and the source is replaced every 3-4 years.

2.2.2.3.3 Conveyor

There is a single conveyor, which is attached to the trailer frame for drum loading and unloading. The conveyor is 5 ft 4 in. wide and extends 5 ft 9 in. from the trailer. The conveyor loads from the end and requires a 20-ft clearance for forklift loading. The conveyor is loaded tested for 1,000 lbs. A drum is loaded, the assay completed, and then that drum must be unloaded before the next drum can be loaded. The entire trailer is fitted with a drop ceiling and vinyl flooring. The walls in the control room are carpeted and those in the assay room are fiberglass panels.

2.2.2.4 Other Components

- HVAC
- Emergency shutdown devices
- Warning lights
- Electrical and lighting
- Communications
- Compressed gases
- Fire detection

2.2.2.4.1 Heating, Ventilation and Air Conditioning

There are two exterior 1-ton wall-mounted HVAC units on the end of the trailer (Control Room end wall), provided for personnel comfort.

2.2.2.4.2 Emergency Shutdown Devices

Emergency stops are located in the Control Room, the assay room as well as on the control panel adjacent to the external conveyor. The assay system also has installed proximity switches, photosensitive detectors, over-travel switches and interlocks.

2.2.2.4.3 Warning Lights

A stack beacon flashes red to indicate neutron generator operation is located on the assay chamber. When the beacon is green there is no neutron operation. A "Neutron On" illuminated indicator over the external conveyor door indicates that the neutron generator is in operation.

2.2.2.4.4 Electrical and Lighting

The electrical requirements for the IPAN are 480 volts, 3 phase, 100 amps. The electrical feed access door is located curbside of the trailer by the Control Room personnel stairs. Communication lines are also located in this box.

2.2.2.4.5 Communications

The mobile unit operations require one normal phone lines and one Internet line for this operation. The phone box is located on the exterior front end of the trailer.

2.2.2.4.6 Compressed Gases

The HPGe Detector Collimator/Dewar Assembly is filled through the fill tube connection. A standard liquid nitrogen cylinder (Dewar) is located and attached to the outside surface of the trailer unit in a bottle rack. The filling of the Dewar is performed by routing a hose through the personnel access door or roll-up door. Once the Dewar is filled, the hose is removed.

2.2.2.4.7 Fire Detection

The IPAN/GEA unit is equipped with several smoke detectors. These detectors can be linked to the site dispatch system. Fire extinguishers are located in the Control Room and Equipment Bay.

2.2.3 Mobile Characterization Services (MCS) Segmented Gamma Scanner (SGS)

The SGS is a gamma spectroscopy-based NDA system that is used to quantify the activity of individual radioisotopes and/or to determine the isotopic ratios for actinides such as plutonium and uranium. Analysis is conducted by rotating and elevating a drum to various positions and collecting the radioactive gamma rays emitted from the drum in SGS detectors. The detectors send a signal through electronic equipment and computer software that converts the signal to numerical information about the types and activities of various radioisotopes present in the drum.

SGS operations are manually initiated through the use of a swing jib crane that travels from the inside of the trailer bay on a trolley to the outside of the trailer wall. The crane is positioned over a single drum using a key panel controller that lowers the hoist from the jib crane trolley. A special drum grabber that is attached to the jib is used to lift the drum to the height of a turntable located inside the SGS. An operator manually positions the drum on the turntable and then releases the drum. Once inside the assay chamber, a collimated SeGe detector is used to view a drum directly across from the transmission source for determining matrix density. The SeGe detector and transmission sources are scanned vertically along the height of the drum in 4-in. segments. Measurements of individual radioisotope activities are made with and without the transmission source being exposed to the drum. A collimated LeGe detector views the entire drum and can determine the ratios of plutonium isotopes, ^{235}U/Pu, ^{241}Am/Pu, ^{237}Np/Pu, ^{239}Np/Pu and ^{243}Am/Pu in the waste container. For radioisotopes, which are not measured by the low-energy version of the Multi Group Analysis (MGA) code, the SGS will measure these radioisotopes directly.

Data is collected as 4096-channel spectra for each detector. There are also additional spectra collected for the SeGe detector, based on the angular position of the turntable. An index pulse issued once each rotation, based on the turntable "index" position, is used to start data collection in "group 1," then "group 2," etc. for eight groups per rotation. This data is used to indicate non-uniform distribution of matrix material and radioactive material. Approximately 16 to 20 drums per day can be processed through the SGS, with each drum taking approximately 30 minutes for examination.

Once the NDA is verified as complete, the operator positions the jib crane and attaches the special drum grabber to the drum. The operator removes the completed drum and returns it back onto the pallet outside the unit. This operation continues until a complete pallet of drums has been processed through the SGS.

2.2.3.1 SGS Unit Description

The SGS is a self-contained, stand-alone unit that requires only electrical power and bottled liquid nitrogen to operate. The SGS Mobile Trailer is a typical corrugated metal trailer with a double axle and a fifth wheel, capable of being hauled by a diesel tractor-trailer. The unit is 48 ft in length, 8.5 ft in width, 13.5 ft in height, and weighs approximately 28,000 lbs. The structure can be transported over the highways without any special provisions.

The SGS trailer is divided into two rooms that include a control room and equipment bay. The control room is located over the fifth wheel section of the trailer and contains the office space, utility supply and fire detection system. The Equipment Bay, which makes up the most of the trailer, houses the SGS equipment. The SGS trailer also has a drum loading station where drums of radioactive waste are lifted into place by the SGS jib crane for analysis. A view of the unit is shown in Figure 2-9. For additional details on system and process descriptions for the SGS, see WSMS-TR-01-0010 (Ref. 2-19).

Access to the loading platform on the SGS trailer is through a double door on one side of the trailer. Access area by forklift is maintained at a minimum of 20 ft from the access door. There is one set of stairs for personnel to access the office space above the fifth wheel. All remaining access areas will require a minimum of 3 ft 6 in.

2.2.3.2 Structural Classification

The SGS structure is classified as a Type II (000) structure per NFPA 220 (Ref. 2-3). NFPA 801, Section 3-5 (Ref. 2-4) requires that buildings used to handle and store radioactive materials have either a fire-resistive or noncombustible construction (Type I or Type II per NFPA 220). NFPA 801, Section 3-8 requires the interior finish of these buildings to be limited combustible.

The exterior walls of the trailer in the equipment bay are type semi-trailer aluminum walls with carbon steel frame bracing. Between each brace is plywood . There is no insulation in this trailer unit. Three doors lead from the Equipment Bay out of the trailer. A 36 in. wide door leads from the Control Room into the Equipment Bay. This door is used for personnel access and remains closed during operations. The end of the semi-trailer has two trailer doors that open outward. These doors are used for equipment placement. The Equipment has a side door used for drum loading and unloading. This door remains open during assay operations. The Control Room has vinyl floor covering and panel walls.

The characterization units and associated equipment were not designed and built to DOE NPH standards. The associated equipment is not seismically qualified. The SGS structure does not perform an emergency function and is not Safety Significant or Safety Class.

2.2.3.3 Major Unit Components

The SGS unit is comprised of the following major system components:

- Canberra Segmented Gamma Scanning System
- Radioactive transmission sources
- Computer and software

- Loading station
- Conveyor system

2.2.3.3.1 Canberra Segmented Gamma Scanning System

The SGS System installed in the trailer is comprised of several subassemblies (for a detailed description of each of the subassemblies, refer to the SGS Hardware reference Manual (Ref. 2-20).

The SGS Detector Vertical Drive mechanism consists of the following sub-assemblies:

1. Detector Vertical Drive Assembly -- The vertical drive assembly provides a means to accurately position the transmission source shutter / collimator assembly vertically during the gamma counting.
2. Horizontal Platform Assembly -- The horizontal detector platform assembly provides a means to accurately position the detector assembly horizontally to reduce the distance between the detector and the container to increase the detector sensitivity.
3. Transmission Source Shutter/Collimator Assembly -- The collimator assembly is made up of a lead collimator (shield) assembly and a shutter assembly. The lead collimator (shield) is used to hold and position the transmission source plus provides lead shielding for personnel protection. The shutter assembly is used to open and close the beam path for the transmission source. The PLC is programmed so that whenever the shutter is open (either electrically or manually) the red "Shutter Open" light on the control cabinet LiteStak is lit.
4. Detector -- The detector is used to perform the gamma measurements of the system.

2.2.3.3.2 Radioactive Transmission Source

The SGS has one radioactive transmission source installed in lead shielding; there is no exposed lead. A tungsten shutter attenuates gamma rays emitted from the source when the shutter is closed. The shutter is opened by an electrical solenoid and closes by gravity so it is fail-safe if power is lost. Potential exposure from this source is possible when the shutter is open. Access to the equipment bay is be controlled during normal operation and when performing maintenance and repairs.

Sealed Source Information:

Radionuclide:	EU-152
Activity:	0 mCi
Serial:	H-534
Reference Data:	7/1/1996

2.2.3.3.3 Loading Station

The SGS jib crane is located in the Equipment Bay of the semi-trailer unit. The crane has a load rating of 1,000 lbs (Jib Crane: Gorbel # FS-300-12-7, 103 in. high, 6 ft span).

2.2.3.3.4 Computer and Software

The heart of the mechanism electrical control is the GE/FANUC Series 90/30 model 331 Programmable Logic Controller. The PLC program is set up as individual routines to perform specific tasks (i.e. shutter open, shutter close, rotate on, rotate off, etc.). The PLC routines are commanded to run by a separate personal computer (PC).

The PC serves as the primary controller of the system. The PC either directly or indirectly controls all subsystems.

2.2.3.3.5 Conveyor System

The rotator conveyor assembly has two purposes; first to provide a means to transport the containers onto and off of the rotator and second to rotate the container during the gamma counting. A drum weighing system has also been incorporated into the design.

The conveyor rollers used to drive the pallet (container) are self-contained motorized AC powered rollers. A total of 6 drive rollers are used. There are also two idler rollers (non-driven). The drive rollers rotate for a container speed of 10 ft per minute (3 meters per minute).

The rotator assembly is designed for a maximum weight of 2000 lbs. (909.1 kg.) The rotator assembly is driven by a Bodine permanent magnet DC gear motor with a Sprint Electric variable DC motor controller. Through the PLC program, rotational speeds of 0-12 rpm in 1 rpm increments are provided. The rotator was designed with an index proximity switch used by the PLC program to check and adjust the speed of the rotator.

The rotator platter is a high-density polyethylene platter designed for a maximum 24.69 in. (627.1 mm) drum rim. There is one inductive proximity switch attached to the assembly. Its function is as follows: 1. Rotator Index Proximity Switch (S21)—When enabled, informs the PLC that the rotator platter is at the index position.

The basis of the drum weighing system is the four Sensotec AL111-CV tension/compression load cells, which are rated at 2,000 lbs. The four cells are mounted under each corner of the rotator top baseplate. The maximum live load for a 55-gallon drum is less than 1,000 lbs.

2.2.3.4 Other Major Components

- HVAC
- Emergency shutdown devices
- Warning lights
- Electrical and lighting system
- Communication
- Compressed gases
- Fire detection

2.2.3.4.1 Heating, Ventilation and Air Conditioning

The SGS control Room has a single wall-mounted commercial HVAC system. This system is provided for comfort control of the control room and has no ductwork. The Equipment Bay is not equipped with a ventilation system.

2.2.3.4.2 Emergency Shutdown Devices

Emergency stop switches have been designed into the system at several points throughout the system to shutoff the mechanism power to prevent personnel injury and mechanical damage. The emergency stop circuitry operates the coil of the main input power contactor. In order for the power to be applied to the system, all of the emergency stop push-pull switches must be pulled out. The power is initially applied by turning on the over/ride keylock switch on the front door of the cabinet.

If an electrical problem occurs the operator can turn off the power switch mounted on the door of the electrical cabinet.

2.2.3.4.3 Electrical

The main input power required for the mechanism electrical control cabinet is 208 VAC, 60 Hertz, 3 phase with neutral and ground at a maximum of 30 amps.

2.2.3.4.4 Communications

The SGS requires two telephone lines: one for data transfer and the other for voice communication.

2.2.3.4.5 Compressed Gas Cylinders

The SeGe detector and the LeGe detector require liquid nitrogen cooling for proper operation. Routine filling of the detector Dewar ensures continuous operation of the detector.

The SGS requires one 160-liter cylinder @22 psi bottle of liquid nitrogen. The cylinder is located outside of the trailer and is used to fill the Dewar. The cylinder requires replacement approximately every 2 weeks. The Dewar capacity is approximately 4 liters and will be filled approximately 40 times over the 2-week period (four times a day).

2.2.34.6 Fire Detection

There are Smoke Detectors installed in the Control Room and Equipment Bay. These detectors can be wired into the site dispatch system. Fire extinguishers are located in the Control Room and Equipment Bay.

2.2.4 High-Efficiency Passive Neutron Counter (HENC)

The purpose of the NDA performed in the HENC unit is to identify the type and amount of fissionable material in the TRU waste drums. The HENC is a self-contained non-intrusive assay unit.

HENC operations begin with the loading of a TRU waste drum onto the conveyor. Only one TRU waste drum at a time is placed on the conveyor. Operations within the assay chamber are normally controlled using a PLC. The assay chamber doors open, the drawbridge lowers into position, and the conveyor moves the drum into the assay chamber and onto the turntable. The drawbridge raises and the doors close. The operator enters pertinent information on the drum into the computer system, and initiates the assay process.

A passive neutron count is performed followed by the AAS measurement. Multiple detectors located within the assay chamber are used to count the number of neutrons from the drum. The neutrons are captured by the detectors and are converted through electronics into data that provide the activities of the radionuclides. The assay chamber is a passive and nonintrusive system, which does not generate any radiological conditions unless the AAS is in the cavity. After counting, the drum is moved out of the assay chamber using the conveyor. The HENC includes an SGS for gamma spectroscopy that is used to quantify the activity of individual radioisotopes and/or to determine the isotopic ratios for actinides such as plutonium and uranium. Approximately 16 to 20 drums per day can be processed through the HENC, with each drum taking approximately 30 minutes for examination.

Upon completion of the assay, the door opens and the drawbridge lowers. The drum exits the assay chamber on the conveyor and is removed by forklift from the HENC unit.

2.2.4.1 HENC Unit Description

The HENC structure is a single prefabricated insulated stand-alone structure that is 40 ft in length, 11.5 ft in width, and 8 ft in height. The unit weighs approximately 37,000 lbs.

The HENC is divided into two separate rooms: the Control Room and the Equipment Operating Room. An access door is provided between the two rooms. There are three personnel doors that provide egress in and out of the containment structure (open outward): one from the Control Room and two from the Equipment Operating Room. A bi-fold and single door are provided at one end of the structure for equipment loading. The height to all door thresholds is approximately 10 in. from ground level. Figure 2-10 shows the layout of the HENC unit.

A single roll-up door is provided to allow for the assay chamber conveyor to penetrate the side of the structure for drum loading and unloading. A second framed opening for a door has been constructed in the opposite wall of the trailer, but it is covered with steel. The height of the load/unload conveyor is less than 3 ft above ground level once installed. When in operation, the roll-up door is open, but weather screening is provided around the opening. This structure can be transported over the highways without any special provisions.

2.2.4.2 Structural Classification

The HENC structure is classified as a Type II (000) structure per NFPA 220 (Ref. 2-3). NFPA 801 Section 3-5 (Ref. 2-4) requires buildings used to handle and store radioactive materials to have either a fire-resistive or noncombustible construction (Type I or Type II per NFPA 220). NFPA 801, Section 3-8 requires the interior finish of these buildings to be limited combustible.

The HENC structure meets these requirements. The exterior walls are constructed of carbon steel over steel studs. The interior walls/ceiling are insulated with Miro-Aire “duct board” insulation panels, which are fiberglass batting with an aluminum foil on the side that faces the room. The insulated wall/ceiling/equipment doors are UL Fire Hazard Classification fire rated with a flame spread rate of less than 25 and smoke development rate less than 50.

The Equipment Operating Room and Control Room walls are covered with Marlite fiberglass reinforced plastic panels, which extend 4 ft up from the floor. The Marlite fiberglass panel has a C/III fire rating, meeting the American Society for Testing and Materials (ASTM) E-84, *Standard Test Method for Surface Burning Characterization of Building Materials* (Ref. 2-21). It has a spread index of 25 or less and a smoke development index of 450 or less. The wall dividing the Equipment Operating Room and Control Room is made of carbon steel studs covered on both sides by carbon steel panels. This wall is insulated with Dow Chemical “Grayboard” brand insulation (Tongue & Groove) with a UL Fire Hazard Classification fire rate at a flame spread rate of less than 5 and smoke development rate of less than 165 (ASTM E-84, Ref. 2-21).

The sub-floor of the unit is wood (i.e., standard floor for a connex container). The floor is covered with aluminum diamond plating in all areas.

The characterization units and associated equipment were not designed and built to DOE NPH standards. The associated equipment is not seismically qualified. The HENC structure does not perform an emergency function and is not Safety Significant or Safety Class.

2.2.4.3 Major Unit Components

The HENC unit is composed of the following major system components:

- Canberra HENC system
- Conveyor system (load/unload conveyor and drawbridge)

For additional details on system and process descriptions for the HENC, see WSMS-TR-02-0030 (Ref. 2-22).

2.2.4.3.1 Canberra HENC System

The HENC assay chamber was developed under a Cooperative Research and Development Agreement between the Los Alamos National Laboratory and Canberra Industries. The primary goal of the development was to produce a passive assay system for 55-gallon drums that has detectability limits and multiplicity counting features that are superior to previous systems. A detectability limit figure of merit was defined that included the detector efficiency, the neutron die-away time, and the detector's active volume and density that determine the cosmic-ray background. Monte Carlo neutron calculations were performed to determine the parameters to provide an optimum figure of merit. The system includes the ^{252}Cf AAS feature to improve the accuracy as well as statistical filters to reduce the cosmic-ray spallation neutron background. The final design gave an efficiency of 32% for plutonium with a detector, ^{3}He tube volume that is significantly smaller than for previous high-efficiency systems for 55-gallon drums. Because of the high efficiency of the HENC, a neutron multiplicity counting is incorporated for matrix corrections for those cases where plutonium is localized in non-uniform hydrogenous materials.

The Canberra HENC assay chamber with the AAS option is an automatic pass-through passive neutron counting system used to provide an accurate, precise and sensitive assay of TRU activity in contaminated solid waste. The counter itself is a large rectangular-shaped neutron counter that is specifically designed to assay 55-gallon drums. The system primarily consists of a turntable, 4π counting shield, AAS mechanism, and control system.

The AAS mechanism consists of a low-level ^{252}Cf source [the source strength is 11.5 to 22 μCi (50,000 to 100,000 n/s)] and storage module, compu-motor drive mechanism, stainless steel tube, and Teleflex cable. The ^{252}Cf AAS is used to monitor performance and to correct assays for moderation in waste.

The HENC unit includes an SGS for gamma spectroscopy that is used to quantify the activity of individual radioisotopes and/or to determine the isotopic ratios for actinides such as plutonium and uranium. The transmission source is a 5 mCi ^{133}Ba source. The source is a sealed source in accordance with ANSI N43.3 (Ref. 2-11), and as such is exempt from the radiological inventory for the segment. The collimated high purity germanium detector views the drum directly across from the transmission source for determining the matrix density. The detector and transmission sources are scanned vertically along the height of the drum in 4-in. segments. Measurements of individual radioisotope activities are made with and without the transmission source. Drums are moved into the SGS through the equipment doors at the end of the unit.

2.2.4.3.2 Conveyor System

The 2-meter, chain-driven live roller conveyor is driven by an electric motor, which produces a conveyor speed of approximately 20 ft per minute. The maximum individual drum capacity for the conveyor is 1000 lbs.

The drawbridge is a motorized conveyor that is used to transfer the drum from the two-meter conveyor into the HENC assay chamber and onto the turntable. After the HENC side door opens or before the door closes, a short segment of conveyor (i.e., drawbridge) is raised or lowered by an electric motor. When lowered to its loading position, the drawbridge mates with the rotator to facilitate drum loading and unloading. Two proximity switches sense whether the conveyor is in its raised (OK to close door) or lowered (OK to load/unload barrel) position. Two polarized retro–reflective photoeyes within the assay chamber sense when a drum is loaded. The conveyor is provided with an automatic drum-weighing system on the drawbridge

2.2.4.4 Other Unit Components

An automatic FM2000 clean agent fire suppression system is installed in the HENC unit. An Underwriters Laboratory (UL) and Factory Mutual (FM) listed fire suppression panel is used to control the fire suppression system. Pull stations that activate the system are located outside of each door. Two smoke detectors, provided within the HENC unit, can also activate the system. On detection of smoke by a detector, an alarm is sounded and a 60-second countdown is started after which the fire suppression agent is released into the HENC unit. There are two heads in the Equipment Operating Room and one in the Control Room. The gas cylinder is located in the Equipment Operating Room next to the control panel.

Other unit components associated with the HENC unit include the following:

- Primary power requirements are 120/208 VAC, 3 phase, 100 amp
- Status lights and manual controls
- Key-actuated control
- Emergency stop switches
- Visible warning signals and audible alarms that sound for 5 seconds prior to each mechanism movement
- Electrical components and installation meet NFPA 70, *National Electrical Code* (Ref. 2-23)
- Over-travel switches/overrides/proximity switches/safety interlocks
- Portable fire extinguishers
- Communication (telephone communication with site)
- Liquid nitrogen (Dewar) (A standard liquid nitrogen cylinder is located and attached to the outside surface of the trailer unit in a bottle rack. The filling of the Dewar is performed by routing a hose through the personnel access door or roll-up door. Once the Dewar is filled, the hose is removed).

2.3 Head Space Gas Sampling (HSGS)

The HSGS activities involve sampling and analyzing the headspace gas of vented TRU waste drums destined for WIPP. The drum headspace gas is analyzed for hydrogen/methane and VOCs. This activity is only performed on vented TRU waste drums that are in compliance with the container equilibrium requirements as documented in the WIPP Hazardous Waste Facility Permit (Ref. 2-24).

HGSG involves the collection of head space gas samples using standard gas sampling methods that meet the general guidelines established by the EPA (Compendium Method TO-14, Ref. 2-25) or by using on-line integrated sampling/analysis. Samples will be directed to an analytical instrument instead of being collected in SUMMA or equivalent canisters if a single sample on-line integrated sampling/analysis is used..

The analytical methods are equivalent in performance to those specified by DOE-CAO for the TRU waste container headspace gas characterization as follows:

- Modified Method TO-14 for the Gas Chromatography/Mass Spectrometry Determination of Volatile Organic Compounds in Waste Container Headspace;
- ASTM Method 1946-82, "Standard Method for Analysis of Reformed Gas by Gas Chromatography" (Ref. 2-26);
- EPA-SW-846, method 8260B, "Volatile Organic Compounds by GC/MS" (Ref. 2-27).

HGSG is performed in four different MCUs that include (1) HSGS-IIA, (2) HSGS-IIB, (3) Drum Venting System #1 – Headspace Gas Sampling System (DVS-1); and (4) Drum Venting System #2 – Headspace Gas Sampling System (DVS-2). The analytical equipment used to support HSGS-IIA and HSGS-IIB is identical, and so these systems are both presented below in Section 2.3.1. The DVS-2 analytical equipment and physical design is identical to the DVS-1 system with the exception of the layout of the Air Filtration Train (i.e., upright verses horizontal). Therefore, these systems are presented together in Section 2.3.2.

2.3.1 HSGS IIA and IIB Units

The Headspace Gas Sampling System Number IIA (HSGS-IIA) unit is a portable, self-contained laboratory constructed of a refurbished refrigerated shipping container that contains the HSGS-IIA and related support equipment. The HSGS-IIB unit uses the same analytical techniques and equipment as HSGS-IIA, but the HSGS-IIB system is configured and placed in a large steel box on wheels (industrial tool box). The HSGS-IIB equipment may be placed in any site facility where adequate space is provided and the unit may be supported by a mobile HEPA system or an exhaust system that ties directly into an approved site HEPA site system.

The HSGS process for both units begins with site operator movement of drums by dolly or forklift from a - facility or container structure in which drums are maintained at a minimum temperature of 65°F for at least 72 hours prior to headspace gas sampling and analysis. Drums that have met the drum conditioning criteria are then processed through the HSGS-IIA and IIB units. Only one drum at a time is normally moved from the climate-controlled area.

An operator receives the 55-gallon drum and transfer of custody of the drum takes place between the site and CCP. The 55-gallon drum is moved in the structure and to the designated drum staging area where the drum filter vent is modified, as necessary, to allow headspace gas sampling. One or more drums may be stored at a time awaiting headspace gas sampling (environmental temperature of the interior of the HSGS-IIA unit or the structure housing HSGS-IIB equipment is maintained between 72ºF and 84ºF during processing). A ramp or platform is provided on the HSGS-IIA to allow the drums to be rolled into the structure from outside of the unit on a drum dolly.

A HEPA filter exhaust hood system is activated and used over the drum being sampled. The protective filter cap is removed first. A septum is placed over the modified filter, and the portable fume hood is placed over the drum. The sample needle probe is inserted through the modified filter to collect the headspace gas. The sample is taken and the probe removed. The septum is removed and a piece of vinyl tape is placed over the drum filter, and the drum is staged for filter replacement. Up to 20 drums are sampled per day.

After the sampling is completed the Radiological Control Technician (RCT) swipes the hood and determines that there is no contamination. If contamination is detected it is evaluated by the RCT and decontaminated. Once the sampling has been completed the drum is processed to the filter change-out area.

The filter is changed out in the filter change-out hood. Change out is a simple process of unscrewing the old filter from the threaded or tapped drum head and screwing in a new filter. The old filter vent is treated as contaminated waste. The drum gasket surface is cleaned on the waste drum, and the new filter vent is installed. Once the vent filter is changed out the drum is inspected by the RCT (several completed drums may be placed in a hold area waiting RCT inspection). Once the RCT has completed the drum inspection and has released the drum, the drum is removed.

2.3.1.1 HSGS-IIA Unit Description

The HSGS-IIA unit is configured into two individual segments, which are bolted together and sealed at the site location. Once the units are bolted and sealed, they form a thermally controlled enclosure. The physical parameters of the HSGS-IIA unit are 24 ft in length, 16 ft in width, and 8 ft in height, and the unit weighs 21,000 lbs. Further information regarding the HSGS-IIA is provided in the System Description Document (Ref. 2-28).

The HSGS equipment is located at one end of the structure. The HSGS system consists of three basic components: 1) Gas Bottle Rack and Gases 2) the HSGS-IIA, and 3) the PC Work Station. Figure 2-11 shows the layout of the HSGS-IIA unit. There are two doors that open in the outward direction. Doors are equipped with standard panic hardware on the inside of the door and a standard key lock on the outside of the door. The key lock does not affect the operation of the panic bar. A ramp or platform is provided to allow the drums to be rolled into the structure from outside the unit on a drum dolly. A third door (equipment door) is positioned in the end of one section of the structure for equipment loading during the setup phase. Once the equipment has been placed in the structure, the double doors are locked and sealed. The automated manifold system equipment is located at one end of the structure.

The interior walls of the structure are made of stainless steel; the ceiling is aluminum. Interior surfaces are smooth, with a minimum number of joints, and all joints are sealed closed after assembly. The interior surface is not painted, with the exception of the ceiling and the interior surfaces of the egress doors. The doors are coated with enamel.

The floor is carbon steel plate, which is welded and ground flush (floor surface is not painted). The floor is designed to support the HSGS-IIA system and up to twenty 1000-lb drums at a time.

2.3.1.2 Structure Classification

The HSGS-IIA unit structure is classified as a Type II (000) structure per NFPA 220)Ref. 2-3). NFPA 801, Section 3-5 (Ref. 2-4) requires that buildings used to handle and store radioactive materials have either a fire-resistive or noncombustible construction (Type I or Type II per NFPA 220). The HSGS-IIA structure meets these requirements.

NFPA 801, Section 3-8 (Ref. 2-4) requires the interior finish of these buildings to be limited combustible. The wall/ceiling/floor are insulated with polyurethane foam, which is encapsulated between the exterior steel wall and the interior steel wall. The insulated wall/ceiling are fire resistant with a flame-spread rate of 25 and smoke development rate of 130-185 (insulation is not exposed). The insulation is sealed between the metal walls and ceiling (metal jacketed with no exposed insulation at the joints).

The characterization units and associated equipment were not designed and built to DOE NPH standards. The associated equipment is not seismically qualified. The HSGS-IIA structure does not perform an emergency function and is not Safety Significant or Safety Class.

2.3.1.3 Major Unit Components

The HSGS-IIA unit consists of two major components:

- HSGS system
- HEPA filter system

2.3.1.3.1 Headspace Gas Sampling System

The HSGS system used in the HSGS-IIA and HSGS-IIB units is an automated manifold system with a gas chromatography/mass spectrometry (GC/MS) and GC/thermal conductivity detector. A batch of up to 20 drums can be sampled and analyzed. The headspace gas of drums is sampled by inserting a needle through a drum filter vent using a sample probe incorporated in the HSGS instrument. Headspace gas sampling is conducted under the portable fume hood. A disposable filter (<0.7 microns) is used to prevent migration of particulates into the gas-handling manifold. A septum is placed over the carbon composite to prevent intrusion of ambient air into the drum during sampling and to mitigate potential radioactive contamination during sample needle insertion or removal. Filter replacement is required after the completion of headspace gas sampling.

If Nuclear Filter Technology Sample Ports (Nucfil-050-SH) are installed in the drum lids, the sample is taken from through sample port. The design of the Sample Port allows the taking of the sample without the need for filter replacement. A pneumatic driver activated by remote radio transmitter is used to install the Sample Ports. Normally the drum will be prepared in another location and delivered to the HSGS-IIA Laboratory for sampling with the Sample Port installed.

2.3.1.3.2 HEPA Filtration System (HSGS-IIA Only)

The operations of sampling through the filter vent and changing the filter vent have a very low probability of creating contamination. This is due to the fact that there is little chance of loose particles of contaminated materials existing inside the drum due to the way waste is multiply contained. All waste packages are doubly contained, and then the waste packages are contained within a sealed drum bag. A ventilation and filtration system is provided to direct any hazardous drum emissions away from the operator during sampling and filter replacement. Two hoods are provided, one for sampling and the other for filter changes. Both the filter change–out hood and the sample hood are coupled directly into the HEPA-filtered ventilation system, which must be operating prior to using either hood. A typical flow through each hood ranges from 300 to 600 cfm. The hoods are open to the atmosphere inside the laboratory and draw air from the laboratory through flexible ductwork to a HEPA filter unit outside the HSGS-IIA unit. The HEPA filter unit is provided to mitigate the release of radioactive particulates that may be vented from the drum during sampling or filter change. The HEPA filter unit is supplied with a tested nuclear grade HEPA filter. A 1000-cfm blower is provided as part of the HEPA filter unit. The blower is equipped with a damper to permit adjustment of air velocity, and hence the pressure differential to the hoods.

2.3.1.4 Other Unit Components

- HVAC system
- Oxygen monitor
- Fire protection system
- Compressed air system
- Continuous Air Monitor (CAM)
- Bottle gas cylinders and gas bottle racks
- Emergency shutdown devices
- Electrical and lighting system
- Communication
- Warning lights

2.3.1.4.1 (HVAC System

The HSGS-IIA unit is provided with an independent HVAC system for climate control. The unit is wall-mounted on the outside end of the laboratory.

2.3.1.4.2 Oxygen Monitor

An oxygen monitor is provided to ensure that oxygen levels are safe for personnel. The monitor is self-calibrating with battery backup power.

2.3.1.4.3 Fire Protection System

An automatic FM2000 clean agent fire suppression system is installed in the unit. A UL and FM listed fire suppression panel is used to control the fire suppression system. Pull stations are located outside of each door, which can activate the system. The system can also be activated by smoke detectors inside the unit. Two smoke detectors are provided within the HSGS-IIA structure. On detection of smoke by one detector an alarm is sounded. When both detectors sense smoke a 60-second count down is started, after which the fire suppression agent is released into the HSGS-IIA structure. The HSGS-IIA fire detection system can be tied to the site fire dispatch system.

2.3.1.4.4 Compressed Air System

The unit is equipped with a portable compressed air system that supplies clean, dry, oil-free compressed air at a 90 psi to the HSGS-IIA by a compressor attached to the outside of the laboratory. An air dryer is also supplied. The compressed air is used for purging the sample lines prior to and after collection of a sample.

2.3.1.4.5 Continuous Air Monitor

A CAM is used during sampling operations. The unit has both audible and visual alarms built–in. Lights are provided at each door to indicate a CAM alarm condition.

2.3.1.4.6 Bottle Gas Cylinders and Gas Bottle Racks

The equipment has a small (1 to 2 liter) Dewar that is filled with liquid nitrogen, as required to support operations. The liquid nitrogen is stored in a bottle rack and connected to the HSGS structure. The liquid nitrogen lines penetrate the HSGS-IIA exterior wall and lead to the Dewar.

Compressed gases, including hydrogen, methane, nitrogen, and helium, are stored in racks inside and adjacent to the HSGS-IIA and HSGS-IIB units. A storage rack is also attached to the exterior of the HSGS-IIA unit to store extra bottle gases (replacement bottles). Gases located inside the unit are placed so as not to come in contact with electrical circuits or with electrically energized systems. The unit is grounded and follows the requirements of NFPA 45, *Standard on Fire Protection for Laboratory Using Chemicals*, and NFPA 55, *Standard for the Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders*, for the handling and use of compressed gases (Ref. 2-29 and 2-30).

2.3.1.4.7 Emergency Shutdown Devices

There are three emergency shutoffs:

- One in the control for the HEPA.
- Electrical breaker panel main shutoff.
- Main electrical panel .

2.3.1.4.8 Electrical and Lighting System

The service panel is mounted inside of the structure. A service disconnect is provided on the outside wall of the structure. The disconnect is a 3-phase 120/208 volt and is fused for 125 amp per phase. The service panel is 220 VAC single phase, sized as following:

All electrical equipment meets NFPA 70 (NEC) (Ref. 2-31) minimum standards (e.g., enclosures power interlocks, 3-prong plugs, breakers, fuses, ground-fault circuit interrupt. A UPS, located inside the structure, supplies power to the HSGS-IIA and computer systems should there be a power outage.

2.3.1.4.9 Communications

The operations of the HSGS-IIA requires one normal telephone line and one data transfer line (minimum of 56K or a T1 Line) to be available at the host site. Hardware terminals for the installation of these lines are provided on the outside wall of the structure

2.3.1.4.10 Warning Lights

The unit has both audible and visual alarms built in. The CAM provides terminals for remote alarm indication. Lights installed at each door to indicate a CAM alarm condition. The oxygen monitor has an audible alarm and visual alarm.

2.3.2 Drum Venting System #1 and #2 Units (DVS-1 and DVS-2)

The DVS-1 and DVS-2 systems (collectively referred to as DVS) are intrusive processes that sample and analyze the headspace gas in a TRU waste drum. Since the DVS has the potential to introduce a spark and a spark source into the TRU waste drum, the process is performed remotely inside a cabinet designed to contain any hydrogen/air deflagration. The DVS automatically collects a representative sample of drum headspace gas through a piping manifold connected to a Gas Chromatograph (GC) with a Flame Ionization Detector (FID), Thermal Conductivity Detector (TCD) and Mass Spectrometer (MS). Further information regarding the DVS-1 is provided in the System Description Document (Reference 2-32).

The DVS system equipment has the capability to perform the multiple functions of drum venting, headspace gas analysis, purging, and installation of HEPA grade filter vents on TRU waste 55-gallon drums. The DVS has two GC/MS units; each processes every other drum loaded into the system to optimize the system's throughput.

The system automatically penetrates the drum using a specially designed, self-drilling, self-tapping hollow core filter vent. The filter or plug is installed into a socket inside the glovebox power head prior to drum processing. A proprietary PLC program commands and controls the process that penetrates the lid, collects a representative headspace gas sample for GC/MS analysis, and then installs and seals the filter vent onto the drum lid. The analytical process is controlled by commercially available Varian GC/MS software.

The analytical methods are equivalent in performance to those specified by DOE-CAO for the TRU waste container headspace gas characterization as follows:

- Modified Method TO-14 for the Gas Chromatography/Mass Spectrometry Determination of Volatile Organic Compounds in Waste Container Headspace;
- ASTM Method 1946-82, Standard Method for Analysis of Reformed Gas by Gas Chromatography (Ref. 2-26);
- EPA-SW-846, method 8260B, Volatile Organic Compounds by GC/MS (Ref. 2-27).

On-line sampling and analysis considerations such as on-line control sampling and on-line Quality Assurance/Quality Control requirements are equivalent to EPA-SW-846 approved draft method 8450 "Determination of Volatile Organic Compounds and Methane in Headspace Gas by Fourier Transform Infrared Spectroscopy." Equivalent performance has been demonstrated through documented system and instrument tests, as well as successful participation in Headspace Gas Performance Demonstration Program analysis of blind samples.

This process is used for the analysis of VOCs listed in Table 1-1 of CCP-TP-029 (Ref. 2-33), in the range from less than QAPjP-specified Method Detection Limits (MDLs) to levels of approximately 500 to 1200 ppmv, that have been collected from waste container headspace using the automated DVS. This DVS uses a fixed sample loop and a split injector to meet minimum VOC concentrations specified in the QAPjP, while extending the upper limit of linear calibration. The process is based upon the introduction of VOCs onto a capillary column using a fixed volume injection loop. An MS is used to identify all of the VOCs listed in Table 1 of CCP-TP-029 (Ref. 2-33).

The DVS also analyzes hydrogen and methane in the range from less than the MDL specified in Table 2 of CCP-TP-029 (Ref. 2-33), to vol% concentrations.

Approximately 16 to 20 drums per day can be processed through the DVS, with each drum taking approximately 30 minutes for examination.

2.3.3.1 DVS-1 & 2 Unit Description

The DVS, as depicted in Figures 2-12 through 2-14 is a stand-alone, self-contained skid-mounted system, requiring only external electrical power. The DVS is capable of properly installing an approved filter vent in a previously filled drum of TRU waste. In this process, a sample of headspace gas is collected and analyzed. In the event of a flammable headspace gas mixture being detected, the system can purge the gases present.

The DVS equipment is skid-mounted and is all together approximately 20 ft in length, 20 ft wide, and 10 ft high and weighs approximately 14,000 lbs.

2.3.3.2 Major Unit Components

The DVS-1 & 2 is comprised of several components and subassemblies:

- Gas Analysis system
- Power head subassembly
- Glovebox
- Drum cabinet
- HEPA air filtration system:
  - Remote controller assembly
  - Drum filter assembly
- Analytical System (GC/FID/TCD/MS system)
- Filter vent plug

2.3.3.2.1 Gas Analysis System

The HSGS system utilizes a Varian Model 3400 CX gas chromatograph (GC) tuned and calibrated to quantify hydrogen, methane, and a selection of VOCs. The dual column system uses a FID to detect the VOCs, and a TCD to detect hydrogen and methane. The system collects a real-time sample of drum headspace gas, and within approximately 5 minutes, prints out the gas concentration results (Figure 2-14 shows a schematic of the gas sample manifold). A PC software package fully automates the analysis and quantification of the HSGS results. The system alarm activates if any gas concentration exceeds the preset levels.

2.3.3.2.2 Power Head Subassembly

The electrically powered power head subassembly is the key mechanical subassembly within the DVS-1. It contains a structural frame that supports and stabilizes a linear drive and nut runner. Inside the glovebox, above the housing that creates a sealed chamber on the drum lid surface, is the linear drive actuator. This mechanism actuates the power head assembly and socket that holds the filter vent. The liner drive actuator provides precise vertical translation of the power head assembly. Attached to the power head assembly is the Roto tool nut runner. The nut runner and linear drive actuator are both controlled by the system ladder logic program that invokes the proper motion sequence at the correct time.

A stepper motor-driven, screw type linear drive controls the vertical movements of the power head assembly. The DVS employs a linear drive controller, which precisely controls the movements of the power head assembly. The DC-motor driven nutrunner is mounted to the power head frame and provides the rotary motion to a socket attachment that holds the head of the filter assembly during the piecing and insertion operations. This nutrunner is a variable-speed unit capable of operating at higher speeds when piercing the lid and slower speeds when installing the filter. The nutrunner functions as the torque source, which enables the filter threads to cut into the drum lid such that the filter seats securely in the drum lid. The nutrunner controller is a microprocessor-based, programmable, rotary motion controller. Metal drum lid cuttings are generated during the boring process and form a small conical pile around the filter vent shaft on the top of the drum lid. To remove these metal chips from the filter gasket to drum lid surface, a small puff of air is directed at the chips to blow them out of the way. This is done by opening valve 1, directing the oil-less air compressor supply, regulated at 10 psi, to the chip pile for 5 seconds.

2.3.3.2.3 Glovebox

The Glovebox is mounted atop the Drum Containment Cabinet. The glovebox that contains the power head assembly was designed and fabricated in accordance with American Glovebox Society Guidelines AGS G001-1994 (Ref. 2-34). An inlet filter housing contains one 8 x 8-in. gasket sealed HEPA filter element. The Glovebox contains standard ambient air, drawn directly from the room atmosphere, filtered using a HEPA filter on the inlet, and filtered using two HEPA grade filters in series prior to discharging to the work area. A small airlock (approximately 10 x 10 x10 in.) is provided to permit entry of drum filter and other small components, as needed.

All electrical components within the DVS-1 glovebox comply with NEC standards in that they are intrinsically safe (non-sparking), or of a “purge” design, which prevents ignitable gases from entering their interior spaces where electrical discharges may be present. For example, the linear drive motor has a constant flow of air to prohibit any contact with ignitable gases, which could possibly be present in the glovebox. The nutrunner, on the other hand, is non-sparking in design.

2.3.3.2.4 Drum Cabinet

The drum cabinet is a rectangular heavy steel box designed to enclose a 55-gallon waste drum, or an 83-gallon overpack drum, and sufficient size as to dissipate the pressure from a worst case headspace gas ignition (drum overpressurization to 136 psig) to < 15 psig. The glovebox is attached to the top of the cabinet, with a common mounting plate used to seal the top of the cabinet and bottom of the glovebox.

Drums are not opened during the venting or sampling operations, but rather the drum lid is penetrated with a drill-bit filter probe. This activity is performed in a fully contained enclosure (i.e., glovebox and explosive-proof chamber) that has a ventilation system to provide a negative differential pressure in the enclosed with respect to the atmosphere. Exhaust air from the DVS-1 is released through the HEPA filter to the atmosphere. Because the vents are installed in the drum that potentially contain flammable gases, the chamber of the DVS-1 is explosion-proof. The maximum hydrogen deflagration pressure is 98.6 psig (6.8 bars) (NFPA 68, Ref. 2-35). The maximum pressure is associated with the adiabatic, isochoric complete combustion condition, and is independent of the volume of the container. The mixture must, however, be within the flammable range. It is postulated that the stoichiometric mixture is present in the 50% void volume in the 55-gallon (7.4 ft^3) drum. The maximum pressure that the 77- ft^3 DVS might experience is less than 10 psig resulting from adiabatic expansion of the mixture deflagration. The maximum deflagration pressure of 136 psig (9.4 bars) is not associated with any flammable gas. The worst is that of acetylene, which is 10.6 bars. But formation of acetylene from radiolysis is unlikely. Formation of a stoichiometric flammable gas-air mixture of any kind is improbable. Radiolytic products are typically carbon dioxide, methane, hydrogen, etc., which are decomposition products associated with gloves, plastic bags for the contaminated materials, etc. And the design is more than adequate to accommodate even the potential deflagration involving acetylene. The design deflagration develops a pressure of 15 psig over a volume of 77 ft^3. Following fabrication, the glovebox was successfully pressure tested to 150% of the design pressure, 22.5 psig, meeting ASME B or pressure vessel criteria.

The cabinet design includes a 24 x 24 in. fluid seal HEPA housing for inlet air. A backflow prevention device is present in the cabinet to minimize the probability of filter failure in the case of overpressurization. Two doors are present. One is small access door used primarily to inspect the top surface of the drum for contaminants prior to opening the large, drum access door. Both doors are gasketed to provide a tight seal during both normal operating conditions and abnormal events. Both doors have sensors to tell the operator of their open or closed status.

The postulated blast would blow the filter out of the plenum's spectrometer, but the chamber is designed to deflect all effects of the blast away from the worker (NFT Incorporated, Engineering Design File DVS III (Ref. 2-36); SRS Calculation S-CLC-E-00115 (Ref. 2-37), and NTF Incorporated Specification DS-9075-1 (Ref. 2-38).

2.3.3.2.5 Air Filtration System

The air filtration system is responsible for ensuring that any radioactive contaminants released from a waste drum by any mechanism within the DVS-1 & 2 are fully contained within the system. During operation, constant negative differential pressure is maintained with the drum containment cabinet and glovebox. The exhaust fan is an induced draft type, which is rated at 1,000 cfm maximum. The fan is equipped with a variable speed controller to permit the adjustment air velocity, and hence the pressure differential within the cabinet and glovebox.

The Air Filtration and Handling Train is used to provide positive airflow through the Headspace Gas System. The airflow through the two enclosures is in parallel and is located on the outlet end of the enclosures. Negative pressure is induced within the enclosures by the suction from the fan. The air being removed from the enclosure is filtered through a roughing filter and two HEPA filters, all in series. The entire assembly is mounted on a skid, which mates to other system skids, to provide an integrated system of subassemblies. The ductwork provides flow balancing dampers and backflow prevention devices. The system ventilation HEPA filter and associated system is aerosol particulate tested before the system is used.

A remote possibility exists for a deflagration of gases contained within a drum. This deflagration could produce a positive internal pressure approaching 15 psig within the Drum Containment Cabinet. The deflagration gives rise to a pressure wave lasting for a fraction of a second, which would then dissipate throughout the system. The cabinet volume and the ductwork volume are utilized to dissipate the pressure transient, along with aid of the normally existing negative pressure and the significant airflow. The flexing characteristics of the ductwork also assist in dissipating the transient. Flexing and deformation of the ductwork and filter train components is acceptable as a result of the deflagration transient, given that the contamination boundary is not breached.

Various speed control of the fan permits performance of the required operational sequence. This requires the air flow/cabinet vacuum to be reduced following completion of the operation to permit opening the cabinet doors for contamination surveys and for routine drum handling operations.

The filter housing is constructed of 11 and 14 gauge type 304 stainless steel and is inline geometry (Ref. 2-36).

2.3.3.2.6 Remote Controller Assembly

An Industrial Process Controller (IPC) is the key interface between the machine and the operating personnel. The IPC is connected to a special touch-screen interface that allows the operator to control the course of action during the drum-venting process. For example, the linear drive controller and the nutrunner controller are electronically connected to the IPC, which issues discrete logic signals that cause the execution of predetermined motion sequences or program. The IPC software provides a flowchart-oriented operational basis for operation of the system (an operation is completed before the next operation in the sequence is begun). The entire control and data station is enclosed in an electrical cabinet affording personnel and equipment protection during operation.

2.3.3.2.7 Drum Filter Assembly

The normal filter has a self-boring, self-tapping stem. The drill-type tip of this filter is made of hardened tool steel (high-speed steel). The housings of both units, which are otherwise identical, are fabricated of 316 stainless steel. The filter media is carbon-bonded-carbon material and is performance tested to provide >99.97% removal of 0.3µ particles. The air delivery capacity of the filter is 200 ml/minute at 1 in. WC. The filter vent plug is a hollow stem filter vent that provides a free path from inside the TRU waste drum rigid liner and the annular space between liner and drum. The free flow path is provided under two conditions: a) when the filter vent is at sample collection depth, and b) when the vent or plug is fully inserted and sealed on the drum lid surface. The self-drilling, self-tapping filter vent employed is HEPA-grade and tested and certified to meet all applicable WIPP container filter requirements.

2.3.3.2.8 Analytical System (GC/FID/TCD/MS System)

Flame Ionization Detector
The FID is piped in parallel with the MS after the capillary column for methane. The detector is sufficiently sensitive to meet the Hydrogen and Methane Analysis Quality Assurance Objectives given in Table 7 of CCP-TP-029 (Ref. 2-33).

Thermal Conductivity Detector
The TCD is piped in parallel to the capillary column. T, the detector, is a TCD type for hydrogen. The detector is sufficiently sensitive to meet the quality assurance objectives given in Table 7 of CCP-TP-029 (Ref. 2-33).

Detector Temperature Control
The detector temperature shall be maintained at a constant temperature (as specified by the manufacturer) during the course of the sample run and the corresponding reference run. The detector temperature shall be higher than or equal to the maximum column temperature.

Sample Inlet System
The sample is collected using the automated sampling manifold connected to the sample inlet. The inlet system is operated at ambient pressure by having the sample loop vented to atmosphere. The Varian Model 3800 GC is self-compensating for temperature and pressure.

2.3.3.3 Other Unit Components

- Bridge and drum dolly
- Electrical
- Compressed gases

2.3.3.3.1 Bridge and Drum Dolly

The bridge is of welded construction and fabricated using 2 in.x2 in.x.25 in. wall mechanical tubing type A-36 steel, with a 1/4-in. steel plate top and 1 in. x 1 in. x 1/8-in. angle iron lip. The loading on this steel frame using standard column and beam design would be upwards of 4000 pounds and the columns (legs) are less than 4% stressed at these loads. The wheels used are the weakest link and are 4 in. diameter cast steel v-groove wheels rated at 800 pounds load each, making the bridge capable of handling a maximum 3200-pound payload.

The bridge base is fabricated using 2 in. x 2 in. x 25 in. wall mechanical tubing type A-36 steel, with a 1 in. x 1 in. x 1/8-in. angle iron track welded on top. The maximum loading on this steel frame using standard beam design would be upwards of 3000 lb/ft unsupported in the middle.

The bridge is fabricated using 2 ft diameter aluminum plate bolted to 10 swivel casters (Faultless #400-3-1.2/4 with Dyna-Tred TPR wheels). As the caster centers are bolted close to the load carrying lip of the 55-gallon drum, the aluminum plate does not bear the load, only the casters. These casters are rated for 180 lbs each such that the cart will handle 1800 lbs of load. The maximum live load of a 55-gallon drum will be less than 1,000 lbs.

2.3.3.3.2 Electrical

All NFT DVS-1 & 2 subsystems operate on 125 VAC power except the air handling train, which is 240 VAC, three-phase. System power is initiated manually. The NFT DVS-1 & 2 system requires a dedicated power source due to costly operational down time and equipment re-calibration time due to loss of power or sudden changes in the power supply. Temporary power supplies (generators) often result in equipment failure because of power fluctuations or maintenance outages. However, the ventilation system from the DVS-1 & 2 system is connected to a glovebox to maintain a negative pressure in the glovebox and draws a sample from the drum. If a power failure occurred, any radioactive material would still be contained in the drum or exhaust system or upstream of the HEPA filter.

2.3.3.3.3 Compressed Gases (Reagents and Stock Standards)

The DVS-1 & 2 system uses compressed helium, hydrogen, and nitrogen gases, stored in cylinders outside the DVS-1 & 2 structure. These gases are stored in accordance with NFPA 55 (Ref. 2-30). The compressed nitrogen is used for purging and as the carrier gas for the GC. The compressed helium is used as the carrier gas for the (MS). Hydrogen is used as fuel for the methane detector, which is used to detect methane in the drum sample. The GC determines the concentrations of methane and hydrogen. The MS is used to identify VOCs in the drum sample and their concentrations.

Before entering the cabinet, the hydrogen is mixed with nitrogen. The ratio of nitrogen to hydrogen is about 2 to 1. The valve on the GC decreases the pressure down to approximately 17 psig. This valve is an electric solenoid value, which is designed to fail closed. It is connected to the PLC, which is set to close this valve if the pressure entering the system is above or below this pressure. The flow rate of hydrogen into system is only about 30 mL/min.

The system is calibrated once per day with calibration gases and liquids. The concentration of these gases, which contain VOC, is between 10 ppm and 100 ppm and less than 100 µL of this gas is delivered to the system. Only about 100 µL of liquid is used for calibration. The calibration liquids are contained in glass vials, which are refrigerated inside the HGS cabinet when in use. They are delivered to the system with a syringe. The calibration gases are stored in cylinders, approximately 2 ft^3 in size, and are delivered to the system directly through tubing. The flow rate into the system is controlled by an electric solenoid valve, which fails closed, and is connected to the PLC. Based on these conditions, the likelihood of combustion gases accumulating inside the HGS cabinet due to leak or process failure is very unlikely.

In addition to gas cylinder of ultra-high purity helium for the MS, and ultra-high-purity nitrogen for the GC, other gases necessary for the operation of the equipment include zero-grade or ultra-high-purity hydrogen and zero-grade or ultra-high-purity air for the FID. Nitrogen carrier gas is used for both percent and parts per million quantities of hydrogen.

The helium bottle supplies carrier gas to the MS and must be left on at all times. If this bottle must be shut off for any reason, the Headspace Gas Technical Supervisor shall be contacted for special shutdown procedures.

The sample chamber, manifold, and piping are purged with ultra-high-purity nitrogen to ensure system cleanliness.

2.4 Mobile Visual Examination and Repackaging (MOVER)

The MOVER unit contains a glovebox housed in a mobile 40 ft long transportainer that is transported to various DOE sites to visually examine the contents of TRU waste drums. The MOVER unit is a certified DOT 7A Type A Container. Only one TRU waste drum at a time is brought inside the MOVER unit for characterization. TRU waste drum contents are bagged into the glovebox and opened. The contents are examined and then bagged out into another drum(s). If items are encountered that are safety concerns, the process is halted pending further evaluation to mitigate any potential hazards. Nonconformance items are identified and bagged out into a third drum. The empty parent drum and newly filled drum(s) are then removed from the MOVER unit. Generally, only one drum a day is processed through the glovebox operations in a normal working shift of 8 hours. [Note, the MAR limit for the MOVER is 100 PE-Ci in parent and daughter drums.]

2.4.1 MOVER Unit Structure

Figures 2-15 and 2-16 show the layout of the MOVER unit. The MOVER structure is classified as a Type II (000) structure per NFPA 220 (Ref. 2-3). Interior walls are 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 non-flammable metal with steel stud construction.

All electrical systems are designed to the NEC.

The characterization units and associated equipment were not designed and built to DOE NPH standards. The associated equipment is not seismically qualified.

Physical parameters of the MOVER unit are as follows:

- Length: 40 ft
- Width: 8 ft 6 in.
- Height: 10 ft
- Gross Weight: 34,000 lbs

2.4.2 Major Unit Components

The MOVER includes the following major components:

- MOVER (DOT 7A Container)
- Glovebox/Drum Lifter
- HEPA ventilation system

Further information regarding the glovebox and associated equipment is provided in the SDDs for the MOVER (Ref. 2-39,. 2-40).

2.4.2.1 MOVER (DOT 7A Container)

There are three zones within the MOVER:

- Zone 1 - Glovebox
- Zone 2 - Glovebox Operation Room
- Zone 3 - Drum Entry Room (Zone 3A) and Control Room (Zone 3B)

Zone 3 consists of the Drum Entry Room, Zone 3A, at one end of the MOVER, and the Control Room, Zone 3B, at the front or opposite end of the MOVER. Zone 3 provides space for personnel entry, a portal radiation monitor, and system controls. The Glovebox Operation Room (Zone 2), located in the middle of the trailer, is the working area around the Glovebox (Zone 1), which is located in this room. The Glovebox Operation Room (Zone 2) contains the glovebox, drum lifter, HEPA filters and differential pressure-monitor panel.

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.

There are doors between each section to isolate each room. Doors are kept closed during the glovebox operations to maintain negative pressure in the unit. Airflow direction is maintained so that air flows from areas of low contamination to areas of potentially higher contamination before being 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 will be lit if the CAM alarms. Exterior doors have a locking handle that can be locked when the MOVER is unattended.

2.4.2.2 Glovebox and Drum Lifter

2.4.2.2.1 Glovebox

The glovebox is 12 ft long, 2.75 ft high and the end is 2.3 ft wide at the top, tapering out for the height of the windows to 3 ft and then straight down. The volume of the glovebox is about 90 ft^3. The HEPA ventilation system allows for over 16 air changes per hour, and is adjusted to maintain a minimum 25 cfm airflow through the glovebox. The blower system has the capability of keeping 125-fpm face velocity when the glovebox is compromised as it has twice the airflow capability used under normal conditions. A credible event is the loss of a rubber glove, which would require about 44 cfm through the glove port. Ionizing radiation exposure is caused by the materials undergoing visual examination (VE) and repackaging, which contain waste contaminated with TRU radionuclides. Since VE is a physical process in which waste is handled, extremity exposures are typically the highest. The glovebox enclosure provides complete protection from the alpha-radiation exposure. Lead-lined neoprene gloves are used, providing protection from gamma radiation.

The glovebox height must allow for the installation of a 55-gallon drum to be placed under the glovebox, thereby requiring the glovebox glove ports and working area to be above an average person's height. Working platforms are positioned on each side of the glovebox, which are positioned approximately 16 in. off 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 (up-right legs). Drums of characterized waste must be moved into and out from under the glovebox: thereby, lifting the section of the platform in the travel path of the drum. Each liftable section of the platform weighs less than 50 lbs.

The glovebox component is fabricated from type 304L stainless steel. The shell material is 0.187–in sheet stock with a No. 2B mill finish on both sides conforming to ASTM standards ASTM A-240 and A-480 Ref. 2-42, 2-43). Plate stock is the same grade of stainless steel as the shell material per ASTM A-240. Bars and shapes used in the glovebox component fabrication are the same grade of stainless steel as the glovebox component shell material and meet the requirements of ASTM A-276 (Ref. 2-43). Forgings and couplings and other forged pieces used in glovebox component are fabricated of the same grade of stainless as the glovebox component shell material. All forgings meet the requirements of ASTM standards ASTM A-182 and ASTM A-479 (Ref. 2-44, 2-45). Welded studs to the glovebox components are made of 304 series stainless steel. Nuts and washers are 300 series stainless steel unless others are specified by the procurement drawings. The windows of the glovebox are shatter-resistant glass.

2.4.2.2.2 Drum Lifter

The TRU waste drums (55-gallon drum) must be lifted and tilted to a horizontal position to a height of 5 ft from the floor or 3.5 ft from the worker platform to be loaded into the glovebox. The worker platform extends 3 ft to the right (as shown in Figure 2-16) of the glovebox. The drum lift is approximately 36 in. wide.

The drum lifter is used to load a TRU waste drum into the glovebox. The working load limit is 500 lbs. Proof load is 2.5 times the Working Load Performance requirements. The Ultimate Load is 5 times the working load limit. The drum lift meets the performance requirements of Federal Specification FF-T-971b, Type 1, Form 1—Class 8, and ASTM F-1145 (Ref. 2-46).

The lifter has an interlock switch to prevent travel of the drum lift carriage assembly beyond a certain point, which could result in damage to equipment and/or personal injury. The interlocks are tested each day to assure proper operations of the lifter. Plexiglas side guards for the drum lifter are installed on each side of the lifter trolley. The Plexiglas guards protect against possible pinch points during lifting and positioning.

The drum lift has a winch to lift the 55-gallon drums in place at the glovebox. The winch meets or exceeds the requirements contained in ANSI/ASME B30.7b, *Base Mounted Drum Hoists*. The winch is operated with a 1/4-in. wire rope. Cables used in the drum lift are fabricated to Federal Specification No. RRN 410 and are proof loaded to 1,350 lbs without deformation or failure.

2.4.2.2.3 Glovebox Equipment Airlock

An equipment airlock is attached to the glovebox to transfer small items into and out of the glovebox. The current preferred method is to bag items into and out of the glovebox rather than using the airlock to avoid opening the glovebox. The equipment airlock is maintained at negative pressure, which flows into the glovebox. The approximate 12 in. by 12 in. access door is a gasketed design, which seals the door to the airlock surface. Once items are placed in the airlock, the outside door is closed and secured. Since the glovebox negative airflow causes a vacuum, any airborne contamination from the airlock flows into the glovebox.

2.4.2.3 HEPA Filtration System

2.4.2.3.1 Glovebox and Filtration System

Air for the three rooms in the MOVER comes in through inlet air pre-filters, mounted on the outside of the MOVER (one each for the Control Room and Drum Entry Room, two on the Glovebox Operation Room). A series of room, glovebox inlet, and glovebox outlet HEPA filters all feed into a final HEPA filter before the exhaust fan (described in the next section).

Differential air pressure zones are maintained throughout the unit to ensure that airflow is directed towards the glovebox—from outside, to airlocks, to the Glovebox Operation Room and then into the glovebox and HEPA ventilation system. All glovebox air is HEPA filtered by the onboard unit before exhausting outside.

The glovebox is the primary confinement barrier that prevents the spread of radioactive contamination into the work area. The glovebox is maintained at a negative pressure of at least 0.2 in. WC relative to the Glovebox Operation Room by the HEPA ventilation system with a minimum flow of 25 cfm (Ref. 2-47), which exhausts through the HEPA filters. The ventilation flow dilutes any flammable vapors that may be in the glovebox.

Glovebox inlet air and exhaust filters for the glovebox are located on top of the glovebox. Air from the glovebox goes through three HEPA filters in series before being exhausted to the outside. Glovebox Operation Room air exhausts through the glovebox inlet air filter as well as through three HEPA filters in parallel mounted on the final HEPA filter housing.

The MOVER operator maintains a trend of differential pressures and airflow to aid in determining when a HEPA filter needs to be replaced. Glovebox HEPA filters are changed out in accordance with CCP procedures.

There are nine differential pressure gauges and five airflow monitors as described in the CCP MOVER startup and shutdown procedure (Reference 2-47). These pressure and airflow indicators are displayed on a visual readout panel located on the inside wall of the Glovebox Operation Room. The signal is fed to the computer interface that can be monitored in the Control Room and /or outside the MOVER. Visual alarms located on the readout activate when the differential pressure or airflow falls outside the normal operating ranges as detailed in the CCP procedure (Reference 2-47). The alarms are checked for proper operation prior to normal daily operations in the MOVER. The low and high alarm points for the differential pressure and airflow meters are listed in Table 2 of the procedure for startup and shutdown of the MOVER (Reference 2-47).

Doors connecting each room in the MOVER are wired to a PLC that provides visual alarms to alert personnel when the doors can or can not be opened. The primary purpose of this system is to maintain negative zonal pressure to protect personnel and prevent the spread of airborne contamination in the event of a release. The PLC has a manual test switch for the CAM and ventilation alarms. The system operability of the alarms is tested each day before normal operations start.

The HEPA filters are positioned in the Glovebox Operation Room adjacent to the glovebox. The HEPA system is a Flanders Filter bag-in/bag-out housing model.

2.4.2.3.2 Belt-Driven Blower

A belt-driven blower is positioned outside of the DOT 7A Container and is connected to the MOVER by a trunk line. Since the internally placed HEPA filter captures all airborne contamination before the air exits the HEPA filter housing, the trunk line is not required to be fire resistant.

2.4.2.3.3 Nuclear Grade, Nipple Connected HEPA Filters

Nuclear grade HEPA filters are 16 in. by 16 in. by 18 in. long with 4-in. male threaded nipples on one end. The HEPA filters are built equivalent to large filters that meet ASME AG-1, *Code on Nuclear Air and Gas Treatment* (Ref. 2-55).

2.4.2.3.4 External Inlet Air Pre-Filters

The MOVER has four external inlet air pre-filters located on the outside wall. Inlets are located as follows:

- One in the Drum Entry Room
- One in the Control Room
- Two in the Glovebox Operation Room.

2.4.3 Other Unit Components

- HVAC
- Fire Protection System

- Camera system/monitors
- CAM alarm system
- Fixed-head air samples system
- Door interlocks
- Canberra neutron coincidence analyzer
- Electrical and lighting system
- Intercom

2.4.3.1 Heating, Ventilation and Air Conditioning

The Glovebox Operation Room inside wall houses a stand-alone air conditioning unit that provides both heated and cooled air to the area. The system is a circulating air system that uses only the air from within the Glovebox Operation Room and Drum Entry Room. It does not draw air from outside of the trailer. The Drum Entry Room inside wall houses a stand-alone air conditioning unit that provides both heated and cooled air to the area. Condensation is drained into a container and then later sampled for contamination. The Control Room also has an installed heating and cooling system that supplies air to the Control Room. Both the Drum Entry Room and the Control Room have room-to-room filters installed.

2.4.3.2 Fire Protection System

Graphite powder or similar material is positioned inside the glovebox prior to the operations to smother and extinguish combustibles that ignite.

The fire suppression system consists of:

A bank of 8 INERGEN cylinders (each 355 cu ft) which are located directly outside of the MOVER in a cylinder rack, which is secured to the MOVER unit using standard industrial practices. A trailer penetration for a 1–in. pipe allows a single line to penetrate the outside wall into the MOVER.

Two 3/4-in. 360^{o} discharge nozzles are located at ceiling level near the glovebox intakes.
The INERGEN fire suppression system, manufactured by Ansul, is an engineered system using a fixed nozzle agent distribution network. The system is designed and installed in accordance with NFPA 2001 (Ref. 2-48). The INERGEN will extinguish surface burning fires in Class A, B, and C hazards by lowering oxygen content below the level that supports combustion. INERGEN agent has also been tested by Factory Mutual Research Corporation for inerting capabilities. Those tests have shown that INERGEN agent, at a design concentration between 40% and 50%, has successfully inerted mixtures of propane/air and methane/air. When INERGEN agent is discharged into a room, it introduces the proper mixture of gases that will allow a person to breathe in the reduced oxygen atmosphere.

The INERGEN system is manually activated by a switch on the outside of the MOVER. The VE operator must physically pull/activate the system. Once the system has been activated, the VE operator (s) immediately evacuate the area.

The primary fire protection systems to alert workers are smoke alarms in the MOVER.

2.4.3.3 Camera System/With Monitor

Videotaping is intended to document activities that manipulate waste during drum opening and inventory. Taping will be halted when VE is suspended. If recording is suspended, the reason is verbally documented on the videotape. There is nothing unusual about this video camera equipment and it can be replaced with any similar off-the-shelf models currently available.

2.4.3.4 CAM Alarm System

CAMs are located in the Glovebox Operation Room to provide an alarm to indicate the airborne alpha contamination. The main instrumentation panel for the CAMs is located in the Control Room. Monitors are located above and near both sides of the glovebox in the MOVER where the VE operators perform work. The filters are checked for alpha contamination on a regular basis to ensure proper operation.

The CAM calculates the activity due to particular isotopes. It accomplishes this using a 256-channel analyzer and a set of parameters and equations, which accurately measure activity by subtracting out counts due to other isotopes. In addition, the ALPHA-6A-1 archives historical data, checks for alarms and responds to user commands. 10 CFR 835.403 (Ref. 2-49) requires monitoring of the breathing air zone where personnel are involved in this type of work.

2.4.3.5 Fixed-Head Air Sample System

The Fixed-Head Air Sample System is located on each side of the glovebox near and above the VE operator's position. The Fixed Head Air Sample System continuously pulls air through filters by a vacuum pump. The vacuum pump is located in the Control Room. The filters are periodically changed, and the old ones checked for the level of alpha contamination. This provides a highly sensitive method of determining the level of airborne contamination over an extended period of time.

2.4.3.6 Door Interlocks

The doors to each room in the MOVER unit are wired to a PLC that provides visual alarms to alert personnel when a door can and can not be opened. The primary function of this system is to maintain a negative zonal pressure to protect personnel and prevent the spread of airborne contamination in the event of a release. The PLC has a manual test switch for the CAM and ventilation alarms. The alarms are checked for proper operation prior to normal daily operations in accordance with the requirements of a CCP procedure.

2.4.3.7 Canberra Neutron Coincidence Analyzer

A passive neutron counter is physically attached and positioned under the glovebox. The Canberra Neutron Coincidence Analyzer is designed to be used with neutron detector systems where it is necessary to separate time-correlated neutrons from random neutron events.

A sealed source is used to calibrate the coincidence analyzer (^{252}Cf neutron source, μgrams 0.01-0.05, contained activity 5). The activity assay is given as the normal value ± 15% only. The 3014 capsule, equivalent to Savannah River Model SR-CF-100, is designed to provide a point source of neutrons only, since the wall thickness of the doubly encapsulated welded container prevents emission or leakage of fission fragments. The activity is contained in a ceramic or cermet pellet about 1 mm^3 in volume located in geometric center of the capsule.

2.4.3.8 Electrical and Lighting System

The MOVER unit requires a minimum, 240-VAC, single-phase, 200-ampere power to support daily operations. Power is supplied to the MOVER unit from the site power grid. All of the equipment associated with the MOVER will be run from the same power supply.

All electrical systems comply with the National Electrical Code. Separate on-board labeled circuit breakers for each trailer function are located in the Control Room of the MOVER. Rigid PVC conduit runs are used throughout the trailer.

An electrical disconnect for the AC power source is located in the recessed area on the outside wall of the MOVER that contains the air conditioning units. The MOVER can be setup outside or inside a building. The MOVER has an independent (separate from the AC power cord) grounding system with an earth ground lug.

Lighting is located directly above the glovebox working area and covers the full working area. Battery-powered lighting is located in all rooms of the MOVER unit. During an emergency event or power failure, these lights illuminate the exit paths. Emergency exits are located at each end of the MOVER unit and are used for exit during a fire event or other emergency.

2.4.3.9 Intercom

The MOVER is equipped with an intercom system.

2.4.4 Examination

The custody of the TRU waste drum is transferred to the VE operator once placed inside of the Drum Entry Room. The drum is placed on a drum dolly. The VE operator then moves the TRU waste drum from the Drum Entry Room to the Glovebox Operation Room. The VE operator positions the drum in front of the lift and closes the Drum Entry door. Once in the Glovebox Operation Room, the drum's retaining bolt is loosened and the trunk of an oversize plastic bag is attached to the drum at the first supporting ring of the drum using tape. The glovebox trailer is pre-setup with bag-out drums for characterized waste and suspect waste.

The operator connects the TRU waste drum to the drum lift-clamping fixture. The drum is then mechanically lifted (approximately 4 ft) along the lifter trolley to a horizontal level plane with the glovebox bag-on port. The open end of the trunk is attached to the bag-on port on the glovebox. The end of the drum is then moved forward into the glovebox to allow for the retaining ring and lid to be removed. The operator removes the inner metal lid on the bag-out port, removes the rigid plastic sleeve in the bag-out port, and replaces the inner lid on the bag-out port.

The waste contents are then slowly removed from the TRU waste drum. Acceptable waste is placed in the characterized drum (bag-out drum). Nonconforming items (items that are unacceptable to the waste receiving facility) are placed into a suspect waste drum at the bag-out port. The bag-out TRU waste drum of characterized and repackaged waste is then removed from the glovebox area. The bag-on drum is also removed from the glovebox. All drums are swiped prior to removing them from the MOVER to ensure the outside of the drums are below the contamination release criteria.

2.5 Mobile Loader Unit (MLU)

The TRUPACT-II is a DOT Type B shipping cask on a tractor-pulled trailer. Up to three casks can be placed on a single trailer for transportation. DOT Type B casks are designed to meet stringent performance standards under a variety of accident scenarios. The TRUPACT-II casks are specifically designed for the safe transport of TRU waste from generating sites to the WIPP long-term storage site.

In order to load drums of waste into the TRUPACT-II casks, the drums are bundled together into a single payload and lifted by a crane into the casks. A payload of fourteen 55-gallon drums is shown in Figure 2-17. This operation is described in more detail in Section 2.5.3.

2.5.1 Facility Structure

TRUPACT-II loading does not involve a traditional facility. The MLU is an assembly of equipment, housed and transported on a trailer, and specifically designed for performing the loading and unloading operations associated with the TRUPACT-II. This equipment can be used indoors or outdoors depending on the loading area. The MLU is operated in conjunction with a minimum of 5-ton mobile or fixed crane that is supplied by the site or commercial vendor. Drums are staged and the occasional vehicle (typically a forklift) used to move the drums, fixtures for bundling and lifting the payload, a crane is used to lift the payload into the TRUPACT-II, and the TRUPACT-II casks on their trailer. In addition, a lift and/or ladders are used to access the TRUPACT-II casks, leak checking equipment, hand or power tools as needed, survey meters, and the stretch wrap system. Electrical supply for the Adjustable Center of Gravity Lift Fixture (ACGLF) requires three 120 VAC/20-amp circuits.

2.5.2 Safety Features

The TRUPACT-II casks are certified by the Nuclear Regulatory Commission (NRC) to meet the 10 CFR Part 71 requirements for a Type B shipping container (Ref. 2-50). There are no unique safety features involved in loading the TRUPACT-II casks. The design and loading of the TRUPACT-II is covered by documents prepared by Washington TRU Solutions CCP, the WIPP management and operating contractor for the DOE (Ref. 2-51, 2-52). The operation of the crane meets the definition of a Critical Lift as defined in DOE-STD-1090-2001 (Ref. 2-53).

2.5.3 Examination

A payload consists of fourteen 55-gallon drums, two Standard Waste Boxes (SWBs), or a ten-drum overpack. Each layer of a drum assembly (seven drums) is secured using stretch wrap. The two SWBs are strapped together using three ratchet-type slings. Drum lifting devices, SWBs lifting devices, forklifts, and crane are used to build the payload.

The staging of drums, assembling the payload, and loading of the payloads into the TRUPACT-II casks can be performed any outdoors harden (soil, asphalt, concrete, etc.) During loading operations, no other activities are permitted in loading segment.

The activity begins with the staging of a single payload of 14 waste drums. If shipping less than 14 loaded drums, empty dunnage drums must be used to form the payload. The total TRU waste per single payload conforms to TRAMPAC requirements. The TRU waste drums will be transported and staged in the TRUPACT-II Loading Segment. The trailer with the TRUPACT-II casks and tractor may be present during this staging or may be moved in once the staging is complete. The casks will not be removed from the trailer unless necessary. A crane, capable of lifting at least 5 tons, is used for pre-staged and used for the loading operation.

The following paragraphs describe the typical process for TRUPACT-II loading:

A 54-in. drum metal payload pallet is positioned on a level surface adjacent to the on the stretch wrap machine. A slip-sheet is placed on the pallet with the guide-tube holes of the pallet and the slip-sheet aligned. The drums are inspected to assure at least one filter is installed in each loaded drum and properly labeled. Seven drums are placed on the slip-sheet in a weight-distributed pattern. Labels on all drums, except the center drum, must be visible. Locking bolts must be between drum gaps and not interfere with the guide tubes. In addition, the heaviest seven-pack must be on the bottom of the payload assembly. Nine wraps of stretch wrap are used on the upper portion of the drums, extending down the side of the drums a maximum of 22 in., with no overlap on top of the drums. A reinforcing plate is placed on top of the drums with all guide tube holes aligned with the bottom slip-sheet and pallet. An additional nine wraps of stretch wrap are added to the drums, with overlap on top of the drums.

A slip-sheet is placed on the top of the bottom layer of drums and aligned with the bottom slip-sheet using the white stripes on the sheets and guide tube holes for alignment. Another seven-drum layer is placed on the slip-sheet in a weight-distributed pattern. As before, labels on all drums must be visible, except for the center drum, and all locking bolts positioned between drum gaps so that they do not interfere with the guide tube holes. The upper parts of the drums are stretch wrapped with nine wraps to extend down a maximum of 22 in., with no overlap on top of the drums. Another reinforcing plate is placed on top of the drums, assuring the guide tube holes are aligned. An additional nine wraps of stretch wrap are added so that there is overlap on top of the drums. Guide tubes are installed, and they are bolted together to lock the whole payload together. This completes the payload preparation.

The TRUPACT-II casks are prepared for payload loading. Since this is performed outdoors, these operations cannot be performed in rain, snow, other wet conditions, or dusty conditions. Water must not be allowed into the Inner Containment Vessel (ICV) of the TRUPACT-II. As part of the Critical Lift process, the crane position will be evaluated such that in case the crane falls, it cannot strike buildings or other structures holding TRU waste, or TRU waste staged in the TRU Waste Characterization Segment.

The Outer Containment Assembly (OCA) lid is prepared for removal by removing the test port plugs, the vent port cover and plug, the lock ringbolts, and the lift pocket covers. The ACGLF is attached to the crane. The ACGLF legs are lowered into the OCA lid lift pockets and locked. A vacuum line is attached to the vent port and evacuated to 3 in. Hg minimum. The Outer Containment Vessel (OCV) lock ring is rotated to the unlocked position, and the vacuum pump is stopped and disconnected from the OCV. The OCV is vented to the atmosphere. The lid is removed, placed on a storage stand, and inspected.

The ICV lid is removed following the same procedure as the OCA lid and placed on a storage stand, inspected, and cleaned. Any payload pallets, guide tubes, slip-sheets, reinforcing sheets, and dunnage containers, are removed from the ICV.

The OCA, the ICV, and their components are inspected, cleaned, and lubricated. If water is found in the ICV absorbent material, a vacuum is required to remove it. Any water or absorbent material will be collected, sampled, and disposed as job control waste in accordance with site procedures. This completes the TRUPACT-II cask preparation for receiving a payload.

The appropriate legs/adapter are attached to the ACGLF, and using a crane, the ACGLF long legs are lowered into the drum payload assembly guide tubes until the red stripes on the legs are no longer visible. The legs are locked.

The payload is raised 2 in. to 6 in. above the ground and balanced, using the ACGLF console, to within $\pm$0.5 degrees. The payload is raised and centered over the ICV cavity. The payload is placed into the

ICV. The ACGLF/adapter is removed from the payload and, using the crane, attached to the lifting pockets on the matched ICV lid and locked. The lid is placed on the ICV and the ICV is prepared for evacuation. The vacuum must be a minimum of 3 in. Hg but not more than 15 in. Hg. A leak rate test is also performed.

The ACGLF/adapter is removed from the ICV lid and, using the crane, attached to the lifting pockets on the matched OCV lid and locked. The lid is placed on the OCV, and the OCV is prepared for evacuation. The vacuum must be a minimum of 3 in. Hg. The lock ringbolts are installed and a torque of 28-32 ft-lbs is applied. A leak test is also performed; lift pocket covers installed, and tamper-indicating seals installed.

The TRUPACT-II casks remain secured on the trailer at all times. The U.S. DOE Safety Analysis Report for the TRUPACT-II Shipping Package (Ref. 2-54) is the controlling Documented Safety Analysis (DSA) at this point. This document limits the grams of Pu-239 or fissile gram equivalents to 325 grams per TRUPACT-II cask.

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CHAPTER 3
HAZARDS ANALYSIS

3.1 Introduction

This section describes the process hazards analysis (PrHA) performed for the TRU waste characterization and TRUPACT-II loading operations. The hazard analysis is based on 10 CFR 830 Subpart B (Ref. 3-1) and DOE-STD-3009-94 (Ref. 3-2). This chapter provides an overview of the hazard analysis methodology, a characterization of the hazards, the impacts of the bounding accidents, the assessment of the risk, and the conclusions from the analysis.

In the first sections, the purpose of these analyses is discussed, and the hazard identification and evaluation methodologies are presented. These sections are followed by the identification of hazards, hazard categorization analysis, the evaluation of hazardous events, and the assessment of preventive and mitigative features.

Postulated hazardous events were evaluated in a qualitatively to identify high frequency or high consequence events. In performing these analyses, a DOE-STD-3009-94 (Ref. 3-2) graded-approach concept is applied such that analysis techniques are no more sophisticated or detailed than necessary to present a comprehensive examination of the hazards associated with a facility. Therefore, the analyses presented here were conducted only to the level necessary to provide a cogent argument that the facility can be operated safely, with minimal risk to workers, the public, and the environment. Consequently, the presentation largely takes the form of a qualitative analysis.

Based upon the analyses reported herein, the TRU Waste mobile unit and TRUPACT-II loading operations were both determined to be Hazard Category 2 for the radionuclide inventory in accordance with DOE-STD-1027-92 (Ref. 3-3). Based on the chemical inventory (chemicals are limited to small quantities used in maintenance, contamination in mixed TRU waste), it is not anticipated that threshold quantities of the OSHA Process Safety Management Standard (29 CFR 1910.119) (Ref. 3-4) would be exceeded. It was demonstrated that the TRU waste characterization operations and TRUPACT-II loading operations do not adversely impact the health and safety of the workers or the public.

This BIO is intended to provide the basis for safe operation for the TRU waste MCUs. This is accomplished by means of a thorough hazard-identification and hazard-assessment process to evaluate potential process-related consequences resulting from internal, external, and natural events. The discussion of this analysis includes the following:

- Description of hazard analysis methodology
- Identification of hazard sources
- Identification of the radiological and chemical inventory by type, form, quantity, and location
- A radiological hazard categorization in accordance with DOE-STD-1027-92 (Ref. 3-3) by a comparison to the radionuclide inventory with threshold quantities
- Identification of potential hazardous events and their respective consequences
- Assessment of a qualitative frequency of occurrence of hazardous events in combination with potential consequences to estimate the risk associated with design and operation of the facility

- Identification of preventive and mitigative features
- Identification of defense-in-depth measures

3.2 Requirements

The primary source of requirements governing hazard analyses is 10 CFR 830 Subpart B (Ref. 3-1). This Rule requires that safety analysis be performed and the facility categorized in relation to the quantity of radioactive material present. According to Table 2 of the Rule, the safety analysis approach for facilities with limited operational life, such as the MCU, is DOE-STD-3011-94 or a successor document, which is now recognized as DOE-STD-3011-2002 (Ref. 3-5). This standard prescribes that hazard analysis and control selection follow Chapters 3 through 5 of DOE-STD-3009-94 (Ref. 3-2). Other requirements and standards that are implemented are listed below.

DOE-STD-1027-92, CN 1	*Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*
DOE-STD-3011-2002	*Guidance for Preparation of Basis for Interim Operation (BIO) Documents*

3.3 Hazards Analysis

3.3.1 Hazard Analysis Methodology

The objectives of the hazard analysis are to identify and characterize hazards present in the facility and to systematically evaluate potential accident scenarios involving those hazards, based on credible initiators. The methodology described in the following text was used to generate a comprehensive list of process-related, natural phenomena, and external hazards that could affect workers or the public. It is based on a graded approach, as described in DOE-STD-3009-94 (Ref. 3-2).

Application of this methodology does not require detailed system information or exhaustive accident-sequence development. Instead, facility equipment, material, environmental factors, and support are considered on a macroscopic level, and accidents that have occurred in the past are researched. A hazard assessment consists of hazard identification followed by hazard evaluation. This includes using a hazard checklist, screening for standard industrial hazards (SIHs), and developing accident scenarios in the PrHA where the risks are binned and the controls identified.

3.3.1.1 Hazard Identification

The hazard identification process involves identifying and inventorying hazardous materials (including radioactive materials), their hazards, and any factors that affect hazards (e.g., quantity, form, or location). Typical energy sources associated with the TRU waste operations were also determined.

Hazard identification includes a review of the following:

- Facility description (including available drawings)
- Inventory (hazardous materials lists, and other sources)
- Existing safety documentation (e.g., SARs, Hazards Analyses for the proposed characterization units and TRUPACT-II loading, Project Design Documents, Fire Hazards Analyses)

- Facility or Operational Safety Plans
- Consultations with system/process experts, operations staff, the ES&H Team, and workers
- Facility occurrence reports
- Hazard Analyses of neighboring facilities, to determine if an event at one of these facilities could initiate an event at the subject facility

The safety analysis team identified hazards by reviewing process descriptions and hazard analysis information that has been prepared by the WIPP characterization contractor, as well as other DOE sites where the MCUs have been employed. These safety basis documents have already been reviewed and approved by various DOE sites (see Section 3.5, "References"). Discussions were also held with participants from each of these sites and experts on the mobile vendor operations. One of the documents considered is the TRUPACT-II Content Codes (Ref. 3-6), which included information about legacy TRU waste.

Common industrial hazards (CIHs) were evaluated only to the extent of determining their ability to initiate or contribute to accidents involving radiological or chemical materials. Additionally, hazards associated with the safe operation of electrical equipment are governed by documents, such as the National Electrical Code, and are screened out.

3.3.1.2 Hazard Evaluation

The methodology utilized is consistent with DOE-STD-3009-94 (Ref. 3-2) and allows for considering potential effects on workers and the public. The hazard evaluation was conducted to ensure that all possible hazards were represented and considered. To reiterate, it is not the purpose of this document to cover safety as it relates to the CIHs that make up a large portion of OSHA regulation compliance, and which are managed routinely by the site's work control process and Safety Management Programs (SMPs). The focus of the hazard evaluation is on potential accident conditions involving the hazards associated with TRU waste operations. Initial conditions and assumptions are considered to be in place and applicable to both unmitigated and mitigated frequencies and consequences. Initial conditions predefine inherent aspects of an operation or activity, such as inventory or capabilities of passive engineered features. Initial conditions assumed in the hazard evaluation are as follows:

- Waste is contained in DOT Type-A containers, or equivalent (approved containers evaluated by site transportation program)
- Waste consists of contaminated, combustible solids and meet WIPP WAC
- Passive vehicle barriers provide protection against large vehicle accidents

The hazards that are not eliminated as SIHs in the Hazard Identification Tables are evaluated in the PrHA. In general, the PrHA consists of a three-step process:

1. Systematically evaluate hazards, develop event sequences, and identify controls;
2. Qualitatively assess frequency and consequence with and without mitigation; and
3. Use the results to identify appropriate controls to minimize the impact on the health and safety of the public and workers.

More specifically, based on the information acquired through the hazard-identification process, operations and systems were evaluated to develop accident scenarios by functional units and include:

- Waste handling and staging (including vehicle accidents)
- Common operational hazards for all characterization units
- Non-Destructive Examination (NDE)
- Non-Destructive Assay (NDA)
- Headspace gas sampling (HGSG)
- Visual examination (VE) and repackaging
- TRUPACT-II loading
- External events
- Natural phenomena hazards (NPHs)

The following information is provided for each PrHA event scenario:

- **ID No** – Identifier to facilitate tracking of scenarios
- **Hazard –** Including description of event type
- **Scenario** – Description of scenario
- **Material at Risk –** Estimate of the inventory involved in the postulated scenario
- **Unmitigated** – For the onsite worker and public, a qualitative estimate of the scenario frequency, potential consequences, and associated risk are provided to determine the scenario risk profile before controls are credited
- **Control Type/Controls** – Appropriate safety features for eliminating, controlling, or mitigating hazards including: 1) Initial conditions used to develop a physically meaningful scenario per DOE-STD-3009-94; (2) Controls credited to reduce the frequency or consequence of the scenario; (3) Controls not specifically credited to reduce the frequency or consequence of the scenario but which serve as defense-in-depth
- **Mitigated** – For the onsite worker and public, a qualitative estimate of the scenario frequency, potential consequences, and associated risk are provided to determine the scenario risk profile after controls are credited
- **Comments** – Statements provided for clarification of the scenario development, hazard evaluation assumptions, etc

The hazard evaluation focused on both workers and the public. Consideration was given to facility workers directly involved in TRU waste characterization operations, as well as those working onsite in adjacent areas. Facility worker impacts were accessed qualitatively as opposed to semi-quantitative evaluations performed for onsite impacts. Additionally, the impacts to the environment from the scenarios identified in the hazard evaluation are considered to be less than the impacts to the public. As such, the controls identified in the hazard evaluation are considered sufficient to address impacts to the environment.

3.3.1.2.1 Frequency Category Estimates

Each event was assigned a frequency class based on the information in Table 3-1.

Table 3-1 Qualitative Frequency of Occurrence of Postulated Events

Frequency Category	**FREQUENCY RANGE (F) (Y-1)**	Definition
A	Anticipated 1E-1*f* ≥1E-2/y	Incidents that might occur several times during the facility's lifetime
U	Unlikely 1E-2/y > *f* ≥1E-4/y	Accidents not anticipated during the facility's lifetime
EU	Extremely unlikely 1E-4/y > *f* ≥ 1E-6/y	Accidents that will probably not occur during the facility's lifetime
BEU	Beyond extremely unlikely 1E-6/y > *f*	All other less frequent accidents

Frequency estimation is based on facility or industry data where available, or analyst's judgment. The frequency of occurrence is not meant to be an absolute number but, rather, to express an expected frequency range. These frequencies are assigned to both unmitigated (i.e., before controls are applied) and mitigated accidents (i.e., after controls are applied).

Frequency estimates for specific types of accident scenarios are based on general assumptions as described below:

Human Error. These events generally are considered to be in the *anticipated* frequency category (once every 1 to 100 years) for the unmitigated case. Such accidents include drum-mishandling accidents and accidents caused by operating equipment incorrectly. Mishandling accidents that significantly impact multiple drums are estimated to be in the *unlikely* frequency category because of the significant amount of energy needed to rupture multiple drums. A concurrent fire and spill is also judged to drop the frequency to *unlikely*.

Frequency estimates for some mitigated accident scenarios would remain the same as the unmitigated frequency category, but the estimate for other scenarios could be reduced to the next lower frequency category depending on the controls that are implemented. Controls such as rigorous training and enhanced equipment and operation design might reduce the frequency estimates to a lower frequency category, but this is sometimes not possible. The frequency estimates for accidents caused by human error that allow time for recovery could be mitigated to a lower frequency category with controls targeted directly at preventing such errors.

Equipment Failures. For unmitigated frequency estimates, equipment failures are generally considered to be in the *anticipated* frequency category (once every 1 to 100 years) or the *unlikely* category (once every 100 to 10,000 years), depending on the particular equipment. Similar to human error initiators, equipment failures are expected more frequently, but most will not lead to a significant release. Types of equipment failures considered include forklift breakdowns, rigging failures, electrical faults, interlock failure and significant degradation of a waste container.

External Fires and Explosions. External fires and explosions that could affect TRUW (TRU waste) containers are generally considered to be *unlikely* for the unmitigated case. These events include fires and explosions involving vehicles adjacent to the characterization units. These types of events are unlikely in themselves, and enabling events that would cause the fire or explosion to affect a waste container are even less likely.

Airplane Crashes. The unmitigated frequency of an airplane crash into the TRU waste characterization and loading operational footprint is estimated based on the methodology presented in DOE-STD-3014 (Ref. 3-7). The frequency of this event is site dependent, but generally expected to be in the *extremely unlikely* range.

Natural Phenomena. Natural phenomena events range from *anticipated* to *extremely unlikely* depending on the phenomena being considered and the site. For example, the density of lightning flashes is much higher in the southern and eastern portions of the United States, as compared to the west. The highest frequency range expected at any site was used to bound the hazard evaluation. NPH events evaluated were a seismic event, a lightning strike starting a fire, and high winds that impact hazardous materials.

Frequency of occurrence estimates for mitigated accident scenarios initiated by equipment failures could be lowered one frequency category if controls are identified to improve the item's reliability significantly. Although controls such as equipment inspections and preventive maintenance will improve equipment reliability, in many cases such controls will not reduce the failure frequency estimate by an entire category.

The estimate for unmitigated frequency of occurrence for each scenario is based on assuming no controls are in place to lower the frequency. These estimates are based on an interpretation of "unmitigated" to be no special controls implemented above and beyond standard industrial practices, waste packaging, and assumed initial conditions. A comprehensive industrial safety program is assumed to be in place.

The frequency of a scenario is a function of the frequency of the initiating event and the frequency of enabling events. Enabling events are those events that must occur following the initiating event to result in the postulated event. For example, for a transportation event that initiates a fire in a storage area, if the initiating event is vehicle equipment failure (e.g., brakes), the enabling event could be a fuel leak that is ignited and starts a fire of sufficient size to involve material in the storage area. The probability of the vehicle initiating the fire is the product of the individual events.

Frequency estimates for mitigated accident scenarios take into account controls that lower the frequency of occurrence of both the initiating event and enabling events. For example, inspection and maintenance programs can reduce the relative frequency of the postulated brake failure. The same program can also lower the frequency estimate for the enabling event, thus minimizing the overall scenario frequency.

The mitigated frequencies, along with the consequence, are used for selecting safety related (Safety Significant) and defense-in-depth controls. It is important to realize that the frequencies of occurrence used in the hazard analysis are not implied to be absolute numbers, but rather to express an expected frequency range of the postulated scenario.

3.3.1.2.2 Consequence Evaluation

Qualitative consequence severity categories are assigned to each of the postulated scenarios within the hazard analysis. For radiological materials these categories consider inventory, material form, and energy of release; for toxic materials they consider toxicity, inventory, and volatility. Consequences are determined based on a qualitative assessment. Table 3-2 identifies the radiological and chemical consequence severity levels, the criteria used to establish them, and their impact.

Unmitigated consequences to the public and workers are qualitatively estimated within the hazard analysis for each scenario based on the material at risk, the form, and available energy sources. The impacts onsite are evaluated based on a receptor distance at 100 meters in order to provide a perspective of the consequences. Consequences to the public are considered at a receptor distance of 200 meters.

The methodology for modeling consequences in the accident analysis is addressed in Section 3.4.

Source terms are evaluated based on the Five-Factor Formula presented in DOE-HDBK-3010 (Ref. 3-8), which is a product of MAR, damage ratio (DR), airborne release fraction (ARF), respirable fraction (RF), and leak path factor (LPF). MAR is modeled as plutonium-239 equivalent curies (PE-Ci). The material at risk assumed for most accidents was generally assumed to be the inventory limit of 100 PE-Ci. This limit is independent of the number of containers that are involved in a given event. This is because one container could theoretically involve the entire inventory limit. Therefore, single drum accidents can result in consequences that are equally as severe as multiple drum accidents. This is a conservative approach to modeling accidents.

LPFs are conservatively set to one for all events. DRs are set to one unless otherwise noted in Section 3.3.2.3. ARF and RF values for are based on DOE-HDBK-3010-94 (Ref. 3-8) and are described in Table 3-3 below for various release mechanisms.

Facility worker consequence estimates are based on judgment rather than calculated exposures. Some initiating events themselves have the potential to produce major worker consequences directly, independent of a radioactive material release. The worker consequences for the cases presented here are based on the resulting release of radioactive or hazardous material. Standard work control and SMPs are relied upon to protect the worker from SIHs.

Mitigated worker consequence estimates are based on a qualitative judgment regarding the effectiveness of applicable controls in reducing the consequences from a release. The analysis identifies effective controls as candidates for TSRs.

Table 3-2
Consequence Levels and Risk Evaluation Guidelines

<table>
<tr><th>Consequence Level</th><th>Offsite Public

MOI location shortest distance to the Site Boundary</th><th>Onsite Collocated Worker

MEI location not less than 100 meters or facility boundary from the point of release
For elevated doses use point of highest doses</th><th>Site Facility Worker

Involved worker within facility boundary
Use highest dose within facility boundary</th></tr>
<tr><td>High

[1]25 rem
100 rem</td><td>Considerable offsite impacts on people or the environs.

>25 rem TEDE or
>ERPG-2/TEEL-2</td><td>Considerable onsite impacts on people or the environs.

>100 rem TEDE or
>ERPG-3/TEEL-3</td><td rowspan="3">[2]For facility worker hazards are typically protected with Safety Management Programs.
For
Safety Significant designation of SSCs, consequence levels such as prompt death, serious injury, or significant radiological and chemical exposure, should be considered</td></tr>
<tr><td>Moderate</td><td>Only minor offsite impact on people or the environs.

≥1 rem TEDE or
>ERPG-1/TEEL-1</td><td>Considerable onsite impact on people or the environs.

≥25 rem TEDE or
>ERPG-2/TEEL-2</td></tr>
<tr><td>Low</td><td>Negligible offsite impact on people or the environs.

< 1 rem or
<ERPG-1/TEEL-1</td><td>Minor onsite impact on people or the environs.

< 25 rem or
<ERPG-2/TEEL-2</td></tr>
</table>

<u>Definitions</u>:
*ERPG: Emergency Response Planning Guideline
DSA: Documented Safety Analysis
SSCs: Structures, Systems, and Components
TSR: Technical Safety Requirement
TEDE: Total Effective Dose Equivalent
TEEL: Temporary Emergency Exposure Limit
SMPs: Safety Management Programs
MOI: Maximally Exposed Offsite Individual
MEI: Maximally Exposed Collocated Worker

*If ERPG values for a chemical do not exist, the TEEL values are used.

[1] Offsite consequences that challenge the 25 rem Evaluation Guideline must be protected with Safety Class SSCs independent of frequency.
[2] Occupational Radiation Protection; unintended (incidental) releases of sufficiently high frequency is considered a part of normal operations governed by 10 CFR 835.

Table 3-3 ARF/RF Values

Release Mechanism	DOE-HDBK-3010 Basis	Bounding ARF/RF
Drum drops/impacts and spill of contents	Contaminated, combustible solids, free-fall spill and impaction stress, where the combustible material is packaged in a robust container	1E-03/0.1
Fire resulting in drum lid loss or lid seal failure (waste burns inside drum)	Contaminated, combustible solids, packaged waste	5E-04/1.0
Burning of TRU waste that is ejected from a drum or uncontained	Contaminated, combustible solids, uncontained cellulosics	1E-02/1.0

3.3.1.2.3 Risk Binning and Control Selection Methodology

The consequence and frequency of hazardous events were qualitatively considered to help determine the overall risks and controls that were needed for public and worker protection. A risk ranking was performed and results used as one input for determining the need for quantitative accident analysis and the control selection process. This process results in a relative risk ranking for each analyzed accident-sequence, based on its risk to the worker and the public. Other considerations for control selection were availability and the cost of implementation and maintenance of candidate controls.

Risk matrices for workers and the public are presented in Table 3-4. The dark and medium shaded areas on these tables define *significant* and *medium* risks, specified as I and II, respectively. The unshaded areas define *minor* and *negligible* risks, specified as III and IV respectively.

The tables are used to bin unmitigated and mitigated risks for each of the scenarios in the PrHA. Controls were identified and credited in order to reduce the unmitigated risk to the worker and public from *significant* (I) or *medium* (II) to *minor* (III) or *negligible* (IV).

Table 3-4 Qualitative Risk Binning Matrix

Consequence		Frequency			
		Beyond Extremely Unlikely	Extremely Unlikely	Unlikely	Anticipated
		$f < 10^{-6}$ /yr	$10^{-6} \le f < 10^{-4}$ /yr	$10^{-4} \le f < 10^{-2}$ /yr	10^{-1} /yr$\ge f \ge 10^{-2}$ /yr
High		**III**	**II**	**I**	**I**
Moderate		**IV**	**III**	**II**	**I**
Low		**IV**	**IV**	**III**	**III**
Negligible	Consequence < Low	**IV**	**IV**	**IV**	**IV**

I= Significant Risk II=Medium Risk III=Minor Risk IV=Negligible Risk

Control selection followed a general hierarchy that give preference to preventive controls over mitigative; passive over active controls; engineering over Administrative Controls; controls with the highest reliability; and controls closest to the hazard. The risk binning results were used to help determine the overall importance and classification of controls.

Risk Class I events must be considered for further analysis within the accident analysis and protected with safety SSCs and TSRs. For offsite public protection, Safety Class SSCs and TSRs are required for radiological events that challenge 25 rem TEDE in accordance with Appendix A of DOE-STD-3009-94 (Ref. 3-2). Events resulting in high offsite radiological consequences must be moved forward into accident analysis for determination of safety classification, without consideration for frequency.

Risk Class II events must also be considered for further analysis within the accident analysis and protected TSRs and safety SSCs. The consideration of control(s) was based on the effectiveness and feasibility of the considered controls along with the identified features and layers of defense in depth. Events resulting in high offsite radiological consequence were moved forward into accident analysis for determination of safety classification, without consideration for frequency.

Risk Class III events are generally protected by the SMPs. These events may be considered for defense in depth SSCs in unique cases. Risk Class IV events do not require additional measures.

Controls are identified that reduce the mitigated risk to the public and worker to *minor* or *negligible*.

3.3.2 Hazard Analysis Results

This section presents the condensed results of hazard identification, hazard categorization, and hazard evaluation results. Significant aspects of defense-in-depth and identification of any Safety Significant components and other items potentially requiring TSR coverage also are summarized.

3.3.2.1 Hazard Identification

This subsection presents the results of the hazard identification activity. The Hazard Identification Tables are provided in Appendix A. The attributes of the hazards identified here are the basis for subsequent hazard evaluation. The principal hazards are primarily radioactive materials. The following summary includes estimates of their form, type, location, and total quantity.

TRU and mixed TRU waste consists of the following:

- Lab trash (wipes, glass and plastic labware, etc.) and personal protective equipment (PPE) (gloves, booties, lab coats, etc.) contaminated with TRU and non-TRU radionuclides, and also with trace chemical contamination
- Equipment (pumps, machines, gloveboxes, vents, pipes, valves, etc.) contaminated with TRU and non-TRU radionuclides, and also with trace chemical contamination
- Crucibles containing solid salts and other processing equipment contaminated with TRU and non-TRU radionuclides, with also with trace chemical contamination
- Solidified aqueous and organic based liquids. Liquids were solidified in small containers and often packaged with lab trash that was generated during the processing of the liquids

TRU and mixed TRU waste is predominantly contaminated solid waste. The storage of water-reactive materials, pyrophorics, and other reactives is not authorized. However, there may also be small quantities of powder and liquid (liquid is limited to less than 1 vol%). Some of the contaminants may include small quantities of beryllium and beryllium compounds, heavy metals, carcinogens and solvents. Pyrophoric materials and water-reactive materials were prohibited when the drums of waste were being filled. Waste packages are typically double contained, either a carton and a bag-out bag or a plastic bag and a bag-out bag.

Radionuclide Inventories. The primary types of radionuclides that may be in the TRU waste are identified in Table 3-5.

TRU waste containers that are destined for shipment to WIPP must meet WIPP WAC (WAC) (Ref. 3-9). Fifty-five gallon drums are the predominate container involved in MCU operations. These containers must have less than 80 PE-Ci and less than 200 ^{239}Pu FGE. An optional packing configuration is permitted for solidified/vitrified wastes or over-packed 55-gallon drums that permit up to 1,800 PE-Ci. Standard Waste Boxes (SWBs), which may also be involved in TRU Waste Characterization activities, may have up to 130 PE-Ci (1800 solidified/vitrified) and 325 ^{239}Pu FGE.

Table 3-5 Dominant Radionuclide Types in the TRU Waste

Am-241
Am-242m
Am-243
Am-244
Cm-244*
Np-237
Pu-238
Pu-239
Pu-240
Pu-241
Pu-242

* Does not meet the definition of a TRU isotope as its half-life is less than 20 years, but can be found as a constituent in waste containing TRU isotopes.

Hazardous Chemicals. The WIPP WAC (Ref. 3-9) requires that TRU waste not contain explosives, corrosives or compressed gases. Non-radionuclide pyrophoric materials are prohibited at WIPP. Additionally, flammable VOCs are restricted to less than 500 ppm within payload container headspace (a level that would not challenge integrity of the container). Polychlorinated biphenyls are also limited to less than 50 ppm. Therefore, chemical hazards are not expected to result in significant consequences or significantly contribute to accidents involving radiological materials.

Hazardous materials are present in less than Reportable Quantities or Threshold Planning Quantities. Liquid nitrogen is used to cool the gamma detectors in the NDA unit and liquid nitrogen is also used for some HSGS analyses. Various calibration and purge gases, including hydrogen and methane, are used with the HSGS and analysis.

3.3.2.2 Hazard Categorization

This section presents the results of the hazard categorization for MCU activities in accordance with DOE-STD-1027-92 (Ref. 3-3). Final hazard categorization has not been adjusted using alternate Airborne Release Fractions (ARFs) as allowed by DOE-STD-1027-92 (Ref. 3-3). This is because the ARF associated with various accident events would not be substantially different than the default value of 1E-03 used to calculate threshold quantities. For example, ARF of 5E-04 could be justified for many events, though ARF of 1E-02 is possible for limited drum fires with ejection of contents. Therefore, the final hazard categorization is based only on an inventory comparison to threshold quantities in DOE-STD-1027-92, Table A.1.

DOE-STD-1027-92 recognizes the concept of independent facility segments where facility features preclude bringing material together or causing harmful interaction from a common severe phenomenon. Mobile units are typically located in relative close proximity to one another, and therefore independence can only be supported when sufficient distance is maintained between individual units to preclude interaction from certain severe phenomena such as aircraft crash or high wind events (see siting criteria in the Application Guide). The total inventory that is considered for hazard categorization includes the highest activity TRU waste containers that are concurrently being staged outside of the mobile units, as well as being characterized in the RTR, neutron assay, HSGS, and VE units. Drum staging, transportation, and equilibrium conditioning are not considered in this evaluation. These activities are addressed in other documents prepared by the host site. These activities must also be appropriately separated to maintain segmentation. If separation cannot be maintained the sum of the material that can be involved in a single accident must be considered.

TRUPACT-II loading operations may also be considered as an independent segment when not conducted in the same operational area as other mobile units (i.e., physically separated and controlled). Inventory that is considered for these operations includes containers being staged for TRUPACT-II loading, as well as involved in a payload (up to 14 drums).

Material inventory estimates are presented according to PE-Ci, which corresponds to the units of measure that are specified in the WIPP WAC. DOE-STD-1027-92 Threshold Quantities for ^{239}Pu are 0.52 curies for Category 3 and 56 curies for Category 2. Based on the WIPP WAC alone, there is the potential that one compliant container alone can exceed the 56 curies (i.e., 80 PE-Ci allowed by WAC) and therefore would be classified as Category 2.

Typically, activity levels associated with waste containers found throughout the DOE complex are much lower than the WIPP WAC. However, there is a possibility that a small percentage of drums could exceed the WAC thresholds, requiring repackaging in the MOVER unit. Based on this possibility, an administrative limit of 100 PE-Ci was analyzed and selected for individual containers, as well MCU segments. This limit is set higher than the WIPP WAC to account for potential uncertainties. Based on this limit, the MCU segments are Hazard Category 2.

3.3.2.3 Hazard Evaluation

The analysis performed in this evaluation relies on the graded-approach concept, which prescribes that an analysis technique be no more sophisticated or detailed than necessary to present a comprehensive examination of the hazards associated with a facility (Ref. 3-2). The hazards for each of the process, external events, and natural phenomena events were developed into hazard scenarios as documented in the PrHA Tables in Appendix B, using the methodology in Section 3.3.1.

The acronyms that are used in the hazard evaluation tables are as follows:

- WH – Waste handling and staging
- CH – (common hazard) Operational hazards that are common to all MCUs
- NDE – Non-Destructive Examination, or Real-Time Radiography
- NDA –Nondestructive Assay
- HSGS – Headspace gas sampling
- VE – Mobile visual examination and repackaging
- L – TRUPACT-II Loading
- EE – External event
- NPH – Natural phenomenon hazard

Accidents outside the units are described as part of waste handling and staging. Operational events that occur inside are common to all the units and are described in one table (CH). The remaining tables describe hazards unique to those operations.

The focus of the hazard evaluation is on potential accident conditions involving the hazards associated with the TRUW. Normal and abnormal conditions can also present hazards to the worker. However, these hazards are likely to involve minor exposures to contamination and other occupational hazards.

The following narrative describes various scenarios from the PrHA for activities and functions of the characterization and loading operations. Additional details supporting evaluations can be found in a supporting calculation package (Ref. 3-11).

3.3.2.3.1 Waste Handling and Staging Accidents

Vehicle and drum mishandling accidents are the most common type of accidents involved in handling and staging of drums. These events are considered to be *anticipated* events. Passive vehicle barriers are an assumed initial condition for mobile characterization activities. Therefore, vehicle accidents are primarily limited to forklifts that are routinely involved in waste handling activities. Forklift accidents involving a breach of waste drum(s) due to drops or punctures were evaluated both with and without a resulting fire. These events are representative of drum drops or other mishandling accidents. Consequences from events with no subsequent fire were considered to have low consequences onsite and offsite. This is primarily because the impacts associated with forklift accidents or other mishandling accidents are not expected to result in catastrophic rupture, ejection and dispersion of all drum contents. Forklifts are relatively slow moving vehicles, and waste handling activities would not involve elevating drums significantly higher than heights to which they are qualified (i.e., Type A containers must withstand drops up to 4 ft). Consequences to workers immediately in the area of an accident could be higher, but are still not expected to be significant.

A forklift collision with staged drums that results in a breach and an ensuing fuel pool fire that impacts TRU waste is considered *unlikely*. Forklifts used for waste handling operations are generally powered by electric current, propane, or diesel fuel. This event is focused on diesel-powered forklifts, which are the only type with potential to create a pool fire. Other types are not considered to result in a fire that engulfs a targeted drum.

The forklift collision/fire event results in a pool fire, but is not expected to result in 100% ejection of drum contents (see above assumptions on assumed damage to drums from forklift accident) resulting from the impact. Based on a Hanford drum study conducted by Hughes Associates and documented by Westinghouse Hanford Company (Ref. 3-10), no significant expulsion of drum contents was observed in full-scale tests of drums engulfed in a pool fire. Therefore, the thermal effects of a pool fire are also not expected to result in ejection of drum contents. This event is modeled based on a fraction of drum contents that is subject to a pool fire consisting of 10 gallons of diesel fuel, which results in a medium size fire as calculated by LLNL (Ref. 3-23). A MAR of 100 PE-Ci is involved in the event, with the majority remaining in the drum and burning as confined combustible waste. Unmitigated consequences to the public or onsite workers could be in the "moderate" range for this event, resulting in a Risk Class II event. Therefore, this event is analyzed further in the accident analysis. Worker exposures for those immediately in the area of an accident could be significant if the worker were to remain in the vicinity for an extended period of time. The consequences of this event can be precluded by the elimination of diesel fuel forklifts, which is the primary recommendation of the Hanford drum study.

3.3.2.3.2 Hazards Common to All MCUs

Electrical Fire. The primary hazardous event that is common to all MCUs is a fire from an electrical short that leads to a fire which impacts waste drums. Electrical fires are conservatively considered as an *anticipated* event. Experimental data in a large-scale drum test (Ref. 3-12) conducted with a relatively large fire yielded a catastrophic drum failure rate less than 0.1 with negligible expulsion of the drum contents. Therefore, this event is modeled as a drum with seal failure or lid loss, resulting in the burning of packaged, contaminated combustible waste. Assuming a MAR of 100 PE-Ci, the public and onsite consequences from this event are considered to be *low*, resulting in a Risk Class III event. Radiological impacts to immediate workers would be *low* unless they remained in an MCU for an extended period of time, in which case physical injuries would be much greater than any radiological consequence.

Deflagration. A deflagration is considered to have an unmitigated frequency of at least *unlikely* (once every 100 to 10,000 years) for unvented drums and *extremely unlikely* (once in 10,000 to 1,000,000 years) for vented drums. Container vents are designed specifically to release gases generated inside waste drums. If they function as designed, they will dramatically reduce the frequency of hydrogen gas buildup that could lead to drum deflagration.

The accident considered a deflagration of a single container due to the accumulation of flammable gas, chemical reaction of incompatible materials, or prohibited containers in waste containers. This event could theoretically occur within any MCU, although unvented drums are either moved directly to the MOVER unit or DVS unit for replacement of the lid. Therefore, these MCUs are the most probable location for a deflagration.

The deflagration causes the lid to release, followed by ejection of some of the drum contents. As supported by the *Safety Analysis and Risk Assessment Handbook* (Ref. 3-13), assumptions for a hydrogen deflagration in a drum, a fraction of flammable gases could potentially occupy the interstitial spaces between the drum contents; however, the primary force of the flammable gas expansion would be downward on the MAR and upward on the drum lid since the drum fails by lid clamping ring failure. The deflagration event is conservative because it is a high-energy event that ejects and burns the contents outside and inside the container. It is also modeled as a non-buoyant, ground level, non-meandering plume, maximizing the dose to the onsite receptor. Based on these assumptions, the consequences are expected to be low for the public, but could be in the moderate range for the onsite worker and high for the immediate worker in the vicinity of the deflagration. This results in a Class II event and is therefore evaluated further within the accident analysis.

Criticality. The likelihood of criticality accidents was evaluated for drums stored at the WIPP (Ref. 3-14). The evaluation concluded that 55-gallon drums, each containing 200 FGE and stacked three high and infinite in the x-y plane, as well as SWBs, each containing 350 FGE stacked three high and infinite in the x-y plane, are sub-critical.

Waste containers that are involved in characterization activities must comply with WIPP WAC requirements regarding FGE content. Therefore, the unmitigated frequency of an inadvertent criticality during staging is considered to be *beyond extremely unlikely*.

These events result in an overall probability of inadvertent criticality of less than 1E-06, which is not credible. Neither a Criticality Detection System nor a Criticality Alarm System is required. In no case will any drum exceed the established fissile limit, 200 Pu-239 FGE. In addition, the TRUPACT-II casks cannot contain more that the WIPP established limit of 325 Pu-239 FGE per cask.

3.3.2.3.3 Non-Destructive Examination (NDE)

No hazard events were identified that were unique to the RTR units. X-ray hazards are considered SIHs that are adequately addressed under OSHA and 10 CFR 835 (Ref. 3-17). See Section 3.3.2.3.2 for events that are common to all MCUs.

3.3.2.3.4 Non-Destructive Assay (NDA)

No hazard event were identified that were unique to the NDA characterization units. See Section 3.3.2.3.2 for events that are common to all MCUs.

3.3.2.3.5 Headspace Gas Sampling (HSGS) and Analysis

The HSGS and analysis operations have no postulated accidents with consequences of concern. Consequences to the worker are considered *low* as a result of an injection injury or inhalation from a dropped HEPA filter. There are no consequences to the public.

Handling accidents involving gas cylinders can also occur. Consequences to the worker are estimated to be *low* before controls are credited. Consequences to the public are estimated to be *low* without controls.

There are no interactions between the systems in the HSGS unit that would result in accident conditions of significance. If the HEPA blower fails (and power is still on to the HVAC unit) there should be no backflow due to the HVAC unit. The HVAC unit is set up for at least 70% outside air (it may be 100%). This means that the HVAC system will draw most of its air from the outside with a small amount of recirculation. The net flow will be into the structure, which would not cause the HEPA system to backflow. There is little possibility of any contamination due to the method used to drawing the sample. The compressed air system is actually installed outside of the unit in the utilities box, and the various pressurized bottles are similar to other bottles used in lab work that are placed in bottle racks.

Deflagrations are the primary accident of concern within the Drum Venting System (DVS). These type of accidents are applicable to the DVS and MOVER units and are evaluated in Section 3.3.2.3.2.

3.3.2.3.6 Mobile Visual Examination and Repackaging (MOVER)

Two events were identified for the MOVER with consequences of concern. A vehicle impact to the MOVER unit with sufficient energy to breach the unit and the glovebox inside the unit is considered to *beyond extremely unlikely* because of the tremendous energy required for such an event and the relative low speed and mass of a forklift that could cause damage (i.e., limited to forklifts because of initial condition regarding vehicle controls).

The primary event of concern is a medium size fire that initiates inside the glovebox because of improper use of tools. This type of operational event is *anticipated* (i.e., human error). Were it to occur, a fire could potentially breach a glovebox port resulting a loss of primary confinement and a release of burning TRUW. The MOVER mobile unit, which is a certified Type A container, could provide confinement in this event. Therefore the event is modeled similar to a drum with lid loss (i.e., Type A container that still provides some confinement of packaged waste). To be conservative, the event is also evaluated without confinement of packaged waste. The MAR for this event is 100 PE-Ci of TRU waste that is contained within a glovebox, rather than a sealed drum. A medium size fire is evaluated since the TRU waste and small amounts of solvents incidental to operations are the only sources of combustible material. Considering the most conservative case, this event could have moderate level consequences to the public and moderate to high level onsite consequences. Radiological impacts to immediate facility workers could be high if they remained in the MOVER unit for an extended period of time, in which case physical injuries would be much greater than any radiological consequence. This accident is considered a Risk I event, primarily because it is an *anticipated* event, and is therefore analyzed further in the accident analysis.

The HEPA filters are rated for high temperature (500°F), so the ventilation system is not expected to be breached (Ref. 3-15). Furthermore, the release is mostly retained by the MOVER unit (i.e., Glovebox Operation Room and also either the Control Room or the Drum Entry Room at either end of the MOVER unit). The mitigated consequence to the worker is expected to be *low*. The Glovebox Operation Room has a manually activated fire suppression system. There is also a can of fire suppression material in the glovebox that can be used on incipient fires. Neither fire suppression application is credited in the PrHA.

A drum deflagration was also considered for the MOVER unit, which may be used at some sites for replacing/installing vents on unvented drums. This event is evaluated in 3.3.2.3.2 and bounded by the glovebox fire event, which assumes a fire and breach of the glovebox. Consequences would be similar to that event.

3.3.2.3.7 TRUPACT-II Loading

The hazardous events that are unique to TRUPACT-II Loading segment involve various drop scenarios of drum payloads. As part of the Critical Lift process, a crane lifts payloads approximately 13 ft in order to put them into the TRUPACT-II cask. A high-speed swing of the drums into a large object (TRUPACT-II cask, building, vehicle) could cause a breach of drums. Operator error leading to a drop and release is *anticipated*. A vehicle accident where the crane or payload is impacted leading to a release is *unlikely*. If the vehicle impacts the crane, the load may swing, but the event requires that the TRUPACT-II lift fixture to fail. In general, equipment failures are considered *unlikely*. The MAR involved in these events is a payload that consists of 14 drums, each loaded to the WIPP WAC of 80 PE-Ci, which results in a MAR of 1120 PE-Ci. Although the payload is lifted to a height that could challenge the integrity of the drums if dropped, it is assumed that only 25% of the drums would have their contents ejected, or 3.8 drums that is conservatively rounded up to 4 drums (320 PE-Ci). This is primarily because of the packaging required by WIPP. Payloads are shrink-wrapped prior to loading into the TRUPACT-II and this provides substantial confinement. Based on these factors, the unmitigated public and worker consequences are considered *low* from these events. This results in a Risk Class III event. Qualified operators are used to operate the crane. The rigging procedure (payload assembly and lift) is per a DOE approved TRUPACT-II SAR (Ref. 3-16). The process of loading the TRUPACT-II is controlled by a special WIPP trained team.

3.3.2.3.8 External Events

The primary external hazard with potential impacts of concern is an aircraft crash. Based on the small footprint size for the MCUs, including TRUPACT-II loading, an aircraft crash leading to the release of radioactive and/or hazardous material is considered *extremely unlikely* (once every 10,000 to 1,000,000 years). Unmitigated consequences of a coincident fire are expected to be in the moderate range for the public and moderate to high range for onsite workers. Facility worker impacts could be high if they are in the immediate vicinity of the crash. For an aircraft crash impacting the footprint of the MCUs, the dose was conservatively estimated based on the entire inventory (100 PE-Ci). This results in a Risk Class II event and is therefore evaluated further in the accident analysis.

3.3.2.3.9 Natural Phenomenon Hazards

Common mode failures were considered in the PrHA presented in Appendix B. Mitigation relies on human performance (e.g., training, evacuation) rather than SSCs. These phenomena are generally not abrupt so that personnel can respond (e.g., move waste in doors).

The frequencies of NPH events are discussed below. The TRU waste characterization and TRUPACT-II loading activities are limited life operations. The probability of an NPH event occurring in the life of the facility is reduced significantly if the actual duration of the project was considered.

Seismic Events. The design basis earthquake (DBE) seismic event is *unlikely*. For each DBE event in the PrHA where controls were required to mitigate the risk to the worker, personnel evacuation was credited to reduce the consequences of the accident. The ability of the MCU structures to withstand a DBE and to not interfere with personnel evacuation is discussed below.

The MCUs were not designed to DOE NPH standards. These units were designed and built to rigorous DOT standards. Furthermore, the MOVER is a DOT-7A Type A Container. Based on engineering judgment regarding the design of these units, it is believed that the characterization units are robust enough to survive a DBE without structural collapse, and personnel evacuation would not be prevented in the event of a DBE.

Another accident scenario initiated by an earthquake is an electrical fault that starts a fire. The unmitigated frequency of this event is *unlikely*. This event is modeled similar to event CH-1 (Table B-3), which results in *low* onsite consequences. Immediate worker impacts could be significant for workers who are incapacitated and encumbered from evacuation, although the radiological consequences would likely be masked by the physical injuries caused of the seismic event.

The mitigated frequency of earthquake accident scenarios in the PrHA are the same as the unmitigated frequency.

Lightning. The MCUs are not protected by lightning arrestors, but the units are of metal construction and they are grounded. Lighting strikes are conservatively estimated to be *unlikely* events based on regions of the United States having a higher flash density. The consequences from these events are expected to be similar to that of an electrical short that initiates a fire, as evaluated in Event CH-1 (Table B-3). This event is expected to result in low radiological consequences.

High Winds. The frequency of high winds is estimated to be in the frequency range of *anticipated* (once every 1 to 100 years). The frequency of a wind-driven missile impacting waste drums and causing a spill of radioactive or hazardous material is estimated to be in the frequency range of *unlikely*. Missiles are typically generated from loose components and materials near a facility, but they could also be generated from building components (such as a door) that are blown free by high wind. The consequences of such an event are estimated to be low based on the high dispersion of impacted radiological materials.

3.3.2.4 Planned Design and Operational Safety Improvements

As a result of the Hazard Analysis, no specific design or operational safety improvement changes were identified.

3.3.2.5 Defense-in-Depth

This section summarizes significant aspects of the defense-in-depth philosophy as implemented to provide safety for MCU operations. Proposed controls are presented in the Appendix B PrHA tables according to specific hazardous events and further discussed with in Section 3.3.2.8 as related to protection of facility workers. This section provides a summary of defense in depth established according to various accident types and consist of Design Features, explicit Administrative Controls and SMPs. Defense-in-depth also includes Safety Significant SSCs and ensures that the health and safety of the public and the workers are not adversely impacted by the design and operation of the TRUW Segments.

Common Controls. There are controls applied throughout MCU operations that apply to all analyzed scenarios. These "common controls" include both engineered and administrative features. The cumulative effects of the common controls typically reduce the unmitigated risk by reducing the likelihood and the consequences to both the public and the worker. The following list identifies controls common to all analyzed accident scenarios:

- Radioactive Inventory Control
- Container Inspection Program
- Emergency Response Program,
- Radiation Protection Program
- Hazardous Material Protection Program
- Quality Assurance Program
- Criticality Safety Program (Note: Criticality accidents are not credible for the amount and physical form of the fissile material)
- Conduct of Operations Program, including working to approved procedures
- Training Program.

Fires. Fire is a significant contributor to the risk, and can result from several different causes. Controls that provide Defense in Depth to prevent or mitigate effects of fire accidents are given in Appendix B. The specific controls in conjunction with the common controls provide adequate protection to the worker and public against exposure to hazardous materials in the event of a fire. These controls are:

- Radioactive Inventory Limits
- TRUW drum integrity (i.e., DOT certified Type A container, or equivalent)
- Container inspection program
- Glovebox confinement (enclosure and associated HEPA filters)
- MOVER design integrity (i.e., DOT certified Type A container, or equivalent)
- Fire suppression system (MOVER glovebox)
- Drum Venting System design
- Equipment designed to NEC
- Combustible control program;
- Ignition control
- Maintenance, testing, and inspection
- Emergency Response

Vehicle Accidents. Several vehicle events were identified that can result in damage to drums through collisions or drops. These incidents are primarily limited to forklifts because of physical vehicle controls (i.e., initial condition) that preclude larger vehicles from impacting staged drums or MCU trailers. Defense in depth is provided through the following controls:

- Radioactive Inventory Control
- TRUW drum integrity (i.e., DOT Type A container, or equivalent)
- Restrictions on use of diesel powered forklifts
- Vehicle access controls
- Operator training
- Vehicle maintenance, testing and inspection

Drum Spills and Mishandling Accidents. Spills are significant contributors to risk, and can result from several different causes, including operator error and vehicle accidents. Safety controls contributing to Defense in Depth regarding spill events are discussed in Appendix B. The specific controls in conjunction with the common controls provide adequate protection for the worker and public against exposure to hazardous materials in the event of a spill. These controls are:

- Radioactive Inventory Control
- TRUW drum integrity (i.e., DOT certified Type A container)
- Ventilation systems and HEPA filtration (MOVER unit and glovebox)
- Equipment design (drum-manipulating devices and positioning systems)
- Prohibition on stacking of drums greater than two high
- Hoisting and rigging (drum loading operations
- Vehicle control
- Conduct of operations
- Maintenance, testing, and inspection
- Emergency Response

External Events. Controls contributing to Defense in Depth for external events, such as vehicle impacts that could cause fires or spills, are listed in Appendix B. The discussion for fire accidents (above) forms the basis for externally initiated fires. The discussion for spill prevention (above) forms the basis for externally initiated spills. The specific controls in conjunction with the common controls provide adequate protection to the worker and public against exposure to hazardous materials in the event of an external event. Unique controls for external events are:

- Radiological Inventory control
- TRUW drum integrity (i.e., DOT certified Type A container)
- Vehicle access controls
- Safe Separation Distance between MCUs
- Emergency Response

Natural Phenomena Hazards. Controls contributing to Defense in Depth for NPHs such as high winds and seismic events that cause spills or fires are given in Appendix B. The discussion for fire accidents (above) forms the basis for seismically initiated fires. The discussion for spill prevention (above) forms the basis for seismically or wind-initiated spills. The specific controls in conjunction with the common controls provide adequate protection for the worker and public from exposure to TRUW materials in the event of a natural phenomena event. Unique controls for NPH events are:

- Securing devices (as needed in high wind areas)
- Lightning protection for MCUs
- Siting of MCUs outside of flood plain

3.3.2.6 Safety Significant Structures, Systems, and Components (SSCs)

The facility and process safety features identified in the hazard analysis were reviewed in the context of the significance of their safety function to identify Safety Significant SSCs. As a general rule of thumb, Safety Significant SSC designations are characterized as SSCs whose failure is estimated to result in a worker fatality or serious injury to workers or significant radiological or chemical exposures to workers. SSCs not designated as Safety Class but whose preventive or mitigative function is a major contributor to Defense in Depth (i.e., prevention of uncontrolled material releases) and/or worker safety as determined from hazard analysis are also considered to be Safety Significant SSCs.

Based on the PrHA and section 3.4, there are no SSCs designated as Safety Class. Table 3-6 provides a listing of Safety Significant SSCs designated based on the PrHA.

Section 4 discusses the safety function for each of these Safety Significant SSCs.

3.3.2.7 Technical Safety Requirements

TSR coverage is required for safety-related SSCs and important Administrative Controls. The derivation of these controls is presented in Section 5.

Table 3-6 provides a breakdown of SSCs and Administrative Controls that are proposed for TSR coverage.

Table 3-6. Safety Significant SSCs and TSR Administrative Controls

Control	Safety Function/Importance to Safety	Designation	TSR
TRU Waste Drum Integrity	Requires DOT Certified Type A containers in order to provide containment of radioactive materials and prevent release of radioactive material to the public and workers. Buildup of flammable gases within the drums is mitigated by the presence of carbon composite filters placed on vented TRU waste drums	SS	TSR-DF TSR-AC
MOVER Structural Integrity and Confinement	Prevent structural failure or damage during and following operational, natural phenomena, or external events. Requires that container be certified Type A container	SS	TSR-DF
MOVER glovebox Confinement (including high temperature HEPA Filtration)	Provide confinement to potential airborne radioactive material, thus preventing release of radioactive material from the glovebox to working areas and the public.	SS	TSR-DF TSR-AC
DVS Design- explosion-proof chamber	Provide blast confinement, protect operator from effects of detonation and pressure release.	SS	TSR-DF
Radiological Inventory Limit	Reduce the consequences of a spill or fire by limiting the amount of radioactive material available for release. Inventory shall be maintained less than 100 PE-Ci per MCU segment or container and 200 Pu-239 FGE per container.	Programmatic	Explicit AC
Ignition Source Controls	Reduces possible initiators for fires within MOVER glovebox	Programmatic	Explicit AC
Prohibition on the Use of Diesel Powered Forklifts	Significantly reduces the likelihood of a significant drum breach and fire resulting from a forklift accident	Programmatic	Explicit AC
Requirement to use non-sparking, spark-resistant, or spark-proof tools within MOVER glovebox	Reduces the likelihood of a fire within the glovebox that could lead to a radiological material release	Programmatic	Explicit AC
Separation Distances Between MCUs	Maintains safe separation distances between MCU (siting criteria)	Programmatic	Explicit AC
Vehicle Access Controls	Defines measures (including physical barricades), policies, and actions to prevent or minimize occurrence of vehicle related accidents.	Programmatic	AC
Container Inspection Program	Provides visual surveillance and inspection of drums to identify signs of pressurization or degradation that could challenge drum integrity	Programmatic	AC
Emergency Response Program	Reduce the consequences of an accident through emergency response procedures, personnel communication systems, emergency drills, and other program elements that ensure effective evacuation.	Programmatic	AC

Table 3-6. Safety Significant SSCs and TSR Administrative Controls

Control	Safety Function/Importance to Safety	Designation	TSR
Hazardous Material Protection Program	Reduce the likelihood of hazardous material accidents, such as fires or toxic releases, through a program that ensures proper handling of hazardous materials by procedures for their use and storage.	Programmatic	AC
Maintenance, Testing, and Inspection Program	Reduce the likelihood of an accident, resulting in release of radioactive material or worker injury caused by equipment failure, through programs requiring maintenance, testing, and inspection of equipment to confirm proper operation and continued reliability.	Programmatic	AC
Quality Assurance Program	Reduce the likelihood and consequences of accidents though a program that ensures commitments made in the safety analysis are properly implemented.	Programmatic	AC
Radiation Protection Program (RPP)	Reduce likelihood of worker exposure to radioactive material or radiation through a program that implements 10 CFR 835, Occupational Radiation Protection (Ref. 3-17).	Programmatic	AC
Training Program	Reduce the likelihood of an accident by ensuring workers can successfully and safely execute actions defined by programs and supporting procedures. Training reduces the frequency of human error by improving awareness of hazards that could lead to worker injury or insults to radioactive waste.	Programmatic	AC
Criticality Safety Program	Prevent the likelihood of a criticality by ensuring that the specified quantities of fissile material are not exceeded.	Programmatic	AC
Fire Protection Program (Including Combustible Loading Control Programs)	Reduce the likelihood of fires by controlling the sources of ignition and reduce the spread and consequences of fires by limiting the quantities of combustibles and maintaining the operability of automatic fire suppression systems. The manually operated fire suppression system on the glovebox provides a means of mitigating the effects of a fire in the MOVER glovebox.	Programmatic	AC
Hoisting and Rigging	Reduces the likelihood of payload drops and spills associated with TRUPACT-II loading operations	Programmatic	AC

3.3.2.8 Worker Safety

The major features protecting workers from hazards associated with accidents occurring during facility operation are discussed in previous section. They include the description of Safety Significant SSCs and Administrative Controls requiring TSRs.

The hazards to workers in the TRUW mobile units associated with normal and abnormal conditions include potential exposure to radionuclides and safety and health hazards. Radiation exposure can occur with radioactive materials within TRU waste drums or from exposure to contamination that may exist on the surfaces of waste drums or waste-handling equipment. The sources of safety and health hazards include electrical hazards, motion hazards, gravity-mass hazards, and pressure, heat, and noise hazards.

SMPs are relied on primarily for worker protection and are described further in Chapter 6. As stated previously, the focus of the Hazards Analysis is on potential accident conditions. From the list of SMPs, the following were considered to be the most significant for worker safety. They are included in the TSRs and are described in Chapter 4.

- Criticality Safety Program. Ensures that the frequency of a criticality is beyond extremely unlikely
- Radiation Protection Program. Ensures that workers are provided adequate protection from radiological hazards, including training and monitoring
- Emergency Preparedness Program. Ensures that workers are aware of the proper response actions in the event of an emergency
- Fire Protection Program. Ensures that the facility has provisions in place for combustible loading control and adequate fire detection capabilities
- Initial Testing, In-Service Inspection and Test, Configuration Management, and Maintenance Program. Ensures the integrity of the Safety Significant SSCs. Inspections are performed by qualified personnel using documented procedures
- Training Program. Ensures that operators are qualified to perform their specified duties and thereby minimize exposure to hazardous conditions

The hazard evaluation in Section 3.3.2.3 concluded that there may be significant radiological consequence to facility workers, i.e., *moderate* consequence in Table 3-2. The expected occupancy of individual units in the MCU is low, and facility workers are directly involved in the operations. In addition, the hazard evaluation in every case in Appendix B concluded that the Safety Management Program, including for example prompt evacuation from the MCU in the event of a fire, will preclude the potential for significant radiological exposures to facility workers. Therefore, no specific additional Safety Significant SSCs based solely on facility worker safety other than those already identified as Safety Significant SSCs to protect the co-located workers and the public were deemed necessary.

3.3.2.9 Environmental Protection

Protection of the environment is the result of design and operational features that reduce the potential for large releases of radioactive waste to the environment. The impacts to the environment from the scenarios discussed in this chapter are considered less than the impacts to the public. The controls identified in the PrHA are considered sufficient to address the impacts to the environment.

3.3.2.10 Accident Selection

Four of the accident scenarios in the hazard evaluation were determined to have a Risk Class I or II based on the qualitative hazard analysis. These events are considered further in Section 3.4, *Accident Analysis*, and include:

- VE-5: Improper use of tools in MOVER glove box
- WH-6: Fire involving a forklift accident with staged drums
- CH-2: Deflagration of Hydrogen in an unvented waste drum
- EE-3: Small aircraft crash into MCUs

3.4 Accident Analysis

This section presents the analysis of the postulated accidents selected from the hazard analysis described in Section 3.3.2.10, "Accident Selection." An evaluation was performed to assess the relative risk for each postulated accident. The methodology to determine the dose consequences of the postulated accidents is discussed in Section 3.4.1. Analyses of the dominant accident scenarios, including controls credited in each accident scenario, are presented in Sections 3.4.2.1 through 3.4.2.3.

Results of the conservative analysis in this section show that the design and operations of the characterization activities in the MCUs do not pose a significant risk on the health and safety of the public and the workers.

3.4.1 Methodology

The accident analysis methodology complies with the guidelines in DOE-STD-3009-94 (Ref. 3-2). For each bounding accident, the accident scenario is developed to enable characterization and quantification of the source term. The dose consequence analysis is based on the source term analysis and the results of the atmospheric diffusion analysis. The source term is calculated by:

$$ST = MAR \times ARF \times RF \times DR \times LPF$$

where *MAR* is the quantity of radioactive inventory at risk, *ARF* and *RF* are airborne release fraction and respirable fraction from DOE-HDBK-3010-94, respectively, *DR* is the damage ratio, and *LPF* is the leakpath factor. For unmitigated cases, a value of unity is assumed for *LPF*.

The source term is then multiplied by the potential dose consequence for unit of radioactivity released to the environment yielded by the atmospheric diffusion analysis. For postulated accidents involving plume buoyancy, the atmospheric diffusion analysis was performed using the computational code MACCS2 based on the joint frequency data, conservative terrain conditions, and building dimensions to maximize the dose consequences. The analysis yielded dose consequences for a unit radioactive release as a function of distance and the plume-sensible heat (Ref. 3-23). For postulated accidents not involving plume buoyancy, building dimensions were ignored for a conservation estimate of the dose consequence.

Radiation dose consequences are the product of the source term and the dose to source term ratio. Dose consequences are expressed in total effective dose equivalent (TEDE), which consists of the effective dose equivalent for radiation exposure from external sources and the committed effective dose equivalent for radiation exposure from internal sources absorbed by inhalation and ingestion. Unmitigated and mitigated dose consequences are reported for the co-located worker (at 100 m) and the Maximally

Exposed Offsite Individual (MOI) located at the nearest site boundary at a minimum of 200 m from the MCU. The potential consequences to the facility workers were qualitatively evaluated in the hazard analysis in Section 3.3.

The accident analysis in this chapter has been simplified consistent with the graded approach. The following conservative and simplifying assumptions were used in the analysis:

- An LPF of unity is assumed for the building. That is, the radioactive particulate entrained in the exhaust ventilation flow is not reduced even though the release that would occur through the ceiling of the MCU would result in reduction of the LPF by gravitational settling and agglomeration.
- The bounding ARF×RF fromDOE-HDBK-3010-94 (Ref. 3-8) is used for the postulated accidents for simplicity and conservatism. As an example, for burning of packaged contaminated waste, a combined value of $5\times10^{-4}\times1$ is recommended as the bounding value for ARF×RF in DOE-HDBK-3010-94. However, experimental data in Figure A.41 of DOE-HDBK-3010-94 supporting $5\times10^{-4}\times1$ show that a value less than 0.3 is more appropriate for RF.

Dose conversion factors (DCFs), whether in Federal Guidance Report (FGR) No. 11 or 13 (Ref. 3-19, 3-20), are based on a particle size distribution of 1 µm AMAD (activity median aerodynamic diameter). The RF in DOE-HDBK-3010-94 is the portion of the airborne particulate with sizes less than 10 µm AED (aerodynamic equivalent diameter). In the example discussed above in Figure A.41 of DOE-HDBK-3010-94, the particle size distribution is approximately 5 µm AMAD. This would lead to a reduction in DCFs. As an example, in ICRP 68 (Ref. 3-18), the DCF for 1 µm AMAD and 5 µm AMAD are 5.6×10^{7} rem/Ci and 3.1×10^{7} rem/Ci, respectively, for Type S ^{239}Pu.

MACCS2 use inhalation DCFs in FGR 11 (Ref. 3-19). For Pu^{239}, the CEDE DCF for inhalation class Y, which is appropriate for the materials in the MCUs, is 3.08×10^{8} rem/Ci in FGR 11. In comparison, the DCF in ICRP 71/72 (Ref. 3-21) for Type S, equivalent to Class Y in FGR 11, is 1.6×10^{-5} Sv/Bq (5.9×10^{7} rem/Ci) for 1 µm AMAD. Data in ICRP 71/72 have been issued by the U.S. EPA as Federal Guidance Report No. 13 (Ref. 3-20) in September 1999.

The DCF is based on solubility of the chemical form of plutonium. Type S in FGR 13 (Solubility Class Y in FGR 11) is assumed for all scenarios since most of the contamination is expected to be plutonium oxide. Type M in FGR 13 (Solubility Class W in FGR 11) is appropriate for nitrates or other soluble plutonium compounds, e.g., plutonium chloride, which have higher DCFs as discussed above. However, the amount of soluble plutonium contamination on most legacy TRU wastes is expected to be minimal. Plutonium nitrate contamination from aqueous plutonium recovery processes is expected to oxidize over time from exposure to air. PuF_4 readily decomposes. Consequently, plutonium nitrate, plutonium chloride, and plutonium fluoride or other soluble plutonium compounds are not expected to be significant portions of the radioactive inventory at most DOE sites.

Even if the particle size distribution is conservatively ignored, there is a reduction factor of 5.2 if FGR 13 (Ref. 3-20) data are used. Based on the results on MACCS2, the estimated dose consequences are manually reduced by a factor of 5.2 in this analysis as means to employ the DCFs in FGR 13. Based on the factors discussed, radiation dose consequences predicted in the accident analysis are conservative.

Results of the accident analysis may be different from those in the hazard analysis; results of the hazard analysis are qualitative in nature whereas the accident analysis is quantitative.

3.4.2 Design Basis Accidents

The PrHA identifies events with potential radiological consequences that require further analysis. The accident analysis requires a radiological analysis to determine the impact to the off-site receptor at the nearest site boundary.

This section analyzes design basis accidents to quantify consequences and compare them to the evaluation guideline. From the hazards analysis, several events were identified as the bounding accidents requiring further evaluation in the accident analysis:

- A potential fire involving combustibles in the glovebox leading to uncontrolled release of radioactive contaminant.
- A spill in the yard with subsequent fire postulated to occur from a high-speed vehicle accident impacting an array of staged TRU waste containers.
- A deflagration involving one container due to ignition of hydrogen gas in an unvented TRU waste container.

3.4.2.1 A Fire Involving TRU Waste in Glovebox of Visual Examination and Repackaging Unit

A potential fire involving flammable liquid or combustibles in the building leading to uncontrolled release of radioactive contaminant in TRU waste containers was considered to ensure that the spectrum of potential credible accidents remains analyzed consistent with the DOE guidance.

While bulk storage of flammable liquid is not permitted, a limited quantity of flammable liquids incidental to operations, such as solvents, may be present. The quantity of flammable liquid present in the facility is substantially below the exempt quantities for the occupancy type of MCU. In a potential fire in the MCU, the dominant release is from burning contaminated waste in the glovebox during visual examination and repackaging.

3.4.2.1.1 Scenario Development

TRU drums are visually examined and repackaged for verification and to bring drums into compliance with WIPP WAC in the MOVER. During the visual examination and repackaging activities, a fire is postulated in the glovebox in the MOVER. The maximum radionuclide inventory of 100 PE-Ci (Pu^{239} Equivalent Ci) is assumed to be spread out in the glovebox.

The pyrolytic decomposition temperature for sustained combustion of cellulosic materials is 280°C. The 1% thermal decomposition temperature, which is not sufficient for sustained combustion, of common plastics, such as HDPE, LDPE, and PVC, exceeds 450°K (from Table 1-7.4, *The SFPE Handbook of Fire Protection Engineering*, 2nd edition [Ref. 3-22]). Thus, a large ignition source would be necessary for a sustained fire involving contaminated waste in the glovebox, which would lead to a conclusion that a potential fire resulting in an uncontrolled release of a significant quantity of radioactivity is *unlikely*. Although the population of TRU waste drums containing 100 PE-Ci, i.e., not in compliance with WIPP WAC, is expected to be small, a potential fire in the MOVER glovebox during repackaging is conservatively assumed to be *anticipated*.

3.4.2.1.2 Source Term Analysis

The container limit of 100 PE-Ci is used as the MAR. For an unmitigated scenario of burning unconfined combustible wastes, ARF×RF of $1\times10^{-2}\times1$ from Section 5.1 of DOE-HDBK-3010-94 (Ref. 3-8) for unconfined "largely cellulosic mixed wastes" is assumed. It is stated in DOE-HDBK-3010-94 that the value of 1×10^{-2} for ARF×RF is very conservative for most applications due to the limited number of experiments, small quantities of plutonium and combustible wastes (that could provide a depth of burn-residue that may attenuate airborne release from large piles of materials), and very fine plutonium oxide particles on the wastes. It also states that "the potential extent of the conservatism needs to be appreciated so that the value is not cavalierly applied to the majority of burning waste circumstances inappropriately".

DOE-HDBK-3010-94 recommends ARF×RF of 5×10^{-2} for burning of unconfined plastics (except polystyrene, which is the same as cellulosics). Most DOE sites with legacy TRU wastes did not separate cellulosic wastes from contaminated plastics, e.g., gloves and windows on the glovebox, because plutonium was not recoverable economically. Therefore, the expected type of contaminated waste in repackaging or visual examination in the MOVER glovebox is largely cellulosic materials with a limited quantity of plastics, including multiple plastic bags used for contamination control. A large quantity of contaminated waste could also be noncombustible materials with a lower ARF×RF value of $6\times10^{-3}\times0.01$, but these are conservatively ignored in the analysis. Thus, the source term estimate using the unconfined burning of contaminated waste is conservative.

The source term for unconfined burning of contaminated waste is then:

$$ST = 100\,\text{PE Ci} \times 1\times10^{-2} \times 1 \times 1 \times 1 = 1\,\text{PE Ci}$$

However, the MOVER is of noncombustible construction that provides a metal confinement feature similar to DOT Type A drums. Combined with the confinement provided by the glovebox, including the exhaust ventilation system with HEPA filtration, the source term for the postulated fire can be reduced. The postulated fire involving the contaminated waste in the glovebox is ventilation-limited. While the value of ARF×RF of $1\times10^{-2}\times1$ is assumed to estimate the source term, the condition is such that the value of ARF×RF would be between the assumed $1\times10^{-2}\times1$ and the April 1973 experiment in DOE-HDBK-3010-94 that yielded the combined ARF×RF of 5×10^{-4} for the packaged burning of the contaminated waste.

In addition, transport phenomena such as thermophoresis, gravitational settling, and agglomeration from a ventilation-limited fire in a small compartment such as the glovebox would significantly reduce the LPF to a value significantly less than unity. However, the value of unity is conservatively assumed for the unmitigated postulated fire, consistent with Appendix A of DOE-STD-3009-94 (Ref. 3-2). Thus, the estimated source term is bounding for the postulated ventilation-limited, small compartment fire in the MOVER glovebox.

3.4.2.1.3 Consequence Analysis

The unmitigated release based on unconfined material release fraction would result in a buoyant plume. This was evaluated with the MACCS2 code using a small 1-MW fire inside the glovebox involving about 2.5 m^2 of trash or one rigid 55-gallon drum liner. The estimated plume sensible heat is then 0.4 MW from a total heat loss of 60% to the surrounding by radiation and conduction to structures, e.g., the glovebox. The unmitigated dose consequence is 77.1 rem/PE-Ci at the nearest site boundary located at 200 m from the MCU based on dose conversion factors in FGR 11 (Ref. 3-19). The radiation dose consequence to the MOI (maximally exposed offsite individual) based on DCFs in FGR 13 (Ref. 3-20) is then:

$$TEDE = 1\,\text{PE Ci} \times \frac{77.1}{5.2}\ \text{rem}/_{\text{PE Ci}} = 15\ \text{rem}$$

The dose consequence result from MACCS2 at 100 m for the 0.4 MW plume is 230 rem/PE-Ci. The radiation dose consequence to the onsite worker is then:

$$TEDE = 1\,\text{PE Ci} \times \frac{230}{5.2}\ \text{rem}/_{\text{PE Ci}} = 44\ \text{rem}$$

For comparison, the sector-specific dispersion analysis yielded results that are lower by a factor of approximately 3, i.e., 27.9 rem/PE-Ci in lieu of 77.1 rem/PE-Ci at 200 m. With the sector-specific atmospheric dispersion analysis results alone, the predicted dose consequence at the nearest site boundary of 200 m would be less than 5 rem. Because the postulated fire in the glovebox will be ventilation limited, transport phenomena such as agglomeration, thermophoresis, and gravitational settling will reduce the actual source term significantly. For the postulated fire, sufficient energy is not available to change the particle size distribution already present in the contaminated waste, which is expected to be plutonium oxide contamination. Furthermore, the particle size distribution would be affected by soot generation to drive the RF to less than unity assumed in this analysis. When these factors are combined, the estimated dose consequences are conservative.

3.4.2.1.4 Comparison to Guidelines

The unmitigated estimate of the radiological consequences to the public is 15 rem. In Section 3.4.2.1.3, it was shown that the sector-specific atmospheric dispersion analysis results would reduce the predicted dose consequence at the nearest site boundary to approximately 5 rem. As discussed in Section 3.4.2.1.2, a mechanistic analysis will lead to a substantial reduction of the LPF and ARF×RF. While the magnitude of reduction is only qualitatively evaluated, the MOVER as a noncombustible metal confinement feature, similar to DOT Type A drums, with robust HEPA filters will decrease the radioactive release from the postulated fire. The HEPA filters, which are shown to be robust for plugging concerns and high temperature effects (Ref. 3-26), are identified as an integral part of the Safety Significant, passive confinement boundary of the MOVER.

In conclusion, uncertainty associated with the predicted dose consequence of 15 rem would lead to a significant reduction because the bounding value for each parameter in the dose consequence analysis was assumed. Thus, the predicted dose consequence of 15 rem is considered not to challenge the evaluation guideline in Appendix A of DOE-STD-3009-94 (Ref. 3-2).

3.4.2.1.5 Summary of Safety Class SSCs and TSR Controls

Because the mission has a short term life expectancy at a temporary location and the radioactive inventory is administratively controlled to 100 PE-Ci, no Safety Class SSCs or administrative provisions are identified from the analysis to prevent or to mitigate the consequences of the postulated fire in the glovebox involving contaminated waste.

The MOVER as a metal container and the glovebox, including high temperature-rated HEPA filters, are required as Safety Significant items to mitigate the dose consequences of the postulated fire in the glovebox. Provisions in the fire protection program, such as combustible loading control and ignition source control, provide defense in depth to assure that the likelihood of occurrence of a fire is minimized. The manually actuated glovebox fire suppression system is not required to mitigate the potential consequences in this analysis. In addition, the inventory limit of 100 PE-Ci per container was assumed in the analysis. These are captured in the TSRs to ensure that the conclusion of the analysis remains valid.

3.4.2.2 Large Fire Involving Staged TRU Waste Containers in Yard

Before containers are transported into an MCU for characterization, they are staged in the yard. An individual container or multiple containers (for instance, a pallet of drums, can be transported at one time). The volume and type of vehicle traffic near MCUs are controlled and the speed of the vehicles is, in addition to the onsite speed limit, spatially limited. A potential collision involving a forklift used to transport TRU waste drums from other facilities for characterization is evaluated.

Based on the results of the hazard analysis in Section 3.3, an array of drums involved in a vehicle accident with a fire involving the fuel from a truck is precluded as one of the scenarios due to physical barriers and other vehicle controls being implemented at the site. Staging TRU waste drums for characterization units is temporary. The likelihood of occurrence of a potential forklift collision with temporarily staged TRU waste drums containing the maximum quantity of radioactivity is small. However, this section provides a bounding analysis involving the staged drums to ensure that the postulated fire ensuing a potential collision with a forklift does not adversely impact the health and safety of the public and the workers.

3.4.2.2.1 Scenario Development

An array of drums containing 100 PE-Ci is staged outside MCU. The total inventory at risk is, thus, 100 PE-Ci. A high-speed forklift is postulated to impact the array of staged drums. Of the staged drums in the array, one third of the drums is assumed directly impacted by the forklift and assumed to lose their structural integrity from the impact, even though each drum is capable of sustaining a 4-ft drop.

The contents of the impacted drums are assumed to be scattered in the yard. Further, 10 gallons of diesel in the fuel tank leak to form a fuel pool with a diameter of 8.9 ft surrounding the drums and the scattered uncontained contaminated waste from the impacted drums. The fuel pool is subsequently ignited into a fire that engulfs the remaining drums and the scattered content of the impact-breached drums. The computed magnitude of the postulated fire was 8.9 MW lasting 140 seconds (Ref. 3-23).

A collision of a forklift involving an array of staged drums is *extremely unlikely*.

The site speed limit and spatial limitation surrounding MCU are ignored in the analysis. Even then, a concurrent high-speed forklift collision leading to the fuel tank failure and the subsequent diesel fuel pool fire in the vicinity of MCU is considered *beyond extremely unlikely*, but is used as a bounding event to estimate the consequences for all credible fires. Hence, the postulated large fire involving staged drums in the yard is evaluated in this section.

3.4.2.2.2 Source Term Analysis

The source term consists of the MAR, the ARF and RF, DR, and the LPF. The array limit of 100 PE-Ci is used as the MAR. The bounding ARF×RF of $5\times10^{-4}\times1$ from Section 5.1 of DOE-HDBK-3010-94 for "contaminated combustible materials heated/burned in packages with largely non-contaminated exterior surfaces (e.g., packaged in bags, compact piles, pails, drums)," is assumed in computing the source term for the waste that burns in the containers.

For the scattered content of breached drums from the collision, the bounding ARF×RF of $1\times10^{-2}\times1$ from Section 5.1 of DOE-HDBK-3010-94 (Ref. 3-8) for "uncontained cellulosics or largely cellulosic mixed waste" is assumed. A higher release fraction from burning contaminated plastics was previously discussed in Section 3.4.2.1.2. The summary of assumptions in the analysis is as follows:

- The total inventory at risk in the array is 100 PE-Ci.
- One third of the contaminated waste is expelled upon impact and burns on the ground (DR = 1/3).

The two-thirds remaining in containers burns as packaged waste (DR = 2/3).

An LPF of unity is used for unmitigated analysis. The source term is a combination of releases from uncontained burning and burning packaged waste, as follows:

$$ST = \sum \begin{bmatrix} 100\text{ PE Ci} \times 1 \times 10^{-2} \times 1 \times \frac{1}{3} \times 1 \\ 100\text{ PE Ci} \times 5 \times 10^{-4} \times 1 \times \frac{2}{3} \times 1 \end{bmatrix} = 0.37\text{ PE - Ci}$$

This is a conservative estimate of the source term. The contribution to the source term from the postulated impact is minimal because the combined value of ARF×RF at $1 \times 10^{-3} \times 0.1$ is lower than the uncontained burning by two orders of magnitude. Experimental data in a large-scale drum test (Ref. 3-12) conducted with a larger 14.5-MW fire yielded a catastrophic drum failure rate less than 0.1 with negligible expulsion of the drum contents. The drum seal failure rate observed in the experiment was 0.5. Thus, the total failure rate for drums engulfed in a large 14.5-MW fire was 0.6. This illustrates the conservatism in assuming 100% failure of all drums in the array with a smaller 8.9-MW fire (Ref. 3-23).

3.4.2.2.3 Consequence Analysis

Ten gallons of diesel fuel is assumed to spill from the fuel tank and form a fuel pool with a resulting diameter of 8.9 ft surrounding the drums and the scattered uncontained contaminated waste from the impacted drums. The computed magnitude of the postulated fire is 8.9 MW lasting 140 seconds (Ref. 3-23) resulting in a plume sensible heat of 5 MW when the fuel pool is ignited.

The potential dose consequence for unit of radioactivity released to the environment for a plume sensible heat of 5 MW is 24.6 rem/PE-Ci at the nearest site boundary for the sector dependent 95th percent result. The radiation dose consequence to the MOI based on FGR 13 (Ref. 3-20) is then:

$$TEDE = 0.37\text{ PE - Ci} \times \frac{24.6}{5.2}\ \text{rem}/\text{PE - Ci} = 1.8\ \text{rem}$$

The potential dose consequence for unit of radioactivity released to the environment is 30.9 rem/PE-Ci at 100 m. The radiation dose consequence to the onsite worker based on FGR 13 (Ref. 3-20) is then:

$$TEDE = 0.37\text{ PE - Ci} \times \frac{63.5}{5.2}\ \text{rem}/\text{PE - Ci} = 4.5\ \text{rem}$$

For the postulated fire, sufficient energy is not available to change the particle size distribution already present in the contaminated waste, which is expected to be plutonium oxide contamination. The particle size distribution of the source material in Figure A.41 of DOE-HDBK-3010-94 (Ref. 3-8) for packaged burning indicates a respirable fraction less than 0.3 for the case representative of contaminated waste. Therefore, the estimated dose consequences are conservative.

3.4.2.2.4 Comparison to Guidelines

The conservative estimate of the radiation dose consequences to the public is 0.73 rem. This is well below, and is considered not to "challenge", the evaluation guideline of 25 rem discussed in Appendix A of DOE-STD-3009-94 (Ref. 3-2).

3.4.2.2.5 Summary of Safety Class SSCs and TSR Controls

No Safety Class SSCs or administrative provisions are identified from the analysis to prevent or to mitigate the consequences of the postulated fire involving the staged TRU waste drums for characterization activities.

Although they are not required to mitigate the dose consequences of the postulated large fire involving a diesel fuel pool, drums or other containers provide the means to packaging contaminated waste for transport and handling and provide defense in depth in postulated accidents. Vehicle access control, including physical barriers, and speed limit around the MCU provide defense in depth to assure that the likelihood of occurrence of an accidental collision with staged TRU waste drums is minimal. In addition, the inventory limit of 100 PE-Ci per array staged in the yard is assumed. These are captured in the TSRs to ensure that the conclusion of the analysis remains valid.

3.4.2.3 Deflagration in TRU Waste Drum

Container handling is a routine part of operations in the MCUs. TRU waste is packaged in polyethylene bags and contained in steel containers, such as vented Type A drums, standard waste boxes, and oversized boxes. A potential exists for the buildup of radiolytic hydrogen in sealed TRU waste containers.

Based on the results of the hazard analysis in Section 3.3, radiolytic hydrogen buildup and deflagration in TRU waste containers is identified as one of the risk-dominant scenarios analyzed in the accident analysis. Consequently, this section provides a bounding analysis involving the staged drums to ensure that the postulated fire does not adversely impact the health and safety of the public and the workers.

3.4.2.3.1 Scenario Development

A deflagration of radiolytic hydrogen scenario can compromise the structural integrity of a drum and lead to an uncontrolled release of radioactive contaminants.

The duration to reach the lower flammability limit (LFL) of 4% hydrogen by volume is calculated as 1,480 hours assuming a 20% void space in a hermetically sealed 55-gallon drum containing 8 PE-Ci (Ref. 3-24). Adjusting the equation in the referenced calculation to account for 80 PE-Ci drums, the duration to reach the LFL of 4% hydrogen by volume becomes approximately 148 hours. This is a conservative estimate because a larger container or a larger void space in a 55-gallon drum would require a longer duration to reach the LFL. For a larger Standard Waste Box or a larger void volume in a 55-gallon drum, the duration to reach LFL will increase linearly—again, only if the container is hermetically sealed. Based on the radioactive inventory in drums, and the required duration and conditions to reach LFL, the postulated radiolytic hydrogen deflagration involving a low hydrogen concentration above LFL in one container with 80 PE-Ci is *unlikely*.

3.4.2.3.2 Source Term Analysis

The container limit of 80 PE-Ci is used as the MAR. The bounding ARF×RF of $1 \times 10^{-3} \times 1$ is recommended in Section 5.1 of DOE-HDBK-3010-94 (Ref. 3-8) for "venting of pressurized gases over contaminated, combustible waste in containers because of the waste material's "flexible nature, which does not provide a rigid surface for airflow to act upon." It is stated in the same section that ARF×RF values of $1\times10^{-3}\times1$ are "applicable only to the portion of waste surfaces that are actually exposed."

The potential combustion energy from a deflagration of a hydrogen-air mixture at LFL in the 20% void space is 20.2 kJ (19 Btu) (Ref. 3-24). Even at the stoichiometric concentration, the potential combustion energy from a deflagration, equal to 150 kJ (142 Btu), is not sufficient to bring contaminated cellulosic materials to the exothermic pyrolytic decomposition temperature of 280°C or a quantity of polyethylene to the 1% thermal degradation temperature of 548°K (Table 1-7.4, *The SFPE Handbook of Fire Protection Engineering*, 2nd ed [Ref. 3-22]), which is not sufficient to initiate a fire. Thus, a fire following a hydrogen deflagration is not postulated consistent with the physical limitation.

According to vendor data for Type A drums, the typical hydrostatic pressures at failure range from 170 kPa (24 psig) to 250 kPa (36 psig). The computed AICC (adiabatic, isochoric complete combustion) pressure from a deflagration of hydrogen at the lower flammability limit (LFL) is 23 psig (HC/AB-B696-0202). Actual pressure measurements indicated that the deflagration is less than 90% of the predicted AICC pressure at low hydrogen concentrations up to 15% by volume. Therefore, a hydrogen deflagration at LFL is not likely to compromise the integrity of a container.

The likely location for accumulation of radiolytic hydrogen is at or near the top of a container because of buoyancy. The exposed surface of contaminated waste would thus be limited. Based on the provision in DOE-HDBK-3010-94 to apply "only to the portion of waste surfaces that are actually exposed," only a nominal portion of waste surfaces would be exposed directly to a deflagration pressure. As discussed above, drum failure is not likely for a deflagration involving low hydrogen concentrations; thus, a DR of 0.2 is used. An LPF of unity is used for unmitigated analysis.

The source term is then:

$$ST = 80\text{ PE Ci}\times10^{-3}\times1\times0.2\times1 = 1.6\times10^{-2}\text{ PE Ci}$$

Gravitational settling and agglomeration would reduce the actual value for the LPF for a potential deflagration in a MCU.

3.4.2.3.3 Consequence Analysis

The dose consequence result is 84 rem/PE-Ci at the nearest site boundary located at 200 m from the MCU. The radiation dose consequence to the MOI based on FGR 13 (Ref. 3-20) is then:

$$TEDE = 1.6\times10^{-2}\text{ PE Ci}\times\frac{84}{5.2}\text{ rem}/\text{PE Ci} = 0.26\text{ rem}$$

The dose consequence result at 100 m is 750 rem/PE-Ci. The radiation dose consequence to the onsite worker based on FGR 13 (Ref. 3-20) is then:

$$TEDE = 1.6\times10^{-2}\text{ PE Ci}\times\frac{750}{5.2}\text{ rem}/\text{PE Ci} = 2.3\text{ rem}$$

This dose consequence of a potential deflagration bounds that of a potential single drum spill in a MCU. This confirms that a spill inside the MCU is a contamination event that does not pose a significant impact on the health and safety of the public.

3.4.2.3.4 Comparison to Guidelines

The conservative estimate of the radiation dose consequences to the public is 0.26 rem. This is well below, and is considered not to challenge, the evaluation guideline of 25 rem discussed in Appendix A of DOE-STD-3009-94 (Ref. 3-8).

3.4.2.3.5 Summary of Safety Class SSCs and TSR Controls

Safety Class SSCs or administrative provisions are identified from the analysis to prevent or to mitigate the consequences of the postulated deflagration, which bounds those of spills. However, vented drums and programmatic provisions (e.g., TRU waste container maintenance program and training program) to limit the potential for a container mishandling and breach provide defense in depth to prevent or to mitigate the consequences of the postulated deflagration and spill in MCU.

Although they are not required to mitigate the dose consequences of the postulated spill in the facility, drums or other containers provide the means for packaging contaminated waste for transport and handling and provide defense in depth in postulated accidents. In addition, the inventory limit of 80 PE-Ci per container was assumed in the analysis. These are captured in the TSR to ensure that the conclusion of the analysis remains valid.

3.4.3 Beyond Design Basis Accidents

The evaluation of accidents beyond the design basis (BDB) are required in DOE-STD-3009-94 (Ref. 3-2) to provide a perspective of the residual risk associated with the operation of the facility. These postulated events serve as bases for cost-benefit considerations if consequences exceeding evaluation guidelines are identified in the beyond DBA range. One external event, a general aviation single-engine aircraft crash, was identified in the hazard analysis for further evaluation and is considered in this section for its potential impact on the health and safety of the public.

Beyond design basis operational accidents are not considered further in this section because the postulated events analyzed in Section 3.4.2 did not require any provisions to mitigate the consequences.

3.4.3.1 Aircraft Crash into MCU

A general aviation aircraft with a single reciprocating engine carrying a full tank of fuel (general aviation gasoline) is postulated to crash into an MCU. The crash is postulated to be followed by a large fire involving gasoline spilled from the aircraft. This leads to additional failure of drums from the engulfing fire in the building. For the purpose of the consequence analysis, the assumed inventory impacted by the postulated crash is 100 PE-Ci.

The total area occupied by the MCUs during characterization activities is small and the projected duration is short. Thus, the administrative control on the radioactive inventory is sufficient to minimize the potential impact on the health and safety of the public and the workers.

3.4.3.1.1 Crash Probability Analysis

The probability of an aircraft crashing into MCU was evaluated using the method and data in DOE-STD-3014-96 (Ref. 3-7). The probability of an aircraft crash must be evaluated to bound the risk presented by surrounding airports and types of aircraft and operations in those airports.

A significant uncontrolled release could occur only if the aircraft crash is followed by a fire involving fuel in the aircraft. The conditional probability of occurrence of a fire from a general aviation aircraft crash is approximately 0.3 (Ref. 3-25). The conditional probability of a direct impact on the stacked drums all containing significant quantities of radioactivity is less than unity. In addition, the expected duration of the characterization activities at the site is on the order of one year. Combining all factors together, the probability of the worst-case, concurrent aircraft crash (a direct impact followed a large fire involving the maximum radioactive inventory of 100 PE-Ci) leading to an uncontrolled release of a significant quantity of radioactivity is *extremely unlikely* or *beyond extremely unlikely*.

3.4.3.1.2 Consequence Analysis

The source term consists of the MAR, the ARF and RF, DR, and the LPF. The facility limit of 100 PE-Ci is used as the MAR. The bounding ARF×RF of $5\times10^{-4}\times1$ from Section 5.1 of DOE-HDBK-3010-94 (Ref. 3-8) for "contaminated combustible materials heated/burned in packages with largely non-contaminated exterior surfaces (e.g., packaged in bags, compact piles, pails, drums)," is assumed in computing the source term for the waste that burns in the containers.

For the scattered content of breached drums from the impact by the postulated aircraft crash, the bounding ARF×RF of $1\times10^{-2}\times1$ from Section 5.1 of DOE-HDBK-3010-94 for "uncontained cellulosics or largely cellulosic mixed waste" is assumed. For conservatism, the aircraft is postulated to breach the integrity of the TRU waste drum containing the maximum radionuclide inventory of 80 PE-Ci.

All TRU waste drums, including the impacted TRU waste drum, are then assumed to be involved in the subsequent fire involving gasoline on board the aircraft. The contribution to the source term from the postulated impact is minimal because the combined value of ARF×RF at $1\times10^{-3}\times0.1$ is lower than the uncontained burning by two orders of magnitude. This bounds the potential source term from the postulated general aviation aircraft crash.

The source term is a combination of releases from uncontained burning and burning packaged waste, as follows:

$$ST = \sum \begin{bmatrix} 80\text{ PE Ci}\times1\times10^{-2}\times1\times1\times1 \\ 20\text{ PE Ci}\times5\times10^{-4}\times1\times1\times1 \end{bmatrix} = 0.81\text{ PE - Ci}$$

The quantity of fuel on board the aircraft in the postulated aircraft crash is assumed to be 10 gallons. A larger quantity of fuel in the analysis will increase the plume sensible heat and, thus, decrease the potential dose consequences because of the increased lofting of the radioactive plume. From Section 3.4.2.2, the potential dose consequence for unit of radioactivity released to the environment for a plume sensible heat of 5 MW from a fire involving 10 gallons of fuel is 24.6 rem/PE-Ci at the nearest site boundary for the sector dependent 95th percent result. The radiation dose consequence to the MOI based on FGR 13 (Ref. 3-20) is then:

$$TEDE = 0.81\text{ PE - Ci}\times\frac{24.6}{5.2}\ \text{rem}/\text{PE - Ci} = 3.8\ \text{rem}$$

The potential dose consequence for unit of radioactivity released to the environment is 63.5 rem/PE-Ci at 100 m. The radiation dose consequence to the onsite worker is then:

$$TEDE = 0.81\,\text{PE - Ci} \times \frac{63.5}{5.2}\ \text{rem}/\text{PE - Ci} = 9.9\ \text{rem}$$

For the postulated fire initiated by the aircraft crash, sufficient energy is not available to change the particle size distribution already present in the contaminated waste, which is expected to be plutonium oxide contamination. The particle size distribution of the source material in Figure A.41 of DOE-HDBK-3010-94 (Ref. 3-8) for packaged burning indicates an RF of less than 0.3 for the case representative of contaminated waste. Therefore, the estimated dose consequences from a postulated aircraft crash are conservative.

Considering that (1) the MCU mission has a short-term life expectancy, (2) the inventory is being administratively controlled to a low level, (3) the MCU footprint is small, resulting in a minimal aircraft crash probability, and (4) the predicted dose consequences are low, no additional administrative control is deemed necessary.

3.5 References

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3-2. DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*. U.S. Department of Energy, Washington, DC, Change Notice 2, April 2002.

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3-20. EPA 402-R-99-001, Federal Guidance Report No. 13, *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, U.S. Environmental Protection Agency, Washington, DC, 2002.

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3-22. *The SFPE Handbook of Fire Protection Engineering*, Society of Fire Protection Engineers, Boston, MA, 2nd edition, 1996.

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CHAPTER 4
SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS

4.1 Introduction

This chapter identifies the safety SSCs that are specifically credited for reducing the frequency and/or consequence of a credible accident leading to an uncontrolled release of radioactive material. They were selected using criteria and hazard analyses derived in this BIO. The selection criterion includes consideration of the need to minimize risk to workers.

4.2 Requirements

This section identifies DOE and industrial design orders, codes, standards, and regulations that establish the safety basis for the facility, that were used in preparing this chapter, and that pertain to the safety analysis. They are:

- 10 CFR 830, Nuclear Safety Management (Ref. 4-1)
- DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, U.S. Department of Energy, Washington, DC, (Ref. 4-2)
- Title 49, Code of Federal Regulations, *Transportation*, Parts 173, U.S. Department of Transportation, Washington, DC (Ref. 4-3)
- Title 49, Code of Federal Regulations, *Transportation*, Part 178, U.S. Department of Transportation, Washington, DC (Ref. 4-4)
- AGS-G-001-94, *Guideline for Gloveboxes*, American Glovebox Society Guideline (Ref. 4-5).
- ASME AG-1, *Code on Nuclear Air and Gas Treatment*, American Society of Mechanical Engineers (Ref. 4-6)

4.3 Safety Class Structures, Systems and Components

No Safety Class SSCs were identified in the hazard analysis in Chapter 3. This is consistent with the designation of the facility as a Hazard Category (HC) 3 non-reactor nuclear facility since HC 3 facilities are not expected to have consequences that challenge the offsite Evaluation Guideline specified in DOE-STD-3009-94 (Ref. 4-2).

4.4 Safety Significant Structures, Systems and Components

Details are provided below on SSCs classified as Safety Significant (SS) as a result of the Hazards Analyses in Chapter 3. The adequacy of controls is established by describing each SSC, its safety function(s) and associated functional requirements, evaluating its functional requirements and describing the associated TSRs. The following Safety Significant SSCs were identified in Section 3.3.2.6 as the most important to safety in terms of their specific preventive or mitigative function:

- TRU waste drums
- MOVER glovebox

- MOVER Unit Glovebox Operation Room Structure
- Drum Venting System

The safety functions that these SS SSCs perform contribute substantially to preventing or mitigating the event scenarios evaluated in the PrHA, providing defense in depth and/or providing for worker safety in potentially life-threatening or disabling situations.

4.4.1 TRU Waste Drum

4.4.1.1 Safety Function

- Provides primary confinement of the TRUW to prevent release of hazardous material during TRUW handling and storage.
- Provides venting of flammable gases that may be generated inside the container from radiolytic decomposition of waste material and other reactions.

This SSC was selected for worker safety. The TRU waste drums are DOT Type-A or equivalent steel containers that provide primary confinement for TRU waste material being handled or staged during the TRUW characterization activities. Type A TRU waste containers provide the means to package contaminated waste for transport and handling and provide primary confinement against significant releases of TRUW in the event of mechanical impacts or thermal stresses.

DOT Type A containers are designed to retain integrity under normal handling and transport conditions, to resist damage due to falls from common conveyances and other mishaps, to be noncombustible to prevent fires from spreading and limit release, and to provide some protection in NPH events (e.g., earthquake, high wind, and flood).

Most of the TRU waste drums handled in the TRUW mobile units are vented. The vent allows flammable gases that may be generated inside the container from radiolytic decomposition of waste material and other reactions to vent to the atmosphere and not build up to an flammable concentration. Vents are installed in drums for flammable gas control in those drums that do not contain vents used as part of the TRU waste HSGS activities.

4.4.1.2 System Description

DOT Type A metal 55-gallon drums are used to package TRU waste that will be shipped to WIPP. Use of such metal drums with secured lids (i.e., prevents loss of primary confinement for radioactive material being characterized, staged, or handled, thus preventing a significant release of radioactive material. Standard carbon-media filter vents that meet WIPP WAC (Ref. 4-7) and the TRUPACT-II SAR Appendix 1.3.5 requirements (Ref. 4-8) are installed in the lid of drums to prevent the build up of flammable gases.

4.4.1.3 Functional Requirements

Drums must provide a level of protection that supports the bases of the hazard and accident analyses. The functional requirements for the TRU waste drums are as follows:

- Constructed of steel

- Meet DOT Type A container requirements. (Note: Requirements for these containers can be found in the Test and Evaluation Document for DOT Specification 7a Type A Packaging; DOE/RL-96-57, Volumes 1 and 2 (see http://www.hanford.gov/pss/t&p/dot7a/pdot7a.htm). The primary specification for Type-A containers is that they can withstand a 4-ft drop, without any leakage.)
- Meet DOT 17C, 17H, or UN1A2, 55-gallon (208-L) steel drum specification
- Capable of venting flammable gases
- Containers must have sound integrity, which is defined as: 1) no significant rusting, 2) sound structural integrity, and 3) does not leak. Significant rust is a readily observable loss of metal due to oxidation (e.g., flaking, bubbling or pitting) that causes degradation of the container's structural integrity. Sound structural integrity is free of denting, deformation or breaches, damage that results in creasing, cracking, or gouging, or that exposes the internal container or affects closure.

4.4.1.4 System Evaluation

The approved metal drums used to package TRU waste meet the above functional requirements. The performance criteria for the containers are that they protect the waste from mechanical and thermal stresses, elements of weather and provide confinement for the waste. To ensure that drums meet the criteria, regular inspections are performed as part of the TRU Waste Container Maintenance Program**.**

4.4.1.5 TSR Controls

The TRU metal waste drums are considered to be Design Features. A TRU Waste Container Maintenance Program is established, implemented, and maintained to preserve container integrity and minimize the likelihood of hydrogen gas buildup as described in Chapter 6. The program ensures that containers are inspected for the presence of a filter and that the containers are conditioned in a temperature-controlled environment prior to HSGS. If the drum is not vented, it is moved to the MOVER or DVS and a vent is installed in the drum.

4.4.2 MOVER Glovebox

4.4.2.1 Safety Function

- Provides confinement to prevent the release of hazardous material.

This SSC was selected for worker safety. The MOVER glovebox serves as the primary confinement structure for TRUW materials that are undergoing visual inspection. The glovebox prevents the spread of contamination in the absence of ventilation and provides confinement of radionuclides from external and operational accident events. By providing a physical barrier from radioactive materials, occupational exposure is minimized. This physical barrier is the outside of the glovebox (including the gloves and glove ports, pigtail bags around the openings, the Plexiglas covers), the first testable HEPA filter on the exhaust and intake vents, and the installed Type 7A metal drums.

4.4.2.2 System Description

The MOVER glovebox is used to visually examine and repackage TRU waste. The system boundary for Safety-Significance is the glovebox (including the gloves, glove ports, pigtail bags around the openings, the Plexiglas covers), the first testable HEPA filters, and the drums installed to support the repackaging operations. The Safety Significant portion of the glovebox does not include any active features of the glovebox. The glovebox is constructed of stainless steel and is approximately 12 ft long by 2.3 to 3 ft wide by 2.75 ft high. The glovebox has windows made of laminated shatter-resistant safety glass. The gloves are made of tear-resistant 30-mil neoprene. The glovebox is a double-sided workstation design, with a horizontal bag-on port for receiving drums. The glovebox height is supported on a stand approximately 54 in. high to allow for two 55-gallon drums to be positioned underneath. The floor of the glovebox is fitted with two specially designed sealable bag-out ports where the 55-gallon drums are positioned to receive waste. Working platforms, positioned approximately 16 in. off the floor, are located on each side of the glovebox to provide worker access to the glove ports. The glovebox is equipped with a neutron coincidence counter in the glovebox, and an equipment airlock used to transfer small items into and out of the glovebox when necessary. A drum lifter outside of the glovebox is used to position TRU waste drums at the horizontal bag-on port for the glovebox. Further information regarding the glovebox and associated equipment is provided in the System Description Document for the MOVER (Ref. 4-9).

Glovebox inlet air and exhaust filters for the glovebox are located on top of the glovebox. Air from the glovebox goes through three HEPA filters in series before being exhausted to the outside. Glovebox Operation Room air exhausts through the glovebox inlet air filter as well as through three HEPA filters in parallel mounted on the final HEPA filter housing.

4.4.2.3 Functional Requirements

As the primary confinement structure in the MOVER, the glovebox and drums (when in place) prevents spread of contamination and provides confinement of radionuclides from external and operational accident events. By forming a physical barrier, occupational exposure is minimized. The pigtail bags and gloves in the glovebox produce a barrier, such that no radionuclides escape into the room and expose personnel. The HEPA filters prevent the escape of radionuclides into the environment.

4.4.2.4 System Evaluation

The glovebox was fabricated in accordance with American Glovebox Society Guideline AGS-G-001-94 (Ref. 4-5). The materials and fabrication techniques used provide a robust structure that resists thermal and impact stresses. Windows are made of shatter-resistant glass. The glovebox is fabricated from type 304L stainless steel. Materials, forgings and fabrication meet the following ASTM standards

- A-240, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications,
- A-480, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip,
- A-276, Standard Specification for Stainless Steel Bars and Shapes,
- A-182, Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service, and
- ASTM A-479, Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels.

HEPA exhaust and inlet filters are designed and tested in accordance with ASME AG-1, *Code on Nuclear Air and Gas Treatment.* High temperature filters are designed to withstand temperatures of 500°F and tested in accordance with IEST RP-CC-001.3.

The drums meet the specification previously discussed in section 4.4.1.3.

Prior to each use, the glovebox is inspected visually to ensure integrity of gaskets, gloves, windows, drum lifter, pigtailed bags, and metal surfaces of the glovebox.

4.4.2.5 TSR Controls

The MOVER glovebox is a passive Design Feature. Prior to each use, there is a visual inspection of the glovebox, including gloves in the pumped out condition. Drums are installed and pigtailed to the glovebox prior to use. The HEPA is tested prior to use.

4.4.3 MOVER Unit Glovebox Operation Room Structure

4.4.3.1 Safety Function

- Provides secondary confinement of the TRUW to prevent release of hazardous material during TRUW sorting and repackaging operations.

This SSC was selected to provide defense in depth. The MOVER Unit is a DOT-certified, Type-A container that provide secondary confinement for TRU waste material being sorted and repackaged in the MOVER glovebox. The Glovebox Operation Room structure portion of the MOVER unit provides a means of confining any material that would escape from the primary confinement (MOVER glovebox) in the event of mechanical impacts or thermal stresses.

Air from the Glovebox Operation Room is exhausted through a room HEPA filter unit.

DOT Type A containers are designed to retain integrity under normal handling and transport conditions, to resist damage due to falls from common conveyances and other mishaps, to be noncombustible to prevent fires from spreading and limit release, and to provide some protection in NPH events (e.g., earthquake, high wind, and flood).

4.4.3.2 System Description

The MOVER Unit structure is a certified DOT 7A Type A container. The Safety Significant portion of the MOVER Unit Structure consists of the double walls including the two doors (one on each end), ceiling, floor and room HEPA filter (only non-active portion is Safety Significant) of the Glovebox Operation Room. The interior walls are sealed, polished stainless steel.

4.4.3.3 Functional Requirements

As secondary confinement, the MOVER Unit Glovebox Operation Room Structure and HEPA Filter prevents spread of contamination and provides confinement of radionuclides from external and operational accident events. By forming a physical barrier, spread of contamination to the environment is minimized.

4.4.3.4 System Evaluation

Being of robust construction, the MOVER Unit Glovebox Operation Room provides protection from thermal and mechanical stresses. The MOVER Unit is a sealed unit constructed of polished stainless steel and is a certified DOT 7A Type A container. The room HEPA filter in the Glovebox Operation Room meets ASME AG-1 *Code on Nuclear Air and Gas Treatment* (Ref. 4-6).

4.4.3.5 TSR Controls

The MOVER Unit Glovebox Operation Room structure and HEPA filter is a passive Design Feature. The HEPA is installed and tested in accordance with AG-1 *Code on Nuclear Air and Gas Treatment*. The HEPA is tested prior to each use. The MOVER Unit is certified as a DOT Type 7A container. Operating personnel are trained to close doors to the Glovebox Operation Room upon entry and exit from the room.

4.4.5 Drum Venting System

4.4.5.1 Safety Function

- Provides confinement to prevent exposure of workers to radioactive and hazardous materials that may be ejected from drums during drum venting activities.
- Provides confinement to prevent spread of radioactive and hazardous materials to the environment that may be ejected from drums during drum venting activities.
- Prevents injury to workers that may result from ejection of the waste container lid during waste container venting.

This SSC was selected for worker safety and defense in depth. Waste container deflagration events are postulated in the safety analysis. The DVS HEPA filter train (inactive portion only), inlet filter (inactive portion only), and drum cabinet protect workers and prevent spread of contamination during waste container venting activities.

4.4.5.2 System Description

The Safety Significant portion of the DVS consists of the DVS HEPA filter train (inactive portion only), inlet filter (inactive portion only), and drum cabinet, which provide confinement to reduce the likelihood and the potential consequences of a deflagration. The drum cabinet is a rectangular heavy steel box designed to enclose a 55-gallon waste drum or an 83-gallon overpack drum. The cabinet design includes a 24 x 4 in. fluid seal HEPA housing for inlet air. A backflow prevention device is present in the cabinet. Two doors are present. One is small access door used primarily to inspect the top surface of the drum for contaminants prior to opening the large, drum access door. Both doors are gasketed to provide a tight seal during both normal operating conditions and abnormal events. Both doors have sensors to indicate their open or closed status. The filter train consists of one roughing filter and two HEPA grade filters, all in series.

4.4.5.3 Functional Requirements

The HEPA Filter Train, Inlet filter and drum cabinet must be capable of withstanding the pressure and mechanical insult that could result if the waste container deflagrates with the equivalent of 15% hydrogen in air. The released radioactive materials from the DVS in a potential deflagration are limited to radioactive gases.

4.4.5.4 System Evaluation

A remote possibility exists for a deflagration of gases contained within a drum. This deflagration could produce a positive internal pressure approaching 15 psig within the Drum Containment Cabinet. The deflagration gives rise to a pressure wave lasting for a fraction of a second, which would then dissipate throughout the system. The cabinet volume and the ductwork volume are utilized to dissipate the pressure transient, along with aid of the normally existing negative pressure and the significant airflow characteristics. The flexing characteristics of the ductwork also assist in dissipating the transient. Flexing and deformation of the ductwork and filter train components is acceptable as a result of the deflagration transient.

The filter housing is constructed of 11 and 14 gauge type 304 stainless steel and is inline geometry. The ductwork provides flow balancing dampers and back-flow prevention devices. The system ventilation HEPA filter and associated system is aerosol particle (e.g., polyalphaolephin) tested before the system is used. The postulated blast would blow the filter out of the plenum's spectrometer, but the chamber is designed to deflect all effects of the blast away from the worker (see SRS Calculation S-CLC-E-00115 and NTF Incorporated Specification DS-9075-1 [Ref. 4-10, 4-11]). The backflow prevention device present in the cabinet minimizes the probability of filter failure in the case of overpressurization. Cabinet doors are gasketed to provide a tight seal during both normal operating conditions and abnormal events. The air filtration system is responsible for ensuring that any radioactive contaminants released from a waste drum by any mechanism within the DVS are fully contained within the system.

4.4.5.5 TSR Controls

The DVS HEPA Filter Train, Inlet filter and drum cabinet are passive Design Features. The HEPA System Train is tested prior to use. Doors on the drum cabinet are closed prior to venting drums.

4.5 References

4-1. 10 CFR 830, *Nuclear Safety Management*. Code of Federal Regulations, U.S. Department of Energy, Washington, DC, January 2001.

4-2. DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*. U.S. Department of Energy, Washington, DC, Change Notice 2, April 2002.

4-3. 49 CFR Part 173, *Shippers – General Requirements for Shipments and Packagings*, Code of Federal Regulations, U.S. Department of Transportation, Washington, DC, March 1999.

4-4. 49 CFR 178, *Specifications for Packagings,* Code of Federal Regulations, U.S. Department of Transportation, Washington, DC, December 1990.

4-5. AGS-G001-1994, *Guideline for Gloveboxes*, American Glovebox Society, Santa Rosa, CA, August 1994.

4-6. ASME Code AG-1-1997, *Code on Nuclear Air and Gas Treatment*, The American Society of Mechanical Engineers, New York, NY, May 1998.

4-7. DOE/WIPP 02-3122, *Contact-Handled Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant (CH-WAC)*, U.S. Department of Energy, Carlsbad Area Office, Carlsbad, NM.

4-8. *Safety Analysis Report for TRUPACT-II Shipping Package*, NRC Docket Number 71-9218, Carlsbad Field Office, U.S. Department of Energy, Carlsbad, NM, 1999.

4-9. WSMS-TR-01-0020, *Central Characterization Project System Description Document (SDD) for Mobile Visual Examination and Repackaging (MOVER)*, WSMS, Aiken, SC, Rev. 0.

4-10. S-CLC-E-00115, *The Risk of an Explosion from Drums Existing the Vent and Purge*, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC, July 1998.

4-11. DS-9075-1, Design Specification, *Design and Fabrication of the Drum Containment Cabinet*, NTF, Incorporated, August 28, 1995.

CHAPTER 5
DERIVATION OF OPERATIONAL CONTROLS

5.1 Introduction

The operational controls were developed to reduce the frequency and consequence of a credible accident leading to an uncontrolled release of radioactive material. The controls were developed using criteria and hazard analyses derived from this BIO. The development methodology also addresses criteria needed to minimize risk to workers. The operational controls that are credited in the PrHA are described in the TSRs. The TSRs constitute an agreement between the DOE and the MCU site operator regarding safe operation of both the TRU Waste Characterization Segment and the TRUPACT-II Loading Segment.

Based on the information in DOE-STD-1027-92 (Ref. 5-1), it was determined that the TRU Waste Characterization Segment and the TRUPACT-II Loading Segment are Hazard Category 3 non-reactor nuclear facilities. The TSRs consist primarily of inventory limits as well as controls preserving the underlying assumptions in the hazard analyses. Further, appropriate commitments to safety programs are presented in the Administrative Controls sections of this chapter.

5.2 Requirements

This section identifies DOE and industrial design orders, codes, standards, and regulations that establish the safety basis for the facility, that were used in preparing this chapter, and that pertain to the safety analysis. They are:

- 10 CFR 830, *Nuclear Safety Management* (Ref. 5-2)
- DOE-STD-3011-2002, *Guidance for Preparation of Basis for Interim Operation (BIO) Documents* (Ref. 5-3)
- DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports* (Ref. 5-4)

5.3 TSR Coverage

This section lists the features identified in Chapter 3 that are needed to do the following:

- provide significant defense-in-depth
- provide significant worker safety

5.3.1 Significant Defense-in-Depth Requiring TSR Coverage

Shown in Table 5-1 are the individual Design Features and their safety functions that require coverage in the MCU Segments TSRs. Table 5-2 shows the specific Administrative Control features and their safety functions that require coverage in the TSRs. Table 5-3 shows the programmatic Administrative Control features and their safety functions that require coverage in the TSRs. The details of these controls are discussed in Section 5.5.

Table 5-1 Design Features Requiring TSR Coverage

Control	Safety Function/Importance to Safety
TRU Waste Drum Integrity	Requires DOT Certified Type A containers in order to provide containment of radioactive materials and prevent release of radioactive material to the public and workers. Buildup of flammable gases within the drums is mitigated by the presence of carbon composite filters on vented TRU waste drums
MOVER Structural Integrity and Confinement	Prevent structural failure or damage during and following operational, natural phenomena, or external events. Requires that container be certified Type A container
MOVER glovebox (including HEPA Filtration)	Provide confinement to potential airborne radioactive material, thus preventing release of radioactive material from the glovebox to working areas and the public.
DVS Design -- explosion-proof chamber	Provide blast confinement, protect operator from effects of detonation and pressure release.

Table 5-2 Specific-AC TSR Coverage

Control	Safety Function/Importance to Safety
Radiological Inventory Limit	Reduce the consequences of a spill or fire by limiting the amount of radioactive material available for release. Inventory shall be maintained less than 100 PE-Ci for each MCU segment. Waste drum limits are 100 PE-Ci and 200 Pu-239 FGE.
Ignition Source Controls	Reduces possible initiators for fires within MOVER glovebox.
Prohibition on the Use of Diesel Powered Forklifts	Significantly reduces the likelihood of a significant drum breach and fire resulting from a forklift accident.
Requirement to use approved non-sparking, spark-resistant or spark-proof tools within MOVER glovebox and inspection of glovebox prior to use to verify that only approved tools are available.	Reduces the likelihood of a fire within the glovebox that could lead to a radiological material release.
Separation Distances Between MCUs	Maintains safe separation distances between MCU (siting criteria).

Table 5-2 Specific-AC TSR Coverage (cont'd)

Control	Safety Function/Importance to Safety
Vehicle Access Controls to prohibit potential impact of TRU waste drums being staged or handled.	Defines measures (including physical barricades), policies, and actions to prevent or minimize occurrence of vehicle related accidents.
Requirement that crane lift for TRUPACT-II loading is considered a critical lift and positioning of the crane such that it cannot impact material at risk in other nuclear segments.	Reduces the likelihood of payload drops and spills associated with TRUPACT-II loading operations.

Table 5-3 Programmatic-AC TSR Coverage

Control	Safety Function/Importance to Safety
Container Inspection Program	Provides visual surveillance and inspection of drums to identify signs of pressurization or degradation that could challenge drum integrity.
Emergency Response Program	Reduce the consequences of an accident through emergency response procedures, personnel communication systems, emergency drills, and other program elements that ensure effective evacuation.
Hazardous Material Protection Program	Reduce the likelihood of hazardous material accidents, such as fires or toxic releases, through a program that ensures proper handling of hazardous materials by procedures for their use and storage.
Maintenance, Testing, and Inspection Program	Reduce the likelihood of an accident, resulting in release of radioactive material or worker injury caused by equipment failure, through programs requiring maintenance, testing, and inspection of equipment to confirm proper operation and continued reliability.
Quality Assurance Program, including Drum Nonconformance program	Reduce the likelihood and consequences of accidents though a program that ensures commitments made in the safety analysis are properly implemented.
Radiation Protection Program (RPP)	Reduce likelihood of worker exposure to radioactive material or radiation through a program that implements 10 CFR 835, Occupational Radiation Protection (Ref. 5-5).

Table 5-3 Programmatic-AC TSR Coverage (cont'd)

Control	Safety Function/Importance to Safety
Training Program	Reduce the likelihood of an accident by ensuring workers can successfully and safely execute actions defined by programs and supporting procedures. Training reduces the frequency of human error by improving awareness of hazards that could lead to worker injury or insults to radioactive waste.
Criticality Safety Program	Prevent the likelihood of a criticality by ensuring that the specified quantities of fissile material are not exceeded.
Fire Protection Program (Including Combustible Loading Control Programs)	Reduce the likelihood of fires by controlling the sources of ignition and reduce the spread and consequences of fires by limiting the quantities of combustibles and maintaining the operability of automatic fire suppression systems.

5.3.2 Worker Safety

Safety Management Programs are relied on primarily for worker protection and are described further in Chapter 6. As stated previously, the focus of the hazards analysis is on potential accident conditions. From the list of Safety Management Programs, the following provide additional protective measures for worker safety.

- Criticality Safety Program. Ensures that the frequency of a criticality is *beyond extremely unlikely.*
- Radiation Protection Program. Ensures that workers are provided adequate protection from radiological hazards, including training and monitoring.
- Emergency Preparedness Program. Ensures that workers are aware of the proper response actions in the event of an emergency.
- Fire Protection Program. Ensures that the facility has provisions in place for combustible loading control and adequate fire detection capabilities.
- Initial Testing, Inservice Inspection & Test, Configuration Management, and Maintenance Program. Ensures the integrity of the Safety Significant SSCs. Inspections are performed by qualified personnel using documented procedures.
- Training Program. Ensures that operators are qualified to perform their specified duties and thereby minimize exposure to hazardous conditions.

5.3.3 Safety Class SSCs

Hazard Category 3 facilities do not have Safety Class SSCs because of the reduced magnitude of hazards. No Safety Class SSCs were identified in the Hazards Analysis in Chapter 3 for the MCU Segments for chemical hazards or radiological hazards.

5.3.4 Safety Significant SSCs

This section provides details on those segment SSCs classified as Safety Significant as a result of the Hazards Analyses in Chapter 3. The adequacy of controls is established by describing for each SSC its safety function(s) and the functional requirements to support the safety function(s), by evaluating its functional requirements, and by describing the associated TSRs. Inspection criteria is invoked as part of the Inservice Inspection & Test Program described in Section 6.5.

The following Safety Significant SSCs were identified in Section 4.3.2.3.2 as the most important to safety in terms of their specific preventive or mitigative function:

- TRU Waste Drum Integrity
- MOVER Structural Integrity and Confinement
- MOVER glovebox (including HEPA Filtration)
- Drum Venting System (DVS) - explosion-proof chamber

The safety functions that these Safety Significant SSCs perform contribute substantially to preventing or mitigating the event scenarios evaluated in the PrHA, or they provide defense in depth, or they provide for worker safety in potentially life-threatening or disabling situations. The safety function, system description, functional requirements, system evaluation, and TSR controls are described in Chapter 4.

5.5 TSR Derivation

Based on the hazard analysis, there are no Safety Limits, Limiting Control Settings, Limiting Conditions of Operation, or Surveillance Requirements. TSR coverage is required for Design Features and Administrative Controls that provide significant defense-in-depth. Table 6-1 of the TSR lists the Design Features requiring TSR coverage. Table 6-2 lists control features and assumptions that require TSR coverage. The details of implementation are specified in the individual programs. The Administrative Controls are described below.

5.5.1 Specific Administrative Controls

The following limits are specified as individual controls:

5.5.1.1 Radiological Inventory Limit

- For each MCU Segment, the radioactive material inventory shall be no greater than 100 PE-Ci. The radionuclide inventory is controlled based on the Waste Disposal Requisition (WDR). Material sealed in a certified Type-B shipping cask is not included in this inventory.

  Explanation of Requirements: The purpose of this requirement is to ensure that the radionuclide inventory in each segment remains below the Nuclear Hazard Category 2 threshold quantities per DOE STD-1027-92 (Ref. 5-1). Inventory controls were identified as an initial assumption for the activities in the PrHA. The radionuclide inventory is maintained in accordance with DOE/WIPP-069, Appendix B.

- For each approved TRU waste drum, the radioactive material inventory shall be no greater than 100 PE-Ci and the fissile material inventory shall be no greater than 200 Pu-239 FGE. If a drum is determined to exceed its initial WDR activity level after being assayed, then the Nonconforming Drum Disposition Program shall be followed.

Explanation of Requirement: Inventory controls were identified as an initial assumption for the activities in the PrHA.

- Each MCU or segment that contains 100 PE-Ci shall be separated from other nuclear facilities using an exclusion or "Keep Clear" zone of 20 ft. The area will be inspected each working day to ensure that no material has been introduced.

  Explanation of Requirement: Inventory controls were identified as an initial assumption for the activities in the PrHA. The exclusion zone ensures that there is no interaction between segments, so the MAR assumed in the analysis remains bounding.

5.5.1.2 Ignition Source Controls

- A combustible material and ignition source control program shall be implemented in MCUs. Attributes for the combustible material and ignition source program include:
  - A Fire Protection Engineering approved combustible control plan shall be implemented.
  - Flammable/combustible liquids shall not be stored outside NFPA approved cabinets
  - Hot work shall be controlled by a permitting process.

  Explanation of Requirement: Limiting combustible material and ignition source controls reduces the likelihood of a fire within the MCU or within the exclusion zone.

- Only non-sparking, spark-resistant or spark-proof tools shall be used within MOVER glovebox. Inspection of glovebox prior to use shall verify that only approved tools are available.

  Explanation of Requirement: Use of non-sparking tools within MOVER glovebox reduces the likelihood of a fire within the glovebox that could lead to a radiological material release.

5.5.1.3 Vehicle Controls

- Traffic controls shall be established and maintained that physically prohibit vehicles while TRU waste drums are staged in MCUs .

  Explanation of Requirement: Protection from vehicular traffic is judged to provide significant benefit in reducing the frequency of events impacting staged drums in the MCU Segments.

- The crane lift for TRUPACT-II loading shall be a critical lift and the crane shall be positioned such that it cannot impact material at risk in other nuclear segments.

  Explanation of Requirement: Crane positioning was identified as a control in the PrHA to ensure failure of the crane would not result in a release of radioactive material in the TRU Waste Characterization Segment or other nuclear segments.

- Diesel forklifts shall not be used.

  Explanation of Requirement: A prohibition on the use of diesel powered forklifts significantly reduces the likelihood of a significant drum breach and fire resulting from a forklift accident.

5.5.2 Programmatic Administrative Controls

5.5.2.1 Criticality Safety Program

A Criticality Safety Program shall be established, implemented, and maintained to ensure that the frequency of a criticality is *beyond extremely unlikely*. The principal controls in this program are a limit of 200 Pu-239 FGE per drum, and 325 Pu-239 FGE per TRUPACT-II cask.

The Criticality Safety Program is discussed in Section 6.1.

5.5.2.2 Radiation Protection Program

A radiation protection program shall be established, implemented, and maintained to ensure that workers are provided adequate protection from radiological hazards, including training and monitoring in accordance with requirements of 10 CFR 835. The Radiation Protection Program encompasses continuous air monitoring and differential pressure monitoring when operating the MOVER glovebox.

The Radiation Protection Program is discussed in Section 6.2.

5.5.2.3 Emergency Preparedness Program

An emergency preparedness program shall be established, implemented, and maintained to ensure that workers are aware of the proper response actions in the event of an emergency. Personnel are expected to leave the area in the event of an accidental release. Operators and others working in the segments are informed about personnel evacuation routes.

The Emergency Preparedness Program is discussed in Section 6.10.

5.5.2.4 Fire Protection Program

A fire protection program shall be established, implemented, and maintained to ensure that the facility has provisions in place for combustible loading control and adequate fire detection capabilities. This program also maintains the assumptions of the hazard analyses by including the following elements:

- Combustibles brought into the characterization units are limited to incidental material necessary to conduct operations. The MCUs are inspected weekly.
- Only incidental quantities of flammable or combustible liquids are allowed in the segments (other than any required for operations). Required materials must be stored in flammable material cabinets.
- Fire detection systems and fire extinguishers are operational.
- Each MCU Segment is separated from any other nuclear facility by a minimum of a 20 ft "Keep Clear" area
- Manually operated fire suppression in the MOVER glovebox shall be designed, installed and tested in accordance with NFPA 2001 (Ref. 5-6).

The Fire Protection Program is described in Section 6.6.

5.5.2.5 Initial Testing, Inservice Inspection & Test, Configuration Management, and Maintenance Program

An Initial Testing, Inservice Inspection & Test, Configuration Management, and Maintenance program shall be established, implemented, and maintained to ensure the integrity of the Safety Significant SSCs. The Inservice Inspection & Test program shall ensure the integrity of the Design Features. Inspections, tests, and maintenance shall be performed by qualified personnel using documented procedures. The Container Inspection Program provides visual surveillance and inspection of drums to identify signs of pressurization or degradation that could challenge drum integrity. The Initial Testing, Inservice Inspection & Test, Configuration Management, and Maintenance Program is described in Section 6.5.

- The MOVER unit HEPA filters shall be aerosol particle tested prior to use.

5.5.2.6 Training Program

A training program shall be established, implemented, and maintained to ensure that operators are qualified to perform their specified duties and thereby minimize exposure to hazardous conditions. A radiation protection training program is included to help ensure that radiation doses are kept ALARA in both MCU segments. Workers are trained in emergency response, which includes training to immediately evacuate in case of fire. Training is provided for truck and forklift operators, critical lift/hoisting and rigging for crane operators, and characterization unit operators to ensure that operators are capable of operating their equipment in a safe manner. CCP personnel are trained and qualified to operate and maintain equipment in accordance with the CCP training and qualification plan.

The Training Program is described in Section 6.7.2.

5.5.2.7 Additional Safety Management Programs

The following Safety Management Programs discussed in Chapter 6 of this BIO provide additional protective measures for worker safety and shall be established, implemented, and maintained:

- Radioactive and Hazardous Waste Management
- Operational Safety
- Procedures
- Quality Assurance, including the Nonconforming Drum Disposition Program

5.6 Design Features

The following Safety Significant SSCs were identified in Section 3.3.2.6 as the most important to safety in terms of their specific preventive or mitigative function:

- TRU waste drums
- MOVER glovebox
- MOVER Unit Glovebox Operation Room Structure
- Drum Venting System

5.6.1 TRU Waste Drums

The TRU metal waste drums are passive Design Features. A TRU Waste Container Maintenance Program is established, implemented, and maintained to preserve container integrity and minimize the likelihood of hydrogen gas buildup as described in Section 6. The program ensures that containers are inspected for the presence of a filter and that the containers are conditioned in a temperature-controlled environment prior to HSGS. If the container is not vented, it is moved to the MOVER or DVS and a vent is installed in the drum.

5.6.2 MOVER Glovebox

The MOVER glovebox is a passive Design Feature. Prior to each use, there is a visual inspection of the glovebox, including gloves in the pumped-out condition. Drums are installed and pigtailed to the glovebox prior to use.

5.6.3 MOVER Unit Glovebox Operation Room Structure

The MOVER Unit Glovebox Operation Room structure and HEPA filter is a passive Design Feature. The HEPA is installed and tested in accordance with ASME AG-1, *Code on Nuclear Air and Gas Treatment* (Ref. 5-7). The MOVER Unit is certified as a DOT Type 7A container. Operating Personnel are trained to close doors to the Glovebox Operation Room upon entry and exit from the room.

5.6.4 Drum Venting System

The DVS HEPA filter train, inlet filter and drum cabinet are passive Design Features. The HEPA system filter train is aerosol particle tested prior to use. Doors on the drum cabinet are closed prior to venting drums.

5.7 Interface with TSRs From Other Facilities

No TSRs from facilities located near the TRU Waste Characterization Segment nor the TRUPACT-II Loading Segment affect this safety basis.

5.8 References

5-1. DOE-STD-1027-92, Change Notice 1, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, U.S. Department of Energy, Washington, DC, September 1997.

5-2. 10 CFR 830, *Nuclear Safety Management*. Code of Federal Regulations, U.S. Department of Energy, Washington, DC, January 2001.

5-3. DOE-STD-3011-2002, *Guidance for Preparation of Basis for Interim Operation (BIO) Documents*. U.S. Department of Energy, Washington, DC, December 2002.

5-4. DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*. U.S. Department of Energy, Washington, DC, Change Notice 2, April 2002.

5-5. 10 CFR 835, *Occupational Radiation Protection*, U.S. Department of Energy, Washington, DC, January 2000.

5-6. NFPA 2001, *Standard on Clean Agent Fire Extinguishing System*, National Fire Protection Association, Quincy, MA, 2000.

5-7. ASME Code AG-1-1997, *Code on Nuclear Air and Gas Treatment*, The American Society of Mechanical Engineers, New York, NY, May 1998.

CHAPTER 6
SAFETY MANAGEMENT

This chapter provides an overview of the programmatic approach to safety management to protect workers, the general public, and the environment for the TRUW Waste characterization and loading activities as described in Chapter 2, Facility Description. The following program descriptions have been generalized to address key elements of SMPs that provide the foundation for an effective Integrated Safety Management System (ISMS).

The primary objective of ISMS is to perform work safely. ISMS integrates safety and environmental management standards/requirements into the work planning and execution processes. When ISMS is fully implemented, protection of the workers, the public, and the environment is a fundamental part of work performance. The Site Contractor is committed to using an integrated process to perform work safely when an ISMS is implemented at the Site. ISMS combines a diverse group of people and graded infrastructure programs to satisfy the multiple safety, environmental, and health needs. ISMS identifies the mechanisms for increasing worker involvement in work planning, including hazard and environmental impact identification, analysis, and control; work execution; and feedback/improvement processes.

The institutionalization of ES&H considerations into the work planning and execution processes at DOE sites is defined in DOE G 450.4-1, *Integrated Safety Management System Guide* (Ref. 6-1). In order to formalize the requirement to development a Safety Management System at DOE facilities, DOE approved and published a change to the DOE Acquisition Regulation (DEAR), or “DEAR Clause” (Ref. 6-2).

These SMPs are necessary to protect the facility worker, other collocated workers onsite, the offsite public, and the environment by providing a layer of defense in depth as described in DOE-STD-3009-94 (Ref. 6-3). Some specific key elements of individual SMPs have also been credited in the BIO Chapter 3 Hazards and Accident Analysis as providing significant defense in depth or are specifically credited to reduce accident frequency or to mitigate consequences, and may also be addressed in the TSR Administrative Controls.

SMPs address three major areas: (1) appropriate control of radiological and hazardous material hazards, (2) regulatory compliance with federal and state requirements, codes and standards, and standard industrial health and safety practices, and (3) good engineering and best management practices. In general, these programs are required and implemented on a sitewide basis to assure the protection of workers, the public, and the environment; however, specific aspects require implementation on a facility-specific basis, such as the TRU Characterization Units. This Chapter addresses the following SMPs as suggested in DOE-STD-3009-94 and DOE-STD-3011-2002 (Ref. 6-3, 6-4):

- Prevention of Inadvertent Criticality
- Radiation Protection
- Hazardous Material Protection
- Radioactive and Hazardous Waste Management
- Initial Testing, In-Service Surveillance, and Maintenance
- Operational Safety

- Procedures and Training
- Human Factors
- Quality Assurance
- Emergency Preparedness Program
- Provisions for Decontamination and Decommissioning
- Management, Organization, and Institutional Safety Provisions

The site contractor has general management responsibility for work performed by the CCP, and is responsible for ensuring that the CCP conducts its activities in compliance with site contractor requirements. Activities supporting the MCUs outside of the units' established facility boundaries (e.g., retrieval of waste containers) are conducted as well in accordance with site contractor plans and procedures.

The CCP is responsible for all activities within the TRU Waste Characterization Units defined facility boundary. Activities will be conducted in accordance with CCP plans and procedures, and ES&H requirements specified in the Statement of Work and Interface Document. These plans and procedures are collectively referred to as "Health and Safety Plans" in the remainder of this chapter. These plans and procedures will be reviewed and accepted by the site contractor to ensure that they meet all applicable ES&H and other requirements. Activities within the TRUPACT-II Loading Unit will be directed by CCP personnel and will be performed in accordance with TRUPACT-II plans and procedures that will be reviewed and accepted by the site contractor.

The following generalized program descriptions reflect the expectation of the combined SMPs being implemented by the Site Contractor (the owner of the TRU waste to be sent to WIPP) and their subcontractor, CCP. Generic references will be used to refer to the Site Contractor's or the CCP's specific SMP on a topic. In some cases the SMP may be a separate program manual, and for others it may be a specific procedure(s) in a broader safety program manual encompassing more than one of the ES&H disciplines. In general, specific references to DOE Orders that are contractual agreements between the Site Contractor and the DOE, as well as specific rules in the Code of Federal Regulations, are not cited. Compliance with these requirements are expected to be addressed in the Site Contractor's and/or CCP's policies, manuals and procedures and should be consulted for further information.

6.1 Prevention of Inadvertent Criticality

The site contractor's Criticality Safety Program shall be defined. The TRU Waste Characterization Unit and the TRUPACT-II Loading Unit are independent Hazard Category 2 nuclear facility segments that will stage and process TRU waste in 55-gallon drums. Based on the Hazard Analysis presented in Chapter 3, the unmitigated frequency of a criticality event related to the TRU characterization activities is considered *extremely unlikely*. With a criticality safety program in place, the mitigated frequency is considered *beyond extremely unlikely*. The double contingency principle has been used in the development of the criticality safety controls to preclude inadvertent criticality for all operations. Criticality safety in the TRU Waste Characterization Unit and the TRUPACT-II Loading Unit are ensured by a combination of engineering and Administrative Controls on the following, as described in the Criticality Safety Program:

- Drum sizes and types
- Quantities of fissionable materials
- Amounts of moderators and reflectors

- Interaction between drums in an array

The Nuclear Criticality SMP is credited in Chapter 3, Hazards and Accident Analysis, with the prevention of criticalities that would result in attributes of this SMP being identified as an Administrative Control in the TSR. This program, and its various elements, are fundamental to the prevention of inadvertent criticality. Specifically, the criticality safety program analyzes and controls fissile material and/or identifies SSCs to prevent a criticality from occurring due to TRU Characterization activities.

6.2 Radiation Protection

The site contractor's Radiation Protection Program, as it applies to the TRU characterization activities, shall be defined, and addresses the following:

- Occupational Radiation Protection per 10 CFR 835 (Ref. 6-5)
- Occupational Radiation Protection ALARA Program
- Radiological Safety Program for Radiation-Generating Devices
- ALARA Program for Radiation Protection of the Public and the Environment

The site contractor's ALARA policy is to plan and conduct its radiological activities in a manner that protects the health and safety of all its employees, contractors, the general public, and the environment. In achieving this policy, the site contractor ensures that efforts are taken to reduce radiological exposures and releases to ALARA levels.

ALARA training has been incorporated into the required General Employee Radiological Training and Radiological Worker training at site contractor. The objectives of the ALARA program are achieved in the TRU characterization activities through implementation of the following factors:

- Management involvement
- Education and training
- Facility designs
- Safety procedures
- Radiation dosimetry
- Workplace monitoring
- Environmental monitoring
- Emergency preparedness
- Program evaluations
- ALARA goal-setting
- Benefit vs. risk analyses

Operations associated with the TRU characterization activities include the potential for exposure to radioactive materials and radiation-generating devices, so they require specific controls in order to achieve occupational radiation protection. During routine operations, the combination of physical Design Features and Administrative Controls ensure that doses are kept below established limits. The characterization units incorporate controls in their design that provide protection from radiation exposure and radioactive contamination, including radiation detectors, continuous air monitors, visual and audible warnings when equipment is in use, shielding, and posted signs. In addition, a radiological control technician will be assigned to support operations. These features protect workers both inside and external to the characterization units. Specific controls for occupational radiation protection are described in the procedures for the TRU characterization activities.

Radiological protection is recognized for protecting all personnel. Based on the results of the Chapter 3 Hazards and Accident Analysis, however, no attributes were specifically identified that warrant elevation to TSR level.

6.3 Hazardous Material Protection

The site contractor's Hazardous Material Protection Program shall be defined. The Hazardous Material Protection Program requires work to be performed in a manner that protects the health and safety of employees and the public, preserves the quality of the environment, and prevents property damage. This policy is implemented through use of engineering and Administrative Controls and personal protective equipment (PPE).

The potential for exposure to hazardous materials, other than radiological hazards, in the TRU characterization activities is limited. No stand-alone chemical inventories are processed. Small quantities of hazardous materials below reportable quantities may be found in TRU waste drums. In addition, some chemicals are present based on the operation of the characterization units (e.g., liquid nitrogen, nitrogen, and helium) and incidental to equipment and maintenance (e.g., lubricants, fuel, bearing grease). Specific controls for minimizing exposures to hazardous materials are identified in the TRU characterization activities procedures and work packages.

Operations in the TRU characterization activities are monitored by the site contractor's ES&H team, which consists of multidisciplinary specialists including industrial hygienists. The industrial hygienists interface with site contractor and vendor personnel and other ES&H team members, including radiological control technicians, occupational safety engineers, health physicists, fire protection engineers, safety analysis engineers, safety and health trainers, and nuclear criticality safety engineers, to ensure the safety of personnel performing activities on the project.

The Hazardous Material Protection SMP is recognized to provide protection to all personnel. Based on the results of the Chapter 3 Hazards and Accident Analysis, however, no attributes were specifically identified that warrant elevation to TSR level.

6.4 Radioactive and Hazardous Waste Management

The site contractor's radioactive and hazardous waste management programs shall be defined. Hazardous and mixed wastes are managed in accordance with the federal RCRA and applicable state requirements as described in the site contractor's Part B Permit Application. The site may also have a "Waste Acceptance Criteria" program manual that describes the methods for meeting requirements for characterizing, packaging, and documenting waste and provides uniform acceptance criteria for storage, transport, treatment, and disposal of waste at the site. Management practices encompassing the safe and proper handling, storage, treatment, packaging, and disposition of hazardous and mixed waste have been established and are implemented. All waste handling activities will be performed in accordance with approved site contractor and CCP procedures, and personnel will be qualified and trained in the activities they are performing.

The types of waste handled in the TRU characterization units include TRU waste and possibly TRU mixed waste. The waste may consists of trash, PPE, and other processing or support equipment contaminated with TRU and non-TRU radionuclides, some of which may have trace chemical contamination. The waste is predominantly contaminated solid waste, both combustible and noncombustible. However, there may also be small amounts of powder and residual liquids. Some of the contaminants may include lead, carcinogens, solvents, and a variety of other chemicals. With the exception of the activities within the MOVER, which involve repackaging of waste, and the HSGS, where filter vents will be punctured with a needle for sampling and then replaced, all other activities in the TRU characterization activities involve handling closed drums. Waste that may be generated from the MOVER and HSGS activities includes segregated prohibited items and unsafe packages, and waste created during repackaging such as wipes, and drum filter vents. Waste may also include PPE, glovebox gloves, and HEPA filters.

The site contractor's primary objective in radioactive and hazardous waste management is to minimize impacts to workers, the public, and the environment while keeping all impacts ALARA.

The Radioactive and Hazardous Waste Management SMP is recognized to provide protection to all personnel. The Chapter 3 Hazards and Accident Analysis does not specifically identify attributes of this SMP for accident prevention or mitigation. However, container integrity, compliance with site packaging requirements, and compliance with WAC upon certification, are important attributes that are adequately controlled within the scope of the Radioactive and Hazardous Waste Management SMP.

6.5 Initial Testing, In-Service Surveillance, and Maintenance

The CCP's initial testing, in-service surveillance, and maintenance program shall be defined. Initial testing or inspection will be performed on the safety SSCs described in Chapter 5. Testing and inspection of the characterization units and TRUPACT-II casks are performed in accordance with applicable CCP procedures, plans, and checklists.

The characterization units' Health and Safety Plans and operational and maintenance procedures, prepared by the CCP and reviewed and accepted by the site contractor, identify maintenance and in-service surveillance requirements for the units, including frequency and assignment of responsibilities. This shall ensure the integrity of the Design Features and implement system checks of the RTR Vault door interlocks. Inspections, tests, and maintenance shall be performed by qualified personnel. The site contractor shall maintain and ensure the linkage between the characterization unit fire detection systems and the Site's dispatch system. Maintenance of the TRUPACT-II casks is in accordance with applicable CCP maintenance procedures that have been reviewed and accepted by the site contractor.

The Initial Testing, In-service Surveillance, and Maintenance SMP is recognized in providing protection to the workers and in the prevention of or protection from hazardous conditions. Based on the results of the Chapter 3 Hazards and Accident Analysis, however, no attributes were specifically identified that warrant elevation to TSR level.

6.6 Operational Safety

The site contractor's operational safety and fire protection programs demonstrate that the TRU characterization activities can operate without posing undue risk to the health and safety of facility workers, other onsite employees, or the general public. The Operational Safety SMP includes Conduct of Operations, Occupational Safety and Industrial Hygiene, and Fire Protection.

The TRU characterization activities shall operate in accordance with a "Conduct of Operations" procedure that is defined. This provides the requirements and guidelines to be used in developing directives, plans, and procedures relating to the conduct of operations for the project. These practices and implementation of the programs provide consistent and auditable requirements, standards, and responsibilities for TRU waste characterization and handling operations. The CCP Health and Safety Plan provides specific guidance for CCP personnel for implementation of the conduct of operations into CCP activities. This document will be reviewed and, if appropriate, accepted by the site contractor as meeting applicable site contractor requirements.

Conduct of Operations is recognized to provide protection to all personnel. However, based on the results of the Chapter 3 Hazards and Accident Analysis, no attributes were identified that warrant elevation to TSR level.

The Occupational Safety and Industrial Hygiene (OS&IH) SMP shall be defined to ensure that all applicable federal health and safety practices are effectively implemented at the site. It ensures that hazard analyses and assessments are performed to anticipate, identify, evaluate, and control facility- or activity-specific chemical, physical, biological, and ergonomic hazards. The goal of the OS&IH program is to achieve a workplace free from recognized hazards that may cause illness, serious physical harm, or death. This SMP encourages employee involvement so workers have control over their own safety and health protection. Employee involvement is implemented by ensuring that workers are properly trained for the activities they perform, participation in development of operations procedures and conducting job safety analyses, and participation in safety meetings and safety inspections. The SMP is also responsible for evaluation and review of internal and external organizations, and facilitating exemptions, exceptions, and variances to DOE and OSHA health and safety requirements.

The Chapter 3 Hazard and Accident Analysis assumes that the OS&IH Program provides protection of workers from industrial hazards associated with the TRU Characterization Units. Examples include the use of a drum lid restraining device to prevent a serious injury or fatality during HSGS and establishing a forklift safety program. This SMP is recognized to provide protection to all personnel. Based on the results of Chapter 3, however, no attributes were specifically identified that warrant elevation to TSR level.

The site contractor's fire protection program shall be defined. The fire protection program for the TRU characterization activities includes provisions for:

- Reducing the potential for the occurrence of a fire or related event in the TRU characterization activities
- Mitigating onsite or offsite releases of hazardous or radioactive materials from a fire
- Providing an acceptable degree of life safety to the site contractor, CCP, subcontractor personnel, and the public from fire in the TRU characterization activities.

The primary fuel sources within the TRU Characterization Units include the combustible contents in the waste drums, propane, liquid fuels, and hydraulic fluid from forklifts and trucks, and some combustible floor and wall coverings in the characterization units. The characterization units are light combustible units. Potential ignition sources within the TRU Characterization Units include vehicles, forklifts, electrical faults, lightning, aircraft crashes, and welding. These potential ignition sources are adequately controlled per fire protection program requirements based on OSHA and NFPA standards. In addition, combustible loading in the TRU characterization activities, excluding TRU waste, is minimized.

To ensure that DOE fire safety objectives for worker protection, property conservation, and programmatic continuity are met, the facilities associated with the TRU characterization activities will be subjected to a fire protection assessment. The formality of the assessment will depend on the monetary or programmatic loss potentials. A Fire Hazards Analysis has been performed for these mobile units.

The Fire Protection SMP is recognized to provide protection to all personnel. The Chapter 3 Hazards and Accident Analysis does not specifically identify attributes of the Fire Protection SMP for accident prevention or mitigation. However, control of combustibles, hot work controls, fire detection for the MCUs, and adequate separation distances are important attributes that are adequately controlled within the scope of the Fire Protection SMP. The fire suppression system for the MOVER glovebox has been elevated as an explicit element of the fire protection SMP.

6.7 Procedures and Training

The WIPP Permit (Ref. 6-6) authorizes the use of acceptable knowledge (AK) in appropriate circumstances to delineate waste streams and to characterize hazardous waste. WIPP WAP AK requirements are addressed in the CCP-PO-001, CCP Transuranic Waste Characterization Quality Assurance Project Plan (QAPjP). AK is further described in *Waste Analysis at Facilities that Generate, Treat, Store, and Dispose of Hazardous Waste, A Guidance Manual* (Ref. 6-7). AK can be used to support waste characterization and certification activities and depending on the application, can be used as an alternative to waste analysis or as the basis for implementing waste testing and sampling programs. Use of AK establishes a fundamental assumption for the Procedures and Training programs that operators have a basic knowledge of the wastes that are being handled.

6.7.1 Procedures

The site contractor implements its programs and controls through procedures, including administrative procedures, operating procedures, and facility or project health and safety plans. Procedures are developed by the site contractor to ensure waste is managed in a manner that will protect human health and the environment and to ensure compliance with applicable regulatory requirements.

A site contractor program shall be defined to develop, verify, maintain, and control administrative and operating procedures. Operations in the TRU Waste Characterization Unit outside of the characterization units are performed in accordance with applicable site contractor procedures. Activities within the characterization units are performed by CCP personnel and are performed in accordance with applicable CCP procedures that dictate the operation of the characterization units. CCP procedures are developed, reviewed, approved, revised, and distributed in accordance with the CCP document control procedure. These procedures have been reviewed and accepted by the site contractor as meeting applicable *Site* requirements.

The Procedures SMP is recognized as providing protection to the workers and in prevention of, or protection from, hazardous conditions. Based on the results of the Chapter 3 Hazards and Accident Analysis, however, no attributes were specifically identified that warrant elevation to TSR level.

6.7.2 Training

The purpose of the site contractor's training program is to provide appropriate instructional support to enable personnel to develop and maintain competencies for successfully executing work assignments. The site contractor's policy for ES&H training is to ensure that all personnel have the training, commensurate with their responsibilities, required to protect their health and to perform work in a competent, safe, and environmentally sound manner. The site contractor's ES&H training program encourages workers to think about safety and integrate ES&H into their work planning and execution. Workers are expected to apply their skills and knowledge to provide protection for themselves, fellow workers, site contractor facilities, the public, and the environment.

The site contractor training program requirements shall be defined. A training implementation matrix for the hazardous waste management personnel describes the selection, qualification, and training requirements for site contractor personnel involved in the operation, maintenance, and technical support of the TRU characterization activities.

The CCP training and qualification plan describes the qualification and training requirements for personnel characterizing, packaging, certifying, transporting, and compiling AK information for TRU waste destined for disposal at the WIPP. CCP personnel operating the characterization units are required to meet the requirements in this plan, as well as site contractor-specific training requirements. Prior to operations, the site contractor training will conduct a job analysis of the activities to be performed and compare the results with site contractor-specific requirements. This job analysis will include a review of the CCP training and qualification plan. If any gaps are identified between CCP personnel training requirements and the site contractor-specific requirements, the site contractor training will ensure that CCP personnel receive the appropriate training prior to performing the activities requiring this training.

The Training SMP is recognized as providing protection to the workers and in prevention of, or protection from, hazardous conditions. Workers are trained in emergency response, which includes instructions to immediately evacuate in case of fire. Training is provided for truck and forklift operators, critical lift/hoisting and rigging for crane operators, and characterization unit operators to ensure operators are capable of operating their equipment in a safe manner. However, based on the results of the Chapter 3 Hazards and Accident Analysis, no attributes were specifically identified that warrant elevation to TSR level.

6.8 Human Factors

Human factors engineering focuses on designing facilities, systems, equipment, and tools so they are sensitive to the capabilities, limitations, and needs of humans. The human factors process considers the involvement of humans in the potential operational accidents of the facility and identifies the important human-machine interfaces for safety-related SSCs. This involvement may be with respect to prevention (e.g., inspection and surveillance activities, drum handling, drum moving) and mitigation (e.g., shutdown of operations during off normal and emergency situations) activities. Human factors considerations are not within the scope of a specialized safety program, but rather are guidelines and requirements that all ES&H disciplines apply during their reviews and assessments.

Chapter 3 describes the accidents that are likely to involve workers. The MCUs were designed and are operated in accordance with applicable human factors practices. Transport of waste drums into and out of the TRU characterization activities area is done with vehicles, including trucks and forklifts. Individual drums of waste are moved within the TRU characterization activities area using forklifts or manually by lifting, rolling drum dollies, or similar drum movers. All operations in the TRU characterization activities area are performed by personnel trained to perform the activities. As part of their training, personnel are made cognizant of major pieces of equipment. The site contractor and CCP personnel use operating procedures in their daily work that list the appropriate PPE required for each operation.

Human factors considerations are recognized as providing protection to the workers and in prevention of, or protection from, hazardous conditions. Based on the results of the Chapter 3 Hazards and Accident Analysis, however, no attributes were specifically identified that warrant elevation to TSR level.

6.9 Quality Assurance

The site contractor's quality assurance (QA) policy requires all programs and line organizations to use QA to assist in providing confidence that objectives will be achieved with due consideration for ES&H concerns. The site contractor's quality assurance program (QAP) shall be defined and shall meet the requirements of 10 CFR 830 Subpart A, "Quality Assurance" (Ref. 6-8). This QAP serves as the primary QA reference for site contractor and CCP personnel performing activities associated with the TRU characterization activities. It serves as the basis for audits and reviews, identifies formal controls and documentation requirements, and provides a means of feedback to verify the effectiveness of the controls and achievement of quality goals. The QAP is implemented through procedures, instructions, and procurement documents established by the site contractor.

TRU waste characterization and certification activities conducted by CCP personnel are performed in accordance with the Quality Assurance Program Document and Quality Assurance Project Plan requirements and implementing procedures identified in the CCP TRU waste characterization QAPD project plan (which must also meet the requirements of 10 CFR 830 Subpart A), waste certification plan, and TRUPACT-II authorized methods for payload control document. These documents will be reviewed and accepted by the site contractor as meeting applicable site contractor QAP requirements.

The CCP provides characterization services for the site contractor's TRU waste according to the Carlsbad, New Mexico WIPP permit and other regulatory requirements, including the WIPP Waste Analysis Plan and WAC. This work is performed under a comprehensive QAP that meets the requirements defined in the WIPP Quality Assurance Program Document.

The QAP is recognized to provide protection to all personnel. Based on the results of the Chapter 3 Hazards and Accident Analysis, however, no attributes were specifically identified that warrant elevation to TSR level.

6.10 Emergency Preparedness Program

The site contractor Division emergency preparedness program administrative and operating procedures. It describes the emergency management system; provides emergency planning procedures for Operational Emergencies; describes the system's organizational elements, interfaces, authorities, responsibilities, resources, and actions to be taken in response to emergencies; and describes the responsibilities for facility personnel during emergency conditions, which includes accounting for personnel, responding to injuries, and search and rescue operations.

The TRU characterization activities Health and Safety Plan describes the procedures for emergency response in the event of spills, releases, overpressurized drums, fire, injury/illness, aircraft crashes, earthquakes, and floods. CCP personnel working on the TRU characterization activities are trained in emergency preparedness at the site through classroom instruction and required reading.

The Emergency Preparedness SMP is recognized to provide protection to all personnel. The Chapter 3 Hazards and Accident Analyses implicitly accounts for an effective Emergency Preparedness Program in the assumptions addressing the duration of specific accident scenarios (i.e., exposure time is limited assuming effective evacuation and/or sheltering and consequence values are limited to unprotected exposure and do not include reentry and recovery exposures). Based on the results of Chapter 3, however, no attributes were specifically identified that warrant elevation to TSR level.

6.11 Provisions for Decontamination and Decommissioning

The site contractor policy for decontamination and decommissioning shall be defined and shall require that facilities and equipment contaminated with radioactive or other hazardous materials be managed safely at all times to ensure the protection of employees, the public, and the environment. Radiological control technicians are the primary contact for information on the decontamination and decommissioning of facilities and equipment associated with the TRU characterization activities, and will perform surveys of the units prior to demobilization.

With the exception of one of the modular units, the TRU Characterization Units do not involve direct contact with unconfined contaminated wastes and will normally meet free-release criteria. One unit involves handling of unconfined contaminated wastes in a glovebox system. The MOVER is a mobile visual examination trailer that has been used to characterize TRU waste at other DOE sites. The MOVER will be classified for shipment per 49 CFR Part 173 Subpart I (Ref. 6-9) before being shipped from the site contractor:

a) The quantity limitations for Limited Quantity per 49 CFR 173.425, or
b) The quantity limitations for Surface Contamination per 49 CFR 173.427, or
c) The quantities limitations for Type A quantities per 49 CFR173.433

If the MOVER meets one of the quantity limitations (a, b, or c) and contains 15 g or less of fissile material (U-233, U-235, U-238, Pu-239, or Pu-241) and the following verifications have been performed, the MOVER may be shipped from the site contractor:

1) Verification of radiation levels on the exterior of the MOVER shall be less than the following:
   - 200 mrem/hr on contact with shipping package
   - 10 mrem/hr at two meters.

2) Verification of the contamination levels on the exterior of the MOVER is less than the following:
   - 2200 dmp/100cm^2 beta-gamma
   - 220 dpm/100cm^2 alpha

Prerequisite actions require that the HEPA filter and used/contaminated gloves be removed and that the glovebox be wiped down prior to initiation of radiological surveys for shipment. Any wastes generated are managed per CCP and site contractor procedures.

6.12 Management, Organization, and Institutional Safety Provisions

The site contractor who owns the TRU wastes and has entered into contractual agreement with the DOE to ship it to WIPP has overall ES&H responsibilities. Their management, organization, and institutional safety provisions shall be defined. This program shall meet the requirements of the DOE Integrated Safety Management System, which consists of seven general principles and five functions that form the basis for how work is to be performed by DOE contractors, such as the site contractor and the CCP. Roles, responsibilities and reporting relationships are specified in the SOW and Interface Document.

The following site contractor responsibilities shall be formally assigned to appropriate management individuals of organizational units or program offices:

- Senior management is responsible for safety of overall TRU characterization activities at the site safety level, and to take any measures needed to ensure acceptable performance of the site staff in operating, maintaining, and providing technical support to the TRU characterization activities to ensure safety.
- A Facility Manager who has responsibility for overall facility operation and to delegate, in writing, the succession to this responsibility during his/her absence. This delegation shall be to a qualified individual. Safe operation shall include, as necessary, interface requirements with other site organizations and facilities to ensure the availability of ES&H subject matter experts, fire department response, electric power, utilities, etc.
- A Facility Shift Supervisor (or equivalent) for the TRU Characterization Unit. Responsibilities include concurring that the work can be safely performed in the facility, identifying hazards associated with the work location and communicating them to the responsible work management chain, participating in the pre-start review of the work (when one is conducted), evaluating proposed operational or activity changes against the facility's existing ES&H documentation (e.g., the authorization basis), and concurring that work may proceed, prior to the start of any work.
- A radiological control technician shall be assigned to the TRU characterization activities.
- Appropriate ES&H supporting personnel (e.g., industrial hygiene, industrial safety, health physics, environmental protection, fire protection engineering, criticality safety, emergency management, emergency response, etc.) to advise on planned and ongoing operations, conduct hazard assessments, etc. Appropriate ES&H disciplines shall have independent safety review, audit, and compliance oversight.
- Individuals who train the operations staff and those who carry out QA functions shall have independent safety review, audit, and compliance oversight.

The CCP provides characterization services for the site contractor's TRU waste according to the Carlsbad, New Mexico WIPP permit and other regulatory requirements, including the WIPP Waste Analysis Plan and WAC. This work is performed under a comprehensive QAP that meets the requirements defined in the WIPP Quality Assurance Program Document, which includes defining responsibilities. The site contractor maintains overall responsibility for the characterization and certification of their waste for disposal at WIPP. The site contractor is also responsible for reporting conditions or concerns that have or may have safety, health, quality assurance, security, operational, or environmental implications.

Each CCP/site contractor contract or agreement establishes the interfaces between the CCP and site contractor for implementing services to be provided for the TRU characterization activities. Specifically, this document identifies CCP and site contractor responsibilities for implementing requirements and deliverables. It provides the following information:

- Describes the general CCP organization
- Identifies the CCP personnel with responsibilities for supporting the TRU characterization activities
- Addresses responsibilities associated with TRU waste characterization, including interface requirements for the following areas:
  - CCP Personnel Training and Qualification
  - Drum Handling

- Deficiencies
- Visual Examination
- Nondestructive Examination
- Nondestructive Assay
- Headspace gas sampling and analysis
- Acceptable Knowledge
- Waste Certification and WIPP Waste Information System Data Entry
- Transportation
- Measurement and Test Equipment
- Work Standards

- Addresses the process for independent safety review and audits
- Addresses the process for nuclear safety evaluations per 10 CFR 830 Subpart B.

6.13 References

6-1. DOE-G-450.4-1, *Integrated Safety Management System Guide*, U.S. Department of Energy, Washington, DC, November 1997.

6-2. Department of Energy DEAR Clause, "Integration of Environment, Safety, and Health Into Work Planning and Execution," Section 35, Subsection 970.5204-2, U.S. Department of Energy, Washington, DC (published in Federal Register, 62 FR 34842, June 27, 1997).

6-3. DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*. U.S. Department of Energy, Washington, DC, Change Notice 2, April 2002.

6-4. DOE-STD-3011-2002, *Guidance for Preparation of Basis for Interim Operation (BIO) Documents*. U.S. Department of Energy, Washington, DC, December 2002.

6-5. 10 CFR 835, *Occupational Radiation Protection*, U.S. Department of Energy, Washington, DC, January 2000.

6-6. WIPP Hazardous Waste Facility Permit NM4890139088-TSDF, Attachment B, "Waste Analysis Plan," U.S. Department of Energy, Carlsbad Area Office, Carlsbad, NM, 1999.

6-7. OSWER 9938.4-03, *Waste Analysis at Facilities that Generate, Treat, Store, and Dispose of Hazardous Waste*, A Guidance Manual, U.S. Environmental Protection Agency, Washington, DC, April 1994.

6-8. 10 CFR 830, *Nuclear Safety Management*. Code of Federal Regulations, U.S. Department of Energy, Washington, DC, January 2001.

6-9. 49 CFR Part 173, *Shippers – General Requirements for Shipments and Packagings*, Code of Federal Regulations, U.S. Department of Transportation, Washington, DC, March 1999.

APPENDIX A
HAZARD IDENTIFICATION TABLES

The Hazard Identification table is based on a predefined list of hazards. One column identifies if the hazard is present in the segment or not. The description column provides information on the nature of the hazard and the location. The last column is titled "SIH" (standard industrial hazard). A "Y" or yes in this column indicates that the hazard is an SIH and is screened out from further consideration in the PrHA.

Those hazards that are not screened out are carried forward into the PrHA. The SIH column provides a pointer of which PrHA scenarios could involve the identified hazard. Below is a list explaining the acronyms used in the PrHA descriptors. SIHs are retained if they can lead to a release.

There are two hazard identification tables in this appendix. Table A-1 is for the TRU Waste Characterization Segment, and Table A-2 is for the TRUPACT-II Loading Segment.

Hazard ID Acronyms

Waste Handling and Staging	WH-
Common Operational Hazards	CH-
Non-Destructive Examination	NDE-
Non-Destructive Assay	NDA-
Headspace Gas Sampling & Analysis	HSGS-
Mobile Visual Examination and Repackaging	VE-
TRUPACT-II Loading	L-
External Events	EE-
Natural Phenomenon Hazards	NPH-
Standard Industrial Hazard	SIH

Table A-1 Characterization Segment Hazard Identification Table

Item	Hazard Energy Source or Material	Exists (Y/N)	Description	SIH Screening
1.	**Electrical**	**Y**		
1.1	Battery banks	Y	UPS in the HSGS provided by a battery bank to protect losing the data in the computer. These batteries do not offgas. Battery-powered emergency lighting in the units, but not battery banks. There is an independent power supply for the HEPA ventilation in the MOVER from a power line that is separate from the MOVER power supply, not a battery bank. (Therefore, a failure of the MOVER power does not affect the blower.)	Y
1.2	Cable runs	Y	For power and instrument lines in the characterization units. Connect computers and control panels with equipment and interlocks.	Y
1.3	Diesel generators	N	Diesel generator in the utility yard is considered an external event. The transformer in the RTR unit is used to provide high-voltage power to the X-ray equipment, but it is not a diesel generator.	See 19.4
1.4	Electrical equipment	Y	Conveyor , drum turntable, audio/video system (e.g. cameras, VCR) are in the RTR and the NDA. In the RTR there is a transformer and an oil-to-air cooler that has a pump to circulate the oil. Electrical shock (SIH) The HSGS has a high-purity nitrogen generator plus a variety of standard laboratory equipment. All units have HVAC, computer equipment, light switches, lighting, miscellaneous motors analytical instrumentation etc. Electrical shock (SIH)	CH-1
1.5	Heaters	Y	Standard UL listed HVAC filters are located on the exterior walls of the RTR, NDA, and HSGS for comfort control only. The HVAC units penetrate the outside wall (i.e., typical wall-mounted units). (SIH) Wall-mounted HVAC filters in Glovebox Operation Room and Drum Entry Room conditions air inside the MOVER (see Item 1.4).	See 1.4
1.6	High voltage (> 600V)	N	Up to 240V power supplied to each unit, not 600V	
1.7	Locomotive, electrical	N		
1.8	Motors	Y	Some vehicles have electric motors (e.g., forklifts) (SIH)	CH-1

Table A-1 Characterization Segment Hazard Identification Table				
Item	**Hazard Energy Source or Material**	**Exists (Y/N)**	**Description**	**SIH Screening**
			RTR unit motors include: Drum manipulator Turntable X-ray equipment/image intensifier (movement) Pump for oil to air cooler HVAC (motors outside) Conveyors, etc NDA motors include: Sliding doors Drawbridge Turntable Positioner for out of source HVAC (motor outside) Conveyors, etc HSGS units motors include: HVAC (motor outside) HEPA blower (motor outside) Air compressor (motor outside) Analytical equipment motors, etc MOVER motors include: HVAC (inside) Drum lifter HEPA blower, etc	
1.9	Power tools	Y	Power tools may be used to remove the filter cap or the filter vent in the HSGS. Could result in a deflagration (see CH) or fire (see HSGS) Incidental use in segment (SIH)	CH-2 HSGS-2
1.10	Pumps	Y	Oil cooling unit in RTR uses a pump to circulate the oil Hydraulic pumps are contained in vehicles and forklifts	Y
1.11	Service outlets, fittings	Y	Potential fire initiator in all units (See Item 1.4) Most outlets are chest high throughout the MOVER.	See 1.4
1.12	Switchgear	N	Switchgear is considered as an external event	See 19.4
1.13	Transformers	N	Transformers are considered as an external event	See 19.4
1.14	Transmission lines	N		
1.15	Wiring / underground wiring	Y	Power lines for the MCUs are on the ground. Vehicles can run over power lines.	Y
1.16	Other:	N		
2.	**Thermal**	**Y**		
2.1	Boilers	N		
2.2	Bunsen burner / hot plates	N		

Table A-1 Characterization Segment Hazard Identification Table				
Item	**Hazard Energy Source or Material**	**Exists (Y/N)**	**Description**	**SIH Screening**
2.3	Electrical equipment	Y	In the RTR unit, two UL listed HVAC filters are located outside the unit. (SIH) The X-ray equipment creates heat and is cooled by an oil-to-air cooler. Standard UL listed HVAC is located on the exterior wall of the RTR, NDA, HSGS control rooms. The unit is used for comfort control in the control room only. HVAC in the glovebox room of the MOVER does not penetrate the walls of the unit (see Item 1.4). HVAC(s) in the MOVER control room penetrates the walls and the motor is outside. (SIH)	See 1.4
2.4	Electrical wiring	N	Incidental to the electrical equipment.	See 2.3
2.5	Engine exhaust	Y	The vehicles and forklifts in the area produce engine exhaust.	Y
2.6	Furnaces	N		
2.7	Heaters	Y	Standard UL listed HVACS are located on the exterior walls of the RTR, NDA, and HSGS for comfort control only. The HVAC units penetrate the outside wall (e.g., typical wall mounted units). (SIH) Wall mounted HVAC filters in glovebox room and entry room conditions air inside the MOVER. The heat from the HVAC is SIH.	See 1.4
2.8	Lasers	N		
2.9	Steam lines	N		
2.10	Welding surfaces	Y	Incidental to maintenance. Potential initiator for a fire. No welding is performed inside units while waste is present.	
2.11	Welding torch	Y	Incidental use in segment. Potential initiator for a fire. No welding is performed inside units while waste is present.	WH-7
2.12	Other	N		
3.	**Pyrophoric Material**	**N**		
3.1	Pu and U metal fines	N	Pu or U oxides may be present in the waste; waste is predominately contaminated material, material is not pyrophoric	
3.2	Other:	N		
4.	**Open Flame**	**Y**		
4.1	Bunsen burners	N		
4.2	Welding / cutting torches	Y	Incidental use in segment. Potential initiator for a fire.	See 2.11
4.3	Other	N		

Table A-1 Characterization Segment Hazard Identification Table

Item	Hazard Energy Source or Material	Exists (Y/N)	Description	SIH Screening
5.	**Flammables**	**Y**		
5.1	Cleaning/decon solvents	Y	Incidental to routine decontamination and maintenance. Operator may be exposed to chemicals.	Y
5.2	Flammable gases	Y	Some hazardous materials in the waste may offgas, but this is insignificant given the nature of the waste. Hydrogen and methane gases in nitrogen used as standards in the HSGS. Bottles are also stored in a bottle rack outside the HSGS unit.	WH-5 HSGS-2
5.3	Flammable liquids	Y	Vehicles and forklifts have gasoline (or diesel fuel) and may use other flammable fluids.	WH-5
5.4	Gasoline	Y	Gasoline powered forklifts and vehicles. Gasoline powered vehicles can be an accident initiator.	WH-5
5.5	Natural gas	N		
5.6	Nitric acid soaked rags (spontaneous combustion)	N		
5.7	Nitric acid and organics	N		
5.8	Paint/paint solvent	Y	Incidental use in segment	Y
5.9	Propane	Y	Propane powered forklifts can be an accident initiator	WH-7
5.10	Spray paint	Y	Incidental use in segment	Y
5.11	Other	N		
6.	**Combustibles**	**Y**		
6.1	Paper/wood products	Y	The requisition is on paper, which is in a plastic sleeve attached to the drum. The plastic sleeve may also contain other documents with information describing the drum or its contents. The rope used to secure drums to the truck may be combustible. Small amounts of miscellaneous paper may be in the staging area. The Control Room walls in some RTR units are covered with carpet over subsurface plywood. The floor in the control room is vinyl tile over plywood sub-flooring. The Loading Area floor and walls have steel plate over the plywood. The ceiling is vinyl covered over thin plywood. The Vault is lead lined (floor, ceiling, and walls) on top of plywood. The drum carriage and turntable assembly consist of steel and a wood frame. In addition, the manuals, operations logs, and other incidentals are paper. The sub-floor of the NDA is wood (i.e., standard	WH-8 CH-1 VE-5

Table A-1 Characterization Segment Hazard Identification Table

Item	Hazard Energy Source or Material	Exists (Y/N)	Description	SIH Screening
			floor for connex container). The sub-floor is covered with diamond plate throughout the unit. Wood is not used in the construction of the HSGS or the MOVER. Combustibles in the operating/equipment rooms are minimal. The control rooms have manuals, forms, and paper incidental to the work.	
6.2	Petroleum based products	Y	Vehicles, forklifts, and other equipment may contain lubricating oils, fuels, etc.	Y
6.3	Plastics	Y	The control room walls of the RTR unit are covered with carpet. The ceiling has drop plastic lighting panels with the actual ceiling covered with vinyl over the steel shell of the trailer. Much of the floor in the RTR-II is vinyl tile. The Loading Area ceiling is also vinyl covered over thin plywood. Plastics are incidental to equipment housing, electrical insulation, instrument lines, other insulation (fire resistant) and construction. In the control room, plastics are incidental to the control panel, computer and electrical cables, office supplies (pens). Polyurethane foam insulation (fire resistant) is used on the walls, ceiling, and floor in many of the units. Also plastics are used incidental to the operation and may be in the waste. These plastics may be potential fuel for a fire.	WH-8 CH-1 VE-5
6.4	Other	N		
7.	**Chemical Reactions**	**N**		
7.1	Concentration	N		
7.2	Disassociation	N		
7.3	Exothermic	N		
7.4	Incompatible chemical mixing	N		
7.5	Uncontrolled chemical reactions	N		
8.	**Explosive Material**	**Y**		
8.1	Caps	N		
8.2	Dusts	N		
8.3	Dynamite	N		
8.4	Electric squibs	N		
8.5	Explosive chemicals	N	Per WIPP WAC	

Table A-1	Characterization Segment Hazard Identification Table			
Item	**Hazard Energy Source or Material**	**Exists (Y/N)**	**Description**	**SIH Screening**
8.6	Flammable gases	Y	In the HSGS methane and hydrogen calibration gases exceed LFL; potential fuel for a fire. Cylinders are stored inside and outside the HSGS unit.	WH-5 HSGS-2
8.7	Hydrogen	Y	Hydrogen gas used for calibration in HSGS.	WH-5 CH-2 HSGS-2
8.8	Hydrogen (batteries)	Y	Lead acid batteries are used in vehicles & forklifts.	Y
8.9	Nitrates	N		
8.10	Peroxides	N		
8.11	Primer cord	N		
8.12	Propane	Y	Propane powered forklifts can be an accident initiator	WH-6
8.13	Other	N		
9.	**Kinetic (Linear and Rotational)**	**Y**		
9.1	Acceleration / deceleration	Y	Forklift or other vehicles could impact staged drums. Forklifts or other vehicles could impact the NDA conveyor, which is approximately 2 ft from the graded surface. The conveyor moves the drum from outside the unit to the counter, past the shield door, into the counter unit, and onto the drum rotator. The drum rotator rotates continuously while surveying drums. (SIH).	WH-1 WH-2 WH-3 WH-4 WH-5 WH-6 VE-1 VE-2
9.2	Bearings	Y	Bearings are used throughout all the characterization units. Bearings are used in motors, conveyors, turntables, etc.	Y
9.3	Belts	N		
9.4	Carts / dollies	Y	Incidental use for moving drums	Y
9.5	Centrifuges	N		
9.6	Crane loads (in motion)	N	Crane is in the Loading Segment.	
9.7	Drills	Y	Incidental to maintenance.	Y
9.8	Fans	Y	Blowers are used for the HVAC, HEPA, and other equipment, but not fans. The analytical instrumentation may have fans incorporated into their design. Oil-to-air cooler in RTR has a fan.	Y
9.9	Firearm discharge	N		
9.10	Forklifts	Y	While loading, forklift has potential of crushing or pinching extremities (SIH). Used for loading/ unloading.	See 9.1
9.11	Gears	Y	The conveyor in the NDA has a set of gears used to raise and lower the drawbridge	Y
9.12	Grinders	Y	In HSGS used to remove protective filter cap or to	CH-2

Table A-1 Characterization Segment Hazard Identification Table				
Item	**Hazard Energy Source or Material**	**Exists (Y/N)**	**Description**	**SIH Screening**
			remove the filter vent; potential deflagration initiator or fire. Incidental use in segment (SIH).	HSGS-2
9.13	Motors – electric	Y	RTR unit motors include: Drum manipulator Turntable X-ray equipment/image intensifier (movement) Pump for oil to air cooler HVAC (motors outside) Conveyors etc NDA motors include: Sliding doors Drawbridge Turntable Positioner for out of source HVAC (motor outside) Conveyors etc HSGS units motors include: HVAC (motor outside) HEPA blower (motor outside) Air compressor (motor outside) Analytical equipment motors etc MOVER motors include: HVAC (inside) Drum lifter HEPA blower	See 1.8
9.14	Power tools	Y	Used to remove protective filter cap or to remove the filter vent in HSGS. Incidental use in segment (SIH).	CH-2 HSGS-2
9.15	Presses / shears	N		
9.16	Rail cars	N		
9.17	Saws	Y	Cutting tools used to remove protective filter cap or to remove the filter vent in HSGS. Incidental use in segment (SIH)	CH-2 HSGS-2
9.18	Vehicles	Y	Vehicles could impact staged drums.	See 9.1
9.19	Vibration	N		
9.20	Other: Lifter	Y	MOVER lifter or drum on lifter is out of alignment and impacts glovebox. Moving parts are potential for injury (SIH).	VE-2 VE-3 VE-5

Table A-1 Characterization Segment Hazard Identification Table				
Item	**Hazard Energy Source or Material**	**Exists (Y/N)**	**Description**	**SIH Screening**
	Other: Hand tools		If tools that can spark are used in the MOVER glovebox, the use of tools could initiate a fire.	
10.	**Potential (Pressure)**	**Y**		
10.1	Autoclaves	N		
10.2	Boilers	N		
10.3	Coiled springs	N		
10.4	Furnaces	N		
10.5	Gas bottles	Y	In HSGS cylinders of calibration gases are under pressure (less than 3000 psig).	HSGS-1
10.6	Gas receivers	N		
10.7	Pressure vessels	Y	Tanks in RTR for the oil associated with the oil-to-air cooler (less than 200 psig) (SIH).	Y
10.8	Pressurized system (e.g., air)	Y	Portable air compressor located outside the HSGS (SIH). Fire suppression system in the NDA, HSGS, and the MOVER is pressurized, but not over 3000 psig (SIH).	Y
10.9	Steam headers and lines	N		
10.10	Stressed members	N		
10.11	Other			
11.	**Potential (Height / Mass)**	**Y**		
11.1	Cranes / hoists	N	Crane is in the Loading segment.	
11.2	Elevated doors	Y	The RTR unit is a semi-trailer truck and is elevated approximately 4 ft from grade level. The NDA doorway is about 10 in. above grade. The conveyor opening and the conveyor are less than 3 ft above ground level. HSGS unit personnel doors and entrance points are 10 in. above grade.	Y
11.3	Elevated work surfaces	Y	Forklifts lift drums over 4 ft. to load the RTR. Drum lifter in MOVER raises drum up (approximately 4 ft) Glovebox platform is elevated in the MOVER. (SIH)	WH-2 VE-2
11.4	Elevators	N		
11.5	Lifts	N		
11.6	Loading docks	N		
11.7	Mezzanines	N		
11.8	Floor pits	N		
11.9	Scaffolds and ladders	N		
11.10	Stacked material	N	Drums will not be stacked.	

Table A-1 Characterization Segment Hazard Identification Table

Item	Hazard Energy Source or Material	Exists (Y/N)	Description	SIH Screening
11.11	Stairs	Y	Stairs leading up to the personnel doors. Steps up to the platform by glovebox in the MOVER Step up in the control room of RTR unit.	Y
11.12	Other:	N		
12.	**Internal Flooding Sources**	**N**		
12.1	Domestic water	N		
12.2	Fire suppression piping	N	Fire suppression systems in the NDA, HSGS, and MOVER are gaseous systems and are not a source for flooding	
12.3	Process water	N		
12.4	Other	N		
13.	**Physical**	**Y**		
13.1	Sharp edges or points	Y	Syringes are inserted through filter vent to extract samples in the HSGS. Worker can be cut and injured with sharps. Sharps from the waste can pierce gloves in the glovebox of the MOVER.	Y
13.2	Pinch points	Y	All units, including waste handling and loading, have potential pinch points.	Y
13.3	Confined space	N		
13.4	Tripping	Y	Power lines, pallets, conveyors, stairs etc. Worker can trip on steps, raised surfaces.	Y
13.5	Other:			
14.	**Radiological Material**	**Y**		
14.1	Radiological material	Y	The waste contains radiological material. Sources are used for calibration. HEPA filters may be contaminated with radioactive particulates by virtue of its function as a filter. This hazard is assumed for most PrHA scenarios.	HSGS-5 HSGS-6 VE-6 VE-7
15.	**Hazardous Material**	**Y**		
15.1	Asphyxiants	Y	Fire suppression can displace oxygen, but not likely to asphyxiate. (SIH) Liquid nitrogen is present in the HSGS and NDA that can leak and displace some of the air in the room. The liquid nitrogen is piped through a wall penetration to the HSGS. A hose is connected as needed to fill the Dewar in the NDA. (SIH) Other bottled gases are present in the HSGS can leak, but not asphyxiate. (SIH)	Y
15.2	Bacteria / viruses	N		

Table A-1 Characterization Segment Hazard Identification Table

Item	Hazard Energy Source or Material	Exists (Y/N)	Description	SIH Screening
15.3	Beryllium and compounds	Y	There may be beryllium-contaminated materials in some waste drums.	Y
15.4	Biologicals	N		
15.5	Carcinogens	Y	Very low concentrations are present in the HSGS calibration gases.	Y
15.6	Chlorine and compounds	N		
15.7	Corrosives	Y	Lead acid batteries in the forklifts and motor vehicles.	Y
15.8	Decontamination solutions	Y	Incidental to routine decon.	Y
15.9	Dusts and particles	Y	May be packaged in plastic bags inside TRU waste drums.	Y
15.10	Fluorides	N		
15.11	Hydrides	N		
15.12	Lead	Y	Lead shielding in RTR. Lead acid batteries in the forklifts and motor vehicles.	Y
15.13	Oxidizers	N		
15.14	Poisons (herbicides, insecticides)	N		
15.15	Other: Cryogenics	Y	Liquid nitrogen is used in the NDA and the HSGS.	Y
16.	**Ionizing Radiation Sources**	**Y**		
16.1	Contamination	Y	The waste is made up of contaminated materials. HSGS and MOVER HEPA filters are contaminated by virtue of their function as a filter. Contaminated waste can be released in most scenarios.	HSGS-4 HSGS-6 HSGS-7 VE-3 VE-4 VE-6
16.2	Electron beams	N		
16.3	Radioactive material	Y	The waste contains radioactive materials and a release is assumed for most scenarios.	Most scenarios
16.4	Radioactive sources	Y	Sources used for calibrating radiation detectors. Sources are assumed to be involved in most scenarios. In the NDA there is a Cf-252 check source, source strength is 11.5 µCi to 22 µCi. There may be other sources used for calibration of equipment.	Y
16.5	Radiography equipment	Y	The RTR unit output power is 20 kV to 420 kV. The X-ray tube and the Image Intensifier are located in the shielded Vault.	Y
16.6	X-ray machines	Y		See 16.5
16.7	Other	N		
17.	**Non-Ionizing Radiation**	**N**		

Table A-1	Characterization Segment Hazard Identification Table			
Item	**Hazard Energy Source or Material**	**Exists (Y/N)**	**Description**	**SIH Screening**
17.1	Lasers	N		
17.2	Other	N		
18.	**Criticality**	**Y**		
18.1	Fissile material	Y	Waste contains fissile material. Although fissile material is present in waste and would be released in most scenarios, criticality accidents are considered in WH and CH.	WH-10 CH-3
19.	**Non-facility Events**	**Y**	**See External Events in PrHA**	
19.1	Explosion	N		Y
19.2	Fire	N		
19.3	Power outage	Y	Loss of power to HEPA system on the HSGS and MOVER	HSGS-5 VE-8
20.	**Vehicles in Motion**	**Y**		
20.1	Airplane	Y	Small aircraft nearby. See external events in PrHA.	EE-2 EE-3
20.2	Crane / hoist	N	Crane is in the Loading Segment.	
20.3	Forklifts	Y	While loading drums, tines pierce drum or forklift impacts drum.	WH-1 WH-2 WH-3 WH-4 WH-5
20.4	Heavy construction equipment	N		
20.5	Helicopter	Y		See 20.1
20.6	Train	N		
20.7	Truck / car	N	Vehicle barriers are an assumed initial condition.	
21.	**Natural Phenomena**	**Y**	**See Natural Phenomenon Events in PrHA**	
21.1	Earthquake	Y		NPH-1 NPH-2 NPH-3 NPH-4
21.2	Flood	N		
21.3	Lightning	Y		NPH-6
21.4	Rain/hail	Y	Standard industrial hazard	Y
21.5	Snow / freezing weather	Y	Unlikely during daytime	Y
21.6	Straight wind	Y		NPH-7 NPH-8
21.7	Tornado	Y		See 21.6

Table A-2 TRUPACT-II Loading Segment Hazard Identification Table

Item	Hazard Energy Source or Material	Exists (Y/N)	Description	SIH Screening
1.	**Electrical**	**Y**		
1.1	Battery banks	N	Some forklifts are battery powered, but these are not battery banks.	
1.2	Cable runs	N		
1.3	Diesel generators	N		
1.4	Electrical equipment	Y	May be electrical equipment such as hand held tools, motors, extension cords, etc.	Y
1.5	Heaters	N		
1.6	High voltage (> 600V)	N		
1.7	Locomotive, electrical	N		
1.8	Motors	Y	Some vehicles have electric motors (e.g., forklifts) (SIH). The vacuum pump used during the loading operations contains a motor. There are also other miscellaneous motors throughout the segment.	Y
1.9	Power tools	Y	Incidental use in segment.	Y
1.10	Pumps	Y	Vacuum pumps are used during the loading of the TRUPACT-II. There are also hydraulic pumps on the crane, forklifts, and other motor vehicles.	Y
1.11	Service outlets, fittings	Y	Incidental use for power tools, vacuum cleaner.	Y
1.12	Switchgear	N	Switchgear considered as an external event.	See 19.4
1.13	Transformers	N	Transformers considered as an external event.	See 19.4
1.14	Transmission lines	N		
1.15	Wiring / underground wiring	N		
1.16	Other:	N		
2.	**Thermal**	**Y**		
2.1	Boilers	N		
2.2	Bunsen burner / hot plates	N		
2.3	Electrical equipment	N		
2.4	Electrical wiring	Y	Extension cords for incidental power tool use.	Y
2.5	Engine exhaust	Y	The vehicles and forklifts in the area produce engine exhaust.	Y
2.6	Furnaces	N		
2.7	Heaters	N		
2.8	Lasers	N		
2.9	Steam lines	N		
2.10	Welding surfaces	N		
2.11	Welding torch	Y	Incidental use in segment. Potential initiator for a fire.	WH-7
2.12	Other	N		

Table A-2 TRUPACT-II Loading Segment Hazard Identification Table

Item	Hazard Energy Source or Material	Exists (Y/N)	Description	SIH Screening
3.	**Pyrophoric Material**	**N**		
3.1	Pu and U metal fines	N	Pu or U oxides may be present in the waste; waste is predominately contaminated material, material is not pyrophoric.	
3.2	Other: Pyrophoric solids	N		
4.	**Open Flame**	**Y**		
4.1	Bunsen burners	N		
4.2	Welding / cutting torches	Y	Incidental use in segment. Potential initiator for a fire.	See 2.11
4.3	Other	N		
5.	**Flammables**	**Y**		
5.1	Cleaning / decon solvents	Y	Incidental to routine decon and maintenance. Operator may be exposed to chemicals.	Y
5.2	Flammable gases	Y	Some hazardous materials in the waste may offgas, but this is insignificant, given the nature of the waste.	WH-5
5.3	Flammable liquids	Y	Vehicles and forklifts have gasoline (or diesel fuel) and may use other flammable fluids.	WH-5
5.4	Gasoline	Y	Gasoline powered forklifts and vehicles. Gasoline powered vehicles can be an accident initiator.	WH-5
5.5	Natural Gas	Y	Considered an external event. The natural gas line does not run under the segment. However, it emerges from underground near the south west corner of B695.	See 19.4
5.6	Nitric acid soaked rags (spontaneous combustion)	N		
5.7	Nitric acid and organics	N		
5.8	Paint / paint solvent	Y	Incidental use in segment.	Y
5.9	Propane	Y	Propane powered forklifts can be an accident initiator.	WH-5
5.10	Spray paint	Y	Incidental use in segment.	Y
5.11	Other	N		
6.	**Combustibles**	**Y**		
6.1	Paper/wood products	Y	The requisition is on paper, which is in a plastic sleeve attached to the drum. The plastic sleeve may also contain other documents with information describing the drum or its contents. The rope used to secure drums to the truck may be combustible. Small amounts of miscellaneous paper may be in staging area.	WH-7
6.2	Petroleum based products	Y	Vehicles and forklifts have lubricating oils, fuels, etc.	Y-
6.3	Plastics	Y	Negligible amount, such as info sleeve on the drum, plastic drum liner. Small amounts of miscellaneous paper may be in staging area. Stretch wrap used to wrap seven drums together.	WH-7

Table A-2 TRUPACT-II Loading Segment Hazard Identification Table

Item	Hazard Energy Source or Material	Exists (Y/N)	Description	SIH Screening
6.4	Other	N		
7.	**Chemical Reactions**	**N**		
7.1	Concentration	N		
7.2	Disassociation	N		
7.3	Exothermic	N		
7.4	Incompatible chemical mixing	N		
7.5	Uncontrolled chemical reactions	N		
8.	**Explosive Material**	**Y**		
8.1	Caps	N		
8.2	Dusts	N		
8.3	Dynamite	N		
8.4	Electric squibs	N		
8.5	Explosive chemicals	N		
8.6	Flammable gases	N		
8.7	Hydrogen	Y	Hydrogen in the waste drum from radiolysis. Potential for deflagration.	WH-8
8.8	Hydrogen (batteries)	Y	Lead acid batteries are used in vehicles and forklifts.	Y
8.9	Nitrates	N		
8.10	Peroxides	N		
8.11	Primer cord	N		
8.12	Propane	Y	Propane powered forklifts can be an accident initiator.	WH-6 L-1
8.13	Other	N		
9.	**Kinetic (Linear and Rotational)**	**Y**		
9.1	Acceleration / deceleration	Y	Forklift or other vehicles could impact staged drums.	WH-1 WH-2 WH-3 WH-4 WH-5 WH-7 L-1 L-2
9.2	Bearings	Y	Bearings are used throughout the Loading Segment. Bearings are used in the crane, motors, vehicles, etc.	Y
9.3	Belts	N		
9.4	Carts / dollies	Y	Incidental use for moving drums.	Y
9.5	Centrifuges	N		
9.6	Crane loads (in motion)	Y	Crane used to lift waste ~11 ft into TRUPACT-II.	L-2
9.7	Drills	Y	Incidental use in segment.	Y

Table A-2 TRUPACT-II Loading Segment Hazard Identification Table

Item	Hazard Energy Source or Material	Exists (Y/N)	Description	SIH Screening
9.8	Fans	N		
9.9	Firearm discharge	N		
9.10	Forklifts	Y	While loading, forklift has potential of crushing or pinching extremities (SIH). Used for loading/ unloading.	See 9.1
9.11	Gears	N		
9.12	Grinders	Y	Incidental use in segment	Y
9.13	Motors	Y	Motors in the crane, forklifts, vacuum pump	Y
9.14	Power tools	Y	Incidental use in segment	Y
9.15	Presses / shears	Y	Stretch wrap system	Y
9.16	Rail cars	N		
9.17	Saws	Y	Incidental use in segment	Y
9.18	Vehicles	Y	Vehicles could impact staged drums.	See 9.1
9.19	Vibration	N		
9.20	Other:	N		
10.	**Potential (Pressure)**	**Y**		
10.1	Autoclaves	N		
10.2	Boilers	N		
10.3	Coiled springs	Y	Vehicles	Y
10.4	Furnaces	N		
10.5	Gas bottles	Y	Used with TRUPACT-II leak testing	Y
10.6	Gas receivers	N		
10.7	Pressure vessels	N		
10.8	Pressurized container or system (e.g., air)	Y		Y
10.9	Steam headers and lines	N		
10.10	Stressed members	N		
10.11	Other – vacuum applied to TRUPACT-II	Y	A minimum of 3 in. Hg and a maximum of 15 in. Hg vacuum applied to the TRUPACT-II cask could rupture poorly vented cask.	Y
11.	**Potential (Height / Mass)**	**Y**		
11.1	Cranes / hoists	Y	Lifts of payload of TRU waste	L-1 L-2 L-3 L-4
11.2	Elevated doors	N		
11.3	Elevated work surfaces	Y	Top of double stacked drums, top of TRUPACT-II.	Y
11.4	Elevators	N		
11.5	Lifts	Y	Might use lift to access top of TRUPACT-II.	Y
11.6	Loading docks	Y	Vehicles can only use the loading dock when the TRUPACT-II Loading Segment is not being used in support of the TWLP.	Y
11.7	Mezzanines	N		
11.8	Floor pits	N		

Table A-2 TRUPACT-II Loading Segment Hazard Identification Table

Item	Hazard Energy Source or Material	Exists (Y/N)	Description	SIH Screening
11.9	Scaffolds and ladders	Y	Might use ladders to access top of stacked drums, top of TRUPACT-II.	Y
11.10	Stacked material	Y	Double stacked drums as part of the payload for TRUPACT-II.	L-1 L-2 L-3
11.11	Stairs	N		
11.12	Other:	N		
12.	**Internal Flooding Sources**	**N**		
12.1	Domestic water	N		
12.2	Fire suppression piping	N		
12.3	Process water	N		
12.4	Other	N		
13.	**Physical**	**Y**		
13.1	Sharp edges or points	Y	Equipment.	Y
13.2	Pinch points	Y	Mating of lifting equipment to payload.	Y
13.3	Confined space	N		
13.4	Tripping	Y	Leak test equipment.	Y
13.5	Other:	N		
14.	**Radiological Material**	**Y**		
14.1	Radiological material	Y	The waste contains radiological material.	L-1 L-2 L-3
15.	**Hazardous Material**	**Y**		
15.1	Asphyxiants	N		
15.2	Bacteria / viruses	N		
15.3	Beryllium and compounds	Y	There may be beryllium contaminated materials in some drums.	Y
15.4	Biologicals	N		
15.5	Carcinogens	N		
15.6	Chlorine and compounds	N		
15.7	Corrosives	Y	Lead acid batteries in the forklifts and motor vehicles.	Y
15.8	Decontamination solutions	Y	Incidental to routine decon.	Y
15.9	Dusts and particles	N		
15.10	Fluorides	N		
15.11	Hydrides	N		
15.12	Lead	Y	Lead acid batteries in the forklifts and motor vehicles.	Y
15.13	Oxidizers	N		
15.14	Poisons (herbicides, insecticides)	N		
15.15	Other	N		

Table A-2 TRUPACT-II Loading Segment Hazard Identification Table				
Item	**Hazard Energy Source or Material**	**Exists (Y/N)**	**Description**	**SIH Screening**
16.	**Ionizing Radiation Sources**	**Y**		
16.1	Contamination	Y	The waste is made up of contaminated materials. There could be contamination inside the TRUPACT-II.	L-1 L-2 L-3
16.2	Electron beams	N		
16.3	Radioactive material	Y	The waste contains radioactive materials and a release is assumed for most scenarios.	L-1 L-2 L-3
16.4	Radioactive sources	Y	Sealed sources are used to calibrate instruments.	Y
16.5	Radiography equipment	N		
16.6	X-ray machines	N		
16.7	Other	N		
17.	**Non-Ionizing Radiation**	**N**		
17.1	Lasers	N		
17.2	Other	N		
18.	**Criticality**	**Y**		
18.1	Fissile material	Y	Waste contains fissile material. Although fissile material is present in waste and would be released in most scenarios, criticality accidents are considered in waste handling.	WH-10
19.	**Non-facility Events**	**Y**	**See External Events in PrHA**	
19.1	Explosion	N		
19.2	Fire	Y	Limited to crane hazards	
19.3	Power outage	Y	Can happen, but does not lead to a release or worker consequence.	Y
20.	**Vehicles in Motion**	**Y**		
20.1	Airplane	Y	Small aircraft nearby. See external events in PrHA.	EE-2 EE-3
20.2	Crane/hoist	Y	Crane used to lift waste into TRUPACT-II.	L-1 L-2 L-3 L-4
20.3	Forklifts	Y	While loading drums, tines pierce drum or forklift impacts drum.	WH-1 WH-2 WH-3 WH-4 WH-5
20.4	Heavy construction equipment	N		
20.5	Helicopter	Y		See 20.1
20.6	Train	N		
20.7	Truck/car	Y	Vehicle impacts staged drums or crane.	WH-1 WH-2

Table A-2 TRUPACT-II Loading Segment Hazard Identification Table

Item	Hazard Energy Source or Material	Exists (Y/N)	Description	SIH Screening
				WH-4 WH-5 WH-6
21.	**Natural Phenomena**	**Y**	**See Natural Phenomenon Events in PrHA**	
21.1	Earthquake	Y	Double stacked drums being prepared for loading in the TRUPACT-II, crane while lifting.	NPH-1 NPH-2 NPH-3 NPH-4
21.2	Flood	Y	TRUPACT-II cannot be loaded in rain.	NPH-5
21.3	Lightning	Y	TRU waste stored outside, TRUPACT-II, crane.	NPH-6
21.4	Rain/hail	Y	TRUPACT-II cannot be loaded in rain.	Y
21.5	Snow/freezing weather	Y	Unlikely during daytime.	Y
21.6	Straight wind	Y	Could blow projectiles into staged waste, cause the crane to sway and the payload to hit the TRUPACT-II.	NPH-7 NPH-8
21.7	Tornado	Y		See 21.6

APPENDIX B
PROCESS HAZARDS ANALYSIS

The Process Hazards Analysis (PrHA) is derived from an evaluation of hazards in the TRU Waste Characterization Segment and the TRUPACT-II Loading Segment. The Hazard Identification Tables are in Appendix A. The tables in this appendix only capture those hazards that are unique to those specific operations. The following acronyms are used in these PrHA tables:

Process hazards ID Numbers

WH	Waste Handling and Staging
CH	Common Operational Hazards
NDE	Non-Destructive Examination
NDA	Non-Destructive Assay (w/ gamma)
HSGS	Headspace Gas Sampling
VE	Mobile Visual Examination and Repackaging
L	TRUPACT-II Loading
EE	External Event
NPH	Natural Phenomenon Hazard

Subject:

W = Onsite Worker
P = Public

Frequency:

A = Anticipated
U = Unlikely
EU = Extremely Unlikely
BEU = Beyond Extremely Unlikely

Consequence:

H = High
M = Moderate
L = Low

Risk:

I = Significant
II = Medium
III = Minor
IV = Negligible

Control Type/controls:

PA = Preventive Administrative
PE = Preventive Engineering
MA = Mitigative Administrative
ME = Mitigative Engineering

Table B-1. Global Notes and Assumptions Related to Process Hazards Analysis

1.	Throughout the PrHA tables the one * indicates an initial assumption; two ** indicate that the control is significant contributor in reducing the frequency or consequences.
2.	In the "Risk" columns of the PrHA tables, "W" denotes risk to the worker, and "P" denotes risk to the public.
3.	Unless otherwise specified, the term "waste" can denote any of the following waste types (i.e., TRU or mixed TRU) in any drum.
4.	The waste may contain the following: beryllium and beryllium compounds, carcinogens, dusts and particles, heavy metals (such as lead, chromium, silver); and solvent-contaminated material. The predominant hazard is radiological material.
5.	The following radiological hazards are assumed to be present in the waste: contaminated material and radioactive material.
6.	The waste is predominantly solid waste. However, some containerized liquid may be present in the waste drums and may need to be segregated in the repackaging mobile unit.
7.	The Inventory Control Program is an initial assumption and is implemented in all activities. The limits are a total of 100 PE-Ci for each characterization unit. Also, no drum shall exceed 200 plutonium-239 FGE.
8.	Emergency response is assumed as a control for all radioactive material release scenarios.
9.	The unit-specific tables identify only those hazards that are unique to the operation of the particular unit. Waste handling, common operational hazards, external events, and natural phenomena hazards are captured in other PrHA tables.
10.	Common mode failures are considered in this PrHA. Mitigation relies on human performance (e.g., training, evacuation) rather than SSCs. Interactions are considered and evaluated.

Table B-2 PrHA –Waste Handling and Staging

ID No.	Hazard	Scenario	Material at Risk	Unmitigated					Control Type/controls	Mitigated					Comments
				Freq.	Consq.		Risk			Freq.	Consq.		Risk		
					W	P	W	P			W	P	W	P	
WH-1	Spill Outside	Large vehicle collides with staged drum(s) with enough force to cause a spill of waste and release of radioactive material	MAR=100 PE-Ci	BEU	L	L	IV	IV	MA – Inventory controls* MA – Emergency Response PA – Maintenance Testing & Inspection (MT&I) (vehicle) PA – Traffic controls* PA – Training** PE – Approved drum*	BEU	L	L	IV	IV	Vehicle barriers preclude vehicle impacts, other than forklifts.
WH-2	Spill Outside	Drums fall (greater than 4 ft) while loading characterization unit or use of loading dock and breaches confinement, releasing radioactive materials.	MAR=100 PE-Ci	A	L	L	III	III	MA – Inventory controls* MA – Emergency Response** PA – Approved procedures PA – Training** PE – Approved drum*	U	L	L	III	III	Initiator is human error while loading a drum. Some of the material spills from drums as a result of the fall.
WH-3	Spill Outside	Forklift punctures drum	MAR=100 PE-Ci	A	L	L	III	III	MA – Inventory controls* MA – Emergency Response** PA – MT&I (forklift) PA – Training** PE – Approved drum*	U	L	L	III	III	A single drum spill accident is anticipated. Material released is limited by the size of the puncture.
WH-4	Spill	Vehicle causes drums to topple, resulting in a breach of the waste drums and the release of radioactive material.	MAR=100 PE-Ci	BEU	L	L	IV	IV	MA – Inventory controls* MA – Emergency Response ME – Approved drum* PA – MT&I (vehicle) PA – Training** PA – No stacking of drums*	BEU	L	L	IV	IV	Vehicle barriers preclude vehicle impacts, other than forklifts.
WH-5	Fire Outside	Vehicle collides with staged drum(s) outside the characterization units and breaches drum. Fuel spills and ignites.	MAR=100 PE-Ci	BEU	M	L	IV	IV	MA – Combustible loading controls MA – Inventory controls* MA – Emergency Response PA – MT&I (vehicle) PA – Traffic controls* PA – Training PE – Approved drum*	BEU	M	L	IV	IV	Vehicle barriers preclude vehicle impacts, other than forklifts.
WH-6	Fire	Forklift collides with	MAR=100	U	M	M	II	II	MA – Combustible loading	EU	L	L	IV	IV	The drum is breached and

Table B-2 PrHA –Waste Handling and Staging

ID No.	Hazard	Scenario	Material at Risk	Unmitigated Freq.	Unmitigated Consq. W	Unmitigated Consq. P	Unmitigated Risk W	Unmitigated Risk P	Control Type/controls	Mitigated Freq.	Mitigated Consq. W	Mitigated Consq. P	Mitigated Risk W	Mitigated Risk P	Comments
	Outside	staged drum(s) outside the characterization units and breaches drum. Fuel spills and ignites.	PE-Ci						controls MA – Inventory controls* MA – Emergency Response PA – MT&I (vehicle) PA- Prohibition on Diesel Powered Forklifts** PA – Training** PE – Approved drum*						a portion of the contents are ignited and released.
WH-7	Fire Outside	Vehicle collides with forklift, breaches propane cylinder. Fire encompasses nearby inventory.	MAR=100 PE-Ci	BEU	M	L	IV	IV	MA – Combustible loading controls MA – Inventory controls* MA – Emergency Response PA – MT&I (vehicle) PA – Traffic controls* PA – Training** PE – Approved drum*	BEU	L	L	IV	IV	A collision of a vehicle and forklift of such force that breaches a propane cylinder near characterization unit or TRUPACT-II, resulting in a fire and involves entire MAR is extremely unlikely.
WH-8	Fire Outside	Welding or other hot works ignites combustibles and impacts staged drums.	MAR=100 PE-Ci	U	L	L	III	III	MA – Combustible loading controls MA – Inventory controls* MA – Emergency Response** PA – MT&I PA – Hot Work Permit PE – Approved drum*	U	L	L	III	III	All material burns inside the drum. This is a small fire and buoyancy is minimal.

Table B-3 PrHA – Common Operational Hazards Inside Characterization Units

ID No.	Hazard	Scenario	Material at Risk	Unmitigated					Control Type/controls	Mitigated					Comments
				Freq.	Consq.		Risk			Freq.	Consq.		Risk		
					W	P	W	P			W	P	W	P	
CH-1	Fire Inside	Electrical short ignites combustibles within the characterization unit, and involves inventory.	MAR=100 PE-Ci	A	L	L	III	III	MA – Combustible loading controls** MA – Inventory controls* MA – Emergency Response** PA – MT&I PE – Approved drum* ME – Fire suppression (except for RTR)	U	L	L	III	III	Electrical wiring, etc. complies with NFPA 70 (NEC). All material burns inside the drum. This is a small fire and buoyancy is minimal. .
CH-2	Deflagra-tion	Ignition of hydrogen gas in an unvented waste drum resulting in deflagration, release of radioactive materials.	MAR=100 PE-Ci	U	L to M	M	II	II	MA – Combustible loading controls MA – Inventory controls* MA – Emergency Response PA – Training PA – Container inspection program PE – Approved drum*	EU	L to M	M	III	III	A deflagration of vented drums is considered extremely unlikely with appropriate hydrogen management program.
CH-3	Criticality	Drums exceed the radionuclide fissile material limit, moderator/ reflector limits and/or configuration controls.	MAR> 200 grams Pu-239 fissile equivalent material in a drum	BEU	H	L	III	IV	MA – Inventory controls* MA – Emergency Response PA – Approved procedures PA – Criticality Safety Program* PA – Training PE – Approved drum*	BEU	H	L	III	IV	Drums that are assumed to be in compliance with the WIPP WAC and therefore a criticality is precluded.

Table B-4 PrHA – Real-Time Radiography

ID No.	Hazard	Scenario	Material at Risk	Unmitigated					Control Type/controls	Mitigated					Comments
				Freq.	Consq.		Risk			Freq.	Consq.		Risk		
					W	P	W	P			W	P	W	P	
NDA-1		No unique scenarios were identified for the NDA.													

Table B-5 PrHA – NDA

ID No.	Hazard	Scenario	Material at Risk	Unmitigated					Control Type/controls	Mitigated					Comments
				Freq.	Consq.		Risk			Freq.	Consq.		Risk		
					W	P	W	P			W	P	W	P	
NDA-1		No unique scenarios were identified for the NDA.													

Table B-6 PrHA – Headspace Gas Sampling and Analysis

ID No.	Hazard	Scenario	Material at Risk	Unmitigated					Control Type/controls	Mitigated					Comments
				Freq.	Consq.		Risk			Freq.	Consq.		Risk		
					W	P	W	P			W	P	W	P	
HSGS-1	Spill Outside	Pressurized gas cylinder valve breaks causing a projectile that breaches sample or staged drum.	MAR=100 PE-Ci	U	L	L	III	III	MA – Inventory controls* MA – Emergency Response** PE – Approved drum*	U	L	L	III	III	
HSGS-2	Fire Inside	Human error during connection of or mechanical leak of flammable gas leads to release of gas, which ignites – fire.	MAR=100 PE-Ci	A	L	L	III	III	MA – Combustible loading controls** MA – Inventory controls* MA – Emergency Response** ME – Fire suppression PA – MT&I PA – Training PE – Approved drum*	U	L	L	III	III	HSGS is constructed of low combustible materials. A human error is anticipated. A leak that ignites is unlikely. Equipment surfaces are not hot and ignition sources are minimal. All material burns inside the drum.
HSGS-3	Exposure	HEPA filter falls during maintenance. disbursing some particles that were contained within it.	Contamination only	A	L	L	III	III	MA – Emergency Response PA – Training PE – PPE	A	L	L	III	III	Replacing the HEPA filter would be needed if the pressure drop becomes too high. Some of the particulates may be released when HEPA filters are dropped. Activities associated with this process are not expected to generate much airborne material. Therefore, minimal contamination is expected on HEPA filters.
HSGS-4	Exposure	HEPA filter fails, leading to exposure of worker to radioactive materials.	Contamination only	U	L	L	III	III	MA – Emergency Response PA – Training PE – PPE	U	L	L	III	III	The amount of contamination available from the filter punch is very low.

Table B-6 PrHA – Headspace Gas Sampling and Analysis

ID No.	Hazard	Scenario	Material at Risk	Unmitigated					Control Type/controls	Mitigated					Comments
				Freq.	Consq.		Risk			Freq.	Consq.		Risk		
					W	P	W	P			W	P	W	P	
HSGS-5	Exposure	Power failure leads to release due to hood failure.	Contamination only	U	L	L	III	III	MA – Emergency Response PA – Training PE – PPE	U	L	L	III	III	The amount of contamination available from the filter punch is very low.

Table B-7 PrHA – MOVER

ID No.	Hazard	Scenario	Material at Risk	Unmitigated					Control Type/controls	Mitigated					Comments
				Freq.	Consq.		Risk			Freq.	Consq.		Risk		
					W	P	W	P			W	P	W	P	
VE-1	Spill Inside	Vehicle strikes MOVER, causing the glovebox to breach confinement, resulting in release of radioactive materials.	MAR=100 PE-Ci	BEU	M	L	IV	IV	MA – Inventory controls* MA – Emergency Response ME – MOVER Structure** ME – Glovebox** PA – MT&I (vehicle) PA – Training PA-Traffic Controls*	BEU	M	L	IV	IV	A vehicle striking the MOVER and breaching the glovebox and release all contents is beyond extremely unlikely. MOVER is a DOT Type A Container. A rugged container is not easy to breach. The glovebox offers some confinement even if it is breached.
VE-2	Spill Inside	Lifter device fails, drum contents spill.	MAR=100 PE-Ci	U	L	L	III	III	MA – Inventory controls* MA – Emergency Response** MA – Radiation Protection Program (CAM and dP monitor)** ME – Ventilation PA – MT&I (drum lifter) PE – Interlock switch	U	L	L	III	III	Equipment failure is unlikely. Open drum can fall and spill or drum can breach when it falls and some contents spill.
VE-3	Spill Inside	Drum is improperly installed or removed, resulting in release of radioactive materials.	MAR=100 PE-Ci	A	L	L	III	III	MA – Inventory controls* MA – Emergency Response** MA – Radiation Protection Program (CAM and dP monitor)** ME – Ventilation PA – MT&I PA – Training**	U	L	L	III	III	Material released is limited by the size of the drum port.
VE-4	Spill Inside	Glovebox confinement is breached, either due to glove or window break or explosion of contaminant chemicals in waste, resulting in release of radioactive materials.	MAR=100 PE-Ci	U	L	L	III	III	MA – Inventory controls* MA – Emergency Response** MA – Radiation Protection Program (CAM and dP monitor)** ME – Ventilation ME – Glovebox PA – MT&I (glovebox) PA – Training	U	L	L	III	III	Material released is limited by the size of the breach such as glove ports or the amount of contaminant chemicals such as nitrates, peroxides, perchlorates, etc. that could be in the waste or could have formed in the waste.

Table B-7 PrHA – MOVER

ID No.	Hazard	Scenario	Material at Risk	Unmitigated					Control Type/controls	Mitigated					Comments
				Freq.	Consq.		Risk			Freq.	Consq.		Risk		
					W	P	W	P			W	P	W	P	
VE-5	Fire Inside Glovebox	Improper use of tools ignites combustibles, fire (inside the glovebox) results. Consumes rubber gloves, resulting in a loss of confinement, a release, and burning of radioactive materials.	MAR=100 PE-Ci	A	H	M	I	I	MA – Emergency response MA – Inventory controls* MA – Emergency Response** MA – Combustible loading controls** ME – Fire suppression material in glovebox ME – MOVER unit** ME – Fire suppression system** ME – Glovebox** ME – Smoke alarms PA – MT&I (fire suppression system) PA – Ignition Source Controls** PA – Training	U	L	L	III	III	Some material burns as unconfined contaminated combustibles. The remainder burns as confined combustibles. Combustible loading controls in the glovebox limits the extent of the fire. Glovebox structure provides a barrier to protect the worker from a fire to permit time for personnel evacuation. The MOVER structure reduces the amount released.
VE-6	Exposure	Power failure leads to contamination due to ventilation system stopping.	Contamination only	U	L	L	III	III	MA – Emergency Response PA – Training PE – PPE	U	L	L	III	IV	The glovebox and exhaust system is a sealed system such that stopping the system is unlikely to lead to contamination.

Table B-8 PrHA – TRUPACT-II Loading

ID No.	Hazard	Scenario	Material at Risk	Unmitigated					Control Type/controls	Mitigated					Comments
				Freq.	Consq.		Risk			Freq.	Consq.		Risk		
					W	P	W	P			W	P	W	P	
L-1	Spill	Vehicle collides with crane, payload swings, TRUPACT-II lift fixture fails, payload drops, and waste is released.	MAR=1120 PE-Ci	U	L	L	III	III	MA – Inventory controls* MA – Emergency Response ME – Waste Packaging** PA – Approved procedures PA – MT&I (vehicle) PA – Traffic controls** PA – Training PE – Approved drum*	EU	L	L	IV	IV	A collision of such force to cause load to drop is unlikely. Note: Only 25% of MAR is assumed to be released from these events because of motive forces and waste packaging used.
L-2	Spill	Payload swings, TRUPACT-II lift fixture fails, payload drops, and waste is released.	MAR=1120 PE-Ci	U	L	L	III	III	MA – Inventory controls* MA – Emergency Response** ME – Waste Packaging** PA – Hoisting and Rigging PA – MT&I PA – Training** PE – Approved drum* PE – TRUPACT-II lift fixture**	EU	L	L	IV	IV	Only trained operators are permitted to operate cranes. The unmitigated frequency is the sum of an anticipated human error with an unlikely failure of the lifting mechanism. Hoisting and rigging/ critical lift training required. Note: Only 25% of MAR is assumed to be released from these events because of motive forces and waste packaging used.
L-3	Spill	Due to operator error, crane drops heavy load or drops lifting mechanism, strikes and breaches waste drums. or drops load of drums.	MAR=1120 PE-Ci	A	L	L	III	III	MA – Inventory controls* MA – Emergency Response** ME – Waste Packaging** PA – Hoisting and Rigging PA – MT&I (crane) PA – Training** PE – Approved drum* PE – TRUPACT-II lift fixture	U	L	L	III	III	Only trained operators are permitted to operate cranes. Hoisting and rigging/ critical lift training required. Note: Only 25% of MAR is assumed to be released from these events because of motive forces and waste packaging used.

Table B-9 PrHA – External Events

ID No.	Hazard	Scenario	Material at Risk	Unmitigated					Control Type/controls	Mitigated					Comments
				Freq.	Consq.		Risk			Freq.	Consq.		Risk		
					W	P	W	P			W	P	W	P	
EE-1	Spill	Crane in the Loading Segment falls and crushes drums in the Characterization Segment.	MAR=100 PE-Ci	BEU	L	L	IV	IV	MA – Inventory controls* MA – Emergency Response PA – Approved procedures PA – Crane positioning** PA – "Keep Clear" area** PA – MT&I PA – Training** PE – Approved drum*	BEU	L	L	IV	IV	This crane is positioned so it cannot fall on buildings or structures holding TRU waste drums, or TRU waste drums staged in the Characterization units.
EE-2	Spill	Small aircraft crashes into one or more of the characterization units, the crane or the staged waste.	MAR=100 PE-Ci	EU	L	L	IV	IV	MA – Inventory controls* MA – Emergency response PE – Approved drum*	EU	L	L	IV	IV	All material is expelled from drums.
EE-3	Fire	Small aircraft crashes into one or more of the characterization units, the crane or the staged waste. Fire burns waste.	MAR=100 PE-Ci	EU	H	M	II	III	MA – Inventory controls* MA – Emergency Response** ME – Fire Response PE – Approved drum*	EU	L	L	IV	IV	Material is expelled from drums and burns: buoyancy assumed.

Table B-10 PrHA – Natural Phenomena Hazards

ID No.	Hazard	Scenario	Material at Risk	Unmitigated					Control Type/controls	Mitigated					Comments
				Freq.	Consq.		Risk			Freq.	Consq.		Risk		
					W	P	W	P			W	P	W	P	
NPH-1	Spill	Design basis earthquake causes drums to topple, resulting in a breach of the waste drums and the release of radioactive material.	MAR=100 PE-Ci	U	L	L	III	III	MA – Inventory controls* MA – Emergency Response** ME – Approved drum*	U	L	L	III	III	
NPH-2	Spill	Design basis earthquake causes MOVER to shake, resulting in a breach of the glovebox or glovebox drum seal and the release of radioactive material.	MAR=100 PE-Ci	U	L	L	III	III	MA – Inventory controls* MA – Emergency Response PA – MT&I (glovebox) PE – MOVER design MA – Industrial Safety inspection	U	L	L	III	III	In addition to providing confinement, the MOVER unit is certified as a DOT 7A Type A container.
NPH-3	Spill	Design basis earthquake swings crane load into TRUPACT-II cask or other object.	MAR=1120 PE-Ci	U	L	L	III	III	MA – Inventory controls* MA – Emergency Response PE – Approved drums*	U	L	L	III	III	This activity is conducted on an infrequent basis. It is assumed that only 25% of the material is breached and spilled in the this event.
NPH-4	Fire	Design basis earthquake initiates electrical fire in one unit, resulting in release and burning of radioactive material.	MAR=100 PE-Ci	EU	L	L	IV	IV	MA – Combustible loading controls MA – Inventory controls* MA – Emergency Response** ME – Fire suppression system PE – Approved drum*	EU	L	L	IV	IV	Fire suppression system provided in MOVER, NDA, & HSGS
NPH-5	Spill	Rain, floods, hail, wind, blowing dust and debris etc prevents maintaining integrity of TRUPACT-II cask.	MAR=1120 PE-Ci	A	L	L	III	III	MA – Inventory controls* PA – Activity not permitted in inclement weather* PE – Approved drum*	A	L	L	III	III	Activity not conducted during inclement weather or there is a potential for adverse conditions It is assumed that only 25% of the material is breached and spilled in the this event.

Table B-10 PrHA – Natural Phenomena Hazards

ID No.	Hazard	Scenario	Material at Risk	Unmitigated					Control Type/controls	Mitigated					Comments
				Freq.	Consq.		Risk			Freq.	Consq.		Risk		
					W	P	W	P			W	P	W	P	
NPH-6	Fire	Lightning strikes one of the characterization units or staged waste, causing a fire which leads to a release of radioactive material.	MAR=100 PE-Ci	EU	L	L	IV	IV	MA – Combustible loading controls MA – Emergency response MA – Inventory controls* MA – Emergency Response ME – Fire suppression system PE – Approved drum*	EU	L	L	IV	IV	Fire suppression system provided in MOVER, NDA, & HSGS Assumes the waste burns inside the drum.
NPH-7	Spill	High wind creates missiles which strike characterization units or staged waste drums resulting in release of radioactive material from drums.	MAR=100 PE-Ci	A	L	L	III	III	MA – Inventory controls* MA – Emergency Response PE – Approved drum*	A	L	L	III	III	Projectiles from nearby buildings are not likely to reach the segment with enough impact as to breach a drum. The missiles themselves are a greater risk to the worker than the postulated radiation release.
NPH-8	Spill	High wind impacts characterization units or staged waste drums resulting in release of radioactive material from drums.	MAR=100 PE-Ci	A	L	L	III	III	MA – Inventory controls* MA – Emergency Response PE – Approved drum*	A	L	L	III	III	High winds will cause additional dispersion to reduce consequences.