# CHAPTER 7

# SITE CONTROLS

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# CHAPTER 7

# SITE CONTROLS

This chapter presents the site controls identified for the Rocky Flats Environmental Technology Site (RFETS). These controls are administrative and can include programmatic controls and specific controls and requirements.

## 7.1 INTRODUCTION

The site controls are administrative controls (ACs) that address several aspects of activities and operations on the site that are important to the site as a whole. The ACs include administrative controls important to overall site safety, engineered controls addressing the capabilities of important site systems, controls important to the safe on-site transport of radioactive and hazardous materials, and controls addressing the unattended outdoor storage of wooden waste boxes.

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The administrative controls addressed in this chapter are as follows:

- Organization and Management
- Site Engineering Control Program
- Site Transportation
-
- Safety Management Programs

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Controls for site-wide systems ensure facility-specific structures, systems, and components, which rely on support from site-wide systems, are capable of functioning as required to comply with the safety envelopes described in applicable facility authorization basis documents. Facility-specific controls provide the detailed requirements to ensure the functionality of the particular facility systems and the required actions associated with failure of the systems. Therefore, failure to meet one of the site controls does not constitute a failure of a facility-specific control, and vice-versa.

## 7.2 DEVELOPMENT OF SITE CONTROLS

The following paragraphs describe the development of the site controls.

### *Organization and Management*

The organizations identified under this control are Fire and Emergency Services and the Emergency Response Organization. These organizations provide support to the site in the event of emergencies and are credited in accident analyses.

*Site Engineering Controls Program*

The site controls address site-wide systems that are not directly covered in individual facility authorization basis documents, but are credited as necessary to support the safe operation of site facilities. The systems identified for site operational controls indirectly reduce the potential risk to the public and workers from uncontrolled releases of radioactive and other hazardous materials by supporting facilities associated with these risks. The preventative or mitigative function of the identified systems contributes to defense-in-depth and/or worker safety, public safety, and safety of the environment. The systems included in the site engineered controls were identified from nuclear facility authorization basis requirements, e.g., systems providing a required support function to a credited system in an individual safety analysis. The following systems were identified as providing important support to facilities:

- Fire protection water supply,
- Site electrical power,
- Site alarm systems,
- Site nitrogen supply, and
- Site propane and natural gas systems.

The site engineered controls are presented in Section 7.5.3.

*Site Transportation*

Site transportation controls (STCs) provide requirements on activities related to the transfer of materials on the site. These controls are identified for the transfer of nuclear materials, residues, and radioactive wastes; for the delivery and transfer of non-radioactive hazardous materials, substances, and wastes; and for the delivery and transfer of fuels. These controls are implemented to provide safe transport of these materials on the site. The transportation controls are presented in Section 7.5.4.

*Site Wooden Waste Box Storage Control Program*

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Site Wooden Waste Box Storage Controls (WWBSC) are addressed in Appendix J.

*Safety Management Programs*

The Safety Management Programs are to protect the health and safety of the public, the worker and the environment.

## 7.3 DEFINITIONS

The following terms are used throughout the operational control section as defined below.

| Term | Definition |
|---|---|
| AC Violation or Violation | An AC violation occurs when there is a programmatic deficiency involving a programmatic element or if an AC limit or condition and action statement are not met. |
| Available | Capability of functioning when required. |
| Bases | Summary statements providing the reasons for the required site engineered controls, administrative controls, and associated surveillance requirements. The bases show how the numeric value, the specified function, or the surveillance requirement fulfills the purpose of the control. |
| Completion Time | The amount of time allowed to complete a required action. The completion time starts when a situation is discovered that requires action for a given condition. The required action shall be performed before the specified completion time expires and is expected to be performed as soon as reasonably achievable. |
| Credited Programmatic Element | A functional (performance language) statement depicting analytical assumptions embodied in safety analysis specific to a given program. These functional statements relate to assumptions that determine the progression of accident scenarios. |
| Defense-in-Depth | Engineered features and/or administrative programs or program elements which are not used in analysis to reduce frequency or consequences, but add additional levels of safe operations. |
| Functional | Capable of providing the expected result when required as documented in the appropriate System Functionality Report (SFR) (RFETS, 1999a). |
| Nuclear Material | All materials so designated by the Secretary of Energy. Includes depleted uranium, enriched uranium, americium-241, americium-243, curium, berkelium, californium, plutonium 238 through 242, lithium-6, uranium-233, normal uranium, neptunium-237, deuterium, tritium, and thorium. Special Nuclear Materials include enriched uranium, uranium-233, uranium-235, or plutonium. |

| Term | Definition |
| --- | --- |
| Out-of-service | Equipment not available or capable of functioning. Equipment may be declared out-of-service due to actual or anticipated equipment failure or for administrative convenience. Removing equipment from service implies a temporary condition. This is used for equipment that is intended to be returned to service. |
| Required Action(s) | The mandatory response when conditions associated with a control are discovered. |
| Surveillance | Process or activity resulting in the documentation of system availability or functional capability. This can include testing, monitoring, inspecting, servicing, and/or auditing of the equipment and/or system. |
| Surveillance Requirements | Requirements relating to testing, calibration, or inspection to ensure the availability or functionality is maintained or is within the specified control parameters. |
| System Functionality Report (SFR) | A system design document that provides system functional requirements which ensure that the system is capable of meeting its credited authorization basis function. |

## 7.4 APPLICATION OF ADMINISTRATIVE CONTROLS

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The controls defined in this chapter are various forms of administrative controls (ACs). They are broken down into three categories depending on the system or activity that they apply to. The administrative control categories are Site Engineered Controls, Site Transportation Controls and Safety Management Programs.

The Site Engineered Controls and the Site Transportation Controls are specific to activities on the site. The controls in these categories are credited programmatic elements that support facility authorization bases or are credited in the accident analyses.

### 7.4.1 General Application

The following rules are generally applied to all the controls identified in this chapter. The bases for these rules are found in Section 7.6.

The rules and deviations for AC use and application are identified below. These rules and the bases for the rules are from the AC template, which was developed in order to provide consistency between facility authorization bases on the definition of administrative controls and how deviations from these controls shall be identified and corrected. The first rule specifies the requirement for meeting the ACs. The remaining four rules identify deviations which may occur with the ACs.

7.4.1.1 Administrative Controls shall be met.

Administrative Controls (ACs) shall be met at all times, unless otherwise specified. Upon failure to meet a site control, refer to *Required Action*, for appropriate action.

AC deviations may occur at three levels: individual failures, programmatic deficiencies, and AC violations.

7.4.1.2 AC Individual Failure

Individual failures to comply with a Credited Programmatic Element of an AC which are isolated and not systemic in nature, do not constitute non-compliance with the AC. Individual failures, deemed to be systemic in nature, are addressed under AC 7.4.1.3, AC Programmatic Deficiency.

An individual failure of an AC limit (i.e., AC specific control or restriction) and its action statement is an AC violation.

7.4.1.3 AC Programmatic Deficiency

The Credited Programmatic Elements in each AC are the standards by which the adequacy of the AC is assessed. The programmatic ACs may be implemented by specific Site Integrated SMP elements or through a building- or activity-specific program.

An AC programmatic deficiency occurs when:

a. The same non-compliance, or a closely similar non-compliance continues to occur, indicating the corrective action, including causal determination, has not been effective;

b. Several non-compliances have occurred that are related but not identical, indicating a common breakdown in a program or program area; or

c. Intentional violation or misrepresentation (typically a failure to perform a substantive activity required by nuclear safety requirements coupled with the alteration, concealment, or destruction of documents pertaining to those activities) as determined by the Price-Anderson Amendment Act (PAAA) program.

Additional information on determining programmatic deficiency is included in the "Bases" provided in Section 7.6.1.

An AC programmatic deficiency shall require the following actions:

a. Notify DOE, RFFO of the programmatic deficiency in accordance with Occurrence Reporting and PAAA requirements;

b. Conduct a causal analysis to identify the corrective actions to ensure future compliance with the AC requirement and prevent recurrence;

c. Inform DOE, RFFO of causal analysis and corrective actions in accordance with Occurrence Reporting requirements; and

d. Implement corrective actions.

7.4.1.4 AC Violation

An AC violation occurs when:

a. There is a programmatic deficiency involving a credited programmatic element; or

b. An AC limit, or condition, and its action statement are not met. Failure to implement required action(s) within the required time frame constitutes a violation.

Upon identification that an AC violation exists, the following actions are required:

a. Ensure a safe configuration (i.e., suspension of affected operations). The termination of operations in facilities affected by the site control failure is to be determined by the affected facility(ies). Other actions shall be limited to those activities needed to restore the safety function.

b. Notify DOE, RFFO of the violation in accordance with Occurrence Reporting requirements and contractor procedures.

   Notification shall be made in accordance with the action required by the control.

7.4.1.5 Exceptions

None.

7.4.1.6 Impacts to Facility Authorization Bases

Impacts to facility authorization bases (including those for nuclear facilities) caused by changes to the supporting systems covered by these administrative controls shall be evaluated using the Unreviewed Safety Question Determination (USQD) process. Evaluations shall be performed or initiated by the involved facility based on notifications received according to the required actions.

## 7.5 SITE ADMINISTRATIVE CONTROLS

### 7.5.1 Organization and Management

7.5.1.1 Requirements for Organization and Management

Staffing requirements ensure an organization is capable of functioning as required in the event of an emergency situation. Two organizations, Fire and Emergency Services and the Emergency Response Organization, provide support to the site in the event of emergencies on the site and are credited in accident analyses. The minimum staff is the number of qualified personnel, e.g., managers/supervisors and operators, necessary for performing the function of the organization.

7.5.1.2 Credited Programmatic Elements

The following program elements shall be maintained to provide adequate staffing for fire and emergency responses:

- Maintain a trained, qualified, and adequately staffed Fire and Emergency Services Department at RFETS 24 hours per day.
- Maintain trained and qualified personnel to staff the Emergency Operations Center in the event of an emergency.

7.5.1.3 Specific Controls or Restrictions

No specific controls are identified.

### 7.5.2 Facility Inventory Control and Material Management

Inventory control is not applicable at the site level.

### 7.5.3 Site Engineering Control Program

7.5.3.1 Requirement for Site Engineering Control Program

Site Engineering Controls include requirements for maintaining systems or components which are important to safety, e.g., that support facilities with the potential to release radiological or hazardous materials. The engineered controls are identified in the following sections. Functionality of the identified systems are defined in the applicable SFR (RFETS, 1999a). The bases for these controls are located in Section 7.7.3.3.

Maintenance, testing, and planned outages of these systems are allowed if required actions for non-functional systems are met.

7.5.3.2 Credited Programmatic Elements

No program elements are associated with the Site Engineered Controls.

7.5.3.3 Specific Controls or Restrictions

The following systems are covered by the Site Engineered Controls.

- Fire Protection Water Supply System
- Site Electrical Power
- Site Alarm System
- Nitrogen Supply System
- Propane and Natural Gas Systems

Fire Protection Water Supply System

**SEC 1. Ensure the fire protection water supply system is functional.**

**Applicability:** At all times to facilities and the nearest fire hydrant. The following buildings require fire suppression capabilities:

- Nuclear hazard Category 2 and 3 facilities - Buildings 371/374, 440, 460, 559, 569, 664, 707, 771/774, 750 Pad, 776/777, 881, 904 Pad, 906, and RCRA units;
- Radiological facilities - Buildings 126, and 444 cluster
- Essential support facilities - Building 115 (Emergency Operations Center [EOC] and Fire Dispatch Center [FDC]), Building 121 (Secondary Alarm Station [SAS] and Secondary Fire Dispatch Center [SFDC]), and Building 765 (Central Alarm Station [CAS]).

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**ACTIONS FOR SEC 1:**

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. Firewater supply system is not functional. | A.1 Notify Shift Superintendent of the lack of firewater.<br>**AND** | 1 hour |
| | A.2 Shift Superintendent determine affected facilities and notify these facilities.<br>**AND** | 1 hour |
| | A.3 Notify the Shift Superintendent when the out-of-service condition is corrected. | NA |

| SURVEILLANCE REQUIREMENTS | FREQUENCY |
|---|---|
| Surveillance of the water supply and distribution system, including pumps, will be conducted in accordance with contractor procedures. Surveillance requirements are defined in Chapter 1 of the Site SFR (RFETS, 1999a). | As required by appropriate procedure. |

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Site Electrical Power

**SEC 2. Ensure the 13.8 kV power is functional.**

**Applicability:** At all times to the following facilities:

- Nuclear hazard Category 2 and 3 facilities - Buildings 371/374, 440, 460, 559, 569, 664, 707, 771/774, 776/777, 881, and 991; and
- Essential support facilities - Building 112 (Telecommunications), Building 115 (EOC and FDC), Building 121 (SAS and SFDC), and Building 765 (CAS).

**ACTIONS FOR SEC 2:**

| CONDITION | REQUIRED ACTION | | COMPLETION TIME |
|---|---|---|---|
| A. Source of 13.8 kV power is not functional. | A.1 | Site Utilities notifies Shift Superintendent following notification by Public Services Company. | 1 hour |
| | <u>AND</u> A.2 | Shift Superintendent determines affected facilities and notifies these facilities. | 1 hour |
| | <u>AND</u> A.3 | Site Utilities notifies the Shift Superintendent when the out-of-service condition is corrected. | NA |
| B. One source of the required two sources of power is degraded. | B.1 | Upon notification by the Site Utilities of the condition or pending condition, the Shift Superintendent shall notify facilities of the degraded condition. | 1 hour |
| | <u>AND</u> B.2 | Upon notification by the Site Utilities that the condition has been corrected, the Shift Superintendent shall notify facilities of the return to normal conditions. | NA |

| SURVEILLANCE REQUIREMENTS | FREQUENCY |
|---|---|
| No surveillance is appropriate for the electrical transmission equipment. The 115 kV equipment is maintained by Public Service of Colorado. Surveillance requirements are defined in Chapter 2 of the Site SFR (RFETS, 1999a). | NA |

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Site Alarm System

**SEC 3. Ensure the Life Safety/Disaster Warning (LS/DW) system is functional.**

**SEC 4. Ensure the site alarm systems are functional.**

**Applicability:** At all times.

- LS/DW in facilities where required by plant procedures or for emergency response.
- Criticality accident alarm relay to the CAS (or the SAS if CAS inoperable).
- Fire alarms from the following facilities to the FDC (or SFDC):
  - Nuclear hazard Category 2 and 3 facilities - Buildings 371/374, 440, 460, 559, 569, 664, 707, 771/774, 776/777, 881, 906, and 991;
  - Radiological facilities - Building 444 cluster,
  - Essential and other support facilities - Building 115 (EOC and FDC), Building 121 (SAS and SFDC), Building 765 (CAS) and Building 331.

**ACTIONS FOR SEC 3 AND SEC 4:**

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. LS/DW is not functional. | A.1 Notify Shift Superintendent of out-of-service condition.<br>**AND** | 1 hour |
| | A.2 Shift Superintendent determine affected facilities and notify these facilities.<br>**AND** | 1 hour |
| | A.3 Notify the Shift Superintendent when the out-of-service condition is corrected. | NA |
| B. Alarm system is not functional for transmission of fire and criticality alarms. | B.1 Notify Shift Superintendent of out-of-service condition.<br>**AND** | 1 hour |
| | B.2 Shift Superintendent determine affected facilities and notify these facilities.<br>**AND** | 1 hour |
| | B.3 Notify the Shift Superintendent when the out-of-service condition is corrected. | NA |

| SURVEILLANCE REQUIREMENTS | FREQUENCY |
|---|---|
| Surveillance of the alarm system and associated equipment shall be in accordance with contractor procedures or other applicable requirements. Surveillance requirements are defined in Chapter 3 of the Site SFR (RFETS, 1999a). | As required by appropriate procedure. |

Site Steam System

**SEC 5. This control has been removed.**

Note: The steam system is no longer credited in facility authorization basis documents, therefore, it no longer requires a site control.

Nitrogen Supply System

**SEC 6. Ensure the nitrogen supply system is functional.**

**Applicability:** At all times to Buildings 371, 707, and 776/777.

**ACTIONS FOR SEC 6:**

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. Nitrogen supply system is not functional. | A.1 Notify Shift Superintendent of the lack of nitrogen pressure or purity<br>**AND** | 1 hour |
| | A.2 Shift Superintendent determine affected facilities and notify these facilities.<br>**AND** | 1 hour |
| | A.3 Notify the Shift Superintendent when the out-of-service condition is corrected. | NA |

| SURVEILLANCE REQUIREMENTS | FREQUENCY |
|---|---|
| Surveillance of the nitrogen supply shall be conducted in accordance with contractor procedures. Surveillance requirements are defined in Chapter 5 of the Site SFR (RFETS, 1999a). | As required by appropriate procedure. |

Propane and Natural Gas Systems

**SEC 7. Ignition sources and parking shall be prohibited within 20 feet of propane storage tanks.**

**Applicability:** At all times for propane storage tanks as follows:

Propane storage tanks located in the vicinity of a nuclear facility:
- 750 #1 through 8 (750 Pad)
- T771B (Building 771)
- T771G (Building 774)
- 904 #1 through 8 (904 Pad and Building 906)

1,000 gallons water capacity located within 150 feet of a nuclear facility,
500 gallons water capacity located within 100 feet of a nuclear facility,
250 gallons water capacity located within 80 feet of a nuclear facility.

Note: Tanks with other nominal water capacities shall follow the restrictions for the next larger size or have a safety evaluation prior to installation.

**ACTIONS FOR SEC 7:**

| CONDITION | REQUIRED ACTION | | COMPLETION TIME |
|---|---|---|---|
| A. Ignition sources and/or vehicles (other than propane tanker) are within 20 feet of the applicable propane tanks. | A.1 | Notify the shift superintendent. | 1 hour |
| | **AND** | | |
| | A.2 | Shift Superintendent to facilitate removal of these items. | 1 hour |

| SURVEILLANCE REQUIREMENTS | FREQUENCY |
|---|---|
| None | |

### 7.5.4 Site Transportation

7.5.4.1 Requirements for Site Transportation

Site transportation controls (STCs) are placed upon activities related to the transfer and delivery of materials on the site. Site transportation controls are identified for the following functions:

- Transfer of nuclear materials, residues, and radioactive wastes, and
- Delivery/transfer of fuels.

Controls are implemented for the transportation of hazardous materials in order to ensure safe transport of these materials. The controls in this section are developed from the hazard and accident analysis of transportation activities discussed in Chapter 8, "Transportation Safety Analysis," of this Site SAR. Controls and requirements are presented in various procedures, policies, and manuals governing transportation activities. Existing controls, such as nuclear material safety limits, will remain in effect and are not superseded by these controls.

The following categories for transfer of nuclear materials, residues and radioactive wastes at RFETS are used in the development of controls:

(1) Total quantity of fissile material transferred in one load is **greater than 6 kilograms (kg) weapons grade plutonium (WG Pu)**. Tables 7-1 and 7-2 identify the controls for transfers of material in this category.

(2) Total quantity of fissile material transferred in one load is **greater than 200 grams but less than or equal to 6 kg WG Pu**. Tables 7-3 and 7-4 identify the controls for transfers of material in this category.

(3) Total quantity of fissile material transferred in one load is **less than or equal to 200 grams WG Pu**. Tables 7-5 and 7-6 identify the controls for transfers of material in this category.

The controls identified do not apply to material transferred on the site that are packaged in Type B containers. The controls also do not apply to off-site shipments.

The bases for the site transportation controls are contained in Section 7.7.4.

Application of the transportation controls will be in accordance with the following guidelines:

- If a load consists of a mixture of material types, e.g., SNM, TRU and LLW, the most restrictive controls will apply.

- Packages without a content determination will be managed based on best process knowledge.
- Requirement for use of security convoy determined by others. Lesser quantities of Pu materials may be transported using a convoy for security purposes.
- No control is identified for controlling transfers during severe weather. The base frequency for the accident scenarios are based on accidents per mile that incorporates accident frequencies due to adverse weather conditions.
- The following controls are for transfer of material using a transfer truck or forklift, they do not apply to hand carry transfers. Hand carry transfers are controlled by the requirements identified in the site transportation safety manual.

7.5.4.2 STC 1. Site Transportation Controls for Quantities > 6 kg WG Pu

**During the transfer on site of radioactive materials with quantities of >6 kg WG Pu per load, the following controls shall be met:**

**Applicability:**

- Drums containing greater than (>) 200 grams WG Pu
- Liquids (>3.5 g/l)
- Drums containing > 350 grams WG Pu dose equivalent
- Boxes containing > 320 grams WG Pu
- Any materials as specified by other requirements

Specific Controls or Restrictions for STC 1

**Table 7-1.** Specific Transportation Controls for Quantities > 6 kg WG Pu

| | | |
|---|---|---|
| **1) No more than 250,000 grams fissile material as WG Pu shall be transferred in one load.** | | |
| **ACTION:** | | |
| **CONDITION** | **REQUIRED ACTION** | **COMPLETION TIME** |
| WG Pu loading exceeds the allowable limit for the appropriate transfer. | Return to below allowable limit. | As soon as possible following discovery, not to exceed 8 hours. |

Credited Programmatic Elements for STC 1

**Table 7-2.** Programmatic Transportation Controls for Quantities > 6 kg WG Pu

| | |
|---|---|
| 2) | **Combustible or flammable materials on the on-site transfer vehicle shall be limited to those necessary to accomplish the transfer.** |
| 3) | **On-site transfer packaging meets or exceeds DOT Type A requirements and/or are approved for on-site use in the site transportation safety manual.**<br>Note: Use of a packaging configuration not described in the site transportation safety manual will require a safety evaluation prior to use. |
| 4) | **Transfer vehicle shall not exceed 15 mph as indicated on the vehicle speedometer, except as directed during emergency or security situations. (For convoy transfers this direction is at the discretion of the Convoy Commander.)** |
| 5) | **Prior to loading/unloading verify/ensure the following:**<br>- Transient combustible materials are not within five feet of the transfer vehicle.<br>- No spark/flame/heat producing work or smoking are on the dock or within 25 feet of the transfer vehicle.<br>- No flammable liquids, except in approved containers, are on the dock or within 25 feet of the transfer vehicle. |
| 6) | **Transfer vehicle engines are off while the transfer vehicle is at the dock for loading and unloading.** |
| 7) | **No staging of materials in the transfer vehicle.** |
| 8) | **The transfer vehicle shall have a metal floor.** |
| 9) | **Propane powered vehicles shall not be used for the transfer of materials in these categories.** |
| 10) | **Prevent the propane bulk delivery vehicle from being within 100 feet of the material transfer vehicle.** |
| 11) | **Establish radio communication. In the event of a security or emergency response in the vicinity of the transfer vehicle, stop the transfer vehicle. (For convoy transfers this response is at the discretion of the Convoy Commander.)** |
| 12) | **Do not initiate a transfer of material if the fire department is unavailable for emergency response.** |

7.5.4.3 STC 2. Site Transportation Controls for Quantities >200 grams to 6 kg WG Pu

**During the transfer on site of radioactive materials with quantities of >200 grams to 6 kg WG Pu per load, the following controls shall be met:**

**Applicability:**

- Drums containing less than, or equal, (≤) 200 grams WG Pu
- Boxes containing ≤320 grams WG Pu
- Liquids (<3.5 g/l)
- POCs
- Samples and uncertified sealed sources >200 grams WG Pu

## Specific Controls or Restrictions for STC 2

**Table 7-3.** Specific Transportation Controls for Quantities >200 grams to 6 kg WG Pu

| **1) No more than 6,000 grams fissile material as WG Pu shall be transferred in one load.** | | |
|---|---|---|
| **ACTION:** | | |
| **CONDITION** | **REQUIRED ACTION** | **COMPLETION TIME** |
| WG Pu loading exceeds the allowable limit for the transfer. | Return to below allowable limit. | As soon as possible, following discovery, not to exceed 8 hours. |

## Credited Programmatic Elements for STC 2

**Table 7-4.** Programmatic Transportation Controls for Quantities >200 grams to 6 kg WG Pu

2) **Combustible or flammable materials on the on-site transfer vehicle shall be limited to those necessary to accomplish the transfer.**

3a) **Materials transferred in drums under this category shall contain less than or equal (≤) 200 grams WG Pu. These drums shall also contain ≤3.5 grams Am or ≤350 grams WG Pu dose equivalents (Solubility Class W).**

Exception: A single drum exceeding 350 grams WG Pu dose equivalent (Solubility Class W material) may be transferred only for the purpose of re-assay or remediation. In such case, the drum Pu content shall not exceed 200 grams, and the total inventory of the transfer vehicle shall be maintained less than or equal to 6,000 grams WG Pu. Any drum that exceeds 200 grams actual Pu content shall be transferred under STC 1 controls. Criticality safety limits are not affected by this control and must still be observed.

3b) **Materials transferred in POCs under this category shall contain ≤885 grams WG Pu dose equivalent (Solubility Class W material) or ≤1,255 grams WG Pu dose equivalent (Solubility Class Y material).**

3c) **Materials transferred in boxes under this category shall contain less than or equal (≤) 320 grams WG Pu.**

Exception: A single box that exceeds 320 grams WG Pu may be transferred, for the purpose of re-assay or remediation, if it contains ≤ 400 grams WG Pu dose equivalent (Solubility Class W). In such cases, the total inventory of the transport vehicle shall be maintained less than or equal to 6,000 grams WG Pu. Any box that exceeds 400 grams actual Pu content shall be transferred under STC 1 controls. Criticality safety limits are not affected by this control and must still be observed.

4) **On-site transfer packaging meets or exceeds DOT Type A requirements and/or are approved for on-site use in the site transportation safety manual.**

*Note:* Use of a packaging configuration not described in the site transportation safety manual and packages with known or suspected physical packaging deficiencies, will require a safety evaluation prior to use.

5) **Transfer vehicle shall not exceed the posted speed limit, as indicated on the vehicle speedometer, except as directed during emergency or security situations.**

6) **Transfer vehicle engines are off while the transfer vehicle is at the dock for loading and unloading.**

7) **Propane powered vehicles shall not be used for the transfer of materials in this category.**

8) **Prevent the propane bulk delivery vehicle from being within 100 feet of the material transfer vehicle.**

9) **Establish radio communication. In the event of a security or emergency response in the vicinity of the transfer vehicle, stop the transfer vehicle.**

7.5.4.4 STC 3. Site Transportation Controls for Quantities ≤200 grams WG Pu

**During the transfer on site of radioactive materials containing ≤200 grams WG Pu per load, the following controls shall be met.**

**Applicability:**

- Drums containing less then or equal (≤) 200 grams WG Pu
- Samples ≤ 200 grams WG Pu each or total load
- Sources ≤ 200 grams WG Pu each or total load
- LLW/LLMW boxes

  For LLW/LLMW, 200 grams WG Pu equates to the following number of drums based on the statistical loading per package of 0.5 grams per 55-gallon drum and 3.0 grams per box (SAE, 1996):

  1) LLW/LLMW wastes in drums = Maximum of 400 55-gallon drums
  2) LLW/LLMW wastes in boxes = Maximum of 66 full or half boxes

Specific Controls or Restrictions for STC 3

**Table 7-5.** Specific Transportation Control for Quantities ≤200 grams WG Pu

| **1) No more than 200 grams fissile material as WG Pu shall be transferred in one load.** | | |
|---|---|---|
| **ACTION:** | | |
| **CONDITION** | **REQUIRED ACTION** | **COMPLETION TIME** |
| WG Pu loading exceeds the allowable limit for the transfer. | Return to below allowable limit. | As soon as possible, following discovery, not to exceed 8 hours. |

Credited Programmatic Elements for STC 3

**Table 7-6.** Programmatic Transportation Controls for Quantities ≤200 grams WG Pu

| | |
|---|---|
| 2) | **Combustible or flammable materials on the on-site transfer vehicle shall be limited to those necessary to accomplish the transfer.** |
| 3) | **On-site transfer packaging is approved for on-site use in the site transportation safety manual.** Note: Use of a packaging configuration not described in the site transportation safety manual will require a safety evaluation prior to use. |
| 4) | **Transfer vehicle shall not exceed the posted speed limit, as indicated on the vehicle speedometer, except as directed during emergency or security situations.** |
| 5) | **Transfer vehicle engines are off while the transfer vehicle is at the dock for loading and unloading.** |
| 6) | **Propane powered vehicles shall not be used for the transfer of materials in this category.** |
| 7) | **Establish radio communication. In the event of a security or emergency response in the vicinity of the transfer vehicle, stop the transfer vehicle.** |
| 8) | **Am bearing material that exceeds LLW activity shall not be transferred under these controls (other than certified, sealed sources).** |

7.5.4.5 STC 4. Site Transportation Controls for Fuels

**During the delivery/transfer of fuels on site, the following controls shall be met:**

**Applicability:**

- All fuel deliveries including (but not limited to) propane, gasoline, diesel fuel, and #6 fuel oil.

Specific Controls or Restrictions

No specific controls or restrictions are identified for the transfer of fuels.

Credited Programmatic Elements

**Table 7-7.** Site Transportation Controls for Fuels

| | |
|---|---|
| 1) | **Prior to unloading, verify/ensure the following:**<br>**- No transient combustibles within 20 feet of the fuel storage tank.**<br>**- No ignition sources (e.g., smoking) within 20 feet of the fuel storage tank** |
| 2) | **Fuel delivery vehicles containing greater than 400 gallons total fuel inventory (excluding the vehicle fuel tank) are restricted to designated routes.** |
| 3) | **In the event of a security or emergency response occurs in the vicinity of the delivery vehicle, stop the vehicle.** |
| 4) | **No fuel deliveries will be made if the Fire Department is not adequately staffed.**<br>Exception: Deliveries from off-site vendors can be made if route is not on roadway adjacent to a nuclear facility, e.g.,Avoid Cactus Avenue south of Buildings 440 and 664, Seventh Street east of Building 664. |

7.5.4.6 STC 5. Site Transportation Controls for Transfer Vehicle Loading/Unloading Operations and Transfer Between Facilities Using Powered Industrial Trucks

**During material transfer vehicle loading and unloading activities using a powered industrial truck (forklift) or crane, the following controls shall be met:**

**Applicability:**

- Material transfer vehicle loading and unloading activities that are not specifically controlled by other Authorization Basis requirements
- LLW Drums (maximum 4 drums)
- Boxes containing $\leq$325 grams WG Pu (maximum 2 boxes)

Specific Controls or Restrictions for transfer vehicle loading and unloading operations

No specific controls or restrictions apply to the use of powered industrial trucks or cranes for material transfer vehicle loading and unloading operations.

Credited Programmatic Elements for material transfer vehicle loading and unloading activities using a powered industrial truck (forklift) or crane

**Table 7-8.a** Programmatic Transportation Controls for Material Transfer Vehicle Loading and Unloading Activities Using a Powered Industrial Truck or Crane

| | |
|---|---|
| 1) | **Loading and unloading of a material transfer vehicle using a powered industrial truck (forklift) shall be limited to a maximum of 4 drums or two boxes per move. Drums must be palletized, except when moving a single drum at a time.** |
| 2) | **Fossil fuel powered industrial trucks (forklifts) and cranes shall not be used to load or unload TRU waste drums.** |
| 3) | **Loading and unloading of a material transfer vehicle using a crane shall be limited to one box, one drum pallet, one drum, or one cargo container at a time.** |
| 4) | **Packaging is approved for on-site use in the Site Transportation Safety Manual.**<br>Note: Use of a packaging configuration not described in the Site Transportation Safety Manual will require a safety evaluation prior to use. |
| 5) | **Propane powered industrial trucks (forklifts) shall not be used for loading or unloading of radioactive materials.** |
| 6) | **PIT and crane operations shall follow the requirements in the Occupational Safety & Industrial Hygiene Program Manual.** |

**During the transfer on-Site of radioactive materials between facilities using a powered industrial truck (forklift), the following controls shall be met:**

**Applicability:**

- SWBs containing ≤ 325 grams WG Pu (maximum 2 SWBs)
- One Overloaded SWB with ≤410 grams WG Pu
- LLW Boxes ≤3 grams WG Pu (maximum 2 boxes)
- LLW Drums (maximum 4 drums)
- TRU drums are prohibited for transfers

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Specific Controls or Restrictions for the use of powered industrial trucks for material transfers between facilities

1. Transfer of TRU SWBs is limited to between Buildings 440 to 664.
2. LLW drums and LLW Boxes transferred between nuclear facilities shall be transferred within an established area of the Site. The established areas of the Site are:
   - The 300 area
   - The 400 area
   - The 700 area (includes Buildings 559 and 569 as part of this area)
   - The 800 area

Credited Programmatic Elements for On-Site Transfer of Radioactive Materials Between Facilities Using Powered Industrial Trucks

**Table 7-8.b** Programmatic Transportation Controls for On-Site Transfer of Radioactive Materials Between Facilities Using Powered Industrial Trucks

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| | |
|---|---|
| **1)** | **Transfers of LLW using fossil fuel powered industrial trucks shall be limited to a maximum of 4 LLW drums or two LLW Boxes per move. LLW drums and LLW Boxes transferred between nuclear facilities shall be transferred within an established area of the Site. LLW Boxes must be secured to the forklift. LLW Drums must be palletized, except when moving a single drum at a time. LLW drums must be secured to the forklift.** |
| **2)** | **Requirements in the Site Transportation Safety Manual shall be followed.** |
| **3)** | **Propane powered forklifts or any type of crane shall not be used for the transfer of radioactive materials.** |
| **4)** | **The transfer of TRU SWBs using fossil fuel powered industrial trucks shall be limited to a maximum of two SWBs with $\leq$325 grams WG Pu each or one overloaded SWB with $\leq$410 grams WG Pu per move. SWBs must be secured to the forklift and must be palletized. The use of lifting lugs/pin-lifters is prohibited. Perform combustible load inspection along the route to ensure that there is no combustible packages >27 cubic feet within 10 feet or >1 gallon flammable liquid within 25 feet of the PIT during the transfer.** |

### 7.5.5 Site Wooden Waste Box Storage Control Program

#### 7.5.5.1 Requirements for Site Wooden Waste Box Storage Controls

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Site wooden waste box storage controls (WWBSCs) are addressed in Appendix J.

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### 7.5.6 Safety Management Programs

7.5.6.1 Requirements for Safety Management Programs

The SMPs, as described in Chapter 6, *Safety Management Programs*, of this Site SAR, shall be maintained to provide worker protection and defense-in-depth safety functions. The SMPs include: Conduct of Operations; Configuration Management; Criticality Safety; Document Management; Emergency Preparedness; Engineering; Environmental Management; Fire Protection; Integrated Work Control; Nuclear Safety; Occupation Safety and Industrial Hygiene; Quality Assurance; Radiological Protection; Testing, surveillance, and Maintenance; Training; Transportation Safety; and Waste Management.

AC General Application, Section 7.4.1, applies to all facilities unless modified by a facility-specific AB document. Facility-specific ABs make a commitment to the SMPs through an AC. The PAAA process screens issues and events occurring in nuclear safety rule. However, non-compliances in an SMP do not necessarily constitute a PAAA Non-compliance Tracking System (NTS) reportable non-compliance unless the discrepancies are so gross as to render the premise of the inherent reliance on the SMP invalid. The AC bases describe this as multiple, serious deficiencies with a program observed over time. Once a programmatic breakdown is identified, its affect on facilities will be evaluated and could result in a PAAA NTS reportable non-compliance.

All SMPs are evaluated through routine performance indicators and self-assessments conducted in accordance with the *Site Integrated Oversight Manual*. All data (e.g., Radiological Improvement Reports, Criticality Safety Infractions, or Occurrence Reports) are tracked, trended and acted upon in accordance with the requirements of the specific SMP.

## 7.6 BASES FOR THE GENERAL APPLICATION OF ACs

### 7.6.1 Bases for General Application of AC

Sections 7.4.1.1 through 7.4.1.5 establish the rules for AC use and application and are applicable to all ACs at all times, unless otherwise stated. Since ACs are primarily for defense-in-depth and worker safety the requirements are typically not as discrete and rigorously defined and the safety impact of individual failures is not as severe as for engineered system LCOs and SRs since there are multiple aspects to the AC programs. These AC rules are fully consistent with the General Applicability LCOs and SRs and their bases, which are provided to control LCOs and SRs for the engineered systems. These AC rules only apply to Credited Programmatic Elements and AC limits (i.e., AC specific controls and restrictions) in Sections 7.5.1 through 7.5.7. These rules do not apply to other aspects of Safety Management Programs in Section 7.5.8. Section 7.4.1.6 describes the potential impact to facilities if violations to the Site Controls are not reviewed appropriately.

AC 7.4.1.1 establishes the requirement that ACs are to be met at all times. Each AC is divided into two distinct requirement sections; credited programmatic elements and specific controls or restrictions, but not all ACs will have both. Certain ACs will contain specific controls or restrictions consisting of limits and controls that have associated action statements and ***may have*** surveillance requirements. The manner in which the ACs are met is defined by either specific controls or restrictions with an associated action statement or by adherence to Credited Programmatic Elements.

ACs in Sections 7.4.1.2 through 7.4.1.4 establish the rules under which failures in AC programs progress from the level of individual failures of Credited Programmatic Elements or failure of specific controls or restrictions through to violation of the AC.

Credited Programmatic Elements is a defined term relating to programmatic elements that are credited for controlling the progression of an accident scenario. These elements minimize the potential frequency or consequence of an accident scenario. They are reflected in the assumptions addressing operational aspects that impact base frequency or amount of hazardous material assumptions. Specific controls or restrictions relate to aspects of operation that limit the frequency or consequence of an accident scenario. These latter conform to the limits of the analysis (e.g. total material at risk available for involvement in an accident).

The rules regarding Credited Programmatic Elements contain a three tiered control structure consisting of AC individual failure, programmatic deficiency, and AC violation. Adequate implementation of programmatic elements is the responsibility of management who must be able to demonstrate that programmatic compliance is achieved at all times. Individual failures are used as a measurement of adequate program implementation and should be tracked at some level by management. Upon occurrence of an individual failure, it is the responsibility of management to ensure a safe configuration. The safety significance of individual failures will be assessed through the site infrastructure program for Occurrence Reporting coupled with the requirements of the USQ process in assessing Occurrence Reports for discovery conditions. Required actions for discovery conditions will be governed by that process.

Programmatic deficiencies are defined through the Contractor's PAAA program. They can occur through repetitive or recurring non-compliances, programmatic breakdown, or intentional violation or misrepresentation. DOE guidance on defining these types of deficiencies is as follows:

- Repetitive or Recurring: The same non-compliance or a closely similar non-compliance continues to occur, indicating that the corrective action, including root cause determination, has not been effective. The expectation is that non-compliances will be tracked in a contractor's self-tracking system, and will be routinely reviewed by the contractor for potential trends and repeat occurrences.

- Programmatic breakdown: Several non-compliances have occurred that are related, but not identical, indicating a common breakdown in a program or program area. These non-compliances might have a common cause indicating a programmatic weakness. A programmatic breakdown generally involves some weakness in administrative or management controls, or their implementation, to such a degree that systematic problems occur. This weakness might be identified as part of the root cause determination for a single event.

- Intentional violation or misrepresentation: Most intentional violations involve the failure to perform substantive activities required by nuclear safety requirements coupled with the alteration, concealment, or destruction of documents pertaining to those activities.

- Failure to meet the action statements for the specific controls or restrictions will lead directly to violation of the AC.

Upon the occurrence of an AC violation, safe facility configuration must be assured and the scope of suspension of operations determined. As these are programmatic requirements, the severity of response will depend on the individual violation and its impact on operations. This assessment is the responsibility of management. The following guidance applies to scoping the termination of operations:

- The scope of termination of operations may be focused when the underlying program deficiency involves a specific repetitive element (7.4.1.3.a).

- A programmatic breakdown (7.4.1.3.b) warrants suspension of those operations with safety reliance on the affected program.

- An intentional violation as determined under the PAAA requirements (7.4.1.3.C) would necessitate suspending affected operations without scope limitation.

Adherence to the Site Engineered Controls (SECs) ensures continued system support to facilities. The SECs are designed to capture systems credited in facility authorization documents. Compliance with the SEC ensures the site support for these authorization documents remains valid.

## 7.7 BASES FOR SITE ADMINISTRATIVE CONTROLS

### 7.7.1 Organization and Management Bases

The establishment and maintenance of a minimum staff provides assurance that the site is capable of operating within the defined controls. Clearly defined lines of authority, responsibility, and communication establish command and control in the event of an emergency.

The minimum staff defines, by position and number, those management and operating personnel that are necessary for site safety. Minimum staffing assures that qualified personnel are available to provide the expertise and decision-making capability required to maintain the safety of the site.

The number required, the shifts to be covered, and the levels of availability are department specific based upon the level, complexity and hazard potential of authorized work. Minimum staffing requirements ensure that sufficient resources are available to fulfill credited safety operations.

Fire and Emergency Services

- The existing Final Safety Analysis Reports (FSARs) identify a 15-minute RFETS Fire Department response time to control or mitigate fire scenarios. Some areas depend on response time in lieu of an automatic fire suppression system.

- The RFETS Fire and Emergency Services Department is available for response 24-hours per day every day of the year to prevent fires and minimize loss to life, material and property in the event of a fire. This includes an adequately staffed, trained and equipped Fire Department. Staffing, training, and equipment requirements are determined by the authority having jurisdiction based upon current site conditions. Reliance on fire suppression and fire fighting capabilities varies depending upon the activities being performed at the site.

- Environmental agencies and permits, such as the Resource Conservation and Recovery Act (RCRA) require the availability of hazardous material cleanup equipment. The site is also part of an interagency mutual aid agreement.

- The RFETS Fire and Emergency Services Department is essential for nuclear and life safety at the site. DOE Order 420.1 (DOE, 1996a) requires a fully staffed, trained, and equipped Fire Department. The department serves many functions: interagency mutual aid, filling of breathing air bottles on the site, 24-hour manned dispatch center, etc. Authorization basis documentation for individual facilities take credit for the RFETS Fire Department to minimize material at risk involvement in the event of an accident involving a fire.

Emergency Response Organization

- DOE Order 151.1 (DOE, 1996b) requires facilities with hazardous materials have an Emergency Operations Center (EOC).

- In the event of a site emergency, the EOC provides oversight of response activities support to incident commander and communications with headquarters and state and local officials.

- The EPLAN (RFETS, 1999b) requires a minimum of two trained and qualified persons to cover every key position of the EOC. Recall drills are held periodically and staffing requirements corrected according to the EPLAN.

### 7.7.2 Facility Inventory Control and Material Management Bases

Inventory control is not applicable at the site level.

### 7.7.3 Site Engineered Controls Bases

#### 7.7.3.1 Requirement for Site Engineered Controls Bases

Site Engineered Controls are developed to maintain site-wide systems that are important to facility accident analyses.

The following table identifies the safety function associated with the systems selected for site controls:

**Table 7-11.** Safety Function of the Site Engineering Controls

| SYSTEM | SAFETY FUNCTION |
|---|---|
| Fire Protection Water Supply System | Automatic fire suppression and fire department response reduce the frequency of a large fire occurrence and mitigates the radiological consequences of some fires. |
| Site Electrical Power | The electrical power provides power to electrical busses in facilities which maintain equipment important to the safety of workers and the public. Examples are the HVAC equipment which maintains the glovebox differential pressures, main power for the criticality detectors, and other monitoring equipment. HVAC provides a defense-in-depth confinement function against the release of radioactive particulate in the exhaust air from the building. |
| Site Alarm System | The alarm systems provide notification of emergency situations to workers to allow for timely evacuation. The fire alarm system alerts the immediate building occupants and the fire department, allowing for a timely response to the fire, providing for worker safety, defense-in-depth, and property protection. The LS/DW system provides a communication function to the work force for emergency warning and other safety information. The LS/DW system also provides the criticality warning tone within a facility. |
| Nitrogen Supply System | The inert atmosphere provided by the nitrogen supply system provides defense-in-depth for preventing pyrophoric fires in gloveboxes and storage areas. |
| Propane and Natural Gas Systems | Control of ignition sources (including parked vehicles) in the vicinity of propane storage tanks eliminates initiators which could result in an explosion or fire in the event of a leak from a propane tank. |

#### 7.7.3.2 Credited Programmatic Elements Bases

No programmatic elements exist for the Site Engineered Controls.

#### 7.7.3.3 Specific Controls or Restrictions Bases

Bases for Site Engineered Controls for the Fire Protection Water Supply System (SEC 1)

Many authorization basis documents for site facilities credit the fire protection water supply system, including the redundancy of supply, in their accident analysis. Redundancy is accomplished by maintaining two separate water supplies and by looping the piping around the major buildings.

This system is important to these facilities because it is relied upon for the mitigation of consequences in the event of a fire both as sprinkler coverage for fire suppression and flow alarms for notification of the fire department. The loss of the fire protection water supply system due to failures on the distribution network impacts fire protection and emergency response capabilities.

The fire protection water supply system is considered capable of supplying firewater if there is an adequate water supply in the fire water tank, 215C, the fire pumps will function when needed, and the water can flow through the distribution system supplying water to the facility fire suppression systems and fire hydrants.

Adequate water is considered to be the amount needed for a 2-hour water supply at 1,500 gpm for sprinklers plus 500 gpm for hoses. This calculates to a minimum water volume of 240,000 gallons (Campbell, 1999). Water storage locations and maximum capacities on the site are:

| Domestic water supply Building 124: | | Fire water supply: | |
|---|---|---|---|
| Tank 215A | 299,000 gallons | Tank 215C | 473,000 gallons |
| Tank 215B | 473,000 gallons | | |
| Clearwell | 275,000 gallons | | |

Prompt notification ensures activities with a high likelihood of initiating a fire are stopped and appropriate fire surveillances are implemented. Reliance on fire suppression and fire fighting capabilities vary depending upon the activities being performed at the site. An engineering evaluation can assess the current conditions and determine an acceptable period of time for corrective actions.

Bases for Site Engineered Controls for the Site Electrical Power (SEC 2)

Public Service Company of Colorado (PSCo) owns the overhead lines and equipment, including the ring bus up to the 115/13.8 kV substations. At this point site personnel assume the responsibility for the power distribution system. RFETS has ownership for all ground mounted equipment, transformers, overhead equipment, 13.8 kV switchgear, and the 13.8 kV transmission system, with the exception of the 132 transformer.

All major buildings are provided with site power lines for building loads. The power to the site is supplied by 115 kV transmission lines that are separately interconnected with the PSCo transmission grid. Two lines enter the site through the "North Switch Yard," and if necessary, each of the lines can be switched to supply the entire site. All the 115 kV transmission facilities are owned and operated by PSCo, including those located on site. Under normal operating conditions, both 115 kV transmission lines are energized to supply substations that serve the site's 13.8 kV electrical distribution system. Each of the substations consists of two transformers with tie-breaker capability.

The system is typically configured so the transformers in each substation are alternately connected to each north line. The north transmission lines have automatic switching capability located in the "North Switch Yard" which allows either line to supply all transformers in the event the other line is lost.

Bases for Site Engineered Controls for the Site Alarm System (SEC 3 and SEC 4)

The alarm panels must be capable of properly receiving and transmitting alarms. This includes the alarm system components that transmit criticality accident alarms to the CAS and SAS. The Site Alarm system is a fully supervised system with immediate reporting capability in the event of failures in the cables or Data Gathering Panels. Precautionary measures will be taken in the event of alarm system failure until the system is repaired.

The uninterruptible power supply (UPS) systems are required to provide power for monitoring capabilities during the interval between the loss of electrical power and the commencement of the emergency generators to provide electrical power. The UPS systems prevent degradation of the Site Alarm System by preventing power fluctuations to computer monitoring equipment and powering detection and annunciating equipment.

Emergency generators supply power to the Central Alarm Station (CAS), the Secondary Alarm Station (SAS), the Fire Dispatch Center (FDC), and the Emergency Operations Center (EOC).

Bases for Site Engineered Controls for the Site Steam System (SEC 5)

No control is required for the site steam system.

Bases for Site Engineered Controls for the Nitrogen Supply (SEC 6)

The nitrogen plant provides pressurized gaseous nitrogen for use in inert environments and as an alternate supply of pressurized gas in instrument air loads. The continued availability of nitrogen is necessary to maintain these inert environments and as a backup supply for instrument air loads.

| Nitrogen Plant Capacity | |
|---|---|
| Production Rate: | 184,000 scfh (design capability) |
| Cryogenic Storage: | 120,000 gallons (2 tanks at 60,000 gallons, normally full to 80% or 48,000 gallons each) |

The cryogenic tanks are maintained full, as a reserve in the event the nitrogen plant is not operating, and can supply nitrogen for three to four days, providing backup capacity necessary to maintain existing and emergency nitrogen loads while the nitrogen plant is brought back into operation. The reserve is automatically engaged in the event nitrogen generation at the plant is interrupted. The nitrogen plant is owned by DOE and operated and maintained by Air Products which has a 2-hour response time in the event of problems. Redundancies are built into the generation system. The nitrogen plant has the capability of being attached to a supply tanker in the event both production capabilities and the reserve are not available.

| Building Requirements | Nominal Usage | Uses |
|---|---|---|
| Building 371/374 | 400 cfm (24,000 cfh) | Inert gloveboxes, stacker/retriever, backup instrument air for ventilation controllers |
| Building 559 | ~10 cfm (600 cfh) | Instrument air |
| Building 707 | 860 cfm (51,600 cfh) | Inert glovebox systems, instrument air, equipment purging |
| Building 771 | Unknown | Backup for plant air (instrument air) |
| Building 776/777 | Unknown | Inert glovebox system, instrument air backup, compressed air backup to operate pneumatic doors on inert gloveboxes |

The quantity of nitrogen used in some facilities is not known because no flow monitoring equipment is available. Normally the nitrogen plant runs at 65% of capacity.

The nitrogen supply system is considered capable of maintaining inert environments when the system is producing nitrogen or the cryogenic tanks are supplying nitrogen or when adequate tanker supplies are available.

Bases for Site Engineered Controls for the Propane and Natural Gas Systems (SEC 7)

Maintaining clear areas around propane storage tanks prevents the development of dangerous overpressure conditions in the event of a vapor cloud explosion. Controlling potential ignition sources (vehicles, smoking) reduces the probability of ignition of the fuel in the event of a spill or leak. Filled propane storage tanks in the vicinity (e.g., within 150 to 200 feet) of a nuclear facility are of concern, based on CALC-RFP-98.0555-RGC (RFETS, 1998a). These tanks are:

- 750 #1 through 8 (750 Pad)
- T771B (Building 771)
- T771G (Building 774)
- 904 #1 through 8 (904 Pad and Building 906)

Controlling the distance between a propane tank and a facility containing nuclear material reduces the potential effects in the event of a BLEVE (boiling liquid evaporating vapor explosion). The distances of concern for the various sizes of propane tanks used on the site are based on CALC-RFP-98.0555-RGC (RFETS, 1998a).

### 7.7.4 Site Transportation Bases

7.7.4.1 Requirement for Site Transportation Bases

Transportation controls are developed for activities related to transfer and delivery of hazardous materials on the site in order to ensure safe transfer of these materials. Implementation of controls maintains the assumptions in the safety analysis for preventing or mitigating the risk of an accident releasing these materials. The consequences and risks associated with these transfers are described in Chapter 8, Transportation Safety Analysis. The following calculations evaluate the transportation activities on the site:

- CALC-RFP-98.0570-KKK, Revision 4 (RFETS, 2000b) - consequences and risks associated with the transfer of nuclear materials and radioactive wastes;
- CALC-RFP-98.0660-MAN (RFETS, 1998b) - transfers of non-radioactive hazardous materials; and
- CALC-RFP-98.1545-KKK, Revision 3 (RFETS, 2000c) - fuel transfers.

The following categories for transfer of nuclear materials, residues and radioactive wastes at RFETS are used in the development of controls. These categories follow the guidance in DOE Guidance, DOE G 460.1-1, *Implementation Guide for Use with DOE O 460.1A, Packaging and Transportation Safety* (DOE, 1997), for the establishment of a hazardous materials hierarchy to grade the controls based on the hazards presented by the material. The more hazards presented by the material, the more stringent the controls on the transfer of that material.

(1) Total quantity of fissile material transferred in one load is **greater than 6 kilograms (kg) weapons grade plutonium (WG Pu)**. Two divisions apply to this category: loads containing greater than 6 kg but less than or equal to 16 kg WG Pu; and loads containing greater than 16 kg WG Pu. These moves are accompanied by a Transportation Safety Officer (TSO). Materials in this category are usually packaged in drums with greater than 200 grams WG Pu per drum and includes special nuclear materials (oxides, metals, etc.), residues, residues with high americium content, liquids, and TRU/TRM wastes. Transfers may be accompanied by a security convoy as required by Safeguards and Security. Tables 7-1 and 7-2 identify the controls for transfers of material in this category.

(2) Total quantity of fissile material transferred in one load is **greater than 200 grams but less than or equal to 6 kg WG Pu**. These moves are controlled by the driver of the transfer vehicle. Materials in this category are packaged in drums less than, or equal to, ($\leq$) 200 grams WG Pu. These drums can also contain $\leq$ 3.5 grams Am or 350 grams total WG Pu dose equivalent, with the exception of POCs. POCs can contain greater than 3.5 grams Am, but must meet the WG Pu dose equivalent requirements of $\leq$885 grams for Solubility Class W material and $\leq$1,255 grams for Solubility Class Y material. This category includes drums containing liquids, TRU/TRM wastes (including pipe overpack containers [POCs]) and residues with

less than 200 grams per drum. Waste boxes containing TRU/TRM wastes can contain $\leq$320 grams WG Pu. Combined loads can contain LLW/LLMW. HEPA filter boxes and coffins could be transferred under this category. Unattended staging in unfiltered areas is permitted for materials identified in this category, provided: 1) each drum does not exceed 200 grams WG Pu or 200 grams Pu in Am-enriched residues; 2) each TRU/TRM waste box does not exceed 320 grams WG Pu; 3) the material is contained in POCs that meet WIPP WAC. Tables 7-3 and 7-4 identify the controls for transfers of material in this category.

(3) Total quantity of fissile material transferred in one load is **less than or equal to 200 grams WG Pu**. This category includes LLW/LLM packaged in drums or wooden boxes, samples, and sources. Although samples are identified in this category, the type and size of the sample may require transfer under the controls of any of the above categories. The current safety basis for this control set does not address Am-enriched material. Material enriched in Am that exceeds LLW activity is not transferred under this category, unless it is a certified, sealed source. Tables 7-5 and 7-6 identify the controls for transfers of material in this category.

The total quantities identified for transfer are based on individual drum limits, such as nuclear material safety limits (NMSLs) and a possible number of drums that could be transferred in one load based on vehicle size. The NMSL is not a transportation control and changes to an NMSL may, or may not, affect the transportation controls.

The controls for the transfer of nuclear materials and radioactive wastes identified in Tables 7-1 through 7-6 do not include requirements made by federal law, e.g., Code of Federal Regulations (CFRs) or independent DOE requirements, e.g., Safeguards and Security requirements. CFR requirements include such things as the use of appropriate tie-downs during transfer and regular vehicle inspection and maintenance. The following caveats apply to the controls in Tables 7-1 through 7-6:

- The controls identified do not apply to material packaged in Type B containers or for off-site shipments.
- If a load consists of a mixture of material types, e.g., SNM, TRU and LLW, the most restrictive controls will apply.

In the controls in Tables 7-1 through 7-6, the terms "transfer truck" or "transfer vehicle" refer to the vehicle being used to transfer nuclear materials, radioactive wastes, or non-radioactive hazardous materials, substances or wastes. Bulk fuel delivery vehicles are identified as "delivery vehicles".

The "discovery" associated with the Controls or Restrictions in Tables 7-1, 7-3, and 7-5 starts from the point in time the determination is made that the control/restriction is not being met. The required action, e.g., return load to below allowable limit, can be completing the transfer if that is the most expedient method and is accomplished within the allowed completion time.

7.7.4.2 Bases for Site Transportation Control for Quantities Greater Than 6 kg WG Pu (STC 1)

Specific Controls or Restrictions Bases for STC 1 (The number in parentheses corresponds to the control in Section 7.5.4.2, Table 7-1.)

(1) Controlling the quantity (inventory) of material placed on a transfer truck directly affects the potential consequences in the event of an accident. Proposed transfers of materials in greater quantities than those analyzed will require further evaluation. The safety basis for this category is based on Am-enriched material that is less than or equal to 9 weight-percent Am (9 grams Am per 100 grams WG Pu). The analyzed maximum quantity of Am in this control set contained in residues corresponds to approximately 24 kilograms of Am, based on 250,000 grams WG Pu in high-Am residues. A small number of containers exist that exceed 9 weight-percent Am, however, it is not considered credible that sufficient containers of Am material greater than 9 weight-percent could be carried on one transport vehicle to exceed 24 kilograms equivalent Am.

Credited Programmatic Elements Bases for STC 1 (The numbers in parentheses correspond to the controls in Section 7.5.4.2, Table 7-2.)

(2) The initiating frequency for a fire in a transfer vehicle is qualitatively estimated for an electrical malfunction spreading to the cargo. Elimination of excess combustible material helps prevent this. It is also a factor in the probability of the fire in Scenario 6, but is not credited in the frequency development.

(3) Use of Type A or better packaging, or packaging approved for use on site ensures the integrity of the container is adequate to contain the contents of the package under normal transfer conditions and minor accidents. Approved packaging ensures compliance with venting/vent inspection requirements, HSP 31.11 compliance requirements, rigidity requirements, etc (RFETS, 1993). Compliance with these requirements reduces the frequency of accident initiators. Venting of packages is credited for reducing the frequency of hydrogen overpressurization accidents (Scenario 7). HSP 31.11 compliance is credited in the frequency for pyrophoric fire accidents (Scenario 8). Implementation of the venting program is controlled under facility authorization bases.

(4) This evaluation considered that vehicle collision speeds up to 15 mph would not breach site transportation safety manual approved packages by qualitatively crediting energy absorption through deformation of the transportation vehicle, deformation of objects hit by the transportation vehicle, and drum tie downs.

(5) Control of combustible and flammable materials and ignition sources reduces the potential for material or initiators to be present that may contribute to a fire scenario. These controls also help control the probability of the fire in Scenario 6, but are not credited in the frequency determination.

(6) Control of ignition sources minimizes initiators. This control requires the engine of the transfer vehicle to be off while loading and unloading material minimizing a potential source of ignition that could lead to fire scenarios. This is a basic assumption in the base frequency value for Scenario 6.

(7) The probability of material being on the transfer vehicle in the event of a fire due to a vehicle malfunction (Scenario 6) is reduced by not allowing material to be staged in the vehicle. The staging of packages in a transfer vehicle is controlled by ensuring packages will not be loaded into a transport vehicle unless the receiving facility is ready to accept the load (RFETS, 1999c; RFETS, 1999d).

(8) The probability that a pool fire under the transfer vehicle will breach the bed and expose the packages directly to the pool fire is reduced by the presence of the metal floor. (Scenarios 5 and 6)

(9, 10) Minimizing the presence of propane, by prohibiting propane powered vehicles and maintaining a safe distance between a transfer vehicle and a propane delivery vehicle, eliminates the potential for explosion external to the transfer vehicle.

(11) Radio communications influence the base frequency number and the On-site Adjustment Factor used in the frequency calculation. Use of a protective force convoy for the transfer of Safeguards Category I and II materials ensures the safety of the material and reduces the potential for an accident. The decision on the response to emergency situations is based on the best estimate of what action will take the material out of the potential path of an emergency vehicle, thereby lessening the exposure of the material to an accident.

(12) Availability of the fire department is credited in the fire scenarios in the probability of the fire breaching the bed of the transfer vehicle.

7.7.4.3 Bases for Site Transportation Control for Quantities >200 grams to 6 kg WG Pu (STC 2)

Specific Controls or Restrictions Bases for STC 2 (The number in parentheses corresponds to the control in Section 7.5.4.3, Table 7-3.)

(1) Controlling the quantity (inventory) of material placed on a transfer truck directly affects the potential consequences in the event of an accident.

Programmatic Controls Bases for STC 2 (The numbers in parentheses correspond to the controls in Section 7.5.4.4, Table 7-4.)

(2) The initiating frequency for a fire on the transfer vehicle is qualitatively estimated for an electrical malfunction spreading to the cargo. Elimination of excess combustible material helps prevent a fire from spreading. It is also a factor in the probability of the fire in Scenario 6, but is not credited in the frequency development.

(3) Controlling the quantity of material in non-waste drums maintains the safety basis analyzed for this category. Waste drums in this category usually contain less than 200 grams WG Pu and waste boxes usually contain less than 320 grams WG Pu. The safety basis for this category is based on 200 grams WG Pu and 3.5 grams Am, or 350 grams total WG Pu dose equivalent for drums, with the exception of POCs which allow a higher Am content. The safety basis for POCs is 885 grams WG Pu dose equivalent for Solubility Class W material, which is the same as 1,255 grams WG Pu dose equivalent for Solubility Class Y material. The safety basis for waste boxes is 320 grams WG Pu. Transfer of an individual container exceeding the safety basis is allowed if it meets additional requirements identified in the exception statement for the control. The basis for allowing transfer of these items is the infrequent occurrence of such moves will not challenge the transportation safety basis, and will help protect the safety basis of facilities affected by non-compliant TRU waste containers.

(4) Use of Type A or better packaging, or packaging approved for use on site ensures the integrity of the container is adequate to contain the contents of the package under normal transfer conditions and minor accidents. Approved packaging ensures compliance with venting/vent inspection requirements, HSP 31.11 compliance requirements, rigidity requirements, etc (RFETS, 1993). Compliance with these requirements reduces the frequency of accident initiators. Venting of packages is credited for reducing the frequency of hydrogen overpressurization accidents (Scenario 7). HSP 31.11 compliance is credited for the frequency in the pyrophoric fire accidents (Scenario 8). Implementation of the venting program is controlled under facility authorization bases.

(5) This evaluation assumed low vehicle speeds for the development of the spill scenario severity categories.

(6) Control of ignition sources minimizes initiators. This control requires the engine of the transfer vehicle to be off while loading and unloading material minimizing a potential source of ignition that could lead to fire scenarios. This is a basic assumption in the base frequency value for Scenario 6.

(7, 8) Minimizing the presence of propane, by prohibiting propane powered vehicles and maintaining a safe distance between a transfer vehicle and a propane delivery vehicle, eliminates the potential for explosion external to the transfer vehicle.

(9) Radio communications influence the base frequency number and the On-site Adjustment Factor used in the frequency calculation.

7.7.4.4 Bases for Site Transportation Control for Quantities ≤200 grams WG Pu

Specific Controls or Restrictions Bases for STC 3 (The number in parentheses corresponds to the control in Section 7.5.4.4, Table 7-5.)

(1) Controlling the quantity (inventory) of material placed on a transfer truck directly affects the potential consequences in the event of an accident.

Programmatic Controls Bases for STC 3 (The numbers in parentheses correspond to the controls in Section 7.5.4.5, Table 7-6.)

(2) The initiating frequency for a fire in a transfer vehicle is qualitatively estimated for an electrical malfunction spreading to the cargo. Elimination of excess combustible material helps prevent this. It is also a factor in the probability of the fire in Scenario 6, but is not credited in the frequency development.

(3) Use of approved packaging for on-site transfers of wastes in drums ensures the integrity of the container is adequate to contain the contents of the package under normal transfer conditions and minor accidents. Approved packaging ensures compliance with venting/vent inspection requirements, HSP 31.11 compliance requirements, rigidity requirements, etc (RFETS, 1993). Compliance with these requirements reduces the frequency of accident initiators. Venting of packages is credited for reducing the frequency of hydrogen overpressurization accidents (Scenario 7), and is applicable to TRU/TRM drums transferred in this category. HSP 31.11 compliance is credited for the frequency in the pyrophoric fire accidents (Scenario 8). Implementation of the venting program is controlled under facility authorization bases.

(4) This evaluation assumed low vehicle speeds for the development of the spill scenarios.

(5) Control of ignition sources minimizes initiators. This control requires the engine of the transfer vehicle to be off while loading and unloading material minimizing a potential source of ignition that could lead to fire scenarios. This is a basic assumption in the base frequency value for Scenario 6.

(6) Minimizing the presence of propane, by prohibiting propane powered vehicles and maintaining a safe distance between a transfer vehicle and a propane delivery vehicle, eliminates the potential for explosion external to the transfer vehicle.

(7) Radio communications influence the base frequency number and the On-site Adjustment Factor used in the frequency calculation.

(8) The safety basis for this category did not address transfer of Am-enriched material.

7.7.4.5 Bases for Site Transportation Control for Fuels

Specific Controls or Restrictions Bases for STC 4

No specific controls are identified for the transfer of fuels.

Programmatic Controls Bases for STC 4 (The numbers in parentheses correspond to the controls in Section 7.5.4.5, Table 7-7.)

(1) Maintaining combustibles and ignition sources 20 feet from fuel storage tanks reduces potential for fire in the area of the storage tank that may affect facilities in the area.

(2) Designated routes limit potential interactions with the fissile material transfer vehicle. Minimizing the presence of propane, by maintaining a safe distance between a transfer vehicle and a propane delivery vehicle, eliminates the potential for explosion external to the transfer vehicle. The designated route for fuel delivery is per the most current procedure.

Designated routes also limit the potential interactions with fuel delivery vehicles (>400 gallons capacity) and Waste Management Cells (WMCs) prohibiting the large fuel delivery vehicles (>400 gallon capacity) on WMCs and roads adjacent to WMCs reduces the major fire accident frequency from unlikely to extremely unlikely. This is accomplished by using alternate routes (not adjacent to WMCs). The designated routes for fuel delivery is per the most current procedure.

(3) Security and emergency response events are imbedded in the base frequency number for accidents per mile and probability of a fuel spill and fire that results in a release of radiological material CALC-RFP-98.1545-KKK, Revision 3 (RFETS, 2000c). It is assumed the delivery vehicles follow the posted speed limits.

(4) Adequate staffing of the Fire Department is credited to reduce the frequency for fuel delivery vehicle accidents that could impact a vulnerable area of a nuclear facility to the incredible range. For the 2,000-gallon diesel tanker and the propane tanker Fire Department staffing provides defense-in-depth to reduce the frequency to well below the 1.0E-06/year to 1.0E-7/year. Deliveries from off-site vendors to the garage will not affect a nuclear facility if the route does not include Cactus Avenue south of Buildings 440 and 664, and Seventh Street east of Building 664.

7.7.4.6 Bases for Site Transportation Controls for Material Transfer Vehicle Loading/Unloading Operations and Transfers Between Facilities Using Powered Industrial Trucks

For the purpose of compliance with STC 5, the boundary between the material transfer vehicle loading and unloading activity and the facility is the point when the package enters or leaves the control of the nuclear facility. In the case of material transfer vehicle unloading operations under STC 5, it is the point where the PIT or crane sets a package down and is no longer in contact with the package. For material transfer vehicle loading operations under

STC 5, it is the point at which the PIT or crane comes into contact with the package for the purpose of moving the package to the material transfer vehicle. The STC 5 controls do not supersede existing dock requirements or controls in facility-specific Authorization Bases. In cases where STC 5 and a facility Authorization Bases are in conflict, the facility Authorization Bases shall take precedence.

Specific Controls or Restrictions Bases for material transfer vehicle loading and unloading operations

No specific controls or restrictions apply to the use of powered industrial trucks or cranes for material transfer vehicle loading and unloading operations.

Programmatic Controls Bases for material transfer vehicle loading and unloading activities using a powered industrial truck (forklift) or crane (The numbers in parentheses correspond to the controls in Section 7.5.4.6, Table 7-8.a)

(1) Controlling the number of packages that are permitted to be loaded and unloaded at a time using a powered industrial truck directly affects the potential consequences in the event of an accident.

(2) Prohibiting the use of fossil fuel (gasoline or diesel) powered industrial trucks or cranes for loading and unloading of TRU waste drums directly affects the potential consequences in the event of a pool fire accident.

(3) Controlling the number of packages that are permitted to be loaded and unloaded at a time using a crane directly affects the potential consequences in the event of an accident.

(4) Use of approved packaging for material transfer vehicle loading and unloading activities ensures the integrity of the container is adequate to contain the contents of the package under normal loading and unloading conditions.

(5) Control of fuel type used for powering the powered industrial truck used in material transfer vehicle loading and unloading activities affects the probability of an explosion (e.g., no propane).

(6) Following the requirements of the Occupational Safety & Industrial Hygiene Program Manual for powered industrial truck and crane operations provides additional assurance the loading and unloading activity will be accomplished safety.

<u>Specific Controls or Restrictions for the use of powered industrial trucks for material transfers between facilities</u>

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The bases for the specific controls and restrictions are included with the bases for the programmatic controls in the next section.

<u>Programmatic Controls Bases for on-Site transfer of radioactive materials between facilities using a powered industrial truck (forklift)</u> (The numbers in parentheses correspond to the controls in Section 7.5.4.6, Table 7-8.b)

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(1) Controlling the number of drums and boxes that are transferred using a forklift directly affects the potential consequences in the event of an accident. Due to their lower MAR values, all other LLW/LLMW forklift transfers using fossil fuel can be performed between facilities that are within an established area of the site. The established areas of the site are:
- The 300 area
- The 400 area
- The 700 area (Includes Buildings 559 and 569 as part of this area)
- The 800 area

(2) Compliance with the requirements in the STSM provides assurance that the integrity of the container is adequate to contain the contents of the package under normal transfer conditions (approved packages) and that the transfer will be accomplished safely.

(3) Controlling the fuel type used for powering the forklift used in transfers of material affects the probability of an explosion (e.g., no propane). Cranes of any type are prohibited from transferring radioactive materials since they were not specifically analyzed.

(4) Restricting areas permitted for TRU forklift transfers using fossil fueled vehicles reduces the potential for an accident. Because of their higher MAR values, TRU SWBs is limited to transfers between Buildings 440 to 664 because they are adjacent to each other. Transfers can be two SWBs with ≤325 g WG Pu each. If it is known that the SWB is overloaded, only one can be moved at a time. The analysis provides consequences for a move with up to 810 g WG Pu which is considered the worst case move for overloaded SWBs where the operator failed to determine the correct MAR prior to transfer. Combustible load control prevents large fires from occurring. Flammable liquids are packaged in accordance with the site Fire Protection Program Requirements. [See NSTR-003-01, Rev. 1, *Combustible Fuel Package Separation Distances*, Kaiser-Hill Rocky Flats Environmental Technology Site.]

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### 7.7.5 Site Wooden Waste Box Storage Control Program Bases

7.7.5.1 Requirement for Site Wooden Waste Box Storage Controls Bases

The bases for the controls for the outside storage/staging of wooden waste boxes are addressed in Appendix J.

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### 7.7.6 Safety Management Program Bases

The safety infrastructure of RFETS is described in the Safety Management Programs and compliance with these programs is required to ensure worker safety during all aspects of operations and activities at the site.

## 7.8 REFERENCES


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RFETS, 1999c *Transfers of Category I and II Special Nuclear Material*, 4-T66-Traffic-TSO-001, Revision 2, Rocky Flats Environmental Technology Site, Golden, CO, June 7, 1999.

RFETS, 1999d *Transfers of Category III and IV Special Nuclear Material*, 4-T67-Traffic-TSO-003, Revision 2, Rocky Flats Environmental Technology Site, Golden, CO, June 7, 1999.

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RFETS, 2000b *Site SAR Transportation Safety Analysis,* CALC-RFP-98.0570-KKK-R04, Revision 3, Rocky Flats Environmental Technology Site, Golden, CO, March 2000.

RFETS, 2000c *Transport of Fuels on Site,* CALC-RFP-98.1545-KKK, Revision 3, Rocky Flats Environmental Technology Site, Golden, CO, March 2000.

SAE, 1996 *Low Level Waste Radionuclide Content*, Nuclear Safety Calculation, 96-SAE-038, Rocky Flats Environmental Technology Site, Golden, CO, October 1, 1996.

# CHAPTER 8

# TRANSPORTATION SAFETY ANALYSIS

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# CHAPTER 8

# TRANSPORTATION SAFETY ANALYSIS

## 8.1 INTRODUCTION

### 8.1.1 Purpose

This chapter evaluates the hazards associated with the transportation of hazardous and radioactive material on the Rocky Flats Environmental Technology Site (RFETS). The methods of transfer on site considered are restricted to truck transport. Also evaluated is the effect to the site from accidents occurring off-site involving hazardous chemicals transported by truck and rail. This evaluation identifies the spills, fires, explosions, and nuclear criticality accidents associated with the transfer of nuclear and/or hazardous materials.

### 8.1.2 Scope

At RFETS, "transportation" is defined as the activity of moving passengers or cargo from one point to another. For this evaluation, only the transfer of nuclear materials, radioactive wastes, and non-radioactive hazardous materials between facilities is being considered. This analysis takes credit for the as-handled packaging and transporting methods in determining consequences of accidents during transportation. Requirements for packaging, labeling, handling, loading, tie-downs, blocking/bracing, routing, vehicle requirements, and documentation are implemented by the Site Transportation Safety Manual (RFETS, 2000a). The following aspects of on-site transportation are included in this evaluation:

- Transfer of all types of nuclear materials and radioactive wastes,

- Transfer and delivery of non-radioactive hazardous substances (chemicals and compressed gas), and

- Transfer and delivery of fuels (propane, gasoline, and diesel fuel).

In addition to evaluation of on-site transportation accidents, impact to the site from accidents off site involving large quantities of non-radioactive hazardous substances is also addressed.

The following activities associated with transportation are not addressed in this evaluation:

- Staging of material that is performed at a facility in the preparation for, or as the result of, a transfer of material. Evaluations of these activities are contained in the individual facility analysis.

- Packages/material that are loaded in vehicles (trucks, trailers) in full compliance with applicable federal regulations and placed/parked in specifically identified parking areas pending off-site shipment. The off-site shipment of nuclear materials has been evaluated by the U. S. Nuclear Regulatory Commission (NRC, 1977) and is beyond the scope of this evaluation.

- Transportation of explosives substances are not included in this transportation analysis. Class 1.1 and 1.2 explosives are not permitted on the site. The only explosives used on the site are related to security operations. Routine transfers of explosives and ammunition are performed by Transportation Safety Officers (TSOs) using the box van or by security personnel as necessary to perform work. In no case are explosives transported in combination with radioactive or hazardous materials.

- Shock sensitive and reactive chemicals present special conditions and activities and are evaluated on a case by case basis.

- Transportation activities associated with "general deliveries" of non-radioactive or hazardous material supplies are not included in this transportation analysis.

### 8.1.3 Applicability

The analysis in this chapter applies to all transfer of hazardous materials, radioactive and chemical, within the boundaries of the site. This assessment is intended to provide bounding analyses for various types of materials transported on the site.

This chapter is maintained along with the Site SAR as part of the site authorization basis. Kaiser-Hill Manager of Traffic and Transportation is responsible for ensuring the information in this document remains current.

## 8.2 SITE DESCRIPTION

RFETS is located approximately 16 miles northwest of Denver, Colorado. Chapter 2 of this volume of the Site SAR describes the characteristics of the geography and demography associated with the site and includes environmental information for the Rocky Flats area, such as meteorology, hydrology, and geology.

There are four vehicle transportation routes near the site. These are used both for site deliveries and for public use. Highway 93 to the west of the site provides a major transportation route from Golden to Boulder; Highway 128 to the north of the site provides a minor transportation route from Highway 36 to Highway 93; Highway 72 to the south of the site provides a minor transportation route from Arvada to Highway 93, and Indiana Street to the east of the site provides a transit route between Highway 128 and Arvada/Highway 72.

There is also one primary rail transportation route near the site. The rail line passing south and west of the site transports all types of materials from Denver to the west. A spur from the main line on the west side of the site serves the site and the aggregate plant to the north of the site. The site spur comes from the northbound spur and runs parallel to the south side of the site. The northbound branch of the spur is infrequently used and the cargo consists of materials such as aggregate and thus is not expected to be important contributor to risk.

Aircraft in the vicinity are primarily from the Jefferson County Airport located approximately 4.5 miles from the site, and the Denver International Airport, located more than 12 miles from the site. No impact to transfer vehicles by aircraft is considered in this evaluation.

There are four vehicle transportation routes near the site. These are used both for site deliveries and for public use. Highway 93 to the west of the site provides a major transportation route from Golden to Boulder; Highway 128 to the north of the site provides a minor transportation route from Highway 36 to Highway 93; Highway 72 to the south of the site provides a minor transportation route from Arvada to Highway 93, and Indiana Street to the east of the site provides a transit route between Highway 128 and Arvada/Highway 72.

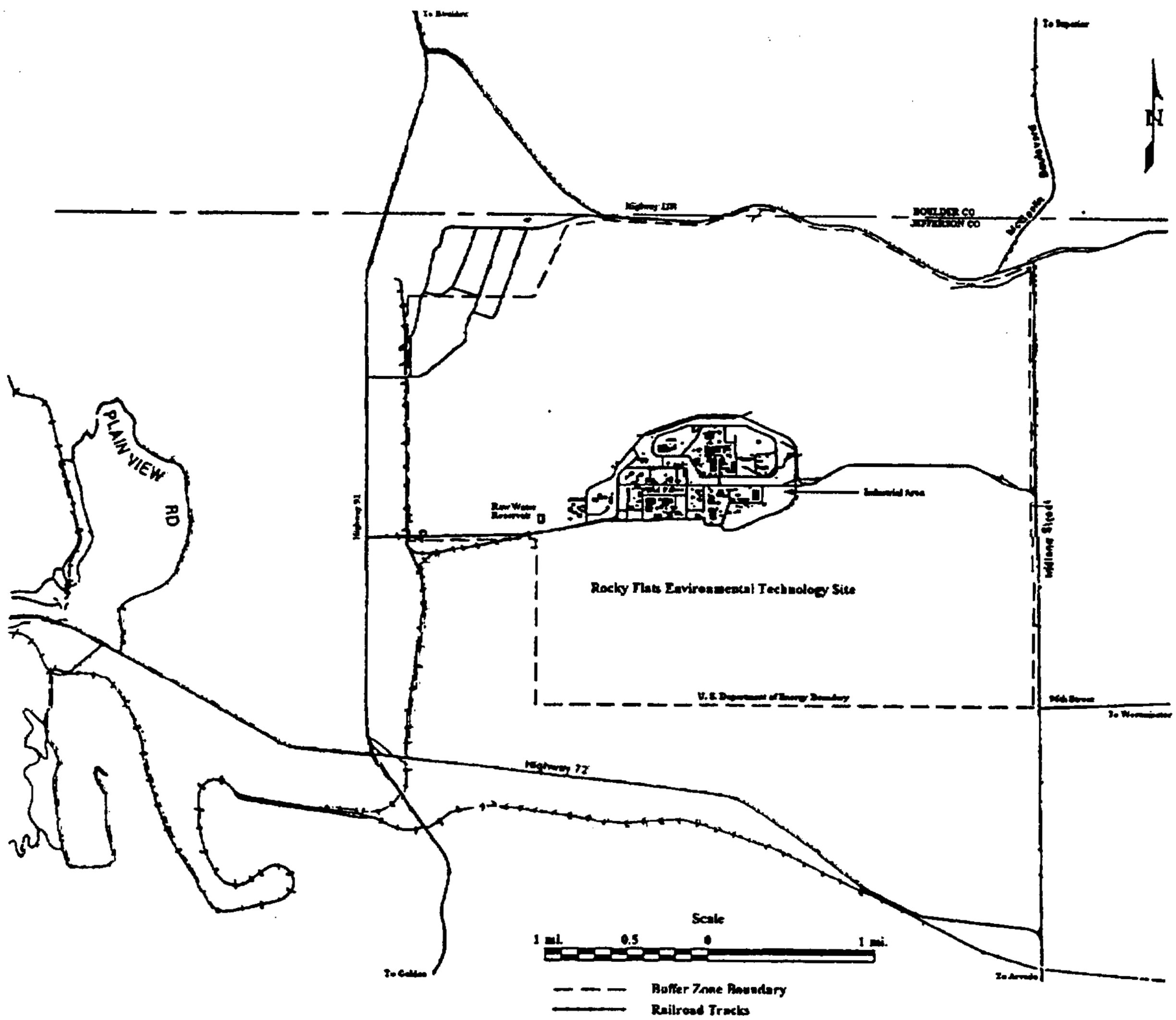


**Figure 8-1.** Configuration of highways and railroads in the vicinity of RFETS

### 8.2.1 Vehicles

RFETS utilizes a variety of vehicles for the transfer of material on the site. Certain vehicles are identified for the transfer of specific types of materials and the quantity of materials and configuration of the loading is determined by the bed size. Table 8-1 identifies the vehicles used for the transfer of nuclear materials and radioactive wastes and provides information on the use, bed size, capacity, and special considerations. These vehicles are fueled with diesel and have 30- to 50-gallon capacity fuel tanks. The TSO (Transportation Safety Officer) trucks, the box van, and the drum trucks are all box trucks with various size boxes. The descriptions in Table 8-1 are for information only and are not intended to be considered as controls. This includes truck bed sizes and number of trucks.

**Table 8-1.** Transfer Vehicle Information

| Transport | Normal Use | Truck Bed Size* | Comments |
|---|---|---|---|
| TSO trucks, box van | >200g/pkg - SNM, residues, high americium residues, high level liquids, TRU/TRM waste | 7' 7" x 12' (2)<br><br>7' 6" x 13' 10" (1) | These vehicles can be used for <200 g/pkg moves if required and if available. If these vehicles are used to transfer TRU wastes in boxes, the number of boxes is limited by the bed size. |
| Drum Truck | <200 g/drum, liquids, LLW/LLMW, TRU/TRM waste | 7' 6" x 15' 10" (4) | Residues and TRU wastes moved in these vehicles will contain less than 200 grams WG Pu material per drum. Drums with Pipe Overpack Containers (POCs) are limited to 200 grams WG Pu each. |
| Flatbed Trailer | Boxes containing LLW/LLMW, TRU/TRM waste | 14' to 54' long (several) | Wastes in boxes are usually transfered in batches of 10; however, half-boxes can be double stacked. The number of boxes that can be placed on one vehicle depends on the size of the bed and the vehicle weight limits.<br><br>Packages with >200 grams normally require an enclosed vehicle, however, work restrictions and lack of loading docks may result in transfer of TRU/TRM waste in metal boxes on flatbed trucks. |
| Other trucks | Other materials | Varies | Various trucks are used for the delivery of non-hazardous material and general supplies. |
| Tanker trucks | Fuel delivery | - 238 gallons in two 119 gallon tanks and 70 gallons in one tank (3)<br>- 2,000 gallon tanker (1) | The small tankers are used to deliver gasoline and diesel fuel to vehicles and small equipment within the PA. The 2,000 gallon tanker is to be used to service the diesel tanks on the stand-by generators. |
| * Number in parentheses () identifies the number of trucks of this size. | | | |

Vehicles used for transfer of chemicals and gases on the site consist of site owned vehicles or vendor vehicles. Vehicles used for transfer of these materials are selected as the most suitable for the lading. For example, stake trucks with adequate tie downs and racks are used to transport compressed gases. Bulk quantities of chemicals and some fuels are delivered to the end user in vendor tanker trucks.

### 8.2.2 Maps

A map showing transportation facilities and possible transfer routes for nuclear materials (SNM route) and for wastes materials at RFETS is provided in the site transportation safety manual (RFETS, 2000a). Potential routes for trucks delivering diesel fuel to the various diesel fuel storage tanks on the site is provided in the procedure covering the delivery and handling of liquid petroleum fuel. Delivery of propane to the propane tanks is not restricted to specific routes, but delivery is to be by the most direct route. The locations of the propane tanks on site are identified on Figure 3-4 in Chapter 3 of this volume of the Site SAR.

## 8.3 TRANSPORTATION MANUAL REQUIREMENTS

RFETS has developed transportation safety manuals (RFETS, 2000a) to cover the transfer of hazardous, non-hazardous, and radioactive materials on site, shipment of these of materials off site. The transportation safety manuals include the following information:

- Site description including a map showing docks and preferred routes;
- Identification of responsibilities;
- External regulations and site-specific standards, procedures, and instructions;
- Safety assessment methodology;
- Requirements for routine and non-routine transfers, including labeling, hand transfers and approved packaging;
- Requirements personnel qualifications and training;
- Requirements for documentation and record keeping;
- Requirements for incident reporting and emergency response;
- Requirements for operation of the transfer vehicle;
- Standards for off-site shipment;
- Definitions and acronyms;
- Requirements and responsibilities for transportation alcohol and controlled substance testing program; and
- Responsibilities for transportation quality assurance.

For detailed information on the above topics, refer to the appropriate portion of the safety manuals.

The terms used in this chapter are defined in the transportation safety manual. In addition to the definitions in the transportation safety manual, this evaluation defines delivery as the conveyance of materials. Materials delivered to the site include chemicals and fuels. Delivery can also include transfer of these materials to the end user.

## 8.4 TRANSPORTATION ACTIVITIES

Transportation accidents with the potential to release hazardous materials (radioactive and chemical) are related to the transfer of these materials. The following transportation activities and potential accidents are covered by this analysis:

- Transfer of all types of nuclear materials and radioactive wastes between facilities on the site. Accidents involving these materials present a potential hazard to the public, collocated worker, and the immediate worker due to a breach in the package containing the material. The damage to packages is assumed to be related to the impact, fire, pressurization, or criticality.

- Transfer or delivery of non-radioactive material (chemicals and compressed gases). Accidents involving chemicals and compressed gases that present potential hazards in the event of a release could occur during delivery from receiving at Building 130 to the final destination. In some cases, materials are delivered directly to the end user without stopping at receiving. Other subcontract organizations may receive materials directly delivered to site local construction areas.

- Transport of fuels (propane, gasoline, diesel fuel, and fuel oil). Fuel vendors deliver directly to site storage locations. Diesel fuel and gasoline are then distributed by limited-capacity site vehicles to individual user facilities where necessary. Propane is vendor-delivered directly to tankage at various locations on site. Accidents involving fuels are associated with delivery vehicle accidents or accidents during unloading activities.

- Impact to the site from accidents off site involving large quantities of hazardous materials. These accidents include releases of chemicals from bulk shipping, such as rail tanker cars in the vicinity of the site. Any potential accidents involving radioactive materials beyond the perimeter of the site are not within the scope of this analysis.

RFETS has developed a transportation infrastructure, described in manuals and procedures, to support the transportation of various materials on the site. These manuals and procedures ensure the correct steps are performed in the required sequence. These steps are not part of the safety analysis provided in this evaluation; however, some aspects of the procedural requirements are identified as controls in ensuring the proper materials are transferred in a safe, secure manner.

This evaluation of the transfer of nuclear materials and radioactive wastes does not analyze the following:

- Accidents occurring ***on the dock*** while the truck is parked at the dock are not included in this evaluation. These are considered and analyzed with the dock scenarios as part of the individual facility authorization bases. Scenarios 7 and 8 are single drum accidents that could occur at any time, including during drum movement within a facility.

- Transfer of materials contained in Type B packages are not evaluated because Type B packages are not expected to be breached in the event of an accident.

- The impact of external fires on the transfer vehicle and the contents are not evaluated because the transfer vehicle can avoid most external fire events, and external fire events will be bounded by Scenario 5.

- Natural phenomena events. It is assumed that the probability of earthquakes, tornadoes, etc. during the transfer is incredible and that transfers during hazardous weather can be avoided.

- Off-site shipments.

## 8.5 EVALUATION METHODOLOGY AND HAZARDS IDENTIFICATION

The hazards associated with on-site transportation of hazardous materials are related to the materials being involved in traffic accidents or vehicle fires. The hazards associated with shipment of hazardous materials off the site are limited to the effects of such an accident on the population and facilities on site. Off-site shipment is regulated by the Department of Transportation (DOT) requirements that provide protection to the public by providing controls on types, quantities, and packaging of hazardous and radioactive materials that are moved on public roads.

### 8.5.1 Evaluation Methodology

This section describes how the hazard and accident analyses are performed for the transportation accidents. The analysis includes the following steps: 1) identification of hazards; 2) identification of accident scenarios that could result in the release of hazardous materials; 3) evaluation of the accident scenarios using frequency and consequence calculations to determine potential risk; and 4) determination of controls necessary to maintain the level of risk. The hazard analysis excludes standard industrial accidents unless they initiate a release of radioactive or other hazardous materials or worsen the consequences of a potential release.

Accident scenarios are developed to evaluate the potential risks posed to the public and collocated workers by Rocky Flats transportation operations. The primary scenarios relating to transportation are vehicle accidents that occur on site. The scenarios for transfer of nuclear materials and radioactive wastes follow the eight scenarios developed in NSTR-015-97, *Salt Stabilization Program Transportation Risk*, (RFETS, 1997a) plus scenarios addressing a spill due to an explosion external to the transfer vehicle and the transfer of wastes using a powered industrial vehicle (forklift). Scenarios for transport of non-radioactive materials, such as chemicals and fuels, are developed to address the potential accidents that could occur during the transport of these materials. The scenarios are developed in Section 8.6.1.1 for transfer of nuclear materials and radioactive wastes and Section 8.7.1.2 for non-radioactive material transport. Analysis of the accident condition, taking credit for mitigative and preventative features, determines the ultimate frequency, consequence and risk of the accident. Scenario-specific assumptions and the results of the calculations are presented in Sections 8.6.3.2 through 8.6.3.9 for accidents involving nuclear materials and in Sections 8.6.4.2 through 8.6.4.9 for accidents involving radioactive wastes.

The methodology used for accident analysis in the Site SAR follows the guidance of the *Safety Analysis and Risk Assessment Handbook (SARAH)* (RFETS, 1997b). This methodology combines frequency and consequence classifications to determine the resultant level of risk. Table 2-4, Risk Classification Levels, provided in SARAH presents the risk classification matrix. The risk classes are defined as Class I, major risk; Class II, serious risk; Class III, marginal risk; and Class IV, negligible risk. The risk associated with Class III and IV does not require credited controls; however, controls are utilized where practical as defense in depth.

Occurrence frequencies are defined in SARAH in Table 2-1, Frequency Bin Designations. These frequencies can be developed qualitatively or quantitatively using standard references for generic values, site-specific data, or generic human error probabilities.

Consequences related to accident scenarios are qualitatively identified according to the definitions in Table 8-2. These qualitative descriptions are from DOE-STD-3009-94 (DOE, 1994a) and can be related to the quantitative values for radioactive and chemical consequence levels given in SARAH in Table 2-2, Radioactive Accident Consequence Levels for RFETS, and Table 2-3, Chemical Accident Consequence Levels for RFETS, respectively.

**Table 8-2.** Consequence Classification Descriptions

| Consequence Category | Description |
|---|---|
| None | Negligible on-site and off-site impact on people or the environs. |
| Low | Minor on-site and negligible off-site impacts on people or environs. |
| Moderate | Considerable on-site impacts on people or the environs; only minor off-site impacts. |
| High | Considerable on-site and off-site impacts on people or the environs |

### 8.5.2 Consequence Determination

Consequence calculations are quantitatively determined for the maximum off-site individual (MOI) and the collocated worker using a distance of 1,900 meters to the MOI and 100 meters to the collocated worker. The distance to the MOI of 1,900 meters is considered to be a generic distance and is identified as the distance from the approximate center of the site to the closest site boundary. Ninety-fifth percentile weather conditions are assumed in order to be consistent with other accident analyses performed for individual facilities. Accident consequences are calculated using *Areal Locations of Hazardous Atmospheres (ALOHA)* computer code (Reynolds, 1992) for pure chemical releases and methodology developed for the RADIDOSE computer code (SAE, 1997) for radioactive releases. The calculation printouts for scenarios involving radioactive materials and wastes are contained in calculation document CALC-RFP-98.0570-KKK-R04 (RFETS, 2000b). The calculations supporting the consequences for non-radioactive hazardous materials are in calculation document CALC-RFP-98-0660-MAN (RFETS, 1998a). Calculations for the consequences related to releases of fuels and chemicals off-site are documented in CALC-RFP-98.1545-KKK (RFETS, 2000c) and CALC-RFP-98.0717-KKK (RFETS, 1998b), respectively.

### 8.5.3 Hazard Identification

A comprehensive checklist of typical hazards (Table 8-3) is used to identify hazards associated with transportation activities. The hazards indicated with a "yes" in Table 8-3 are described in more detail in Table 8-4, which provides information on quantity, form, packaging and location of the hazards. The primary hazards associated with transportation are related to the materials being transported and include radioactive materials, hazardous materials, mixed radioactive/hazardous materials, bulk chemicals, and fuels. As indicated in the remarks column in Table 8-4, many of the hazards are considered standard industrial hazards and/or those that represent a publicly accepted risk. This table also discusses preventive and mitigative features that apply to reduce frequency or consequences of these events.

**Table 8-3.** Transportation Hazard Identification Checklist

| Hazard | Yes/No | Hazard | Yes/No |
|---|---|---|---|
| 1. High Voltage | No | 14. High Intensity Magnetic Fields | No |
| 2. Explosive Substances | Yes | 15. Effects of Chemical Exposures | Yes |
| 3. Cryogenic Systems | Yes | 16. Toxic, Hazardous, or Noxious Material | Yes |
| 4. Inert & Low-Oxygen Atmospheres | No | 17. Inadequate Ventilation | No |
| 5. Direct Radiation Sources | No | 18. Material Handling | Yes |
| 6. Radioactive Materials | Yes | 19. Ambient Temperature Extremes | No |
| 7. High Noise Levels | No | 20. Working at Heights | Yes |
| 8. Flammable Gases, Liquids, Dusts | Yes | 21. Pesticide Use | No |
| 9. Compressed Gases | Yes | 22. Lasers | No |
| 10. High Temperature & Pressure Systems | No | 23. Inadequate Illumination | No |
| 11. Kinetic Energy | Yes | 24. Biohazard | No |
| 12. Potential Energy | Yes | 25. Unknown or Unmarked Materials | No |
| 13. Non-Ionizing Radiation Sources | No | 26. Any Other Hazards | No |

**Table 8-4.** Transportation Hazard Description

| Hazard/ Energy Source | Description | Preventive & Mitigative Features | Remarks |
|---|---|---|---|
| **2. EXPLOSIVE SUBSTANCES** | | | |
| Ammunition and other explosives as required by security | Quantities and descriptions as required by security | - No Class 1.1 or 1.2 explosives allowed on the site<br>- Transfer of large quantities, e.g., deliveries, are done by TSOs<br>- No explosives are transferred with radioactive and hazardous material | Transfer of explosives is not covered by this evaluation. The requirements of the transportation safety manuals are to be followed. See Section 8.1.2. |
| **3. CRYOGENIC SYSTEMS** | | | |
| Liquid nitrogen or argon transport tankers | 40,000 lb tanker | - Tankers meet DOT requirements<br>- Tractor undergoes safety inspection before being allowed near site facilities | Standard industrial hazard that represents a publicly accepted risk. |
| **6. RADIOACTIVE MATERIALS** | | | |
| Radionuclides | Various types and forms of nuclear material and radioactive waste in sealed packages. Nuclear material includes oxides, residues, and liquids. Radioactive waste includes transuranic and low level wastes and mixed wastes. | - The Radiation Protection Program identifies administrative controls and procedures for handling, accountability, monitoring, shielding<br>- Packages meet site Transportation Manual or DOT requirements | - Packages provide substantial containment properties.<br>- Packages transported with personnel distanced from them except during loading/unloading.<br>- Requirements for dose rates at external surfaces of truck applied as required. |
| **8. FLAMMABLE GASES, LIQUIDS, AND DUSTS** | | | |
| Hydrogen gas | Hydrogen gas is generated by the radiolytic decomposition of water or plastics. Possible to be present in drums containing plutonium compounds. | - Drum vents<br>- Visual inspection of drums for bulging before movement | - Potential for drum rupture from hydrogen buildup and ignition. Evaluated as Scenario 7. |

**Table 8-4.** Transportation Hazard Description (Continued)

| Hazard/ Energy Source | Description | Preventive & Mitigative Features | Remarks |
|---|---|---|---|
| **8. FLAMMABLE GASES, LIQUIDS, AND DUSTS CONTINUED** | | | |
| Bulk liquified petroleum gas, propane, P-10, acetylene, and natural gas | Compressed gas cylinders and truck based tanks (bulk) delivered to various locations on site. | - Packaging meets site Transportation Manual or DOT requirements<br>- Gas distribution on site in many locations is buried pipe service | Standard industrial hazard that represents a publicly accepted risk. |
| Gasoline | Vehicle tanks and bulk delivery tanks operate on site. | - Tanks meet site Transportation Manual or DOT requirements<br>- Limited delivery locations on site | Standard industrial hazard that represents a publicly accepted risk. |
| Fuel oil and diesel fuel | Vehicles tanks and bulk delivery tanks operate on site. | - Tanks meet site Transportation Manual or DOT requirements<br>- Limited delivery locations on site | Standard industrial hazard that represents a publicly accepted risk. |
| **9. COMPRESSED GASES** | | | |
| Compressed Gases (acetylene, chlorine, hydrogen, P10, propane, nitrogen, oxygen, nitrous oxide, etc.) | 150 lb cylinders considered the normal type handled. Delivery trucks may contain multiple cylinders of multiple gas types. | - Gas cylinders conform to DOT and NFPA requirements<br>- Gas cylinders are transported and handled with caps on | Standard industrial hazard that represents a publicly accepted risk. |
| **11. KINETIC ENERGY** | | | |
| Vehicular traffic | Vehicles on site roads and on public roads. | - Site Transportation Manual requirements for low speeds on site<br>- Barriers near most on-site tanks, pipes, and buildings<br>- Safety inspection of delivery vehicles allowed on site | Standard industrial hazard both on and off site that is considered to be a publicly accepted risk. |
| Material handling equipment | Forklift or other package moving equipment on facility docks. | - Fork truck use covered by HSP<br>- Qualification for equipment operators<br>- Safety inspection of material handling equipment | Standard industrial hazard that is considered to be a publicly accepted risk. |

**Table 8-4.** Transportation Hazard Description (Continued)

| Hazard/ Energy Source | Description | Preventive & Mitigative Features | Remarks |
|---|---|---|---|
| **12. POTENTIAL ENERGY** | | | |
| Elevated package | Package falling from truck bed in the event of an accident. | - Truck bed approximately 4 feet high | Drop of a package from a forklift evaluated in Scenario 10. |
| **15. EFFECTS OF CHEMICAL EXPOSURES** | | | |
| General chemicals | Delivery of general chemicals for laboratory and other uses. See item 16 for bulk chemicals. | - Small quantities<br>- Manufacture packaging | Standard industrial hazard. Individual package quantities below threshold quantities. |
| **16. TOXIC, HAZARDOUS, OR NOXIOUS MATERIAL** | | | |
| Bulk chemical deliveries | Various quantities and types of chemical products. Delivered by vendors using commercial tanks. | - Tanks meet DOT requirements<br>- Vehicles are safety inspected in accordance with the site Transportation Manual<br>- Limited delivery locations on site<br>- Facilities designed with off-loading area to simplify transfers | Standard industrial hazard. Operations do not challenge the integrity of the delivery tanks. |
| **18. MATERIAL HANDLING** | | | |
| Material handling | Hand carts used to transfer material from dock to transfer vehicle | - Qualification for equipment operators<br>- Safety inspections of material handling equipment | Standard industrial hazard that is considered to be a publicly accepted risk. |
| **20. WORKING AT HEIGHTS** | | | |
| Docks and truck beds | Relatively small elevation differences (few feet) from dock or truck bed to the ground. | - Approved guard rails in place<br>- Dock levelers in place at most facilities | Standard industrial hazard. Worker safety issue. |

## 8.6 ON-SITE TRANSPORTATION OF NUCLEAR MATERIALS AND RADIOACTIVE WASTES

The transportation of nuclear materials encompasses transfers of all materials containing quantities of fissionable (includes depleted uranium) material. These materials range from nuclear materials to radioactive wastes. The nuclear materials considered include plutonium oxide, average residues, high americium residues, average liquids, and high level liquids. The radioactive wastes evaluated include transuranic wastes (TRU), including high americium wastes, and low level wastes (LLW) in two different packaging configurations. The evaluation of radioactive wastes (TRU and LLW) will be considered to include transuranic mixed and low level mixed wastes.

Plutonium oxide is selected to bound transfers of metals and other types of oxide, with the exception of americium oxide. Plutonium oxide is considered to bound metals because oxide is more dispersible than metals and, therefore, has a higher release fraction. Plutonium oxide generally represents the highest accident consequences because of the greater amount of material that can be placed in a package and on a transportation vehicle, compared to residues and other materials. High americium residues are a limited quantity with a program for stabilization and repackaging for off-site disposal. For this evaluation it is assumed all materials are packaged and transferred in accordance with HSP 31.11 requirements (RFETS, 1997c; RFETS, 2000a). A liquid category is included which includes average liquids and high concentration liquids. Liquids are assumed to contain less than 200 grams fissile material per package (e.g., drum), with the exception of single and partial load accident scenarios. For these scenarios, the fissile loading is assumed to meet that specified in the criticality limits, thereby including high concentration solutions in the evaluation. High concentration solution transfers have special handling considerations that may require additional evaluation on a case-by-case basis.

Typical accident scenarios are used for all materials to evaluate the consequences and risk to the public and collocated worker. The following sections describe the development of the accident scenarios, Section 8.6.1.1, the development of the accident frequencies, Section 8.6.1.2, and the method of determining the consequences and risk of the accident, Section 8.6.1.3 and Section 8.6.1.4, respectively. Material at risk is developed in Section 8.6.3.1 and the results of the calculations are provided in Section 8.6.3.2.

Features identified that control or reduce the risk of an accident become a control set.

### 8.6.1 Methodology

The methodology described in this section is limited to the on-site transfer of nuclear materials and radioactive wastes within the boundaries of the industrial area of the site. (Off-site accidents are evaluated in Section 8.9.)

#### 8.6.1.1 Scenario Development

Ten accident scenarios are considered in the evaluation and evaluate the risk associated with three of the four typical accident types: spills, fires, and explosions. The fourth accident type is inadvertent nuclear criticality, for which a typical consequence calculation is provided. Criticality Safety Evaluations have been performed that support the Nuclear Material Safety Limits (NMSLs) for package configurations used in the transfers (RFETS, 1999a).

The first five accident scenarios are related to a collision or accident of the transfer vehicle with a stationary object or another moving vehicle. The severity of the accident is related to the impact velocity of the accident with the higher velocity impacts resulting in the greater consequences, e.g., release of material. The accident in Scenario 1 is not severe enough to rupture the cargo or cause a fire. Scenarios 2, 3, and 4 result in a spill of the contents of the transfer vehicle, but do not result in a fire. The accidents in Scenarios 5 and 6 result in a fire. Scenarios 7 and 8 are related to releases caused by the movement of the drums, hydrogen gas overpressurization and pyrophoric material fire. These two scenarios do not involve the entire contents of the transfer vehicle. Scenario 9 is a spill resulting from an explosion external to the transfer vehicle, and the tenth scenario involves the transfer of material using a powered industrial vehicle (forklift). The first eight of these scenarios were developed for the salt stabilization program (RFETS, 1997a). The percentage of packages damaged in an accident scenario is based on the damage ratio which is related to the severity or type of the accident.

The following paragraphs briefly describe the scenario and provide parameters and assumptions used in the determination of the frequency and consequence calculations.

Scenario 1: Truck Accident with No Release

This scenario involves a transfer vehicle collision or accident that is not severe enough to rupture drums or cause a fire. The accident may involve a collision with a stationary object or other moving vehicle, but does not involve sufficient energy to breach the packaging (e.g., the impact speed of the vehicle(s) involved does not exceed the package capability). This accident falls into Severity Category I described in Table 8-5.

Scenario 2: Truck Accident Resulting in Minor Spill

This scenario addresses a transfer vehicle collision or accident that results in a minor spill of the contents of the vehicle. The accident may involve a collision with a stationary object or another moving vehicle. It is assumed the impact is equivalent to a collision with a massive stationary object at approximately 30 mph. The impact of the transfer vehicle contents at 30 mph exceeds the package capability. The material at risk in this scenario is assumed to be the entire contents of the transfer vehicle with one percent of the truckload is involved (damage ratio (DR) = 0.01). Damage ratios are discussed in Section 8.6.1.3. This is a Severity Category II accident from Table 8-5.

Scenario 3: Truck Accident Resulting in Medium Spill

This scenario addresses the transfer vehicle collision or accident that results in a medium spill of the transfer vehicle contents. The accident may involve a collision with a stationary object or another moving vehicle. It is assumed the impact is equivalent to a transfer vehicle collision with a massive stationary object at a speed between 30 and 55 mph. Because the transfer vehicle is limited to a maximum speed of 15 mph, the scenario assumes the transfer vehicle is impacted by a vehicle responding to an emergency situation. Package capability is exceeded at these velocities. The material at risk in this scenario is assumed to be the entire contents of the transfer vehicle. Ten percent of the truckload is involved (DR = 0.1). This is a Severity Category III accident from Table 8-5.

Scenario 4: Truck Accident Resulting in Major Spill

This scenario addresses the possibility of a transfer vehicle collision or accident that results in spilling the contents of the transfer vehicle. The accident may involve a collision with a stationary object or another moving vehicle. It is assumed the impact is equivalent to a transfer vehicle collision with a massive stationary object at a speed between 55 and 80 mph. An 80 mph velocity is not considered feasible for vehicles moving within the boundaries of the protected area. The transfer vehicles are limited to a speed of 15 mph, and the short, straight stretches of road preclude any emergency vehicle reaching these speeds on routes normally used for transportation. The material at risk in this scenario is assumed to be the entire contents of the transfer vehicle and one hundred percent of the truckload is involved (DR = 1.0). This is a Severity Category IV-VIII accident from Table 8-5 that results in a spill.

Scenario 5: Truck Accident Resulting in Fire That Engulfs Entire Vehicle

This scenario addresses the possibility of a collision that results in a fire which releases fissile material. The accident may involve a collision with a stationary object or another moving vehicle, such as security or fire vehicles responding to an emergency situation. The fire may be caused by ignition of a ruptured fuel tank or other, unspecified external sources and is assumed to have a sufficient fuel source to result in a fire which involves the contents of the vehicle if the fire location and intensity cause a breach of the truck bed. The fire is assumed to be lofted. The source of the fuel is unspecified, but exceeds the quantity carried by the transfer vehicle alone. This scenario is conservative because only fuel pool fires with the drums directly in the fuel are considered capable of causing drums to lose their lids (WHC, 1995). If drums are rapidly heated causing pressurization, they may lose their lids, whether or not the lids are vented. Gasoline pool fires and fires involving trash and wood are capable of producing enough heat to cause drums to lose their lids, if the drums are directly exposed to the fire (WHC, 1996). However, drums in the transfer vehicle are partially shielded by the metal truck bed and enclosure, and therefore are expected to experience a comparatively slow pressure rise as the drum contents pyrolize and the drum lid seals fail before the truck bed/enclosure is significantly breached. Transient combustibles are controlled and minimized on the transfer vehicles and in the vicinity of the docks. A blazing drum does not produce enough heat to cause a horizontally adjacent drum to lose its lid (WHC, 1995). This scenario represents the worst possible fire, i.e., one with sufficient intensity to involve all the drums and response by the RFETS Fire Department is not credited in determining the consequences of the accident, but is associated with the frequency of the accident. Therefore, the material at risk in this scenario is assumed to be the entire contents of the transfer vehicle and one hundred percent of the truckload is involved (DR = 1.0). This is a Severity Category IV-VIII accident from Table 8-5 that results in a fire.

Scenario 6: Vehicle Fire Spreads and Involves Partial Load

This scenario addresses the possibility of a transfer vehicle fire initiated by an electrical malfunction or short that results in a fire in the engine compartment. This scenario assumes that the fire spreads through the fuel system or from leaking fuel until it breaches the fuel tanks and consumes all available fuel in the transfer vehicle fuel tanks. No other sources of combustibles or fuel are considered. This scenario involves the ignition of the fuel in the transfer vehicle during transit or while the vehicle is located at a dock. The resulting fire is assumed to involve a maximum of three 55-gallon or five 10-gallon drums, if the location and intensity of the fire cause a breach of the truck bed. The number of drums is based on 10% of the entire load, 30 or 50 drums. The fire is assumed to be lofted. The entire load will not be involved due to the limited fuel supply. For accidents involving metal waste boxes, the footprint area similar to three 55-gallon drums would be one box. The damage ratio for the drums or boxes involved is considered to be 100% (DR = 1.0). The likelihood of this event occurring is greatly reduced with the use of diesel fuel instead of gasoline because diesel fuel is less flammable than gasoline and more difficult to ignite.

Scenario 7: Drum Ruptures Due to Hydrogen Buildup/ignition

This scenario addresses the possibility of a hydrogen deflagration in a drum containing nuclear materials, such as plutonium oxide or plutonium residues. Hydrogen is generated by the radiolytic decomposition of water or plastics. An explosive mixture of hydrogen and oxygen could accumulate in a drum over time, and extremely small energy sources (pyrophoric material, electrostatic spark) could be generated as a result of friction or pyrophoric reactions induced during transportation activities which could ignite the hydrogen. This accident could occur on the transfer vehicle during vehicle movement, or during drum movement between the transfer vehicle and the dock. Ignition of a flammable concentration of hydrogen within a drum results in a deflagration (versus a detonation). This scenario assumes that fire does not occur following ignition of the hydrogen, which is considered a rapid, low-energy overpressurization excursion (SAE, 1996a). The material at risk in this scenario is assumed to be limited to one package because of the low probability that the hydrogen in two drums will ignite at the same time. The damage ratio for this scenario assumes that some of the drum's contents have breached the inner containment and that 10% of the contents are released (DR = 0.1) (RFETS, 1997b).

Transfer of oxides, including high americium oxides, packaged in 10-gallon containers are not considered in this scenario because the permeability of the gasket is considered great enough to prevent hydrogen buildup. In the event oxide is to be transferred in other than a 10-gallon container, an evaluation must be performed for that evolution. This scenario is not evaluated for low level waste transfers because the quantity of fissile material is considered too small to generate sufficient hydrogen to create a hazard.

Scenario 8: Movement Disturbs Reactive or Pyrophoric Materials Resulting in Fire

This scenario addresses the possibility of reactive or pyrophoric material initiating a fire during transfer operations. This scenario assumes reactive or pyrophoric material is present and postulates that transferring the packages disturbs the contents in such a manner that the material comes into contact with oxygen causing an exothermic reaction which heats the package contents, causes the plastic packaging to burn, resulting in the loss of containment of the drum and exposure of the burning contents to the atmosphere. This accident could occur on the transfer vehicle during vehicle movement, or during drum movement between the transfer vehicle and the dock. The material at risk in this scenario is assumed to be limited to one package because of the low probability that two drums will independently ignite at the same time. This scenario is not evaluated for liquid and low level waste transfers because of the lack of pyrophoric materials in these matrices. The damage ratio for the containers involved is considered to be 100% (DR = 1.0).

Scenario 9: Explosion External to Transfer Vehicle

This scenario addresses the possibility of an explosion of the contents of a propane bulk delivery vehicle in the proximity of the transfer vehicle. The presence of flammable gases can result in a vapor cloud explosion (VCE) or a boiling liquid, expanding vapor explosion (BLEVE) or flash fire. The likelihood of these occurrences are reduced by equipment design, e.g., safety features of the propane delivery tanker. The most likely accident scenario for potential explosion damage to the transfer vehicle involving a propane tanker is a collision between the two vehicles that damages a valve or fitting on the tanker.

In the event the contents of the propane tanker are released due to a collision and a vapor cloud forms before ignition takes place, either a detonation or a deflagration may take place. Several features need to be present for a vapor cloud explosion (VCE) with damaging overpressures to occur. First, the material must be flammable, second, a cloud of sufficient size must form before ignition. If ignition occurs instantly, a large fire, a jet flame, or a fireball may occur, but significant blast pressure damage is unlikely. If ignition is delayed, higher blast pressures can develop. Third, a sufficient amount of the vapor cloud must be within the flammable range of the material. This is dependant on variables such as confinement, wind, humidity and other environmental effects. Fourth, the blast effects are related to the speed of flame propagation. In most cases this results in a deflagration. The presence of obstructions can produce turbulence which will significantly increase the blast overpressure.

A vapor jet explosion could occur the vapor discharging from the tanker is ignited at the point of discharge. The current consensus is that turbulence is the major cause of explosive, blast-generating combustion (AIChE, 1994). The high-velocity flow from a pressurized vessel (e.g., leak from a tanker truck) from a small break such as a pipe or valve, is turbulent. A VCE occurring outside will not produce a significant pressure wave unless the immediate area contains obstruction capable of producing turbulence. A collision of the transfer vehicle and the propane tanker on a roadway would not have the necessary obstructions to produce a dangerous overpressure.

A BLEVE is an explosion resulting from the failure of the vessel containing the liquid, the propane tanker, due to heating of the contents of the tank. BLEVEs caused by external heating can produce blast and fragmentation effects, and buoyant fireballs. In order to have a BLEVE associated with the fuel tanker the spilled fuel must ignite and heat the tank on the propane delivery truck sufficiently to weaken the tank wall to the point an explosion occurs due to the pressure of the heated vapors within the tank. Associated with a BLEVE situation can be a fireball.

Releases of material due to accidents associated with the propane tanker could be the result of an overpressure impacting the transfer vehicle, or a fire due to the ignition of the fuel. The material in the transfer vehicle is confined to a drum or box and therefore an overpressurization is considered the same as a spill of confined material and is bounded by the major spill scenario (Scenario 4). If the explosion results in a fire, the consequences would be bounded by the major fire evaluated in Scenario 5. The consequences of a fireball is not expected to ignite the material as the flame front passes due to the speed of the flame front. The material at risk in this scenario is assumed to be the entire contents of the transfer vehicle with 100% of the truckload involved (DR = 1.0).

Scenario 10: Powered Industrial Trucks (Forklift)

The transfer of waste containers using powered industrial trucks addresses the possibility of an accident involving the container during the transfer of the container between facilities using a forklift. This forklift accident is assumed to result in a spill or a fire, and does not consider a puncture of the container by a forklift tine as being relevant to transfer scenarios. Therefore, the material transferred by forklift is considered to be confined and the ARF and RF for confined materials is used in the calculation of consequences. Transfer of boxes, both wood and metal, by forklift assumes one hundred percent of the load is involved in the accident resulting in a damage ratio of 1.0. Movement of drums by forklift requires the four drums to be banded, therefore, only one drum is postulated to be breached in the event of a spill scenario, giving a damage ratio of 0.25. The damage ratio for all materials for forklift fire accidents is considered to be 1.0.

The first five scenarios evaluate accidents that may occur during the actual transfer time, i.e., from the time the loaded truck starts its engine and pulls away from one dock until it pulls up to another dock and the engine is turned off. Scenario 6 considers an accident involving the transfer vehicle fuel supply whether in transit or parked at a dock, and is not related to the actual miles traveled by the vehicle. Scenarios 7 and 8 are accidents that are initiated by movement of the material, (i.e., movement during transfer activities), and are not directly related to the miles traveled. Scenario 9 is related to the miles traveled by the propane fuel delivery vehicle.

8.6.1.2 Accident Frequency Development

The final frequency of occurrence for each accident scenario is developed using a base frequency which is modified by various factors and probabilities specific to the accident scenario. The following paragraphs identify and describe the terms associated with the determination of the final frequency for each accident scenario. The basis and development of each term is given following the first formula in which it appears.

Scenarios 1 - 4: Truck Accidents Resulting in Spills

Final Frequency = $F_b * P_{SC} * OAF * Miles * \% * P_{liq} * P_{hi\ am}$

where:
- $F_b$ = Base Frequency based on accidents per mile
- $P_{SC}$ = Severity Category Probability
- OAF = On-site Adjustment Factor
- Miles = Total miles per year
- % = Percentage the truck is used for the material type
- $P_{liq}$ = Reduction in frequency because of the limited liquid inventory on the site
- $P_{hi\ am}$ = Reduction in frequency because of the limited inventory of high americium materials on site

Base Frequency

Table 5-1 in NUREG-0170 (NRC, 1977) provides data for numerous types of accidents involving trucks and delivery vans on public highways and evaluates vehicle accidents as an initiating event for releases of fissile material. The base frequency for accidents involving trucks is 1.71E-06 accidents per mile (1.06E-06 accidents per kilometer). This base frequency incorporates accident frequencies due to adverse weather conditions, and includes all road types.

Severity Category Probability

Accident severities are categorized according to the divisions given in Table 8-5. The division between Severity Categories and I and II is based on the design capabilities of a Type A package. Type A packages are expected to withstand Severity Category I accidents with no loss of contents. Type B packages are realistically expected to withstand Severity Category V accidents (i.e., significantly more severe than Severity Category I and II accidents) with no loss of contents (NRC, 1977). Type A quantities of nuclear materials are transported in Type A packages both on-site and off-site. However, for Type B quantities of nuclear materials, Type A packages may be used for on-site transfers (between site buildings) only. For off-site shipments of Type B quantities of SNM, Type B packages are required. Furthermore, the SNM must be packaged in Type B packages at the on-site point of origin and therefore, some on-site travel is required to reach the site boundary. However, because of the robust construction of Type B packages, transfer of material in these packages is not included in this evaluation.

On-site Adjustment Factor

The base accident rate includes all road types, so to relate this rate to the conditions found at Rocky Flats, the salt NSTR developed an "on-site adjustment factor". This factor is the inverse of the speed of the impact, e.g., an impact at 30 miles per hour (mph) would have an adjustment factor of 1/30 or 0.033. This term was developed to account for the assumption that beneficial site conditions (e.g., short distances/low fatigue, restricted traffic volume, low traffic speeds) more than make up for detrimental site conditions (e.g., narrow, lower-design-standard roads) and that the base frequency of site accidents is lower than those on public highways (RFETS, 1997a). The inverse nature of this factor reflects the decreasing probability of progressively higher vehicle speeds on site.

The following table describes the accident severity categories from Table 5-3 of NUREG-0170 (NRC, 1977) and provides the distribution of occurrence of accidents and the on-site adjustment factor for each severity category.

Severity Category IV-VIII accidents that result in fire conservatively use the on-site adjustment factor for Severity Category I accidents because, based on actual data (DOT, 1997; NRC, 1977), accidents resulting in fire may occur in any accident severity categories (I - III). Although accidents resulting in fire can occur in less severe accidents categories (I - III), the total percentage of accidents resulting in fire is approximately 1.5% of all accidents, based on actual data (DOT, 1997; NRC, 1977). This corresponds well with the 2% probability of Category IV-VIII accidents.

**Table 8-5.** Accident Severity Categories and Associated Factors

| Accident Severity Category | Consequence Description, Type A Packages | Severity Category Probability | On-site Adjustment Factor |
|---|---|---|---|
| I | No loss of containment. Impact equivalent to less than 4-foot drop (comparable to drum impacting an unyielding surface at up to 11 mph) or crush force of less than 1,500 pounds. Assumes that fires are not involved or are easily extinguished. | 0.55 | 0.091 (11 mph) |
| II | Results in a minor spill. Impact equivalent to less than 30-foot drop (comparable to drum impacting an unyielding surface at 11 to 30 mph) or a crush force less than 4,950 pounds. Assumes that fires are incidental and are extinguished before involving drums. | 0.36 | 0.033 (30 mph) |
| III | Results in medium spill. Impact equivalent to greater than 30-foot drop (comparable to drum impacting an unyielding surface at 30 to 55 mph) or a crush force less than 20,000 pounds. Assumes that fires are controlled and extinguished before involving drums. | 0.07 | 0.018 (55 mph) |
| IV-VIII | Results in major spill or fire. Impact comparable to drum impacting unyielding surface between 55 to 80 mph or crush force greater than 20,000 pounds. This probability distribution is consistent with recent national traffic statistics which indicate that approximately 1.5% of transportation accidents involve fire (DOT, 1997). | 0.02 | 0.013 (80 mph) |

Mileage Determination

The number of miles used in frequency calculations is the number of miles per year estimated for transfers of each material category.

Total Miles/year = Miles/Trip * Number of Trips/year

Number of Trips/year = Trips/day * Number of Days

where: Miles/Trip = For SNM/Residue moves within the PA, the distance used is 1 mile (the distance from Building 371 north dock to Building 991).

For wastes, the distance used is 1.5 miles. The maximum distance determined was from Building 991 to the north dock of Building 440 at 1.4 miles.

A trip is considered as a transfer between two buildings.

Number of days = 155 days per year was used. This is the *Integrated Transportation and Shipping Infrastructure Plan*, Final Draft, Revision 1 (RFETS, 1999b).

Trips/year = For SNM/Average Residues: 620 trips. An estimate of 4 trips per day for 155 days was used. The *Integrated Transportation and Shipping Infrastructure Plan* (RFETS, 1999b) identifies a maximum of 150 SNM movements in the year 2000. The projected number for residues is 450 trips per year. 620 trips per year is based on 4 trips per day, 155 days per year and bounds the projected number of transfers.

For Wastes: 3,100 trips per year. The maximum total projected number from the *Integrated Transportation and Shipping Infrastructure Plan* is 2,754 trips for TRU/TRM, LLW and LLMW. The 3,100 miles used in the analysis bounds this. High Am residues are not specifically counted in this mileage calculation; however, the number is sufficiently conservatively to include the small number of high Am drums on the site.

The miles per trip are from measured distances between building docks. The longest distance was taken for all transfers for the category. The distances was determined using an AutoCAD drawing of the site to measure distances between identified points (e.g., intersections and corners).

Transfers of quantities with greater than 6 kg total WG Pu, e.g., oxides, residues, and/or average liquids (not identified as wastes), have the potential to be transferred within the PA between any combination of Buildings 371, 374, 559, 569, 707, 771, 776, 777, and 991. Evaluation of the actual road miles of the most direct routes between the aforementioned buildings, results in the longest direct route being 1.0 mile or 1.6 kilometers between Buildings 371 and 991.

Within the PA, wastes are transferred between Buildings 371, 559, 569, 707, 774, 776, 771, and 991. In addition, wastes are transferred from facilities within the PA to Buildings 440, 664, 906 and to the various RCRA Units outside the PA. The type of waste and the packaging configuration controls the destination of the waste. Wastes are transferred from generation points to storage areas either within the PA or outside the PA. For off-site shipment, wastes are staged in buildings such as Building 440 or Building 664. This evaluation does not cover the shipment of the wastes from the loading facility to the end of the access road. Utilizing a site map, the distances between facilities within the PA and PAC1 and from PAC1 to waste storage areas outside the PA were determined. The longest distance for waste transfers within the PA is from Building 371 to Building 440. This distance combines 0.6 miles within the PA and 0.8 miles outside the PA for a total of 1.4 miles per transfer. Low level waste in the form of sewage sludge can be transferred from Building 995 to other facilities for off-site shipment. The longest potential transfer is between Buildings 995 and 440 at a distance of 1.2 miles. This is bounded by the 1.4 miles determined for a transfer from within the PA to Building 440.

Percentage of Truck Usage

The percentage the truck is used for the material type is related to the fact that the same truck is used for different types of loads, e.g., the total fissile material content is greater than 16 kg versus between 6 kg and 16 kg. Also, the same trucks will be used for the transfer of TRU/TRM wastes as is used for LLW/LLWM. It is assumed a 50-50 split based on information received from K. Lenarcic.

Probability Liquids Present

Because of the limited inventory of liquids on the site, the accident frequency involving liquids is qualitatively assumed to be a factor of 10 less than transfers of other materials. Transfer of high concentration solutions is not evaluated separately from other liquid transfers.

Probably High Americium Material Present

Because of the limited number of high americium drums, the accident frequency involving these drums is qualitatively reduced by 10% for packages containing greater than 200 grams WG Pu and by 50% for packages containing less than or equal to 200 grams, e.g., TRU wastes, etc. The reduction is smaller for the waste categories because of the likelihood of producing more of these types of waste as the site moves towards closure.

Scenario 5: Truck Accident Resulting in Fire

Final Frequency = $F_b * P_{SC} * OAF * Miles * P_{location} * P_{breach} * \% * P_{liq} * P_{hi\ am}$

where: $F_b$ = Base Frequency based on accidents per mile
$P_{SC}$ = Severity Category Probability
OAF = On-site Adjustment Factor
Miles = Total miles per year
$P_{location}$ = Probability the fire centers under the truck bed
$P_{breach}$ = Probability the fire breaches the truck bed
% = Percentage the truck is used for the material type
$P_{liq}$ = Reduction in frequency because of the limited liquid inventory on the site
$P_{hi\ am}$ = Reduction in frequency because of the limited inventory of high americium materials on site

Accidents resulting in fire can occur in any of the accident severity categories, therefore, this evaluation used the most conservative on-site adjustment factor, e.g., for Category I accidents at 11 mph.

For the > 6 kg category, the probabilities for the fire centering under the truck bed and for the fire breaching the truck bed are 0.5 and 0.02, respectively. For the waste categories, these probabilities are 0.5 and 1.0, respectively. The increase in the probability for the fire breaching the bed is because the flatbeds used for waste boxes have wooden beds. The 0.5 assumes the fire has a 50/50 chance of centering under the truck bed. This accounts for crowning and slopes on roads versus low spots on the road. The 0.02 factor was developed based on information from Traffic and Fire Protection that a fire is not likely to breach the metal floor or box of the truck, and assumes the Fire Department is able to respond before the time needed for a breach is reached. For transfers using flatbed trucks, which are assumed to have wood floors, the probability of breaching the bed is taken as 1.0.

Scenario 6: Vehicle Fire Spreads and Involves Partial Load

Final Frequency = $F_b * P_{location} * P_{breach} * P_{material} * \% * P_{liq} * P_{hi\ am}$

where:
- $F_b$ = Base Frequency as events per year
- $P_{location}$ = Probability the fire centers under the truck bed
- $P_{breach}$ = Probability the fire breaches the truck bed
- $P_{material}$ = Probability material is on the truck
- % = Percentage the truck is used for the material type
- $P_{liq}$ = Reduction in frequency because of the limited liquid inventory on the site
- $P_{hi\ am}$ = Reduction in frequency because of the limited inventory of high americium materials on site

This scenario considers an accident involving the transfer vehicle fuel supply whether in transit or parked at a dock, and is not related to the actual miles traveled by the vehicle. The base frequency for Scenario 6 is from the salt NSTR (RFETS, 1997a). Based on past experience and DOE data on transportation incidents, vehicle engine fires are not an anticipated event. In addition, the trucks used for transportation at Rocky Flats have low mileage and receive regular preventative maintenance that helps reduce the probability of an engine fire. The salt NSTR estimated the probability of an electrical malfunction or short that results in an engine fire as an *unlikely* event at 5.0E-04 /yr. The probabilities for the fire centering under the transfer truck and for the fire breaching the truck floor are the same as those given for Scenario 5. The development of the frequency for this scenario does not take credit for control of combustibles on the truck or dock.

The probability a specific material type is on the transfer vehicle is related the amount of time material could be present on a transfer vehicle vs time the transfer vehicle is empty. Staging on the transfer vehicle is not allowed for transfers of >16 kg and >6 kg categories, therefore this probability is less than 1.0 and is calculated for the number of hours in a 24 hour period that material could be present on the transfer vehicle. Determination of the probability the truck is loaded assumes that transfers could be made during two shifts and that there are three vehicles available for transfer, e.g., [155 days/year (Number of days/year transfers occur) * 2 shifts/day @ 8 hours/shift ÷ 8,760 hours/year * 3 vehicles available].

Because waste transfers could involve staging (e.g., a loaded vehicle is left unattended) the probability the material is on the transfer vehicle is assumed to be 1.0.

Scenario 7: Rupture due to Hydrogen Buildup/Ignition

Final Frequency = $F_b * P_{M/S} * Drums * P_{agitation} * \% * DV * P_{liq} * P_{hi\ am}$

where: $F_b$ = Base Frequency as explosions per drum-year
$P_{M/S}$ = Probability explosion could occur during moving vs. during storage
Drums = Number of drums moved per year
$P_{agitation}$ = Probability there is sufficient agitation to ignite the hydrogen
% = Percentage the truck is used for the material type
DV = Credit for drum venting program and inspection
$P_{liq}$ = Reduction in frequency because of the limited liquid inventory on the site
$P_{hi\ am}$ = Reduction in frequency because of the limited inventory of high americium materials on site

The base frequency used is 7.0E-06 explosions per drum-year for a hydrogen explosion in an unvented, high-risk residue drum in storage. This was developed in CALC-RFP-95.0183-E_S (RFETS, 1994). The probability that an explosion could occur within a drum is considered ten times more likely during transfer of that drum than when the drum is in storage. The value of this factor is from the salt NSTR (RFETS, 1997a).

The number of drums is determined from the number of moves assumed to be made in one year times the maximum number of drums that can be moved at one time. The maximum number of 55-gallon drums that can be transferred in one load in the vehicles currently in use on the site is 30 drums. The number for 55-gallon drums is used because it is the most commonly used container for transfer of materials that are likely to generate hydrogen and 10-gallon containers do not have a tight enough seal to allow the build-up of hydrogen gas. The engineered feature of having vents on drums is credited with a reduction in frequency of 0.01.

The probability for agitation to occur is based on the time the drums is being moved, both during loading and unloading and during the actual transfer on the transfer vehicle. Because of the short distances on the site, the actual time the transfer vehicle is moving is assumed to be not more than 10 minutes. Loading and unloading activities are assumed to add an additional 20 minutes to the movement of a drum. This is a total of 30 minutes (0.5 hours) of agitation time per transfer. The hours available for transfer, based on the 155 days per year that transfers occur from the *Integrated Transportation and Shipping Infrastructure Plan* (RFETS, 1999b) and two shifts per day at eight hours per shift, is 2,480 hours. Based on these assumptions, the agitation probability is 2.02E-04 per year (0.5 hrs/transfer ÷ 2,480 hrs/transfer-yr).

Scenario 8: Fire due to Reactive/Pyrophoric Material

The frequency for pyrophoric fires is qualitatively estimated to be 1.0E-05, *extremely unlikely*. This is based on USQD-RFP-93.1170-TLF (RFETS, 1993b) which evaluated the storage of potentially pyrophoric plutonium. Because of the campaigns to bring materials into compliance with the requirements of 1-W89-HSP 31.11, *Transfer and Storage of Plutonium for Fire Safety*

(RFETS, 1997c), and the regular inspection program and stabilization requirements of HSP 31.11, the frequency identified in the USQD is reduced by a factor of 10. This scenario is not credible for liquid and low-level waste transfers due to the absence or minimal quantity of pyrophoric material.

Scenario 9: Explosion External to Transfer Vehicle

Final Frequency = $F_b * P_{SC} * OAF * Miles * P_{spill/ign} * \% * P_{liq} * P_{hi\ am}$

where: $F_b$ = Base Frequency based on accidents per mile
$P_{SC}$ = Severity Category Probability
OAF = On-site Adjustment Factor
Miles = Total miles per year traveled by the propane tanker
$P_{spill/ign}$ = Probability the propane spills and ignites
% = Percentage the truck is used for the material type
$P_{liq}$ = Reduction in frequency because of the limited liquid inventory on the site
$P_{hi\ am}$ = Reduction in frequency because of the limited inventory of high americium materials on site

The base frequency, severity category probability and the on-site adjustment factor are from the same sources as identified for Scenarios 1 through 5. For this accident, the factors for Severity Category II accidents are used because the 15 mph speed limit within the PA would create a resultant impact velocity of approximately 30 mph. This would also bound the possibility the propane tanker is damaged from hitting a stationary object or the leak is associated with an unloading operation at a propane storage tank. Use of these values is conservative for accidents that may occur at higher speeds.

The number of miles for this frequency determination uses the number of miles the propane tanker travels rather than the number of miles the transfer vehicle travels used in the other frequency determinations. This is because this is the only time with the potential for an explosion. Within the PA, the total miles traveled by the propane tanker was determined based on the distance from PAC1 to the propane storage tank at T771G and from T771G to PAC2 plus the distance from PAC1 to the 750 Pad tanks and from the 750 Pad to PAC2 for 1.76 miles. This distance was taken time 26 weeks per year that deliveries take place within the PA (45.8 miles) and rounded up to the nearest 10 (50 miles total within the PA). Outside the PA, the distance from Building 130 to the road on the east side of the site that leads to the ponds was determined, multiplied by 26 weeks and multiplied by 2 for the return to Building 130. Plus, twice the distance from Building 130 to PAC1 times 26 weeks to account for the time the tanker is outside the PA on the days it is refueling within the PA. The total milage for outside the PA is 210 miles. These milage determinations are provided in Appendix A of the calculation (RFETS, 2000b).

The probability of the propane in the tanker spilling and igniting is conservatively identified as 1.0. The percentage the material is on the truck is as discussed for the other scenarios.

Scenario 10: Powered Industrial Trucks

Transfer of waste items using powered industrial equipment (forklifts) is assumed to become more prevalent with the move toward decommissioning facilities. LLW/LLMW is more commonly transferred with forklift than TRU/TRM wastes and therefore is assumed to have a higher frequency. The frequency of accidents while transferring material by forklift is assumed to be *anticipated*; however, because of forklift operator training, the forklift safety program, forklift safety features, preventative maintenance, and banding and securing requirements, a final frequency of 1.1E-02/year is used. Transfer of TRU/TRM wastes is assumed to be a relatively low number compared to transfer of LLW/LLMW, therefore, the frequency of these transfers is decreased to 1.0E-03/year, *unlikely*.

The base frequency used for fires involving forklifts is the probability from Scenario 6, 5.0E-04 /yr, from the Salt NSTR (RFETS, 1997b) that estimated that the probability of an electrical malfunction or short that results in an engine fire is an *unlikely* event. This frequency is reduced by a factor of 10 to account for the limited amount of fuel (the only source of fuel is assumed to be the fuel tank on the forklift) and the proximity of the fuel in relation to the material being transferred. For example, a fuel spill with enough area to involve the cargo of the forklift would be so shallow that the fire duration would be less than 10 minutes.

**Table 8-6.** Evaluated Accident Scenario Frequencies

| Base Frequency | Severity Cat. Prob. | On-site Adjust. Factor | Final Frequency (/yr) | | | |
|---|---|---|---|---|---|---|
| | | | >16 kg | >6 - 16 kg | >200 g - 6 kg | <200 g |
| Scenario 1: Truck accident with no release | | | | | | |
| 1.71E-06 accidents/mi | 0.55 | 0.091 | 2.7E-05<br>2.7E-06 (liq)<br>2.7E-06 (hi Am) | 2.7E-05<br>2.7E-06 (liq)<br>2.7E-06 (hi Am)<br>2.7E-07 (hi Am TRU) | 2.0E-04<br>2.0E-05 (liq)<br>2.0E-05 (hi Am)<br>2.0E-06 (hi Am TRU) | 2.0E-04<br>NA (liq)<br>NA (hi Am) |
| Scenario 2: Truck accident resulting in minor spill | | | | | | |
| 1.71E-06 accidents/mi | 0.36 | 0.033 | 6.4E-06<br>6.4E-07 (liq)<br>6.4E-07 (hi Am) | 6.4E-06<br>6.4E-07 (liq)<br>6.4E-07 (hi Am)<br>6.4E-08 (hi Am TRU) | 4.8E-05<br>4.8E-06 (liq)<br>4.8E-06 (hi Am)<br>4.8E-07 (hi Am TRU) | 4.8E-05<br>NA (liq)<br>NA (hi Am) |
| Scenario 3: Truck accident resulting in medium spill | | | | | | |
| 1.71E-06 accidents/mi | 0.07 | 0.018 | 6.7E-07<br>6.7E-08 (liq)<br>6.7E-08 (hi Am) | 6.7E-07<br>6.7E-08 (liq)<br>6.7E-08 (hi Am)<br>6.7E-09 (hi Am TRU) | 5.1E-06<br>5.1E-07 (liq)<br>5.1E-07 (hi Am)<br>5.1E-08 (hi Am TRU) | 5.1E-06<br>NA (liq)<br>NA (hi Am) |
| Scenario 4: Truck accident resulting in major spill | | | | | | |
| 1.71E-06 accidents/mi | 0.02 | 0.013 | 1.3E-07<br>1.3E-08 (liq)<br>1.3E-08 (hi Am) | 1.3E-07<br>1.3E-08 (liq)<br>1.3E-08 (hi Am)<br>1.3E-09 (hi Am TRU) | 9.9E-07<br>9.9E-08 (liq)<br>9.9E-08 (hi Am)<br>9.9E-09 (hi Am TRU) | 9.9E-07<br>NA (liq)<br>NA (hi Am) |

**Table 8-6.** Evaluated Accident Scenario Frequencies (Continued)

| Base Frequency | Severity Cat. Prob. | On-site Adjust. Factor | Final Frequency (/yr) | | | |
|---|---|---|---|---|---|---|
| | | | >16 kg | >6 - 16 kg | >200 g - 6 kg | <200 g |
| 1.71E-06 accidents/mi | 0.02 | 0.091 | 9.6E-09<br>9.6E-10 (liq)<br>9.6E-10 (hi Am) | 9.6E-09<br>9.6E-10 (liq)<br>9.6E-10 (hi Am)<br>9.6E-11 (hi Am TRU) | 3.6E-06<br>3.6E-07 (liq)<br>3.6E-07 (hi Am)<br>3.6E-08 (hi Am TRU) | 3.6E-06<br>NA (liq)<br>NA (hi Am) |
| Scenario 6: Vehicle fire spreads and involves partial load | | | | | | |
| 5.00E-04 events/yr | NA | NA | 2.1E-06<br>2.1E-07 (liq)<br>2.1E-07 (hi Am) | 2.1E-06<br>2.1E-07 (liq)<br>2.1E-07 (hi Am)<br>2.1E-08 (hi Am TRU) | 1.3E-04<br>1.3E-05 (liq)<br>1.3E-05 (hi Am)<br>1.3E-06 (hi Am TRU) | 1.3E-04<br>NA (liq)<br>NA (hi Am) |
| Scenario 7: Rupture due to hydrogen buildup/ignition | | | | | | |
| 7.00E-06 exp/drum-yr | NA | NA | 1.3E-06<br>1.3E-07 (liq)<br>1.3E-07 (hi Am) | 1.3E-06<br>1.3E-07 (liq)<br>1.3E-07 (hi Am)<br>1.3E-08 (hi Am TRU) | 6.6E-06<br>6.6E-07 (liq)<br>6.6E-07 (hi Am)<br>6.6E-08 (hi Am TRU) | 6.6E-06<br>NA (liq)<br>NA (hi Am) |
| Scenario 8: Fire due to reactive/pyrophoric material | | | | | | |
| 1.00E-05 /yr | NA | NA | 1.0E-05<br>NA (liq)<br>1.0E-06 (hi Am) | 1.0E-05<br>NA (liq)<br>1.0E-06 (hi Am)<br>1.0E-07 (hi Am TRU) | 1.0E-05<br>NA (liq)<br>1.0E-06 (hi Am)<br>1.0E-07 (hi Am TRU) | 1.0E-05<br>NA (liq)<br>NA (hi Am) |
| Scenario 9: Explosion external to transfer vehicle | | | | | | |
| 1.71E-06 accidents/mi | 0.36 | 0.033 | 5.1E-07<br>5.1E-08 (liq)<br>5.1E-08 (hi Am) | 5.1E-07<br>5.1E-08 (liq)<br>5.1E-08 (hi Am)<br>5.1E-09 (hi Am TRU) | 2.2E-06<br>2.2E-07 (liq)<br>2.2E-07 (hi Am)<br>2.2E-08 (hi Am TRU) | 2.2E-06<br>NA (liq)<br>NA (hi Am) |
| Scenario 10: Powered industrial trucks | | | | | | |
| 1.1E-02/yr (spill) | NA | NA | NA | NA | 1.0E-03 (TRU)<br>1.0E-05 (hi Am TRU) | 1.1E-02 (LLW)<br>NA (hi Am) |
| 5.0E-04 events/yr (fire) | NA | NA | NA | NA | 5.0E-05<br>5.0E-07 (hi Am TRU) | 5.0E-05 (LLW)<br>NA (hi Am) |

8.6.1.3 Consequence Determination

Consequences (doses) related to an accident scenario are calculated using the following equations and terms. The terms are defined and developed below.

$$\text{Dose} = \text{MAR} \times \text{DR} \times \text{LPF} \times \text{ARF} \times \text{RF} \times \chi/Q \times \text{BR} \times \text{DCF}$$

where:
- MAR = Material At Risk
- DR = Damage Ratio
- LPF = Ambient Leak Path Factor
- ARF = Airborne Release Fraction
- RF = Respirable Fraction
- $\chi/Q$ = Atmospheric Dispersion Factor
- BR = Breathing Rate
- DCF = Dose Conversion Factor

Material at Risk (MAR)

The MAR for transportation accidents is related to the type of transfer being made. The transfer categories are described below in Section 8.6.3, Accident Analysis of Material Transferred. For many scenarios the maximum quantity of material for the category is used as the bounding MAR. The calculation (CALC-RFP-98.0570-KKK, Revision 4 (RFETS, 2000b) provides the quantities and MAR development used in each scenario.

Aged Weapons Grade plutonium (WG Pu) is used as the material contributing to the consequences because the resulting doses are higher than for non-aged WG Pu. High americium residues are specifically analyzed as high americium material, or are converted to WG Pu equivalent for material in pipe overpack containers (POCs).

Uncertainties in Non-Destructive Assay (NDA) instrument readings associated with determination of Pu content in non-liquid residues have been identified to potentially affect the consequences of the accident analysis. USQD-RFP-98.1568-SMS (RFETS, 1998c) concluded that due to the conservatism inherent in the calculations for dose estimation, the increase in MAR due to the uncertainties in NDA is minimal and does not pose a significant change in the consequence calculations. Therefore, no additional controls or compensations for the uncertainties are needed to account for the uncertainties in the dose calculations.

Damage Ratio (DR)

The damage ratio is the fraction of material that could be released from the packages in the event of an accident. This value is based on realistic expectations of a Type A package in an accident. The damage ratios used in this evaluation, listed in Table 8-7 below, are taken from Table 5-8 of NUREG-0170 (NRC, 1977) for the accident severity category classifications. The damage ratios for accidents not related to the NUREG severity categories are based on engineering judgement.

**Table 8-7.** Damage Ratios

| Scenario | | Parameters | |
|---|---|---|---|
| | | **Severity Category** | **Damage Ratio (DR)** |
| 1 | Truck accident with no release | I | 0 |
| 2 | Truck accident resulting in minor spill | II | 0.01 |
| 3 | Truck accident resulting in medium spill | III | 0.1 |
| 4 | Truck accident resulting in major spill | IV-VIII | 1.0 |
| 5 | Truck accident resulting in fire | IV-VIII | 1.0 |
| 6 | Vehicle fire spreads, involves truck contents | NA | 1.0 |
| 7 | Drum ruptures due to hydrogen buildup/ignition | NA | 0.1* |
| 8 | Reactive or pyrophoric material causing a fire | NA | 1.0 |
| 9 | Explosion external to transfer truck | II | 1.0 |
| 10 | Powered Industrial vehicles | NA | ** |

* Damage ratio for hydrogen explosion is less than 1.0 because it is assumed that only part of the contents are spilled.

** Spills: Drums, DR = 0.25; Boxes, DR = 1.0. Fires: All containers, DR = 1.0.

These damage ratio values are based on expectations of Type A packages for the various Severity Category accidents. For example, the damage ratio of 1.0 assumes that all of the material at risk in the transfer is released due to packages being crushed or engulfed in flames.

Ambient Leakpath Factor

The leakpath factor for transportation activities is equal to 1.0 because the accidents occur outside with no credit for containment systems.

Airborne Release Fraction (ARF) and Respirable Fraction (RF)

The materials in this evaluation are considered to be confined because they are packaged for transfer by placing the material container(s) into transfer packaging. The ARFs and RFs associated with these materials and most accident scenarios in this evaluation are taken from SARAH (RFETS, 1997b). Table 8-8 summarizes the values used for these parameters used in this evaluation.

The overpressurization scenarios (Scenario 7) assume that a fire does not occur following ignition of the hydrogen, which is considered a rapid, low-energy overpressurization excursion (SAE, 1997). The ARF and RF for this scenario are 0.1 and 0.7, respectively, based on DOE direction. Overpressurization is not considered feasible for material in 10-gallon drums due to the amount of leakage allowed by the seal, therefore, Scenario 7 is not evaluated for oxides.

**Table 8-8.** Airborne Release Fraction and Respirable Fractions Used

| Material | Spill | | Fire | | Overpressurization | | Explosion | |
|---|---|---|---|---|---|---|---|---|
| | ARF | RF | ARF | RF | ARF | RF | ARF | RF |
| Oxide | 1.0E-03 | 0.1 | 5.0E-04 | 1.0 | NA | NA | 1.0E-03 | 0.1 |
| Avg Residue | 1.0E-03 | 0.01 | 5.0E-04 | 0.01 | 1.0E-01 | 0.7 | 1.0E-03 | 0.01 |
| TRU Waste/drums | 1.0E-03 | 0.1 | 5.0E-04 | 1.0 | 1.0E-01 | 0.7 | 1.0E-03 | 0.1 |
| TRU Waste/boxes | 1.0E-03 | 0.1 | 5.0E-04 | 1.0 | 1.0E-01 | 0.7 | 1.0E-03 | 0.1 |
| Hi-Am Oxide | 1.0E-03 | 0.1 | 5.0E-04 | 1.0 | NA | NA | 1.0E-03 | 0.1 |
| Hi-Am Residue | 1.0E-03 | 0.01 | 5.0E-04 | 0.01 | 1.0E-01 | 0.7 | 1.0E-03 | 0.01 |
| Hi-Am Residue/POC | 2.0E-03 | 0.01 | 6.0E-06 | 0.01 | NA | NA | NA | NA |
| Hi-Am TRU Waste | 1.0E-03 | 0.1 | 5.0E-04 | 1.0 | 1.0E-01 | 0.7 | 1.0E-03 | 0.1 |
| Liquid | 4.0E-05 | 1.0 | 2.0E-03 | 1.0 | 5.0E-05 | 0.8 | 4.0E-05 | 1.0 |
| LLW/drums | 1.0E-03 | 0.1 | 5.0E-04 | 1.0 | NA | NA | 1.0E-03 | 0.1 |
| LLW/wood boxes | 1.0E-03 | 0.1 | 5.0E-04 | 1.0 | NA | NA | 1.0E-03 | 0.1 |
| Samples | 1.0E-03 | 0.1 | 5.0E-04 | 1.0 | NA | NA | 1.0E-03 | 0.1 |
| Sources | 1.0E-03 | 0.1 | 5.0E-04 | 1.0 | NA | NA | 1.0E-03 | 0.1 |

Notes:
1) Overpressurization for oxide not applicable to this calculation due to the permeability of the gasket on 10-gallon drums.
2) Assumes materials are confined, with the exception of liquids.
3) The RF of 0.01 for residues and high Am residues is based on the 750/904 Pad safety evaluation. The ARF of 0.1 and RF of 0.7 for hydrogen overpressurization are per DOE direction (residue and TRU waste).

Atmospheric Dispersion Factor ($\chi/Q$)

The plume concentration is related to the atmospheric dispersion factor, $\chi/Q$, which is determined from the distance to the receptor (MOI or collocated worker), the atmospheric conditions, and whether the plume is at ground level or lofted. The distance to the public (MOI) used in transportation calculations is assumed to be 1,900 meters. It is recognized that transportation accidents may occur at various distances from the site boundary; however, 1,900 meters is the distance to the nearest site boundary from the approximate middle of the site and is used when a specific distance is not available. For a lofted fire, the individual receiving the maximum dose is located at 4,020 meters from the event (RFETS, 1997b). A distance of 100 meters to the collocated worker is used for dose determinations. The atmospheric conditions used to calculate the consequences of a transportation accident is 95th percentile weather conditions. The following table shows the values for $\chi/Q$ used in the calculations:

**Table 8-9.** Atmospheric Dispersion Factors for 95th Percentile Weather Conditions

| Receptor | Spill and non-lofted fire | | Fire (lofted plume) | |
|---|---|---|---|---|
| | $\chi/Q$ (sec/m$^3$) | Distance | $\chi/Q$ (sec/m$^3$) | Distance |
| MOI | 1.02E-04 | 1,900 meters | 1.02E-05 | 4,020 meters |
| Collocated worker | 9.94E-03 | 100 meters | 3.59E-04 | 100 meters |

Breathing Rate (BR)

The breathing rate for heavy levels of activity is 3.6E-04 m$^3$/sec, which is the most conservative assumption (RFETS, 1997b).

Dose Conversion Factor (DCF)

The dose conversion factors for a 50-year commitment period CEDE for aged weapons grade plutonium are related to the solubility class of the material (RFETS, 1997b). Plutonium oxide (oxide transfer) is evaluated as Solubility Class Y. The remainder of the materials evaluated are considered Class W. These include residues, high americium residues, liquids, transuranic wastes (TRU/TRM), and low-level wastes (LLW/LLMW). Wastes are considered Class W to be conservative for a site evaluation because of the various points of generation of wastes. The following DCFs are used in the consequence determination for transportation accidents:

**Table 8-10.** Dose Conversion Factors

| | DCF rem/gram-mix | Solubility Class | Material |
|---|---|---|---|
| Aged WG Pu | 3.03E+07 | Y | Oxides |
| | 4.35E+07 | W | Average Residue<br>TRU Waste in drums<br>TRU Waste in boxes*<br>Liquid<br>LLW in drums<br>LLW in wood boxes<br>Samples<br>Sources |
| Non-aged WG Pu**<br>(as WG Pu dose equivalent) | 4.28E+07 | W | TRU Waste in boxes*<br>High Am residue in POCs<br>High Am TRU waste |
| | 2.77E+07 | Y | High Am Oxide |
| High Am | 2.03E+8 | W | High Am residue not in POCs |

* Aged WG Pu is used for TRU Waste in drums for full load accidents, WG Pu dose equivalent is used for accidents involving a single drum.

** Calculations involving WG Pu dose equivalents and use the DCF for non-aged weapons grade Pu to avoid double counting the Am contribution to the dose.

#### 8.6.1.4 Risk Determination

To be consistent with the BIO documents developed for individual facilities and future authorization basis safety analyses, the risk matrix in DOE-STD-3011-94 (DOE, 1994b) is used to determine the risk class for each accident scenario. To be consistent with the Final Safety Analysis Report (FSAR) risk methodology, risk numbers are also presented as a tool for determining relative risk between scenarios. Risk numbers are determined by multiplying the scenario consequence (rem-CEDE) by the scenario frequency (probability per year), and are expressed in rem-CEDE/yr. These risk numbers are not directly compared to FSAR risk numbers, and therefore are not converted to 50-year bone doses. There is no defined relationship between the risk matrix in DOE-STD-3011-94 (DOE, 1994b) and the FSAR-type risk numbers.

The high, moderate, and low determinations for the consequences calculated for the accident scenarios are derived from Table B.II in DOE-STD-3011-94, with high consequences defined as greater than 5 rem to the public at the site boundary and greater than 25 rem to the collocated worker. Moderate consequences to the public are considered to be greater than 0.1 rem at the site boundary, up to 5 rem. Collocated worker dose for moderate classification is greater than 0.5 rem, up to 25 rem at 600 meters. Low consequences are those that are less than the moderate thresholds. RFETS uses 100 meters as the distance from an event to the collocated worker for determination of consequences; therefore, selection of the severity classification is extremely conservative.

The risk class matrix in DOE-STD-3011-94, Table B.I, is a three-by-three matrix and does not include the *incredible* frequency bin and the *no* consequence category given in DOE-STD-3009-94

(DOE, 1994a). Because these classifications are not included, the risk for incredible scenarios defaults to the risk class for extremely unlikely events. For instance incredible events with high consequences are identified as risk class II when possibly a risk class of III is more appropriate. However, to remain consistent with other safety evaluations, the risk classification of II will be retained for incredible frequency, high consequence scenarios in this evaluation.

### 8.6.2 Assumptions

The following assumptions are considered in the development of the accident scenarios and the determination of the accident consequences. The assumptions in bold are specifically credited as controls.

*Traffic Accident Assumptions*

1) The frequency of traffic accidents or collisions is related to the distance traveled, vehicle speeds, the amount of traffic, weather, road conditions, vehicle maintenance, and driver qualifications. Adverse weather conditions are incorporated into the base frequency number, which is based on all types of accidents.

2) **Transfer vehicle** [within the PA] **shall not exceed 15 mph as indicated on the vehicle speedometer, except as directed during emergency or security situations. (For convoy transfers this direction is at the discretion of the Convoy Commander.)** The posted speed limit within the PA for all other vehicles is 25 mph.

   **Transfer vehicle** [outside the PA] **shall not exceed the posted speed limit, as indicated on the vehicle speedometer, except as directed during emergency or security situations.**

   Traffic is assumed to abide by this limit. Transfer vehicles inside the protected area travel at a maximum of 15 mph (RFETS, 1999c; RFETS, 1999d), and those outside the PA at 25 mph. Although the posted speed limit on the site is 25 mph with the exception of the North Perimeter Road, vehicles responding to security or emergency situations could be traveling faster. The assumption that these vehicles or other traffic can be traveling at speeds greater than 15 mph is the basis for accident scenarios developed for accidents at 30, 55, and 80 mph.

3) On-site transportation vehicles follow the Federal Motor Carrier Safety Regulations which requires the vehicles undergo regular safety inspections and preventative maintenance (RFETS, 2000a; 49CFR350). This reduces the probability of vehicle malfunctions that could result in an accident or an engine fire.

4) **Establish radio communication. In the event of a security or emergency response in the vicinity of the transfer vehicle, stop the transfer vehicle. (For convoy transfers this response is at the discretion of the Convoy Commander.)**

*Transfer Assumptions*

1) **The quantity of material at risk (MAR) is controlled.** Controlling the quantity (inventory) of material placed on a transfer truck directly affects the potential consequences in the event of an accident. It is assumed the quantity of fissile material per package is in accordance with approved NMSLs (RFETS, 1999a) and that the material is packaged in accordance with approved packaging procedures. It is also assumed that the number of packages in a load will be in accordance with the appropriate NMSLs. Proposed transfers of materials in greater quantities than those analyzed will require further evaluation.

2) **No staging of materials in the transfer vehicle.** Safeguards Category I and II transfers will not be staged or stored inside a transfer vehicle. The Transportation Safety Officer (TSO) verifies that the originating facility has confirmed acceptance at the receiving facility.

3) Safeguards Category III and IV transfers will be by the safest and most (reasonably) direct route. Diversion from the identified route will be to comply with emergency or security situations (WSI, 1997; RFETS, 1999d).

*Container Integrity Assumptions*

1) **Packaging meets the requirements of the site transportation safety manual.** This assumption implies that the materials are packaged in accordance with the proper packaging guidance and meets the nuclear materials safety limits for the specific material.

2) **Packages meet or exceed the DOT Type A requirements or have approval for on-site use in the site transportation safety manual.** Use of Type A or better packaging, or packaging approved for use on site ensures the integrity of the container is adequate to contain the contents of the package under normal transfer conditions and minor accidents. Approved packaging ensures compliance with venting/venting inspection requirements, HSP 31.11 compliance requirements, rigidity requirements, etc (RFETS, 1995a, RFETS, 1997c). Compliance with these requirements reduces the frequency of accident initiators.

   - Containers with >200 grams WG Pu meet or exceed DOT Type A requirements or are approved for on site use in the site transportation safety manual.

   - Wooden low-level waste boxes are classified as "strong secure containers" or "strong tight containers".

- Pipe Overpack Containers (POCs) are assumed to have a lower damage ratio for impact accidents than typical drums due to the robustness of the container, e.g., they meet most of the requirements of a Type B package.

3) Packages used for on-site transfers (and their inner containers) are in accordance with current, or formally approved, package assembly requirements, and can withstand a 4-foot drop test without loss of contents (RFETS, 2000a, 49CFR173). Any exception to this requirement must be authorized by the On-Site Transportation Safety Committee and have a written transfer plan that establishes administrative controls that ensure the transfer system operates within the package's performance envelope (RFETS, 2000a). Packaging configurations are described in the site transportation safety manual (RFETS, 2000a). It is assumed that the integrity of aged packages meets the original requirements. Visual inspections are performed before transfer of all packages. SNM packages are transferred using a gasoline- or diesel-powered truck with a metal bed and enclosure.

4) The safety analysis assumes that all packaging is compliant until proven otherwise.

*Spill Scenario Assumptions*

1) Contents of the transfer vehicle are tied down in accordance with good industrial practice to prevent any change in position under normal transportation conditions.

2) The tiedown requirements restrain the drums during normal transportation activities and reduce the impact force experienced by a drum during an accident. Use of blocking, bracing, and tie-downs to secure the load is in accordance with Federal law (49CFR350) and good industrial practices.

3) Only vehicle accidents that subject the 10-gallon or 55-gallon drums to impact energies greater than that of a 4-foot drop are assumed to damage/breach the packages. This analysis evaluated vehicle collisions at speeds of 11, 30, 55, and 80 mph. A collision at 11 mph is considered equivalent to a 4-foot drop, and therefore is not considered to breach the packages. The NSTR for salt transfers (RFETS, 1997a) considered that vehicle collision speeds up to 15 mph would not breach Type A packages by qualitatively crediting energy absorption through deformation of the transportation vehicle, deformation of objects hit by the transportation vehicle, and drum tie downs. Accidents and collisions at the higher evaluated speeds are assumed to breach the packages with progressively more severe damage ratios relative to increases in speed. The entire material at risk inventory in the transfer vehicle (modified by the appropriate damage ratio) is assumed to be involved in the spill.

4) POCs are designed to withstand a 30-foot drop test which equates to a collision speed of 30 mph, therefore, only severe crashes, e.g., at speeds of 55 and 80 mph, are considered.

*Fire and Explosion Scenario Assumptions*

1) **Transfer vehicle engines are off while the transfer vehicle is at the dock for loading and unloading.**

2) **Combustible or flammable materials on the on-site transfer vehicle shall be limited to those necessary to accomplish the transfer.**

3) **Prior to loading/unloading verify/ensure the following:**
   - **Transient combustible materials are not within five feet of the transfer vehicle.**
   - **No spark/flame/heat producing work or smoking are on the dock or within 25 feet of the transfer vehicle.**
   - **No flammable liquids, except in approved containers, are on the dock or within 25 feet of the transfer vehicle.**

   Control of combustible and flammable materials reduces the potential for material to be present that may contribute to a fire accident scenario. Control of ignition sources minimizes initiators that could lead to fire scenarios.

4) **The transfer vehicle shall have a metal floor.** This assumption is a control for the >6 kg quantity transfers and is used in the development of the fire scenario frequencies.

5) **Propane powered vehicles shall not be used for the transfer of materials in these categories.**

6) **Prevent the propane bulk delivery vehicle from being within 100 feet of the material transfer vehicle.**

7) **Do not initiate a transfer of material if the fire department is unavailable for emergency response.**

*Criticality Scenario Assumptions*

Packaging of materials in accordance with the applicable NMSLs controls the potential for a criticality accident (RFETS, 1999a). Criticality accidents associated with the transportation activities are not specifically evaluated in this document because they are evaluated in the Criticality Safety Evaluations supporting the applicable NMSLs (RFETS, 1999a). A discussion of the potential for a criticality to occur during transfer operations is provided in Section 8.6.3.3.

### 8.6.3 Accident Analysis of Material Transfers

The transportation accidents involving nuclear materials (plutonium oxide, residues, liquids, and wastes) are evaluated below and quantified in terms of frequency of occurrence, material at risk, and consequences and risk to the public and collocated workers. The calculations are based on the inventory of material associated with the transfer. The total quantity of material that may be involved in a traffic accident during a transfer is related to the allowed packaging configurations of that material and the capacity of the transfer vehicle.

The materials transferred on the site fall into three general categories:

(1) Total quantity of fissile material transferred in one load is **greater than 6 kilograms (kg) weapons grade plutonium (WG Pu)**. Two divisions apply to this category: loads containing greater than 6 kg but less than or equal to 16 kg WG Pu; and loads containing greater than 16 kg WG Pu. The category is divided because the maximum quantity of material will not be transferred in a load 100% of the time. Dividing the category provides more realistic frequency and risk values in the calculations. These moves are accompanied by a Transportation Safety Officer (TSO). Materials in this category are usually packaged in drums with greater than 200 grams WG Pu per drum and includes special nuclear materials (oxides, metals, etc.), residues, residues with high americium content, liquids, and TRU/TRM wastes. Transfers may be accompanied by a security convoy as required by Safeguards and Security.

    Whenever practicable, loads should be evaluated to reduce the quantity of fissile material transferred in order to reduce potential radiological consequences.

(2) Total quantity of fissile material transferred in one load is **greater than 200 grams but less than or equal to 6 kg** WG Pu. These moves are controlled by the driver of the transfer vehicle. Materials in this category are usually packaged in drums with less than 200 grams WG Pu per drum and includes liquids and TRU/TRM wastes in drums or boxes.

(3) Total quantity of fissile material transferred in one load is **less than or equal to 200 grams** WG Pu. This category includes LLW/LLM packaged in drums or wooden boxes, samples, and sources.

The quantity of fissile material in the above categories is shown as "WG Pu". The calculated consequences associated with these transfers is based on "aged WG Pu". When material is transferred, it is inventoried as WG Pu; however, because of the time since the production of these materials, the ingrowth of americium has occurred making the use of aged WG Pu in the calculation more appropriate. The consequences for aged WG Pu bounds the consequences of a like quantity of WG Pu.

#### 8.6.3.1 MAR Development

The MAR for the transportation accident scenarios are developed to provide a representative sample of type and quantities of materials that are transferred on the site. The materials evaluated include oxide, residues, wastes and liquids. These categories are further broken down based on Pu content, Am content, waste type, and/or packaging, as appropriate. The type of material evaluated and the quantities of radioactive material involved in the accident varies with the scenario evaluated. The MAR for the accidents scenarios is based on the maximum quantities identified for each category, with some exceptions. For scenarios that do not involve the entire truckload of material, the MAR used in the calculation is based on the loading per container.

Materials on the site are normally packaged in metal drums, metal boxes, or wood boxes. A special drum packaging configuration referred to as a pipe overpack container (POC) was developed for packaging stabilized residues. Some metal configurations are also packaged in POCs for on-site storage and transfer. POCs represent a special case of transfer packaging because of the robustness of the container. Although POCs are not Type B containers, they meet most of the requirements of a Type B package. One difference is that no vents are allowed on the inner containment vessel of Type B packages and the POCs are vented.

The MARs for each accident are included in the results tables in Section 8.6.3.2. The following paragraphs describe the MAR development for the three categories of transfers described above:

<u>>6 kg WG Pu</u>

The quantity of material that may be transferred under the first category (>6 kg WG Pu per load) is divided into two types: loads containing >16 kg and loads containing >6 kg to 16 kg. Materials that may be transferred under this category include, but are not limited to the following:

1) Oxide
2) Residues (including SS&C, ash, etc.)
3) High Americium residues, oxides, etc.
4) Liquids, including high concentration liquids
5) Metal product
6) TRU/TRM wastes, high americium TRU/TRM wastes
7) Combinations of above

The maximum MAR for the >16 kg division is 250 kg WG Pu. This is based on the quantity of oxide that can be transferred in one hypothetical load. Transfer of plutonium oxide on-site is normally in 10-gallon drums with a maximum loading of two interior containers per package. The inner containers can be loaded with a maximum of 2,500-grams oxide each per the Nuclear Material Safety Limits for 10-gallon drums (RFETS, 1999a). The number of packages involved in an individual transfer is limited to the size of the transfer vehicle. A maximum of fifty 10-gallon drums can be placed in a currently used authorized transfer vehicle at one time (Lenarcic, 1997). Assuming each 10-gallon drum contains a maximum of 5 kilograms (kg) plutonium oxide, a maximum of 250 kg (250,000 grams) Pu oxide may be moved in a single vehicle transfer.

Residues are commonly packaged in 55-gallon drums. The quantity of fissionable material in a residue drum varies greatly, based on the matrix of the material contained in the drum. For the calculations in this evaluation associated with average residues, the quantity of fissionable material per drum is taken to be 1,000 grams in the form of aged weapons grade plutonium (WG Pu) in non-oxide compounds. The number of 55-gallon drums that can be placed on one of the currently used transfer vehicles is less than 10-gallon drums, therefore, the maximum of 250 kg WG Pu for residues bounds any transfers of this material and allows for use of larger vehicles if needed.

A population of material exists with Am content greater than that found from natural ingrowth. These materials are mainly residues from the molten salt and the salt scrub processes, non-specification oxides, non-routine metals, and TRU wastes. From previous information (the salt NSTR) it appears that most of the residues are packaged in 55-gallon or 10-gallon metal drums. For accident scenarios in the categories where the maximum vehicle load is greater than 6 kg, the MAR for high Am residues equals the maximum Pu loading for the material type. The Am content is accounted for by using the DCF for high Am materials.

Oxides and metals with high Am content have been identified to be processed through the PuSPS Project for transfer off site and are more likely to be identified as individual items rather than drums. Information on oxides and metals was provided by the PuSPS project. The information from these lists was used to determine the quantity of material to be used in the consequence/risk calculations. The population of high Am oxides is small. Transfer of these for accidents involving the entire contents of the transfer vehicle are bounded by the consequences of normal oxides. However, for single drum and partial load scenarios, information from the evaluations described in the paragraph above were used to develop the MAR. From the list of 19 containers provided by the PuSPS project, the worst ten were selected to develop the five drum MAR for the partial load accident and the worst two containers were selected for the single drum accident (Scenario 8). It is assumed two packages will be placed in one 10-gallon drum for transfer. Scenario 7, hydrogen overpressurization, was not evaluated for high Am oxide because 10-gallon drums are not evaluated for overpressurization due to leaky seals. The ten worst case packages contain 296 grams Am and 10,557 grams Pu or 30,093 grams WG Pu dose equivalent (Solubility Class Y). The single worst drum is assumed to contain 108 grams Am and 1,865 grams Pu (8,993 grams WG Pu dose equivalent, Solubility Class Y). These MAR values are very conservative estimate because of the limited number of oxides with high Am (19 packages (not drums) identified) and the probability of the worst two packages being combined into the same drum is extremely low. Because these packages are oxide, the conversion factor for Solubility Class Y material is used to determine Pu equivalents, e.g., Am content times 66.0 grams Pu per gram Am plus the grams of Pu.

Liquids are commonly packaged in 4-liter plastic bottles within a facility. The Site Wide Criticality Safety Limits provide nuclear material safety limits for the transfer of liquid solutions with up to 200 grams fissile material per drum (RFETS, 1999a). The MAR for liquids in the accident scenarios which involve the entire load in the transfer vehicle is based on a load of 30 55-gallon drums. The MAR for 30 drums at 200 grams WG Pu per drum of 6,000 grams WG Pu will support transfers of high level solutions if the total transfer quantity is less than 6,000 grams. Special transfers, for example, the use of 10-gallon drums or transfer of high concentration solutions with a total load greater than 6 kg require specific evaluation. The single drum and three drum accident scenarios use MARs of 1,200 grams and 3,600 grams, respectively. This is based on the criticality limit for transfer of high concentration solutions of 150 gram/liter, 4 liters/bottle, and

2 bottles per drum. High concentration solutions can not be transferred in 10-gallon drums per current requirements, e.g., criticality limit.

>200 g to 6 kg

The maximum MAR that may be transferred under this category (>200 grams to 6 kg WG Pu per load) is 6 kg. Materials that may be transferred under this category include, but are not limited to the following:

1) TRU/TRM waste in drums and boxes (including high Am)
2) LLW/LLMW wastes in drums and boxes
3) Liquids
4) Average residues if <200 grams WG Pu per drum
5) High Am residues (in POCs and not in POCs)

Materials transferred under this category are commonly packaged in 55-gallon drums and metal waste boxes and limited to 200 grams WG Pu per 55-gallon drum based on the NMSL allowing a maximum of 200 grams of fissionable material per drum (RFETS, 1999a) for TRU waste, or 320 grams WG Pu per waste box (TRU) (RFETS, 1999a). The maximum MAR for this category is 6,000 grams which allows the transfer of thirty 55-gallon drums containing 200 grams WG Pu each. Flatbeds are normally used for the transfer of boxes of TRU wastes with a normal load of 10 boxes per transfer. This equates to a maximum material at risk in a TRU transfer to 3,200 grams. The category MAR limit of 6,000 grams bounds transfers of this configuration of boxes.

For accidents involving the entire load, the maximum for the category is used for average residues, TRU waste in drums and boxes, and liquids.

The MAR for high Am residues and high Am TRU wastes is 350 grams as WG Pu equivalents per drum as Solubility Class W material. Normal packaging for containers to be transferred under the less than 6 kg category is less than or equal to 200 grams Pu dose equivalent. Performing the consequence calculations assuming 350 grams Pu equivalents allows for transfer of "legacy" packages and those with uncertainties or errors in packaging and assay techniques. The dose associated with 350 grams WG Pu equivalent is used to determine the Pu and Am maximums allowed in a drum.

For partial load and single container accidents involving TRU wastes in boxes, a MAR of 400 grams WG Pu equivalents per box is used based on previous evaluation (RFETS, 1999e). Evaluating TRU wastes in boxes at this level allows for transfer of boxes with high Am content as well as transfer of boxes that have been determined, after counting, to have greater than the amount of Pu as allowed by the criticality limits (e.g., 320 grams WG Pu). This allows the over packed box to be transferred back to the originator for repack without addition evaluation for quantities up to 400 grams Pu equivalent.

A category of TRU waste in wood boxes exists; however, these boxes are loaded based on the assumption they will contain LLW quantities of fissile material. During counting to determine the actual gram loading, these packages did not meet the 100 ηCi/gram limit due to the type of material (light in weight) in the package, or were packaged to hold large objects destined for size reduction. There is only a small population of these boxes and historically, they contain well under 3 grams WG Pu. These boxes are returned to the generator to be repackaged to meet the Curie per gram requirements for LLW or to be packaged in the appropriate container for TRU.

POCs are used for packaging stabilized high Am content residues (now classified as TRU waste) and can contain up to 200 grams WG Pu and approximately 16 grams of Am. Calculations involving POCs use WG Pu equivalents as the MAR to account for the Am. For Solubility Class W materials, Pu equivalents are determined by multiplying the number grams of Am by 42.76 and adding the number of grams of Pu. This gives 885 grams WG Pu equivalents per POC (200 grams Pu + 16 grams Am * 42.76). The MAR used for these accidents is 885 grams WG Pu equivalents per drum. The DCF is 4.28E+07 (Class W, non-aged WG Pu). The damage ratio for a spill is assumed to be 1.0 based on NSTR-001-97, *Evaluation of Pipe Overpack Containers for TRU Waste Storage* (RFETS, 1998d). Airborne release fractions (ARFs) for the accidents were also taken from the NSTR, with the respirable fraction (RF) for residues used for instead of the RFs from the NSTR with the exception of the hydrogen overpressure event. The ARF and RF used for residues are based on DOE direction.

<= 200 grams

The maximum MAR that may be transferred under this category (< or = 200 grams WG Pu per load) is 200 grams. Materials that may be transferred under this category include, but is not limited to the following:

1) LLW/LLMW wastes in drums
2) LLW/LLMW wastes in boxes
3) TRU/TRM in drums
4) Samples
5) Sources

LLW (and LLW mixed) is commonly packaged in 55-gallon drums or plywood boxes. Plywood boxes are either full boxes (4' x 4' x 7') or half boxes (2' x 4' x 7'). The fissile material loading per box is limited to less than or equal to 100 ηCi/gram waste. Based on the maximum weight allowed for drums the quantity of fissile material per drum is less than 0.5 grams and for boxes is less than 3.0 grams. For evaluation purposes, 0.5 grams per drum will be used and 3.0 grams will be used for both full and half boxes. LLW drums are transferred using the drum truck which has a capacity of thirty 55-gallon drums per transfer. Boxes containing LLW are transfered using flatbed trailers. The site has several flatbed trailers of varying length and the number of boxes that can be transferred is based on weight capacity of the trailer and the total gross weight limit for boxes of 5,000 pounds each for both full and half plywood boxes (RFETS, 1995b). Normally LLW boxes are transferred in batches of ten boxes.

Based on this information, the quantity of fissile material available for release in an accident involving LLW in drums is 15 grams (0.5 grams/drum*30 drums/transfer). The material available during transfer of LLW in plywood boxes is 60 grams based on a worst case transfer of 20 boxes with 3.0 grams per box.

Radioactive Samples

The hazards associated with the transfer of radioactive materials as samples are bounded by transfers of larger quantities of the material.

8.6.3.2 Accident Analysis Results

The following sections provide the results, frequency and consequences, of the evaluation of the nuclear materials in the postulated accident scenarios. The calculation supporting the evaluation is CALC-RFP-98.0570-KKK, Revision 4 (RFETS, 2000b). The MAR development for each scenario and material are provided in the calculation.

Scenario 1: Truck Accident with No Release

This scenario involves a transfer vehicle collision or accident that does not involve sufficient energy to breach the packaging. The frequency for this scenario is estimated to be *unlikely* and *extremely unlikely* for the various material transfer configurations. These accidents are minor and do not result in releases of fissile material (damage ratio is zero).

Scenario 2: Truck Accident Resulting in Minor Spill

This scenario addresses a transfer vehicle collision or accident that results in a minor spill of the contents of the vehicle. This is a Severity Category II accident from Table 8-5.

The frequencies developed in Section 8.6.1.2 and tabulated in Table 8-6 place minor spill transportation accidents involving all materials in the *extremely unlikely* and *incredible* frequency bins. The frequency for some materials is less than other materials due to the limited quantities on the site. The bounding accident for a minor spill is *extremely unlikely* and involves an entire truck load of plutonium oxide. This accident results in *moderate* consequences to the MOI (Risk Class III) and *high* consequences to the collocated worker (Risk Class II).

The MAR in this accident scenario is assumed to be the entire contents of the transfer vehicle with 1% being damaged (DR = 0.01). Applying the appropriate airborne release fraction and respirable fraction (Table 8-8), the resulting consequences and risk from a truck accident resulting in a minor spill are determined for the MOI and the collocated worker. The frequency, MAR, consequences, and risk class information for this scenario are given in Tables 8-11a, b, c, and d.

**Table 8-11a.** Truck Accident - Minor Spill (Scenario 2), >16 kg/transfer

| Material | Frequency | MAR (grams) | MOI | | Collocated Worker | |
|---|---|---|---|---|---|---|
| | | | Consequences (rem) | Risk Class (rem/yr) | Consequences (rem) | Risk (rem/yr) |
| Oxide | Ext unlkly 6.4E-06 | 250,000 | Mod 2.8E-01 | III 1.8E-06 | High 2.7E+01 | II 1.7E-04 |
| Avg Residue | Ext unlkly 6.4E-06 | 250,000 | Low 4.0E-02 | IV 2.5E-07 | Mod 3.9E+00 | III 2.5E-05 |
| Hi-Am Residue | Incredible 6.4E-07 | 250,000 | Mod 1.9E-01 | III 1.2E-07 | Mod 1.8E+01 | III 1.2E-05 |
| Liquid | Incredible 6.4E-07 | 6,000 | Low 3.8E-03 | IV 2.4E-09 | Low 3.7E-01 | IV 2.4E-07 |

**Table 8-11b.** Truck Accident - Minor Spill (Scenario 2), >6 kg/transfer

| Material | Frequency | MAR (grams) | MOI | | Collocated Worker | |
|---|---|---|---|---|---|---|
| | | | Consequences (rem) | Risk Class (rem/yr) | Consequences (rem) | Risk (rem/yr) |
| Oxide | Ext unlkly 6.4E-06 | 16,000 | Low 1.8E-02 | IV 1.1E-07 | Mod 1.7E+00 | III 1.1E-05 |
| Avg Residue | Ext unlkly 6.4E-06 | 16,000 | Low 2.6E-03 | IV 1.6E-08 | Low 2.5E-01 | IV 1.6E-06 |
| TRU Waste/drums | Ext unlkly 6.4E-06 | 16,000 | Low 2.6E-02 | IV 1.6E-07 | Mod 2.5E+00 | III 1.6E-05 |
| Hi-Am Residue | Incredible 6.4E-07 | 16,000 | Low 1.2E-02 | IV 7.6E-09 | Mod 1.2E+00 | III 7.4E-07 |
| Hi-Am TRU Waste | Incredible 6.4E-08 | 10,500 | Low 1.7E-02 | IV 1.0E-09 | Mod 1.6E+00 | III 1.0E-07 |
| Liquid | Incredible 6.4E-07 | 6,000 | Low 3.8E-03 | IV 2.4E-09 | Low 3.7E-01 | IV 2.4E-07 |

**Table 8-11c.** Truck Accident - Minor Spill (Scenario 2), >200 grams to 6 kg/transfer

| Material | Frequency | MAR (grams) | MOI | | Collocated Worker | |
|---|---|---|---|---|---|---|
| | | | Consequences (rem) | Risk Class (rem/yr) | Consequences (rem) | Risk (rem/yr) |
| Avg Residue | Ext unlkly 4.8E-05 | 6,000 | Low 9.6E-04 | IV 4.6E-08 | Low 9.3E-02 | IV 4.5E-06 |
| TRU Waste/drums | Ext unlkly 4.8E-05 | 6,000 | Low 9.6E-03 | IV 4.6E-07 | Mod 9.3E-01 | III 4.5E-05 |
| TRU Waste/boxes | Ext unlkly 4.8E-05 | 6,000 | Low 9.6E-03 | IV 4.6E-07 | Mod 9.3E-01 | III 4.5E-05 |
| Hi-Am Residue | Ext unlkly 4.8E-06 | 10,500 | Low 1.7E-03 | IV 7.9E-09 | Low 1.6E-01 | IV 7.7E-07 |
| Hi-Am TRU Waste | Incredible 4.8E-07 | 10,500 | Low 1.7E-02 | IV 7.9E-09 | Mod 1.6E+00 | III 7.7E-07 |
| Liquid | Ext unlkly 4.8E-06 | 6,000 | Low 3.8E-03 | IV 1.8E-08 | Low 3.7E-01 | IV 1.8E-06 |

**Table 8-11d.** Truck Accident - Minor Spill (Scenario 2), ≤200 grams/transfer

| Material | Frequency | MAR (grams) | MOI Consequences (rem) | MOI Risk Class (rem/yr) | Collocated Worker Consequences (rem) | Collocated Worker Risk (rem/yr) |
|---|---|---|---|---|---|---|
| LLW/wood boxes | Ext unlkly<br>4.8E-05 | 200 | Low<br>3.2E-04 | IV<br>1.5E-08 | Low<br>3.1E-02 | IV<br>1.5E-06 |
| LLW/drums | Ext unlkly<br>4.8E-05 | 200 | Low<br>3.2E-04 | IV<br>1.5E-08 | Low<br>3.1E-02 | IV<br>1.5E-06 |
| TRU Waste/drums | Ext unlkly<br>4.8E-05 | 200 | Low<br>3.2E-04 | IV<br>1.5E-08 | Low<br>3.1E-02 | IV<br>1.5E-06 |
| Samples | Ext unlkly<br>4.8E-05 | 200 | Low<br>3.2E-04 | IV<br>1.5E-08 | Low<br>3.1E-02 | IV<br>1.5E-06 |
| Sources | Ext unlkly<br>4.8E-05 | 200 | Low<br>3.2E-04 | IV<br>1.5E-08 | Low<br>3.1E-02 | IV<br>1.5E-06 |

Scenario 3: Truck Accident Resulting in Medium Spill

This scenario addresses the transfer vehicle collision or accident that results in a medium spill of the contents of the transfer vehicle. This is a Severity Category III accident from Table 8-5.

The frequencies developed in Section 8.6.1.2 and tabulated in Table 8-6 place medium spill transportation accidents involving transfers of greater than 6 kg WG Pu in the *incredible* frequency bin and transfers less than 6 kg in the *extremely unlikely* and *incredible* frequency bins. The bounding accident for a medium spill is *incredible* and involves an entire truck load of plutonium oxide. This accident results in *moderate* consequences to the MOI (Risk Class III) and *high* consequences to the collocated worker (Risk Class II).

The MAR in this accident scenario is assumed to be the entire contents of the transfer vehicle with 10% being damaged (DR = 0.1). Applying the appropriate airborne release fraction and respirable fraction (Table 8-8), the resulting consequences and risk from a truck accident resulting in a medium spill are determined for the MOI and the collocated worker. The frequency, MAR, consequences, and risk class information for this scenario are given in Tables 8-12a, b, c, and d.

**Table 8-12a.** Truck Accident - Medium Spill (Scenario 3), >16 kg/transfer

| Material | Frequency | MAR (grams) | MOI Consequences (rem) | MOI Risk Class (rem/yr) | Collocated Worker Consequences (rem) | Collocated Worker Risk (rem/yr) |
|---|---|---|---|---|---|---|
| Oxide | Incredible<br>6.7E-07 | 250,000 | Mod<br>2.8E+00 | III<br>1.3E-06 | High<br>2.7E+02 | II<br>1.8E-04 |
| Avg Residue | Incredible<br>6.7E-07 | 250,000 | Mod<br>4.0E-01 | III<br>2.7E-07 | High<br>3.9E+01 | II<br>2.6E-05 |
| Hi-Am Residue | Incredible<br>6.7E-08 | 250,000 | Mod<br>1.9E+00 | III<br>1.3E-07 | High<br>1.8E+02 | II<br>1.2E-05 |
| Liquid | Incredible<br>6.7E-08 | 6,000 | Low<br>3.8E-02 | IV<br>2.6E-09 | Mod<br>3.7E+00 | III<br>2.5E-07 |

**Table 8-12b.** Truck Accident - Medium Spill (Scenario 3), >6 kg to 16 kg/transfer

| Material | Frequency | MAR (grams) | MOI Consequences (rem) | MOI Risk Class (rem/yr) | Collocated Worker Consequences (rem) | Collocated Worker Risk (rem/yr) |
|---|---|---|---|---|---|---|
| Oxide | Incredible 6.7E-07 | 16,000 | Mod 1.8E-01 | III 1.2E-07 | Mod 1.7E+01 | III 1.2E-05 |
| Avg Residue | Incredible 6.7E-07 | 16,000 | Low 2.6E-02 | IV 1.7E-08 | Mod 2.5E+00 | III 1.7E-06 |
| TRU Waste/drums | Incredible 6.7E-07 | 16,000 | Mod 2.6E-01 | III 1.7E-07 | Mod 2.5E+01 | III 1.7E-05 |
| Hi-Am Residue | Incredible 6.7E-08 | 16,000 | Mod 1.2E-01 | III 8.1E-09 | Mod 1.2E+01 | III 7.9E-07 |
| Hi-Am TRU Waste | Incredible 6.7E-09 | 10,500 | Mod 1.7E-01 | III 1.1E-09 | Mod 1.6E+01 | III 1.1E-07 |
| Liquid | Incredible 6.7E-08 | 6,000 | Low 3.8E-02 | IV 2.6E-09 | Mod 3.7E+00 | III 2.5E-07 |

**Table 8-12c.** Truck Accident - Medium Spill (Scenario 3), >200 grams to 6kg/transfer

| Material | Frequency | MAR (grams) | MOI Consequences (rem) | MOI Risk Class (rem/yr) | Collocated Worker Consequences (rem) | Collocated Worker Risk (rem/yr) |
|---|---|---|---|---|---|---|
| Avg Residue | Ext unlkly 5.1E-06 | 6,000 | Low 9.6E-03 | IV 4.8E-08 | Mod 9.3E.-01 | III 4.7E-06 |
| TRU Waste/drums | Ext unlkly 5.1E-06 | 6,000 | Low 9.6E-02 | IV 4.8E-07 | Mod 9.3E+00 | III 4.7E-05 |
| TRU Waste/boxes | Ext unlkly 5.1E-06 | 6,000 | Low 9.6E-02 | IV 4.8E-07 | Mod 9.3E+00 | III 4.7E-05 |
| Hi-Am Residue | Incredible 5.1E-07 | 10,500 | Low 1.7E-02 | IV 8.4E-09 | Mod 1.6E+00 | III 8.1E-07 |
| Hi-Am TRU Waste | Incredible 5.1E-08 | 10,500 | Mod 1.7E-01 | III 8.4E-09 | Mod 1.6E+01 | III 8.1E-07 |
| Liquid | Incredible 5.1E-07 | 6,000 | Low 3.8E-02 | IV 1.9E-08 | Mod 3.7E+00 | III 1.9E-06 |

**Table 8-12d.** Truck Accident - Medium Spill (Scenario 3), ≤200 grams/transfer

| Material | Frequency | MAR (grams) | MOI Consequences (rem) | MOI Risk Class (rem/yr) | Collocated Worker Consequences (rem) | Collocated Worker Risk (rem/yr) |
|---|---|---|---|---|---|---|
| LLW/wood boxes | Ext unlkly 5.1E-06 | 200 | Low 3.2E-03 | IV 1.6E-08 | Low 3.11E-01 | IV 1.6E-06 |
| LLW/drums | Ext unlkly 5.1E-06 | 200 | Low 3.2E-03 | IV 1.6E-08 | Low 3.11E-01 | IV 1.6E-06 |
| TRU Waste/drums | Ext unlkly 5.1E-06 | 200 | Low 3.2E-03 | IV 1.6E-08 | Low 3.11E-01 | IV 1.6E-06 |
| Samples | Ext unlkly 5.1E-06 | 200 | Low 3.2E-03 | IV 1.6E-08 | Low 3.11E-01 | IV 1.6E-06 |
| Sources | Ext unlkly 5.1E-06 | 200 | Low 3.2E-03 | IV 1.6E-08 | Low 3.11E-01 | IV 1.6E-06 |

Scenario 4: Truck Accident Resulting in Major Spill

This scenario addresses the possibility of a transfer vehicle collision or accident that results in spilling the contents of the transfer vehicle. This is a Severity Category IV-VIII accident from Table 8-5 that results in a spill.

The frequencies developed in Section 8.6.1.2 and tabulated in Table 8-6 place major spill transportation accidents involving all materials in the *incredible* frequency bin. The bounding accident for a major spill is *incredible* and involves an entire truck load of plutonium oxide. This accident results in *high* consequences to both the MOI and the collocated worker (both Risk Class II).

The MAR in this accident scenario is assumed to be the entire contents of the transfer vehicle with 100% being damaged (DR = 1.0). Applying the appropriate airborne release fraction and respirable fraction (Table 8-8), the resulting consequences and risk from a truck accident resulting in a major spill are determined for the MOI and the collocated worker. The frequency, MAR, consequences, and risk class information for this scenario are given in Tables 8-13a, b, c, and d.

**Table 8-13a.** Truck Accident - Major Spill (Scenario 4), >16 kg/transfer

| Material | Frequency | MAR (grams) | MOI | | Collocated Worker | |
|---|---|---|---|---|---|---|
| | | | Consequences (rem) | Risk Class (rem/yr) | Consequences (rem) | Risk (rem/yr) |
| Oxide | Incredible 1.3E-07 | 250,000 | High 2.8E+01 | II 3.7E-06 | High 2.7E+03 | II 3.6E-04 |
| Avg Residue | Incredible 1.3E-07 | 250,000 | Mod 4.0E+00 | III 5.3E-07 | High 3.9E+02 | II 5.2E-05 |
| Hi-Am Residue | Incredible 1.3E-08 | 250,000 | High 1.9E+01 | II 2.5E-07 | High 1.8E+03 | II 2.4E-05 |
| Liquid | Incredible 1.3E-08 | 6,000 | Mod 3.8E-01 | III 5.1E-09 | High 3.7E+01 | II 5.0E-07 |

**Table 8-13b.** Truck Accident - Major Spill (Scenario 4), >6 kg to 16kg/transfer

| Material | Frequency | MAR (grams) | MOI Consequences (rem) | MOI Risk Class (rem/yr) | Collocated Worker Consequences (rem) | Collocated Worker Risk (rem/yr) |
|---|---|---|---|---|---|---|
| Oxide | Incredible 1.3E-07 | 16,000 | Mod 1.8E+00 | III 2.4E-07 | High 1.7E+02 | II 2.3E-05 |
| Avg Residue | Incredible 1.3E-07 | 16,000 | Mod 2.6E-01 | III 3.4E-08 | Mod 2.5E+01 | III 3.3E-06 |
| TRU Waste/drums | Incredible 1.3E-07 | 16,000 | Mod 2.6E+00 | III 3.4E-07 | High 2.5E+02 | II 3.3E-05 |
| Hi-Am Residue | Incredible 1.3E-08 | 16,000 | Mod 1.2E+00 | III 1.6E-08 | High 1.2E+02 | II 1.5E-06 |
| Hi-Am Residue/POC | Incredible 1.3E-08 | 26,550 | Mod 8.3E-01 | III 1.6E-08 | High 8.1E+01 | II 1.1E-06 |
| Hi-Am TRU Waste | Incredible 1.3E-09 | 10,500 | Mod 1.7E+00 | III 2.2E-09 | High 1.6E+02 | II 2.1E-07 |
| Liquid | Incredible 1.3E-08 | 6,000 | Mod 3.8E-01 | III 5.1E-09 | High 3.7E+01 | II 5.0E-07 |

**Table 8-13c.** Truck Accident - Major Spill (Scenario 4), >200 grams to 6 kg/transfer

| Material | Frequency | MAR (grams) | MOI Consequences (rem) | MOI Risk Class (rem/yr) | Collocated Worker Consequences (rem) | Collocated Worker Risk (rem/yr) |
|---|---|---|---|---|---|---|
| Avg Residue | Incredible 9.9E-07 | 6,000 | Low 9.6E-02 | IV 9.5E-08 | Mod 9.3E+00 | III 9.3E-06 |
| TRU Waste/drums | Incredible 9.9E-07 | 6,000 | Mod 9.6E-01 | III 9.5E-07 | High 9.3E+01 | II 9.3E-05 |
| TRU Waste/boxes | Incredible 9.9E-07 | 6,000 | Mod 9.6E-01 | III 9.5E-07 | High 9.3E+01 | II 9.3E-05 |
| Hi-Am Residue | Incredible 9.9E-08 | 10,500 | Mod 1.7E-01 | III 1.6E-08 | Mod 1.6E+01 | III 1.6E-06 |
| Hi-Am Residue/POC | Incredible 9.9E-08 | 26,550 | Mod 8.3E-01 | III 8.3E-08 | High 8.1E+01 | II 8.1E-06 |
| Hi-Am TRU Waste | Incredible 9.9E-09 | 10,500 | Mod 1.7E+00 | III 1.6E-08 | High 1.6E+-02 | II 1.6E-06 |
| Liquid | Incredible 9.9E-08 | 6,000 | Mod 3.8E-01 | III 3.8E-08 | Mod 3.7E+01 | II 3.7E-06 |

**Table 8-13d.** Truck Accident - Major Spill (Scenario 4), ≤200 grams/ transfer

| Material | Frequency | MAR (grams) | MOI | | Collocated Worker | |
|---|---|---|---|---|---|---|
| | | | Consequences (rem) | Risk Class (rem/yr) | Consequences (rem) | Risk (rem/yr) |
| LLW/wood boxes | Incredible 9.9E-07 | 200 | Low 3.2E-02 | IV 3.2E-08 | Mod 3.1E+00 | III 3.1E-06 |
| LLW/drums | Incredible 9.9E-07 | 200 | Low 3.2E-02 | IV 3.2E-08 | Mod 3.1E+00 | III 3.1E-06 |
| TRU Waste/drums | Incredible 9.9E-07 | 200 | Low 3.2E-02 | IV 3.2E-08 | Mod 3.1E+00 | III 3.1E-06 |
| Samples | Incredible 9.9E-07 | 200 | Low 3.2E-02 | IV 3.2E-08 | Mod 3.1E+00 | III 3.1E-06 |
| Sources | Incredible 9.9E-07 | 200 | Low 3.2E-02 | IV 3.2E-08 | Mod 3.1E+00 | III 3.1E-06 |

Scenario 5: Truck Accident Resulting in Fire

This scenario addresses the possibility of a collision that results in a major fire which releases fissile material. The fire is assumed to be lofted. This is a Severity Category IV-VIII accident from Table 8-5 that results in a fire.

The frequencies developed in Section 8.6.1.2 and tabulated in Table 8-6 place transportation accidents resulting in fire in the *extremely unlikely* and *incredible* frequency bins. Waste transfers fall into the *extremely unlikely* frequency bin because credit can not be taken for a metal floor on the transfer vehicle with the exception of high americium materials, which are *incredible* based on the limited quantity on the site. The bounding accident for a truck fire is *incredible* and involves an entire truck load of plutonium oxide. This accident results in *high* consequences to the MOI and the collocated worker (both Risk Class II).

This scenario assumes that the fire involves all of the material, e.g., the MAR is the entire contents of the transfer vehicle, if the fire location and intensity cause a breach of the truck bed, giving a damage ratio of 1.0. Applying the appropriate airborne release fraction and respirable fraction (Table 8-8), the resulting consequences and risk from a truck accident resulting in a major fire are determined. The resulting doses and risk from this accident scenario for the MOI and the collocated worker are given in Tables 8-14a, b, c, and d.

**Table 8-14a.** Truck Accident - Fire (Scenario 5), >16 kg/transfer

| Material | Frequency | MAR (grams) | MOI Consequences (rem) | MOI Risk Class (rem/yr) | Collocated Worker Consequences (rem) | Collocated Worker Risk (rem/yr) |
|---|---|---|---|---|---|---|
| Oxide | Incredible 9.6E-09 | 250,000 | High 1.4E+01 | II 1.3E-07 | High 4.9E+02 | II 4.7E-06 |
| Avg Residue | Incredible 9.6E-09 | 250,000 | Mod 2.0E-01 | III 1.9E-09 | Mod 7.0E+00 | II 6.8E-08 |
| Hi-Am Residue | Incredible 9.6E-10 | 250,000 | High 9.3E-01 | III 9.0E-10 | High 3.3E+01 | II 3.2E-08 |
| Liquid | Incredible 9.6E-10 | 6,000 | Mod 1.9E+00 | III 1.8E-09 | High 6.7E+01 | II 6.5E-08 |

**Table 8-14b.** Truck Accident - Fire (Scenario 5), >6 kg to 16 kg/transfer

| Material | Frequency | MAR (grams) | MOI Consequences (rem) | MOI Risk Class (rem/yr) | Collocated Worker Consequences (rem) | Collocated Worker Risk (rem/yr) |
|---|---|---|---|---|---|---|
| Oxide | Incredible 9.6E-09 | 16,000 | Mod 8.9E-01 | III 8.6E-09 | High 3.1E+01 | II 3.0E-07 |
| Avg Residue | Incredible 9.6E-09 | 16,000 | Low 1.3E-02 | IV 1.2E-10 | Low 4.5E-01 | IV 4.3E-09 |
| TRU Waste/drums | Incredible 9.6E-09 | 16,000 | Mod 1.3E+00 | III 1.2E-08 | High 4.5E+01 | II 4.3E-07 |
| Hi-Am Residue | Incredible 9.6E-10 | 16,000 | Low 6.0E-02 | IV 5.8E-11 | Mod 2.1E+00 | III 2.0E-09 |
| Hi-Am Residue/POC | Incredible 9.6E-10 | 26,550 | Low 2.5E-04 | IV 2.4E-13 | Low 8.8E-03 | IV 8.5E-12 |
| Hi-Am TRU Waste | Incredible 9.6E-11 | 10,500 | Mod 8.3E-01 | III 8.0E-11 | High 2.9E+01 | II 2.8E-09 |
| Liquid | Incredible 9.6E-10 | 6,000 | Mod 1.9E+00 | III 1.8E-09 | High 6.7E+01 | II 6.5E-08 |

**Table 8-14c.** Truck Accident - Fire (Scenario 5), >200 grams to 6kg/transfer

| Material | Frequency | MAR (grams) | MOI | | Collocated Worker | |
|---|---|---|---|---|---|---|
| | | | Consequences (rem) | Risk Class (rem/yr) | Consequences (rem) | Risk (rem/yr) |
| Avg Residue | Ext unlkly 3.6E-06 | 6,000 | Low 4.8E-03 | IV 1.7E-08 | Low 1.7E-01 | IV 6.1E-07 |
| TRU Waste/drums | Ext unlkly 3.6E-06 | 6,000 | Mod 4.8E-01 | III 1.7E-06 | Mod 1.7E+01 | III 6.1E-05 |
| TRU Waste/boxes | Ext unlkly 3.6E-06 | 6,000 | Mod 4.8E-01 | III 1.7E-06 | Mod 1.7E+01 | III 6.1E-05 |
| Hi-Am Residue | Incredible 3.6E-07 | 10,500 | Low 8.3E-03 | IV 3.0E-09 | Low 2.9E-01 | IV 1.0E-07 |
| Hi-Am Residue/POC | Incredible 3.6E-07 | 26,550 | Low 2.5E-04 | IV 9.0E-11 | Low 8.8E-03 | IV 3.2E-09 |
| Hi-Am TRU Waste | Incredible 3.6E-08 | 10,500 | Mod 8.3E-01 | III 3.0E-08 | High 2.9E+01 | II 1.0E-06 |
| Liquid | Incredible 3.6E-07 | 6,000 | Mod 1.9E+00 | III 6.9E-07 | High 6.7E+01 | II 2.4E-05 |

**Table 8-14d.** Truck Accident - Fire (Scenario 5), ≤200 grams/transfer

| Material | Frequency | MAR (grams) | MOI | | Collocated Worker | |
|---|---|---|---|---|---|---|
| | | | Consequences (rem) | Risk Class (rem/yr) | Consequences (rem) | Risk (rem/yr) |
| LLW/wood boxes | Ext unlkly 3.6E-06 | 200 | Low 1.6E-02 | IV 5.8E-08 | Mod 5.6E-01 | III 2.0E-06 |
| LLW/drums | Ext unlkly 3.6E-06 | 200 | Low 1.6E-02 | IV 5.8E-08 | Mod 5.6E-01 | III 2.0E-06 |
| TRU Waste/drums | Ext unlkly 3.6E-06 | 200 | Low 1.6E-02 | IV 5.8E-08 | Mod 5.6E-01 | III 2.0E-06 |
| Samples | Ext unlkly 3.6E-06 | 200 | Low 1.6E-02 | IV 5.8E-08 | Mod 5.6E-01 | III 2.0E-06 |
| Sources | Ext unlkly 3.6E-06 | 200 | Low 1.6E-02 | IV 5.8E-08 | Mod 5.6E-01 | III 2.0E-06 |

Scenario 6: Vehicle Fire Spreads and Involves Partial Load

This scenario addresses the possibility of a transfer vehicle fire initiated by an electrical malfunction or short that results in a fire in the engine compartment. This scenario assumes the fire consumes all available fuel in the transfer vehicle fuel tanks with no other sources of combustibles or fuel and is lofted. The fire is assumed to be concentrated enough to breach the metal truck bed or enclosure, but not be extensive enough to engulf the entire load. The NSTR for salt transfer (RFETS, 1997a) assumed the heat of the fire would have to be concentrated to breach the metal bed or enclosure, and only three 55-gallon drums (or 10% of the load) in the area of the breach would be exposed directly to flames. For transfers of 10-gallon drums, five drums (10% of 50 drums) are assumed to be exposed to the flames. This is consistent with the classification in SARAH (RFETS, 1997b) for a medium fire.

This fire scenario is postulated to occur regardless of whether the transfer vehicle is located at the dock or is in transit. Therefore, the frequency of occurrence is not based on the number of miles traveled, rather it is based on 1) the probability the malfunction occurs and the fire spreads to involve the transfer vehicle fuel supply, 2) the probability the MAR is on the transfer vehicle, 3) the probabilities of the fire occurring under the transfer vehicle and breaching the truck bed or enclosure. Based on past experience and DOE data on transportation incidents, vehicle engine fires are not an anticipated event. In addition, trucks used for transportation at Rocky Flats have low mileage and receive regular preventive maintenance that helps reduce the probability of an engine fire. The NSTR for salt transfer (RFETS, 1997a) qualitatively estimated the probability an electrical malfunction or short that results in an engine fire as an *unlikely* event (approximately 5.0E-04/yr). Due to the inherent uncertainty and conservatism (due to the limited fuel supply) associated with the assumption of three drums being involved, differences in drum sizes (i.e., 55-gallon vs. 10-gallon) are ignored.

The probability a specific material type is on the transfer vehicle is related the amount of time material could be present on a transfer vehicle vs time the transfer vehicle is empty. Staging on the transfer vehicle is not allowed for transfers of >16 kg and >6kg categories, therefore this probability is less than 1.0 and is calculated for the number of hours in a 24 hour period that material could be present on the transfer vehicle. Determination of the probability the truck is loaded assumes that transfers could be made during two shifts and that there are three vehicles available for transfer [155 days/year (Number of days/year transfers occur) * 2 shifts/day @ 8 hours/shift ÷ 8,760 hours/year * 3 vehicles available]. The number of days per year transfers are made (155 days) is based on information in the *Integrated Transportation and Shipping Infrastructure Plan* (RFETS, 1999b). This number for waste transfers is 1.0 because these transfers could involve staging (e.g., a loaded vehicle is left unattended).

The NSTR for salt transfer (RFETS, 1997a) previously estimated the probability that a fuel fire centers under the bed to be 0.5, and the probability of a fire breaching the metal bed or enclosure of a vehicle at 0.02. The limited quantity of available fuel may not be sufficient to breach the metal bed or enclosure, however, this is conservatively assumed to occur. The probability of breaching the bed of the transfer vehicle containing wastes is taken to be 1.0 because of the wood construction of the bed of flatbed trucks. This is conservatively used for all waste transfer categories even though waste drums are usually transferred in trucks with metal floors.

Based on the inputs related to this scenario, the frequency is estimated to be *extremely unlikely* and *incredible* for transfers containing greater than 6 kg WG Pu. Transfers of material in the less than 6 kg WG Pu categories fall into the *unlikely* and *extremely unlikely* frequency bins. The bounding accident this fire is *extremely unlikely* and involves three drums containing plutonium oxide. This accident results in *moderate* consequences to the MOI (Risk Class III) and *high* consequences to the collocated worker (Risk Class II). The frequency, MAR, consequence, and risk class information for this scenario are given in Tables 8-15a, b, c, and d.

**Table 8-15a.** Vehicle Fire Involving Partial Load (Scenario 6), >16 kg/transfer

| Material | Frequency | MAR (grams) | MOI | | Collocated Worker | |
|---|---|---|---|---|---|---|
| | | | Consequences (rem) | Risk Class (rem/yr) | Consequences (rem) | Risk (rem/yr) |
| Oxide | Ext unlkly 2.1E-06 | 25,000 | Mod 1.4E+00 | III 3.0E-06 | High 4.9E+01 | II 1.0E-04 |
| Avg Residue | Ext unlkly 2.1E-06 | 3,000 | Low 2.4E-03 | IV 5.1E-09 | Low 8.4E-02 | IV 1.8E-07 |
| Hi-Am Oxide | Incredible 2.1E-08 | 30,100 | Mod 1.5E+00 | III 3.3E-08 | High 5.4E+01 | II 1.1E-06 |
| Hi-Am Residue | Incredible 2.1E-07 | 3,000 | Low 1.1E-02 | IV 2.4E-09 | Low 3.9E-01 | IV 8.4E-08 |
| Liquid | Incredible 2.1E-07 | 3,600 | Mod 1.2E+00 | III 2.4E-07 | High 4.0E+01 | II 8.6E-06 |

**Table 8-15b.** Vehicle Fire Involving Partial Load (Scenario 6), >6 kg to 16 kg/transfer

| Material | Frequency | MAR (grams) | MOI | | Collocated Worker | |
|---|---|---|---|---|---|---|
| | | | Consequences (rem) | Risk Class (rem/yr) | Consequences (rem) | Risk (rem/yr) |
| Oxide | Ext unlkly 2.1E-06 | 16,000 | Mod 8.9E-01 | III 1.9E-06 | High 3.1E+01 | II 6.7E-05 |
| Avg Residue | Ext unlkly 2.1E-06 | 3,000 | Low 2.4E-03 | IV 5.1E-09 | Low 8.4E-02 | IV 1.8E-07 |
| TRU Waste/drums | Ext unlkly 2.1E-06 | 600 | Low 4.8E-02 | IV 1.0E-07 | Mod 1.7E+00 | III 3.6E-06 |
| TRU Waste/boxes | Ext unlkly 2.1E-06 | 400 | Low 3.1E-02 | IV 6.7E-08 | Mod 1.1E+00 | III 2.3E-06 |
| Hi-Am Residue | Incredible 2.1E-07 | 3,000 | Low 1.1E-02 | IV 2.4E-09 | Low 3.9E-01 | IV 8.4E-08 |
| Hi-Am Residue/POC | Incredible 2.1E-07 | 2,655 | Low 2.5E-05 | IV 5.3E-12 | Low 8.8E-04 | IV 1.9E-10 |
| Hi-Am TRU Waste | Incredible 2.1E-08 | 1,050 | Low 8.3E-02 | IV 1.8E-09 | Mod 2.9E+00 | III 6.2E-08 |
| Liquid | Incredible 2.1E-07 | 3,600 | Mod 1.2E+00 | III 2.4E-07 | High 4.0E+01 | II 8.6E-06 |

**Table 8-15c.** Vehicle Fire Involving Partial Load (Scenario 6), >200 grams to 6 kg/transfer

| Material | Frequency | MAR (grams) | MOI | | Collocated Worker | |
|---|---|---|---|---|---|---|
| | | | Consequences (rem) | Risk Class (rem/yr) | Consequences (rem) | Risk (rem/yr) |
| Avg Residue | Unlkly 1.3E-04 | 600 | Low 4.8E-04 | III 6.0E-08 | Low 1.7E.-02 | III 2.1E-06 |
| TRU Waste/drums | Unlkly 1.3E-04 | 600 | Low 4.8E-02 | III 6.0E-06 | Mod 1.7E+00 | II 2.1E-04 |
| TRU Waste/boxes | Unlkly 1.3E-04 | 600 | Low 3.1E-02 | III 3.9E-06 | Mod 1.1E+00 | II 1.4E-04 |
| Hi-Am Residue | Ext unlkly 1.3E-05 | 1,050 | Low 8.3E-04 | IV 1.0E-08 | Low 2.9E-02 | IV 3.6E-07 |
| Hi-Am Residue/POC | Ext unlkly 1.3E-05 | 2,655 | Low 2.5E-05 | IV 3.1E-10 | Low 8.8E-04 | IV 1.1E-08 |
| Hi-Am TRU Waste | Ext unlkly 1.3E-06 | 1,050 | Low 8.3E-02 | IV 1.0E-07 | Mod 2.9E+00 | III 3.6E-06 |
| Liquid | Ext unlkly 1.3E-05 | 600 | Mod 1.9E-01 | III 2.4E-06 | Mod 6.7E+00 | III 8.4E-05 |

**Table 8-15d.** Vehicle Fire Involving Partial Load (Scenario 6), ≥200 grams/transfer

| Material | Frequency | MAR (grams) | MOI Consequences (rem) | MOI Risk Class (rem/yr) | Collocated Worker Consequences (rem) | Collocated Worker Risk (rem/yr) |
|---|---|---|---|---|---|---|
| LLW/wood boxes | Unlkly<br>1.3E-04 | 9 | Low<br>7.2E-04 | III<br>9.0E-08 | Lov<br>2.5E-02 | III<br>3.2E-06 |
| LLW/drums | Unlkly<br>1.3E-04 | 2 | Low<br>1.2E-04 | III<br>1.5E-08 | Low<br>4.2E-03 | III<br>5.3E-07 |
| TRU Waste/drums | Unlkly<br>1.3E-04 | 200 | Low<br>1.6E-02 | III<br>2.0E-06 | Mod<br>5.6E-01 | III<br>7.0E-05 |
| Samples | Unlkly<br>1.3E-04 | 200 | Low<br>1.6E-02 | III<br>2.0E-06 | Mod<br>5.6E-01 | III<br>7.0E-05 |
| Sources | Unlkly<br>1.3E-04 | 200 | Low<br>1.6E-02 | III<br>2.0E-06 | Mod<br>5.6E-01 | III<br>7.0E-05 |

Scenario 7: Rupture Due To Hydrogen Buildup/Ignition

This scenario addresses the possibility of a hydrogen deflagration in a drum containing nuclear materials, such as plutonium oxide or plutonium residues. Hydrogen is generated by the radiolytic decomposition of water or plastics. An explosive mixture of hydrogen and oxygen could accumulate in a drum over time, and extremely small energy sources (pyrophoric material, electrostatic spark) could be generated as a result of friction or pyrophoric reactions induced during transportation activities which could ignite the hydrogen. This accident could occur on the transfer vehicle during vehicle movement, or during drum movement between the transfer vehicle and the dock. Ignition of a flammable concentration of hydrogen within a drum results in a deflagration (versus a detonation). This scenario assumes that fire does not occur following ignition of the hydrogen, which is considered a rapid, low-energy overpressurization excursion (SAE, 1996a).

The frequency for a hydrogen deflagration is based on 1) an initiating frequency, 2) the increase in probability of detonation of the hydrogen due to transfer versus storage, 3) the number of drums transferred per year, 4) the probability there is sufficient agitation to ignite the hydrogen, and 5) the drum venting program. The initiating frequency for a hydrogen deflagration, based on that for an unvented, high-risk residue drum (containing reactive metals and compounds) in storage, is estimated to be approximately 7.0E-06 events per drum/year (RFETS, 1994). The remaining parameters used in determining the frequencies for this scenario are described in the frequency development section earlier in this chapter.

The material at risk in this scenario is assumed to be limited to one package because of the low probability that the hydrogen in two drums will independently ignite at the same time. The damage ratio for this scenario is assumes that some of the drum's contents have breached the inner containment and that 10% of the contents are released (DR = 0.1) (RFETS, 1997a).

Transfer of oxides packaged in 10-gallon containers are not considered in this scenario because the permeability of the gasket is considered great enough to prevent hydrogen buildup. In the event oxide is to be transferred in other than a 10-gallon container, an evaluation must be performed for that evolution. (Dustin, 1994, Hergert, 1994). This scenario also is not evaluated for low level waste transfers because the quantity of fissile material is considered too small to generate sufficient hydrogen to create a hazard.

Based on the inputs related to this scenario, the frequency is estimated fall in the *extremely unlikely* and the *incredible* frequency bins, depending on the material being transferred. The bounding accident for a rupture due to hydrogen buildup is *incredible* and involves a drum containing high americium residues. This accident results in *high* consequences to the MOI and the collocated worker (both Risk Class II).

The estimated frequencies are for a single drum experiencing ignition of a flammable concentration of hydrogen, given the total postulated number of drum moves. Two or more drums simultaneously experiencing hydrogen ignition in one year of transfers, could be associated to a common causal factor; however, the events are not stastistically dependent because a hydrogen deflagration in one drum is not expected to cause a deflagration in another drum. The probability that two drums experience a hydrogen overpressurization, modeled as two independent events, is equal to probability of one event times the probability of the second event (P[A and B] = P[A] * P[B]) (Brase, 1991). The probability of a single drum experiencing a hydrogen deflagration in one year has been calculated to be 1.3E-06 for transfers of material containing a total of greater than 6 kg WG Pu per load. Determination of the probability for the independent events is 1.3E-06 * 1.3E-06 which equals a probability of 1.7E-12. Similar calculations for wastes is 6.6E-06 * 6.6E-06 equals 4.4E-11. In both cases, the probability of the two independent events occurring simultaneously is *incredible.* Therefore the evaluation of this scenario only involves one drum of the material present on the transfer vehicle.

This scenario assumes a damage ratio of 0.1 which is consistent with previous analysis of hydrogen explosions at Rocky Flats (RFETS, 1997b). This assumes that some of the drum's contents have breached the inner containers, and that 10% of the drum's contents are released as a result of the overpressurization. A leakpath factor of 1.0 is assumed, which ignores any potential confinement provided by a dock or vehicle enclosure.

The consequences and risk class for a drum rupture due to hydrogen buildup and ignition of the hydrogen are given in Tables 8-16a, b, c, and d.

**Table 8-16a.** Rupture due to Hydrogen (Scenario 7), >16 kg/transfer

| Material | Frequency | MAR (grams) | MOI | | Collocated Worker | |
|---|---|---|---|---|---|---|
| | | | Consequences (rem) | Risk Class (rem/yr) | Consequences (rem) | Risk (rem/yr) |
| Avg Residue | Ext unlkly 1.3E-06 | 1,000 | High 1.1E+01 | II 1.5E-05 | High 1.1E+03 | II 1.4E-03 |
| Hi-Am Residue | Incredible 1.3E-07 | 1,000 | High 5.2E+01 | II 6.9E-06 | High 5.1E+03 | II 6.7E-04 |
| Liquid | Incredible 1.3E-07 | 1,200 | Low 7.7E-03 | IV 1.0E-09 | Mod 7.5E-01 | III 9.8E-08 |

**Table 8-16b.** Rupture due to Hydrogen (Scenario 7), >6 kg to 16 kg/transfer

| Material | Frequency | MAR (grams) | MOI Consequences (rem) | MOI Risk Class (rem/yr) | Collocated Worker Consequences (rem) | Collocated Worker Risk (rem/yr) |
|---|---|---|---|---|---|---|
| Avg Residue | Ext unlkly 1.3E-06 | 1,000 | High 1.1E+01 | II 1.5E-05 | High 1.1E.+03 | II 1.4E-03 |
| TRU Waste/drums | Ext unlkly 1.3E-06 | 200 | Mod 2.2E+00 | III 2.9E-06 | High 2.2E+02 | II 2.9E-04 |
| TRU Waste/boxes | Ext unlkly 1.3E-06 | 400 | Mod 4.4E+00 | III 5.8E-06 | High 4.3E+02 | II 5.6E-04 |
| Hi-Am Residue | Incredible 1.3E-07 | 1,000 | High 5.2E+01 | II 6.9E-06 | High 5.1E+03 | IV 6.7E-04 |
| Hi-Am TRU Waste | Incredible 1.3E-08 | 350 | Mod 3.9E+00 | III 5.1E-08 | High 3.8E+02 | II 4.9E-06 |
| Liquid | Incredible 1.3E-07 | 1,200 | Low 7.7E-03 | IV 1.0E-09 | Mod 7.5E-01 | III 9.8E-08 |

**Table 8-16c.** Rupture due to Hydrogen (Scenario 7), >200 grams to 6 kg/transfer

| Material | Frequency | MAR (grams) | MOI Consequences (rem) | MOI Risk Class (rem/yr) | Collocated Worker Consequences (rem) | Collocated Worker Risk (rem/yr) |
|---|---|---|---|---|---|---|
| Avg Residue | Ext unlkly 6.6E-06 | 200 | Mod 2.2E+00 | III 1.5E-05 | High 2.2E+02 | II 1.4E-03 |
| TRU Waste/drums | Ext unlkly 6.6E-06 | 200 | Mod 2.2E+00 | III 1.5E-05 | High 2.2E+02 | II 1.4E-03 |
| TRU Waste/boxes | Ext unlkly 6.6E-06 | 400 | Mod 4.4E+00 | III 2.9E-05 | High 4.3E+02 | II 2.8E-03 |
| Hi-Am Residue | Incredible 6.6E-07 | 350 | Mod 3.9E+00 | III 2.5E-06 | High 3.8E-02 | II 2.5E-04 |
| Hi-Am TRU Waste | Incredible 6.6E-08 | 350 | Mod 3.9E+00 | III 2.5E-07 | High 3.8E+02 | II 2.5E-05 |
| Liquid | Incredible 6.6E-07 | 200 | Low 1.3E-03 | IV 8.4E-10 | Low 1.2E-01 | IV 8.2E-08 |

**Table 8-16d.** Rupture due to Hydrogen (Scenario 7), ≤200 grams/transfer

| Material | Frequency | MAR (grams) | MOI Consequences (rem) | MOI Risk Class (rem/yr) | Collocated Worker Consequences (rem) | Collocated Worker Risk (rem/yr) |
|---|---|---|---|---|---|---|
| **TRU Waste/drums** | **Ext unlkly 6.6E-06** | **200** | **Mod 2.2E+00** | **III 1.5E-05** | **High 2.2E+02** | **II 1.4E-03** |

Scenario 8: Fire due to Reactive/Pyrophoric Material

This scenario addresses the possibility of reactive or pyrophoric material initiating a fire during transfer operations. This scenario assumes reactive or pyrophoric material is present and postulates that transporting the packages disturbs the contents in such a manner that the material comes into contact with oxygen causing an exothermic reaction which heats the package contents, causes the plastic packaging to burn, resulting in the loss of containment of the drum and exposure of the burning contents to the atmosphere. This accident could occur on the transfer vehicle during vehicle movement, or during drum movement between the transfer vehicle and the dock. This scenario is not evaluated for liquid and low level waste transfers because of the lack of pyrophoric materials in these matrices.

The frequency for pyrophoric fires is qualitatively estimated to be 1.0E-05, *extremely unlikely*. This is based on USQD-RFP-93.1170-TLF (RFETS, 1993b) which evaluated the storage of potentially pyrophoric plutonium. Because of the campaigns to bring materials into compliance with the requirements of 1-W89-HSP 31.11, *Transfer and Storage of Plutonium for Fire Safety* (RFETS, 1997c), and the regular inspection program and stabilization requirements of HSP 31.11, the frequency identified in the USQD is reduced by a factor of 10.

Only one drum at a time is postulated to experience a pyrophoric reaction that results in fire. As discussed in Scenario 7, the probability of multiple drums independently experiencing a simultaneous pyrophoric reaction would be extremely low (i.e., 1.0E-10 or lower). A pyrophoric fire in a single drum is not considered sufficient to cause significant lofting of the resultant plume; therefore this scenario will be treated as a non-lofted fire.

The frequencies developed in Section 8.6.1.2 and tabulated in Table 8-6 place a fire due to reactive/pyrophoric material during transportation in the *extremely unlikely* and *incredible* frequency bins. The bounding accident for a pyrophoric fire is *incredible* and involves a drum of high americium oxide. This accident results in *moderate* consequences to the MOI (Risk Class III) and *high* consequences to the collocated worker (Risk Class II).

This scenario conservatively assumes a damage ratio of 1.0 (all of the material in the drum is involved). The frequency, MAR, consequences, and risk class information for a fire caused by the ignition of pyrophoric material are given in Tables 8-17a, b, c, and d.

**Table 8-17a.** Pyrophoric Material Fire (Scenario 8), >16kg/transfer

| Material | Frequency | MAR (grams) | MOI | | Collocated Worker | |
|---|---|---|---|---|---|---|
| | | | Consequences (rem) | Risk Class (rem/yr) | Consequences (rem) | Risk (rem/yr) |
| Oxide | Ext unlkly 1.0E-05 | 5,000 | Mod 2.8E+00 | III 2.8E-05 | High 2.7E+02 | II 2.7E-03 |
| Avg Residue | Ext unlkly 1.0E-05 | 1,000 | Low 8.0E-03 | IV 8.0E-08 | Mod 7.8E-01 | III 7.8E-06 |
| Hi-Am Oxide | Incredible 1.0E-07 | 9,000 | Mod 4.6E+00 | III 4.6E-07 | High 4.5E+02 | II 4.5E-05 |
| Hi-Am Residue | Ext unlkly 1.0E-06 | 1,000 | Low 3.7E-02 | IV 3.7E-08 | Mod 3.6E+00 | III 3.6E-06 |

**Table 8-17b.** Pyrophoric Material Fire (Scenario 8), >6kg to 16 kg/transfer

| Material | Frequency | MAR (grams) | MOI Consequences (rem) | MOI Risk Class (rem/yr) | Collocated Worker Consequences (rem) | Collocated Worker Risk (rem/yr) |
|---|---|---|---|---|---|---|
| Oxide | Ext unlkly 1.0E-05 | 5,000 | Mod 2.8E+00 | III 2.8E-05 | High 2.7E+02 | II 2.7E-03 |
| Avg Residue | Ext unlkly 1.0E-05 | 1,000 | Low 8.0E-03 | IV 8.0E-08 | Mod 7.8E-01 | III 7.8E-06 |
| TRU Waste/drums | Ext unlkly 1.0E-05 | 200 | Mod 1.6E-01 | III 1.6E-06 | Mod 1.6E+01 | III 1.6E-04 |
| TRU Waste/boxes | Ext unlkly 1.0E-05 | 400 | Mod 3.1E-01 | III 3.1E-06 | High 3.1E+01 | II 3.1E-04 |
| Hi-Am Residue | Ext unlkly 1.0E-06 | 1,000 | Low 3.7E-02 | IV 3.7E-08 | Mod 3.6E+00 | III 3.6E-06 |
| Hi-Am Residue/POC | Ext unlkly 1.0E-06 | 885 | Low 8.3E-05 | IV 8.3E-11 | Low 8.1E-03 | IV 8.1E-09 |
| Hi-Am TRU Waste | Incredible 1.0E-07 | 350 | Mod 2.8E-01 | III 2.8E-08 | High 2.7E+01 | II 2.7E-06 |

**Table 8-17c.** Pyrophoric Material Fire (Scenario 8), >200 grams to 6 kg/transfer

| Material | Frequency | MAR (grams) | MOI Consequences (rem) | MOI Risk Class (rem/yr) | Collocated Worker Consequences (rem) | Collocated Worker Risk (rem/yr) |
|---|---|---|---|---|---|---|
| Avg Residue | Ext unlkly 1.0E-05 | 200 | Low 1.6E-03 | IV 1.6E-08 | Low 1.6E.-01 | IV 1.6E-06 |
| TRU Waste/drums | Ext unlkly 1.0E-05 | 200 | Mod 1.6E-01 | III 1.6E-06 | Mod 1.6E+01 | III 1.6E-04 |
| TRU Waste/boxes | Ext unlkly 1.0E-05 | 400 | Mod 3.1E-01 | III 3.1E-06 | High 3.1E+01 | II 3.1E-04 |
| Hi-Am Residue | Ext unlkly 1.0E-06 | 350 | Low 2.8E-03 | IV 2.8E-09 | Low 2.7E-01 | IV 2.7E-07 |
| Hi-Am Residue/POC | Ext unlkly 1.0E-06 | 885 | Low 8.3E-05 | IV 8.3E-11 | Low 8.1E-03 | IV 8.1E-09 |
| Hi-Am TRU Waste | Incredible 1.0E-07 | 350 | Mod 2.8E-01 | III 2.8E-08 | High 2.7E+01 | II 2.7E-06 |

**Table 8-17d.** Pyrophoric Material Fire (Scenario 8), ≤200 grams/transfer

| Material | Frequency | MAR (grams) | MOI Consequences (rem) | MOI Risk Class (rem/yr) | Collocated Worker Consequences (rem) | Collocated Worker Risk (rem/yr) |
|---|---|---|---|---|---|---|
| TRU Waste/drums | Ext unlkly 1.0E-05 | 200 | Mod 1.6E-01 | III 1.6E-06 | Mod 1.6E+01 | III 1.6E-04 |
| Samples | Ext unlkly 1.0E-05 | 200 | Mod 1.6E-01 | III 1.6E-06 | Mod 1.6E+01 | III 1.6E-04 |

Scenario 9: Explosion External to Transfer Vehicle

This scenario addresses the possibility of an explosion of the contents of a propane bulk delivery vehicle in the proximity of the transfer vehicle. Releases of material due to accidents associated with the propane tanker could be the result of an overpressure impacting the transfer vehicle, or a fire due to the ignition of the fuel. The material in the transfer vehicle is confined to a drum or box and therefore an overpressurization is considered the same as a spill of confined material and is bounded by the major spill scenario (Scenario 4). If the explosion resulted in a fire, the consequences would be bounded by the major fire evaluated in Scenario 5. The consequences of a fireball is not expected to ignite the material as the flame front passes due to the speed of the flame front.

The frequencies associated with the transfer vehicle in association with the propane delivery tanker is based on the number of miles the propane tanker travels per year, not the number of miles the material transfer vehicle travels per year as used in the other frequency determinations. The bounding accident for an explosion external to the transfer vehicle is *incredible* and involves an entire truck load of plutonium oxide. This accident results in *high* consequences to the MOI and the collocated worker (both Risk Class II).

The frequency, MAR, consequences, and risk class information for an explosion external to the transfer vehicle are given in Tables 8-18a, b, c, and d.

**Table 8-18a.** External Explosion (Scenario 9), >16 kg/transfer

| Material | Frequency | MAR (grams) | MOI | | Collocated Worker | |
|---|---|---|---|---|---|---|
| | | | Consequences (rem) | Risk Class (rem/yr) | Consequences (rem) | Risk (rem/yr) |
| Oxide | Incredible 5.1E-07 | 250,000 | High 2.8E+01 | II 1.4E-05 | High 2.7E+03 | II 1.4E-03 |
| Avg Residue | Incredible 5.1E-07 | 250,000 | Mod 4.0E+00 | III 2.0E-06 | High 3.9E+02 | II 2.0E-04 |
| Hi-Am Residue | Incredible 5.1E-08 | 250,000 | High 1.9E+01 | II 9.6E-07 | High 1.8E+03 | II 9.3E-05 |
| Liquid | Incredible 5.1E-08 | 6,000 | Mod 3.8E-01 | III 2.0E-08 | High 3.7E+01 | II 1.9E-06 |

**Table 8-18b.** External Explosion (Scenario 9), >6 kg to 16 kg/transfer

| Material | Frequency | MAR (grams) | MOI | | Collocated Worker | |
|---|---|---|---|---|---|---|
| | | | Consequences (rem) | Risk Class (rem/yr) | Consequences (rem) | Risk (rem/yr) |
| Oxide | Incredible 5.1E-07 | 16,000 | Mod 1.8E+00 | III 9.1E-07 | High 1.7E+02 | II 8.9E-05 |
| Avg Residue | Incredible 5.1E-07 | 16,000 | Mod 2.6E-01 | II 1.3E-07 | Mod 2.5E+01 | III 1.3E-05 |
| TRU Waste/drums | Incredible 5.1E-07 | 16,000 | Mod 2.6E+00 | III 1.3E-06 | High 2.5E+02 | II 1.3E-04 |
| Hi-Am Residue | Incredible 5.1E-08 | 16,000 | Mod 1.2E+00 | II 6.1E-08 | High 1.2E+02 | II 6.0E-06 |
| Hi-Am TRU Waste | Incredible 5.1E-09 | 10,500 | Mod 1.7E+00 | III 8.5E-09 | High 1.6E+02 | II 8.2E-07 |
| Liquids | Incredible 5.1E-07 | 6,000 | Mod 3.8E-01 | III 2.0E-07 | High 3.7E+01 | II 1.9E-05 |

**Table 8-18c.** External Explosion (Scenario 9), >200 grams to 16 kg/transfer

| Material | Frequency | MAR (grams) | MOI | | Collocated Worker | |
|---|---|---|---|---|---|---|
| | | | Consequences (rem) | Risk Class (rem/yr) | Consequences (rem) | Risk (rem/yr) |
| Avg Residue | Ext unlkly 2.2E-06 | 6,000 | Low 9.6E-02 | IV 2.1E-07 | Mod 9.3E.+00 | III 2.0E-05 |
| TRU Waste/drums | Ext unlkly 2.2E-06 | 6,000 | Mod 9.6E-01 | III 2.1E-06 | High 9.3E+01 | II 2.0E-04 |
| TRU Waste/boxes | Ext unlkly 2.2E-06 | 6,000 | Mod 9.6E-01 | III 2.1E-06 | High 9.3E+01 | II 2.0E-04 |
| Hi-Am Residue | Incredible 2.2E-07 | 10,500 | Mod 1.7E-01 | III 3.6E-08 | Mod 1.6E+01 | II 3.5E-06 |
| Hi-Am TRU Waste | Incredible 2.2E-08 | 10,500 | Mod 1.7E+00 | III 3.6E-08 | High 1.6E+02 | II 3.5E-06 |
| Liquid | Incredible 2.2E-07 | 6,000 | Mod 3.8E-01 | III 8.3E-08 | High 3.7E+01 | II 8.0E-06 |

**Table 8-18d.** External Explosion (Scenario 9), ≤200 grams/transfer

| Material | Frequency | MAR (grams) | MOI | | Collocated Worker | |
|---|---|---|---|---|---|---|
| | | | Consequences (rem) | Risk Class (rem/yr) | Consequences (rem) | Risk (rem/yr) |
| LLW/wood boxes | Ext unlkly 2.2E-06 | 200 | Low 3.2E-02 | IV 6.9E-08 | Mod 3.1E+00 | III 6.7E-06 |
| LLW/drums | Ext unlkly 2.2E-06 | 200 | Low 3.2E-02 | IV 6.9E-08 | Mod 3.1E+00 | III 6.7E-06 |
| TRU Waste/drums | Ext unlkly 2.2E-06 | 200 | Low 3.2E-02 | IV 6.9E-08 | Mod 3.1E+00 | III 6.7E-06 |
| Samples | Ext unlkly 2.2E-06 | 200 | Low 3.2E-02 | IV 6.9E-08 | Mod 3.1E+00 | III 6.7E-06 |
| Sources | Ext unlkly 2.2E-06 | 200 | Low 3.2E-02 | IV 6.9E-08 | Mod 3.1E+00 | III 6.7E-06 |

Scenario 10: Powered Industrial Trucks

The transfer of waste containers using powered industrial trucks addresses the possibility of an accident involving the container during the transfer of the container between facilities using a forklift. Spills during forklift operations are considered *anticipated* for LLW in boxes or drums, *unlikely* for TRU waste in boxes or drums, and *extremely unlikely* for high Am TRU wastes. The frequency is greatest for LLW due to the larger number of items in this category with the potential for being moved.

Fires during transfer of material using a forklift that involve the material being transferred are estimated to be *extremely unlikely* for all material types except high Am TRU waste which is incredible due to the limited number of items available for transfer. The bounding accident for a transfer using a forklift is a fire involving four drums of high americium TRU waste, not packaged in POCs. This accident results in *moderate* consequences to the MOI (Risk Class III) and *high* consequences to the collocated worker (Risk Class II). The frequency, MAR, consequences, and risk class information for forklift accidents are given in Table 8-19a, and b.

**Table 8-19a.** Powered Industrial Trucks - Spill (Scenario 10)

| Material | Frequency | MAR (grams) | MOI Consequences (rem) | MOI Risk Class (rem/yr) | Collocated Worker Consequences (rem) | Collocated Worker Risk (rem/yr) |
|---|---|---|---|---|---|---|
| LLW/wood boxes | Anticipated 1.1E-02 | 3 | Low 4.8E-04 | III 5.3E-06 | Low 4.7E-02 | III 5.1E-04 |
| LLW/drums | Anticipated 1.1E-02 | 2 | Low 8.0E-05 | III 8.8E-07 | Low 7.8E-03 | III 8.6E-05 |
| TRU Waste/drums | Unlkly 1.1E-03 | 800 | Low 3.2E-02 | III 3.2E-05 | Mod 3.1E+00 | II 3.1E-03 |
| TRU Waste/boxes | Uinlkly 1.1E-03 | 320 | Low 5.0E-02 | III 5.0E-05 | Mod 4.9E+00 | II 4.9E-03 |
| Hi-Am TRU Waste | Unlkly 1.0E-05 | 1,400 | Low 5.5E-02 | IV 5.5E-07 | Mod 5.4E+00 | III 5.4E-05 |

**Table 8-19b.** Powered Industrial Trucks - Fire (Scenario 10)

| Material | Frequency | MAR (grams) | MOI Consequences (rem) | MOI Risk Class (rem/yr) | Collocated Worker Consequences (rem) | Collocated Worker Risk (rem/yr) |
|---|---|---|---|---|---|---|
| LLW/wood boxes | Ext unlkly 5.0E-05 | 3 | Low 2.4E-03 | IV 1.2E-07 | Lov 2.3E-01 | IV 1.2E-05 |
| LLW/drums | Ext unlkly 5.0E-05 | 2 | Low 1.6E-03 | IV 8.0E-08 | Low 1.6E-01 | IV 7.8E-06 |
| TRU Waste/drums | Ext unlkly 5.0E-05 | 800 | Mod 6.4E-01 | III 3.2E-05 | High 6.2E+01 | II 3.2E-03 |
| TRU Waste/boxes | Ext unlkly 5.0E-05 | 320 | Mod 2.5E-01 | III 1.3E-05 | Mod 2.5E+01 | III 1.2E-03 |
| Hi-Am TRU Waste | Ext unlkly 5.0E-07 | 1,400 | Mod 1.1E+00 | III 5.5E-07 | High 1.1E+02 | II 5.4E-05 |

### 8.6.3.3 Potential Criticalities

Criticality requires occurrence of several concurrent conditions: accumulation of fissile material in sufficient amount, arrangement of the fissile material into correct geometry, and moderation and/or reflection of the assembly to attain critical state. These conditions are not possible for nuclear material shipments conducted in DOT Type B packages for off-site shipment because these packages and their interior components will not allow the reconfiguration of the individual package's fissile materials to occur when contents are packaged and assembled per the Certificate of Compliance (COC) or Safety Analysis Report SARP requirements. In addition, these packages have been certification tested to provide mechanical and fire protection to vehicle collision type forces such that the nuclear material does not become available to accumulate even upon impacts and fuel pool fires of 30-minute duration.

In order to demonstrate the potential for a criticality accident to occur during the transport of nuclear materials each accident scenario was qualitatively evaluated based on the following criteria:

- The amount of damage expected to drums, e.g., number of drums breached. It is assumed that breaching the drums is necessary to provide the potential of the fissile material to meet the optimum conditions for criticality, due to the packing configurations with spacers and multiple layers of packaging.

- The probability that, following breaching drums, the material arrangement meets optimum conditions for criticality. This probability is taken to be 10%.

- The probability that the material configuration has the optimum moderation needed, e.g., the addition of water to the accident scene. This probability is taken to be 10%

The frequency for the occurrence of each accident scenario is developed in Section 8.6.1.2 for transfer loads containing drums with greater than 200 grams fissile material. Starting with this accident frequency and the expected damage to the cargo due to the accident (e.g., the damage ratio), the probability of a criticality occurring is evaluated. Table 8-20 below summarizes this information and evaluation.

Based on the semi-qualitative evaluation of possible criticality accident occurring during the transport of nuclear materials given in the above section "Criticality Evaluation", no credible criticality accident exists. DOE-STD-3011-94 states *"Externally initiated man-made accident scenarios should be evaluated in they can cause a release of greater than* $10^{-6}$ */yr as conservatively estimated, or* $10^{-7}$ */yr as realistic estimated, in accordance with DOE-STD-3009-94."* Per this guidance, no consequences related to a potential criticality accident are determined.

**Table 8-20.** Evaluation of Potential Criticalities During Transfer Operations

| Scenario | Scenario Frequency | Damage Ratio | Criticality Frequency* | Conclusion |
|---|---|---|---|---|
| 1 Up to 15 mph | 2.7E-05 | DR = 0. No drums breached. | NA | No release of material, therefore, no potential to meet conditions necessary for a criticality to occur. |
| 2 Up to 30 mph | 6.4E-06 | DR = 0.01. Potential for one drum breached. | 6.4E-08 | Quantity of material available for criticality less than amount required. Probability of optimum conditions <E-07. |
| 3 Up to 55 mph | 6.8E-07 | DR = 0.1. 3 55-gallon drums breached or 5 10-gallon drums breached | 6.8E-09 | Potential for released material to meet optimum conditions << E-07. |
| 4 Up to 80 mph | 1.3E-07 | DR = 1.0. Possible all drums breached. | 1.3E-09 | Potential for released material to meet optimum conditions << E-07. |
| 5 Fire, entire load | 9.6E-09 | DR = 1.0. Possible all drums breached. | 9.6E-11 | Potential for released material to meet optimum conditions << E-07. |
| 6 Fire, partial load | 2.1E-06 | DR = 1.0 for 3 drums. | 2.1E-08 | Potential for released material to meet optimum conditions < E-07. |
| 7 Hydrogen explosion | 3.7E-06 | DR = 0.1 for one drum involved. | 3.7E-08 | Quantity of material available for criticality less than amount required. Probability of optimum conditions <E-07. |
| 8 Pyrophoric fire | 1.0E-05 | DR = 1.0 for one drum involved. | 1.0E-07 | Quantity of material available for criticality less than amount required. Probability of optimum conditions =E-07. |
| 9 External explosion | 5.1E-07 | DR = 1.0. Possible all drums breached. | 5.1E-09 | Potential for released material to meet optimum conditions << E-07. |
| 10 Forklift | NA | DR = 0.25 for drums. | | Insufficient material available for criticality in one drum. |
| * With optimum conditions met. | | | | |

A criticality safety evaluation for transportation accidents was performed by Cruse, 1992. To simulate a potential criticality event, a 4 x 4 x 5 array of eighty 10-gallon drums was used to represent a vehicle collision event causing rearrangement of the load. This was shown to be subcritical. In addition, Cruse evaluated the potential for drum dimensional damage. The 10-gallon drums were shown to be dented only 1.5 inches by a 4-foot high drop (which is representative of damage from a vehicle roll over or impact) and is not considered sufficient to significantly decrease the size of the array such that criticality will result. The requirements implemented by the site Transportation Safety Manual to perform safety inspections of the truck and the site speed limits are considered to ensure criticalities do not occur.

## 8.7 ON-SITE TRANSPORTATION OF NON-RADIOACTIVE HAZARDOUS SUBSTANCES (EXCLUDING FLAMMABLE SUBSTANCES)

The on-site transportation of non-radioactive hazardous substances includes the on-site delivery/transfer of flammable fuels, compressed gases, bulk chemicals, Resource Conservation and Recovery Act (RCRA) wastes, and Toxic Substance Control Act (TSCA) wastes. This section evaluates the hazards and risks associated with over-the-road transportation of non-radioactive hazardous substances with the exception of flammable fuels, flammable compressed gases, and RCRA mixed wastes. Flammable fuels and flammable compressed gases are addressed in Section 8.8 and the radioactive consequences associated with RCRA mixed wastes are addressed with radioactive wastes in Section 8.6. The chemicals associated with RCRA mixed wastes are discussed in Section 8.7.2.1, Inventory Identification, under the heading of "Chemicals in Waste".

This evaluation assumes that non-radioactive hazardous substances are transported in accordance with the on-site transportation safety manual (RFETS, 2000a) and DOT requirements. Typical accident scenarios are used to evaluate the risk to collocated workers and the public resulting from an airborne release during transportation activities.

### 8.7.1 Methodology

The following sections describe the methodology used for the accident analysis pertaining to the transportation of non-radioactive hazardous substances within the boundaries of the industrial area of the site including (1) identification of hazardous substances transferred on-site that warrant further analysis, (2) development of representative transportation accident scenarios, (3) analysis of accident scenarios to determine event frequencies and consequences, (4) determination of the risks associated with the postulated accident scenarios, and (5) identification of necessary operational controls in order to manage transportation risks.

#### 8.7.1.1 Identification of Hazardous Substances Requiring Further Analysis

Information involving the on-site transportation of hazardous substances was reviewed to identify those materials with a potential for on-site and off-site releases resulting in adverse health effects to collocated workers and the public.

In general, the screening methodology used to identify hazardous substances requiring further analysis included (1) identifying hazardous substances transferred on-site and regulated by EPA or DOT, (2) postulating credible releases of hazardous substances based on the quantities being transferred, and (3) qualitatively determining if postulated release scenarios involve significant quantities, that if released, could result in potential health effect to the collocated worker or public. Information regarding the on-site transport of hazardous substances was obtained through interviews with personnel from the Site Transportation Department, Chemical Dispensary personnel, Building 552, (serves as an interim storage location and distribution point for compressed gases), and end-user facilities. A review of authorization basis documents for end-user facilities was also performed to determine hazardous substance usage and shipping and receiving requirements. The potential for human health effects considered the toxicity of the substance based on a review of the Material Safety Data Sheet (MSDS), physical properties including volatility, and exposure limits including Emergency Response Planning Guideline (ERPG) values.

For the purpose of this analysis "hazardous substances" include (1) regulated toxic substances listed in 40 CFR Part 68, *Accidental Release Prevention Requirements: Risk Management Programs,* (2) extremely hazardous substances listed in 40 CFR Part 355, *Emergency Planning and Notification*, (3) hazardous substances listed in 49 CFR Part 172.101, Appendix A, *List of Hazardous Substances and Reportable Quantities*, and (4) specific chemicals that have Emergency Preparedness Screening Thresholds (EPSTs) indicating that they are significant enough to warrant consideration in site-prepared Emergency Preparedness Hazard Assessments (EPHAs). Chemicals that have EPSTs are listed in RFETS procedure PRO-359-151-05.01, *Development and Maintenance of Emergency Preparedness Hazards Assessments* (RFETS, 1995c).

#### 8.7.1.2 Scenario Development

A review of potential accident initiating events was conducted and included natural phenomena (earthquake, high winds, flooding, heavy rain or snow, or lightning), external events (vehicle collisions, range fires), and internal events (vehicle electrical system shorts causing fire, fuel pump failure causing fire, human error in vehicle operation). Based on these potential initiating conditions, the only potential accident type analyzed is spills. Fire and explosion scenarios were not considered because none of the non-radioactive hazardous substances evaluated are listed as flammable substances in 40 CFR Part 68. An airborne release of a non-flammable hazardous substance generally results in toxic health effects to the collocated worker and/or public rather than thermal or blast effects associated with fires and explosions. Flammable substances are addressed separately in Section 8.8.

#### 8.7.1.3 Accident Frequency Development

The frequencies of occurrence for transportation accident scenarios involving the on-site transportation of hazardous substances were determined based on the accident frequency development for the *On-Site Transportation of Nuclear Materials and Radioactive Wastes,* Section 8.6.1.2. This section developed a final frequency of occurrence for each accident scenario using a base frequency which is modified by various factors and probabilities specific to the accident scenario. The frequencies for accident scenarios involving hazardous substances were estimated using the following formula. The basis and development of each term is described.

Final Frequency = $F_b$ * OAF * Miles

where: $F_b$ = Base Frequency based on accidents per mile
OAF = On-site Adjustment Factor, 1 (mph) ÷ accident speed (mph)
Miles = Total miles per year, (transfers/year × miles/transfer)

In accordance with Table 2.1 in the SARAH (RFETS, 1997b), Frequency Bin Designations, events more frequent than $10^{-2}$/ year are classified as *anticipated*, those between $10^{-4}$ and $10^{-2}$/year are classified as *unlikely*, and those between $10^{-6}$ and $10^{-4}$/year are classified as *extremely unlikely*. Those with less frequent than $10^{-6}$ are classified as *incredible*. These terms are consistent with the usage in DOE-STD-3009-94 (DOE, 1994a).

Base Frequency

Table 5-1 in NUREG-0170 (NRC, 1977) provides data for numerous types of accidents involving trucks and delivery vans on public highways and evaluates vehicle accidents as an initiating event for releases of fissile material (or hazardous substances). The base frequency for accidents involving trucks is 1.71E-06 accidents per mile (1.06E-06 accidents per kilometer). This accident frequency is consistent with the truck accident rates by highway type (e.g., controlled, non-controlled, and public streets) published in *Hazardous Materials Transportation Risk Analysis* (Rhyne, 1994).

On-Site Adjustment Factor

The base accident rate includes all road types, so to relate this rate to the conditions found at Rocky Flats, the salt NSTR developed an "on-site adjustment factor". This factor is the inverse of the speed of the impact, and was developed to account for the assumption that beneficial site conditions (e.g., short distances/low fatigue, restricted traffic volume, low traffic speeds) more than make up for detrimental site conditions (e.g., narrow, lower-design-standard roads) and that the base frequency of site accidents is lower than those on public highways (RFETS, 1997a). An on-site adjustment factor of 0.018 (1 mph ÷ 55 mph) is used based conservatively on an assumed accident speed of 55 miles per hour which would correspond to an accident involving an emergency or security vehicle impacting the transfer vehicle.

Mileage Determination

The mileage for transfers of hazardous substances was developed using information about the number of on-site transfers per year and the distance between shipping and receiving facilities. Travel distances between site buildings were used to determine the total miles traveled per year for each hazardous substance as documented in Table 8-21.

**Table 8-21.** Transfer miles for Non-Radioactive Hazardous Materials

| Origin | Destination | Distance (miles) |
|---|---|---|
| Building 130 | Building 891 | 1.7 |
| Building 881 | Building 552 | 0.7 |
| Building 552 | Building 130 | 1.1 |
| Building 130 | Building 551 | 1.1 |
| Building 551 | Building 124 | 0.7 |
| Building 130 | Building 124 | 0.7 |

The Severity Category Probability included in the frequency determinations for transfers of nuclear materials and radioactive wastes is conservatively assumed to be 1.0 for accidents involving chemicals since it is assumed that postulated accident scenarios result in reasonable worst-case releases.

8.7.1.4 Consequence Determination

The toxicity of a substance, defined as the ability to cause an adverse health effect, depends on the dose-response relationship, which depends on the type of exposure and the route of entry into the body. Potential exposure to toxic substances involves the dispersion and migration of the plume to receptor locations. The consequences considered in this analysis were the immediate health effects expected from a one-time acute exposure to a chemical resulting from an accidental release; rather than the potential consequences of long-term chronic exposure resulting from continuous releases. For toxic substances, the primary exposure hazard to the collocated worker and the public is inhalation of vapor or particulates.

This analysis assessed the toxicological dose consequence effects of an accidental release of toxic substances on two receptor groups (1) collocated workers located at or within 100 meters from the point of release and (2) Maximally Off-site Exposed Individuals (MOI) located off-site at the nearest point of access to the point of release who would receive the largest exposure from a release. For this analysis the MOI is assumed to be located at 1,900 meters from the point of release.

The consequences from accidental releases of toxic substances were estimated based upon a comparison of the airborne concentrations at defined receptor locations to ERPG values. The ERPG values were developed by the American Industrial Hygiene Association to aid emergency planners and emergency responders in dealing with hazardous materials incidents. The ERPGs include a set of three numbers (ERPG-1, ERPG-2, ERPG-3) that quantify the air concentrations for specific chemicals, corresponding to low, moderate, and severe health effects in humans when exposed for up to one hour. The values derived for ERPGs are applicable to most individuals in the general population. Accident consequence levels (low or high) were determined according to the comparison criteria in Table 2-3, *Chemical Accident Consequence Levels at RFETS,* of SARAH

(RFETS, 1997b). Low consequences are defined as exposure concentrations that are less than or equal to ERPG-3 values for the collocated worker or less than or equal to ERPG-2 values for the MOI. High consequences are defined as exposure concentrations that exceed ERPG-3 values for the collocated worker or exceed ERPG-2 values for the MOI.

The computer model chosen for computation of airborne concentrations (toxicological dose) was Computer Aided Management of Emergency Operations (CAMEO)/Areal Locations of Hazardous Atmospheres (ALOHA) Version 5.2 developed by the National Safety Council, the EPA, and the National Oceanic and Atmospheric Administration (NOAA) (Reynolds, 1992). ALOHA allows for modeling of airborne releases of chemicals via either a dense gas or gaussian model. ALOHA defines the plume at pre-determined threshold concentrations (level of concern) as well as predicting chemical concentrations within the plume at desired distances (receptor locations).

The ALOHA software is designed to address spills or discharges of pure substances. Because the hazardous substance analyzed (36% hydrochloric acid) is an aqueous solution, an evaporative model for chemical solutions (RFETS, 1996) was used to calculate the evaporation rate based on molecular weight, vapor pressure, pool size, temperature, and wind speed. The calculated evaporation rates were then input into ALOHA as direct releases of pure chemical and the vapor dispersion plume characteristics were subsequently determined. Use of the evaporative model in conjunction with ALOHA in this manner is an appropriate methodology to evaluate accident consequences of chemicals in aqueous solutions.

8.7.1.5 Risk Determination

The risks identified for the various accident scenarios evaluated in Section 8.7.3 are quantified/classified according to a combination of their expected frequencies and consequences, as shown in Table 2-4 of SARAH. Class I risks are considered *major*, Class II risks are *serious*, Class III are *marginal*, and Class IV are *negligible*. The analysis evaluates the risk for each accident scenario and each receptor.

The risks associated with the on-site transfer of RCRA and TSCA wastes are determined qualitatively based on an accident frequency determination as described above and a qualitative assessment of accident consequences based on the anticipated quantities of hazardous chemical constituents contained in the wastes.

### 8.7.2 Hazard Identification and Accident Scenario Development

This section identifies hazardous substances being transferred on-site that, if released, could result in adverse health impacts to collocated workers and the public. Subsequent to identifying the hazardous substances, representative bounding accident scenarios were developed in order to determine airborne concentrations at defined receptor locations, associated accident consequence levels, and accident risk.

8.7.2.1 Inventory Identification

Table 8-22 lists the hazardous substances being transferred on-site that were evaluated to determine which substances warranted formal accident analysis. The table includes information on the quantity being transferred, frequency of movement, and distances traveled. The paragraphs following the table provides characteristics of the substance and toxicological information.

Compressed Gases

Compressed gases ordered by site facility representatives are delivered by off-site vendors to Building 130, then transferred to Building 552 for storage until requested by the end-user facilities. Historically, several toxic compressed gasses were routinely used on-site including chlorine, anhydrous ammonia, and sulfur dioxide. Any transfer of these gases on the site will be the result of transferring the gas from a facility to Building 552 for eventual disposal. Any order of these gases would fall under special management and require K-H approval.

**Table 8-22.** Non-Radioactive Hazardous Substance Identification

| Hazardous Substance | Inventory Present During a Transfer/Delivery | Frequency of Movement | Distance Traveled per Transfer/Delivery | Total Miles per Year |
|---|---|---|---|---|
| Anhydrous Ammonia, Chlorine, Sulfur Dioxide | Historically several 150 lb cylinders could be on a truck during delivery. Current transfer would be limited to cylinders found during the deactivation of a facility. | All toxic gas cylinders have been removed from the site. Movement as needed if a cylinder is discovered during D&D activities. | Maximum distance transferred would be approximately 2.1 miles from Building 995 to Building 130 via Building 552. | 21 (Conservatively estimated that 10 transfers could occur in one year.) |
| Liquid Argon | 40,000 lb tanker capacity | Twice per month | Not analyzed | Not analyzed |
| Liquid Nitrogen | 40,000 lb tanker capacity | Once per week | Not analyzed | Not analyzed |
| 36% Hydrochloric Acid | 1,800 gallons maximum per delivery | Twice per year | 1.7 | 1.7 + 1.7 = 3.4 |
| 50% Hydrogen Peroxide | One 400 gallon tanker | Once per year | 1.7 | 1.7 |
| 98% Sulfuric Acid | One 1,000 gallon tanker | Once per three years | 1.7 | 1.7 |
| 50% Sodium Hydroxide | One 5,000 gallon tanker | Once per year | 1.7 | 1.7 |
| 50% Potassium Hydroxide | One 5,000 gallon tanker | Not yet determined | Not analyzed | Not analyzed |
| Calcium Hypochlorite | 800 to 1,000 pounds | Every two to three months | 0.7 | 6 @ 0.7 = 4.2 |
| Beryllium | 55-gallon drums of beryllium scrap each | Not yet determined | Not analyzed | Not analyzed |
| RCRA Waste | Varies | Daily | Not analyzed | Not analyzed |
| TSCA Waste | Varies | Daily | Not analyzed | Not analyzed |

When compressed gases are delivered to the site, the vendor transportation vehicles often carry gases for subsequent deliveries to other unrelated off-site locations. These gases may include anything that is allowed under DOT regulations and requirements. As long as the vendor transportation vehicle cargo is properly packaged and labeled, there are no additional restrictions that prohibit bringing other hazardous substances on-site at Rocky Flats. It is possible that cylinders of ammonia or sulfur dioxide may be discovered during ongoing decontamination and decommissioning activities at the site. These materials, if found would eventually need to be transferred about the site for eventual disposal off site. Therefore, full 150-pound cylinders of chlorine, anhydrous ammonia, and sulfur dioxide are likely to be transported on-site either because they are being delivered for on-site usage, being shipped off site, or are part of a vendor shipment to other off-site users. Other less commonly used toxic gases that could potentially be brought on-site were evaluated in calculation CALC-RFP-98.0660-MAN (RFETS, 1998a) to determine whether they present greater risk than those analyzed.

Because the commonly past used gases could be present in a facility until the decommissioning of that facility, scenarios involving the transfer of chlorine, sulfur dioxide, and anhydrous ammonia gases will be further evaluated.

Bulk Chemicals

Bulk chemicals that are transported on-site include carbon dioxide, 36% hydrochloric acid, 50% hydrogen peroxide, liquid argon, liquid nitrogen, 50% potassium hydroxide, 50% sodium hydroxide, 98% sulfuric acid. Each of these bulk chemical substances are qualitatively evaluated below in order to determine those requiring further analysis.

*Carbon Dioxide:* Carbon dioxide is no longer received on the site in bulk quantities.

*Liquid argon:* Liquid argon is currently being used in Building 559. It is not listed in 40 CFR Part 68 or 40 CFR 355 nor does it have an EPST value assigned to it. It is a inert non flammable gas that acts as a simple asphyxiant. As an inert gas, it has no specific inherent dangerous properties and has no adverse toxicological effects. It is therefore excluded from further analysis. However, contact with liquid argon may cause frostbite to response personnel. Refrigerated liquid argon is listed as a hazardous substance in 49 CFR Part 172.101 and is required to meet DOT transportation requirements including actions to be taken by first responders during the initial phase of a hazardous materials incident.

*Liquid nitrogen:* Liquid nitrogen is currently being used in Buildings 371 and 559. It is not listed in 40 CFR Part 68 or 40 CFR 355 nor does it have an EPST value assigned to it. It is a inert non-flammable gas that acts as a simple asphyxiant. As an inert gas, it has no specific inherent dangerous properties and has no adverse toxicological effects. It is therefore excluded from further analysis. However, contact with liquid nitrogen may cause frostbite to response personnel. Compressed nitrogen and refrigerated liquid nitrogen are listed as hazardous substances in 49 CFR Part 172.101 and are required to meet DOT transportation requirements including actions to be taken by first responders during the initial phase of a hazardous materials incident.

*36% hydrochloric acid:* Hydrochloric acid is currently being used at the Consolidated Water Treatment Facility, Building 891. Hydrochloric acid is a corrosive material that can form toxic vapors. It is listed in 40 CFR Part 68 and 40 CFR Part 355. For concentration above 40%, an EPST value has been assigned. The maximum amount of 1,800 gallons per delivery exceeds the threshold quantities of both 40 CFR Part 68 and 40 CFR Part 355. Hydrochloric acid is analyzed further based on its high volatility and low exposure limits for identified receptors. Hydrochloric acid is listed as a hazardous substance in 49 CFR Part 172.101 and is required to meet DOT transportation requirements including actions to be taken by first responders during the initial phase of a hazardous materials incident.

*50% hydrogen peroxide:* Hydrogen peroxide is currently being used in at the Consolidated Water Treatment Facility, Building 891. It is an oxidizer and corrosive material. It is not listed in 40 CFR Part 68 or 40 CFR Part 355 nor does it have an EPST value assigned to it. Hydrogen peroxide solution poses a negligible hazard to the collocated worker and the MOI, if released, based its low volatility and established exposure limits for identified receptors. It therefore, is screened from further analysis. However, since it is corrosive to the skin at concentrations greater than 30%, it is a moderate hazard to immediate workers responding to a transportation accident. Hydrogen peroxide in solution is listed as a hazardous substance in 49 CFR Part 172.101 and is required to meet DOT transportation requirements including actions to be taken by first responders during the initial phase of a hazardous materials incident.

*98% sulfuric acid:* Sulfuric acid is currently being used at the Consolidated Water Treatment Facility, Building 891. It is listed in 40 CFR Part 355 and 1,000 gallons of this substance exceeds the TPQ of 1,000 pounds. It is not listed in 40 CFR Part 68 and has no EPST value assigned to it. It is screened from further analysis because the high boiling point and low vapor pressure associated with sulfuric acid solutions will not result in significant evaporation and dispersion if released during a transportation accident. It therefore poses a negligible hazard to the collocated worker and MOI in the event of a release. The toxicological consequences associated with a release of sulfuric acid are considered to be bounded by the analysis performed for hydrochloric acid. Sulfuric acid however can cause serious injury to workers responding to a transportation accident and is therefore a moderate hazard to the immediate worker. Sulfuric acid is listed as a hazardous substance in 49 CFR Part 172.101 and is required to meet DOT transportation requirements including actions to be taken by first responders during the initial phase of a hazardous materials incident.

*50% sodium hydroxide:* Sodium hydroxide is currently being used at the Consolidated Water Treatment Facility, Building 891. It is not listed in 40 CFR Part 68 or 40 CFR Part 355 nor does it have an EPST value assigned to it. It is a non-volatile component in aqueous solution. Sodium hydroxide solution poses a negligible hazard to the collocated worker and MOI if released during an on-site transportation accident and is therefore screened from further analysis. Because it is a strong base, it is a moderate hazard to immediate workers responding to a transportation accident. Sodium hydroxide is listed as a hazardous substance in 49 CFR Part 172.101 and is required to meet DOT transportation requirements including actions to be taken by first responders during the initial phase of a hazardous materials incident.

*50% potassium hydroxide:* Potassium hydroxide is currently being used in Building 371. It is not listed in 40 CFR Part 68 or 40 CFR Part 355 nor does it have an EPST value assigned to it. It is a non-volatile component in aqueous solution. Potassium hydroxide solution poses a negligible hazard to the collocated worker and MOI if released during an on-site transportation accident and is therefore screened from further analysis. Because it is a strong base, it is a moderate hazard to immediate workers responding to a transportation accident. Potassium hydroxide is listed as a hazardous substance in 49 CFR Part 172.101 and is required to meet DOT transportation requirements including actions to be taken by first responders during the initial phase of a hazardous materials incident.

*Nitric Acid:* The Building 371/374 outside nitric acid storage tank (designated as Tank D222) has a 16,000-gallon capacity. The tank currently contains 56% by weight nitric acid. The Building 371/374 Basis for Interim Operation (BIO) specifies a 1,000 gallon tank inventory limit. The current inventory is expected to meet current and future building needs without procuring additional quantities. Since additional on-site shipments are not expected, transportation accidents involving nitric acid are not evaluated.

*65% Calcium Hypochlorite:* Calcium hypochlorite (CAS No. 7778-54-3) is currently being used in the treatment of domestic water for site use. It is an oxidizer and has a 40 CFR Part 304 RQ of 10 pounds. There is no corresponding 29 CFR 1910.119 threshold quantity or 40 CFR 355 threshold planning quantity. The chemical is purchased in tablet form in 55 pound drums and contains 65% calcium hypochlorite (35% inert ingredients). Calcium hypochlorite is ordered every 2 to 3 months in 800 to 1,100 pound quantities. The quantity of calcium hypochlorite in an order exceeds the RQ quantity.

Beryllium

Beryllium in various forms is present on-site and is destined to be shipped off-site for recycling. Additionally, waste containing beryllium will be generated during site D&D activities and will require on-site transportation from points of generation to storage locations. Beryllium is not listed in 40 CFR Part 68 or 40 CFR Part 355 nor does it have an EPST value assigned to it. However, beryllium can enter the body through inhalation of dusts and fumes and can cause severe lung damage. Based on its high toxicity and low exposure threshold values (ERPG equivalents), a transportation accident involving a release of beryllium particulate is analyzed.

Chemicals in Waste

*RCRA Waste:* RCRA containerized wastes are routinely transfered on-site in compliance with engineered and administrative controls mandated by EPA. It is not possible to determine exact chemical quantities in RCRA waste since the actual chemical constituents are not always known. A low accident consequence has been qualitatively assigned to transportation accident scenarios involving RCRA containerized waste that could result in the release of the contents of multiple containers. This determination is based on the fact that for those waste packages analyzed to date (approximately 20% of the various types of waste containers present on-site), typical ERPG fractions (at a distance of 1,900 meters) for fire and spill scenarios involving specific Item Description Codes (IDCs) range from $10^{-13}$ to $10^{-14}$ per Nuclear Safety Calculation 96-SAE-006 (SAE, 1996b). With ERPG fractions this low, an on-site transportation accident involving multiple packages of RCRA wastes would not result in exceeding ERPG values when summing individual ERPG fractions (the sum of the ERPG fractions for various IDCs would be less than unity). Therefore, transportation accidents involving packaged RCRA wastes are not further analyzed.

*TSCA Waste:* Containerized wastes with TSCA regulated Polychlorinated Biphenyls (PCBs) are also transfered on-site in compliance with engineered and administrative controls mandated by the EPA. Site PCB wastes include liquid PCB waste forms (oil with PCBs and fluorescent light ballasts) and solid PCB waste forms (drained PCB equipment, rags, debris, and soil). A low accident consequence has been qualitatively assigned to transportation accident scenarios involving TSCA waste that could result in the release of the contents of multiple packages. Typical ERPG fractions for PCB liquids, without hazardous constituents, range from $10^{-8}$ to $10^{-5}$ for various accident scenarios per Nuclear Safety Calculation 96-SAE-006 (SAE, 1996b). With ERPG fractions this low, an on-site transportation accident involving multiple packages of TSCA wastes would not result in exceeding ERPG values when summing individual ERPG fractions. Therefore, transportation accidents involving packaged TSCA wastes are not further analyzed.

### 8.7.3 Accident Analysis of Non-Radioactive Hazardous Material

This section determines the accident frequency for the chemical spill being evaluated and calculates the consequences and risk to the public and collocated worker. The consequences are compared to ERPG values to determine the risk class for the postulated accident. The tables containing the results of the evaluation for each scenario include the ERPG level for the material of concern.

Fire scenarios were not specifically analyzed because an accident resulting in fire is even less probable than a spill. The consequences for spills of toxic gases and hydrochloric acid are high, therefore, any increase in consequences due to the heating of the chemicals would not affect the consequence range. Fires involving chemicals contain hazards associated with the combustion products plus the material released by the specific chemical. These hazards are a function of the fire conditions. In a fire, Be dust is extremely hazardous and probably fatal if the receptor is standing in the plume.

#### 8.7.3.1 Scenario CHEM-1: Toxic Gas Release

Three toxic gases are analyzed; chlorine, anhydrous ammonia, and sulfur dioxide. Although these chemicals are not routinely used on the site, the possibility exists a cylinder may require transfer for disposal from a building being decommissioned. This scenario addresses the possibility of a transfer vehicle collision or accident that results in releasing the contents of one 150-pound cylinder of a toxic gas in ten minutes. The accident may involve a collision with a stationary object or another moving vehicle.

The maximum distance for transfer of a cylinder for disposal is 2.1 miles from Building 995 to Building 130. In order to estimate a frequency number, it is estimated that ten (10) transfers a year would conservatively bound any transfers of cylinders of toxic gases for disposal. Using the frequency determination described in Section 8.7.1.3, the scenario frequencies are calculated as follows:

1.71E-06 accidents/mile × (21 miles/year) × (1 mph ÷ 55 mph) = 6.49E-07 accidents/yr

Scenario CHEM-1 is therefore considered to be *incredible*. The CHEM-1 scenario for chlorine and sulfur dioxide have a *high* consequence for both the collocated worker and MOI because the maximum concentration is greater than the ERPG-3 values at 100 meters and greater than the ERPG-2 values at 1,900 meters. The scenario for anhydrous ammonia has a *high* consequence for the collocated worker and a *low* consequence to the MOI because the maximum concentration is greater than the ERPG-3 value at 100 meters and less than the ERPG-2 value at 1,900 meters. The consequences of an accident resulting in the release of toxic gas are given in Table 8-23.

**Table 8-23.** Accident Resulting in a Toxic Gas Release (CHEM-1)

| Scenario | Frequency | Quantity | Collocated Worker | | MOI | |
|---|---|---|---|---|---|---|
| | | | Consequences | Risk Class | Consequences | Risk Class |
| Chlorine | Incredible | 150 pounds | High (434 ppm)<br>ERPG-3 = 20 ppm | II | High (3.9 ppm)<br>ERPG-2 = 3 ppm | II |
| Anhydrous Ammonia | Incredible | 150 pounds | High (6,800 ppm)<br>ERPG-3 = 1000 ppm | II | Low (26 ppm)<br>ERPG-2 = 200 ppm | IV |
| Sulfur Dioxide | Incredible | 150 pounds | High (486 ppm)<br>ERPG-3 = 15 ppm | II | High (4.4 ppm)<br>ERPG-2 = 3 ppm | II |

8.7.3.2 Scenario CHEM-2: Major Chemical Spill: Hydrochloric Acid

Deliveries of 36% hydrochloric acid solution are required for Building 891 operations. No more than 1,800 gallons of acid are ordered or delivered to the site at any one time. The acid is metered and weighted (on a DOT-certified scale) prior to delivery by off-site vendors. The amount of acid delivered is verified by meter or by weighing at Building 130 and compared with the amount ordered, and the shipment then continues to Building 891.

This scenario addresses the possibility of a transfer vehicle collision or accident that breaches the tank wall or valving and causes the entire 1,800 gallons to be spilled. The bulk deliveries are made up to two times per year and therefore the total number of miles traveled on-site carrying the acid is 3.4 miles per year.

Using the frequency determination described in Section 8.7.1.3, the scenario frequency is calculated as follows:

1.71E-06 accidents/mile × (1 mph ÷ 55 mph) × (3.4 miles/year) = 1.1E-07 accidents/year

This scenario is therefore considered to be *incredible*. The scenario has a *high* consequence for the collocated worker and a *low* consequence to the MOI because the maximum concentration is greater than the ERPG-3 value at 100 meters and less than the ERPG-2 value at 1,900 meters. The consequences of this scenario are given in Table 8-24.

**Table 8-24.** Accident Resulting in a Major Chemical Spill (CHEM-2)

| Scenario | Frequency | Quantity | Collocated Worker | | MOI | |
|---|---|---|---|---|---|---|
| | | | **Consequences** | **Risk Class** | **Consequences** | **Risk Class** |
| CHEM-2 (Hydrochloric Acid - 36%) | Incredible | 1,800 gallons | High (7,890 ppm)<br>ERPG-3 = 100 ppm | II | High (62 ppm)<br>ERPG-2 = 20 ppm | II |

8.7.3.3 Scenario CHEM-3: Calcium Hypochlorite

Building 124 used calcium hypochlorite for water purification. Transfer of the material is limited to the orders which occur every two to three months. 800 to 1,100 pounds are ordered at a time, depending on the time of year. Usage increases in the summer months due to increased water demands.

This scenario addresses the possibility of a transfer vehicle collision or accident that breaches one drum containing 55 pounds of calcium hypochlorite pellets. Using the frequency determination described in Section 8.7.1.3, the scenario frequency is calculated as follows:

1.71E-06 accidents/mile × (1 mph ÷ 55 mph) × (4.2 miles/year) = 1.3E-07 accidents/year

This scenario is therefore considered to be *incredible*. Dispersion of calcium hypochlorite in the event of a spill will have little on-site impact, and will not disperse to the collocated worker or the public due to the characteristic (tablet form) of the material available for release. A release of chlorine gas is possible in the event of an accident resulting in fire. Calcium hypochlorite will decompose at temperatures of 100 to 180 degrees Centigrade (°C) or 212 to 365 degrees Fahrenheit (°F) releasing chlorine gas with the speed of release a function of the severity of the fire. The number of variables influencing a release makes it impossible to quantify the potential exposure levels to the collocated worker and the public. Because the frequency of an accident involving the transfer of calcium hypochlorite is considered *incredible*, and the quantity of material is limited, the potential risk is considered to be within industrial standards for the transfer of this type of material.

8.7.3.4 Scenario CHEM-4: Beryllium Dust Spill

Building 444 contains several hundred drums of beryllium in various forms that are eventually destined to be shipped off-site for recycling. Decontamination and decommissioning activities at the site may also produce more beryllium waste that will require transfer on-site and/or shipment off-site.

This scenario addresses the possibility of a transfer vehicle collision or accident that breaches one drum containing 100 pounds of beryllium dust or fines. Because of the uncertainty of transfer/shipment rates, it is assumed conservatively that 50 one-mile transfers occur on-site in a given year (i.e., 50 miles per year). Using the frequency determination described in Section 8.7.1.3, the scenario frequency is calculated as follows:

1.71E-06 accidents/mile × (1 mph ÷ 55 mph) × (50 miles/year) = 1.6E-06 accidents/year

This scenario is therefore considered to be *extremely unlikely*. The scenario has a *high* consequence for the collocated worker and a *low* consequence for the MOI because the maximum concentration is less than the ERPG-3 values at 100 meters and less than the ERPG-2 values at 1,900 meters. The consequences of this scenario are given in Table 8-25.

**Table 8-25.** Accident Resulting in a Beryllium Dust Spill (CHEM-4)

| Scenario | Frequency | Quantity | Collocated Worker | | MOI | |
|---|---|---|---|---|---|---|
| | | | Consequences | Risk Class | Consequences | Risk Class |
| CHEM-4 (Beryllium Dust) | Extremely Unlikely | 100 pounds | High (1.59 $mg/m^3$)<br><br>ERPG-3 = 0.1 $mg/m^3$ | II | Low (1.6E-02 $mg/m^3$)<br><br>ERPG-2 = 0.025 $mg/m^3$ | IV |

## 8.8 ON-SITE TRANSPORTATION OF FUELS

The combustible and flammable liquids and gases transported on the site include bulk quantities of diesel fuel, fuel oil, gasoline, and propane. Bottled fuel gases, such as acetylene, propane, and methane, are also transported on the site. This section addressed the transportation of these fuels within the boundary of the industrial area of the site. Potential spills, fires, and explosions associated with these fuels are evaluated. In addition to this evaluation, propane and natural gas distribution to facilities on site are described in Chapter 3 and evaluated in Appendix D of Volume I of the Site SAR.

### 8.8.1 Methodology

The methodology used for the evaluation of the transportation of fuels on the site includes identification of the inventory, determination of the probability of an accident occurring, development of potential accident scenarios, and identification of the assumptions used during the analysis. The consequences associated with accidents involving fuels are discussed qualitatively or calculated quantitatively, as appropriate. This section also provides information on the characteristics of the fuels being evaluated.

#### 8.8.1.1 Inventory Identification

Table 8-26 identifies the fuels transported on the site and provides a general description of the material, the quantity of material transported, and the destination of the transfers. The information in Table 8-27 is provided to illustrate the differences in the physical characteristics and behavior between the various fuels transferred within the boundaries of the site. The characteristics of a fuel are the factors that determine if the fuel will ignite readily, be more likely to burn than explode, etc.

**Table 8-26.** Fuels Transport Identification

| Material | Delivery Vehicle Capacity | Description of Transfer |
|---|---|---|
| Propane | 2,750-gallon | Vendor delivery to storage tanks at various locations on site. |
| Diesel Fuel | 8,500 gallons | Deliveries to site depend on requirements. |
| Diesel Fuel within PA | 2,000 gallon | Refueling vehicles and emergency generator storage tanks in the PA. |
| Diesel Fuel within PA | 2 tanks with 119 gallons each | Truck has an additional tank which will contain 70 gallons, usually filled with unleaded gasoline. |
| Fuel Oil, #6 | 12,000 gallon | Delivered to steam plant for back up fuel source. |
| Unleaded gasoline | 8,500 gallons | Delivery to garage. |
| Unleaded gasoline (on-site delivery) | 2 tanks with 119 gallons each | Refueling vehicles and gas generators on site. Truck has an additional tank which will contain 70 gallons, usually filled with diesel fuel. |
| Flammable gas cylinders | Various sizes, up to 150 pounds | Delivered to various locations on site. Excess cylinders are transferred between facilities on site in preparation for disposal or return. |

**Table 8-27.** Fuel Characteristics

| Material | Classification | Flammable limits | Physical Properties | Characteristics |
|---|---|---|---|---|
| Propane<br>CAS No.<br>74-98-6 | Flammable Gas | LEL = 2.1%<br>UEL = 9.5% | Vapor specific gravity: 1.5<br>Vapor press: 8.4 atm<br>Ignition Temp: 842°F<br>Flash point: -156°F<br>Boiling point: -44°F at 1 atm | Flammable.<br>Tanks or cylinders may explode in fire.<br>Vapor may explode if ignited in an enclosed area.<br>Hazard ID: H-1, F-4, R-0 |
| Diesel Fuel #1 | Combustible Liquid | LEL =0.7%<br>UEL =5 % | Vapor specific gravity: NA<br>Vapor press: 0.03 atm<br>Ignition Temp: 444°F<br>Flash point: 100°F<br>Boiling point: 392-500°F at 1 atm | Combustible.<br>Hazard ID: H-0, F-2, R-0 |
| Fuel Oil #6 | Combustible Liquid | LEL, UEL not available | Vapor specific gravity: NA<br>Vapor press: Unknown<br>Ignition Temp: 765°F<br>Flash point: >150°F<br>Boiling point: 415->>1093°F at 1 atm | Combustible.<br>Hazard ID: H-0, F-2, R-0 |
| Gasoline<br>CAS No.<br>8006-61-9 | Flammable Liquid | LEL = 1.4%<br>UEL = 7.4% | Vapor specific gravity: 3.4<br>Vapor press = 0.05-0.39 atm<br>Ignition Temp: 853°F<br>Flash point: -36°F<br>Boiling point: 140-390°F at 1 atm | Flammable.<br>Vapor may explode if ignited in an enclosed area.<br>Mildly toxic by inhalation.<br>Hazard ID: H-1, F-3, R-0 |
| Acetylene<br>CAS No.<br>74-86-2 | Flammable Gas | LEL = 2.5%<br>UEL = 100% | Vapor specific gravity: 0.9<br>Vapor press: 40 atm @ 16.8°F<br>Ignition Temp = 581°F<br>Flash point: Gas<br>Boiling point: -119°F at 1 atm | Flammable.<br>Cylinders may explode in fire.<br>Vapor may explode if ignited in enclosed area<br>Mildly toxic by inhalation.<br>Hazard ID: H-1, F-4, R-3 |
| Information from *CHRIS Hazardous Chemical Data* (DOT, 1984), *Dangerous Properties of Industrial Materials* (SAX, 1989), *Pocket Guide to Chemical Hazards* (NIOSH, 1994), and *Fire Protection Guide on Hazardous Materials* (NFPA, 1991). | | | | |

8.8.1.2 Scenario Development

Scenarios for accidents involving fuels are divided into three categories, spills, fires, and explosions. Within these three categories are accident types considered for the development of the accident scenarios and frequencies. The following accident types are from *Hazardous Materials Transportation Risk Analysis* (Rhyne, 1994) and have the potential to result in a spill or fire:

- Collision of the transfer vehicle with another truck,
- Collision of the transfer vehicle with a stationary object,
- Overturn of the transfer vehicle (no other vehicles involved),
- Transfer vehicle runs off the road into a drain ditch,
- Other non-collision accidents, and
- Vehicle fire.

These same accidents could ultimately result in an explosion with the correct set of circumstances.

The following paragraphs describe the fuels that are transported, describes the characteristics of the transfers, and discusses the possible accident scenarios.

Compressed Gases

Compressed gases are used for maintenance operations (e.g., acetylene, propane), laboratory operations (e.g., propane) and miscellaneous activities (e.g., methane, etc.). Some of these compressed gases are no longer needed and are (or will be) transferred to Building 552, the gas storage facility, for eventual disposal or shipping off site. The propane used for laboratory operations is the source of fuel for Bunsen burners. Any accidents involving these compressed gases are bounded by the transport of larger quantities of flammable/explosive materials. In addition, pressurized cylinders are transported with their protective cap in place and secured in the appropriate vehicle for transport of this type of configuration.

Diesel Fuel

Diesel fuel is delivered to the site for use in emergency/standby generators and for diesel fueled vehicles. Diesel fuel is delivered to the garage and to generator locations. The diesel fuel deliveries range from 5,500 gallons to 8,000 gallons, depending on demand. The accident scenario addressing this delivery vehicle assumes a total capacity of 8,500-gallons to bound variations in the delivery vehicle capacity. Diesel fuel #1 and #2 are the most commonly used types of diesel fuel in highway vehicles and generators. Diesel fuel #1 (kerosene) is used in the winter because it is less viscous than #2. It is slightly more reactive than #2 and therefore is the type that will be evaluated.

The site has tanker trucks for delivering diesel fuel and gasoline into the PA. The smaller of the delivery vehicles has two 119-gallon tanks and one 70-gallon tank. There are three of these small tankers being used, two which normally carry diesel fuel in the larger tanks and gasoline in the smaller tank and the other normally carrying gasoline in the larger tanks and diesel fuel in the smaller tank. The other method of delivering diesel fuel is by a 2,000-gallon tanker.

A 2,000-gallon tanker consisting of two 1,000-gallon compartments is used to service the generator fuel tanks. Use of this tanker reduces the security impacts of multiple entries of a smaller capacity tanker into the PA for refueling. This tanker will be filled at the suppliers facility. An accident involving this diesel fuel tanker is assumed to release the entire contents of both compartments for a total of 2,000 gallons involved in a spill, fire, or explosion. Diesel fuel has a fire hazard rating of 2, which indicates it must be heated or exposed to relatively high ambient temperatures before ignition can occur. It would not, under normal conditions, form hazardous atmospheres with air. Use of these tanker trucks for delivery of fuels into the PA were evaluated in calculations CALC-RFP-99.1561-KKK (RFETS, 1999f) for the smaller trucks and CALC-RFP-98-1545-KKK, Revision 3, for the 2,000-gallon tanker.

Fuel Oil, #6

Number 6 fuel oil is delivered by the vendor using a tanker with a 12,000-gallon capacity. The vendor tanker delivers fuel oil to the steam plant for backup fuel to the steam boilers.

Explosion of fuel oil is not considered credible based on the low vapor pressure. Fire involving fuel oil is extremely unlikely based on the high flash point and high ignition temperature. Fuel oil also has a fire hazard rating of 2 and would not under normal conditions form a hazardous atmosphere with air and would require heating to ignite.

Gasoline

Gasoline is delivered to site garage facilities for fueling vehicles and some generators. Delivery is by a tanker with an 8,500-gallon capacity. This tanker is not expected to be in the proximity of any facility containing fissile or hazardous materials. A smaller tanker (238 gallons), described above, is used for delivering gasoline to the PA. Gasoline has a fire hazard rating of 3, and would be expected to more readily be ignited if spilled than diesel fuel or fuel oil.

Propane

Of all the fuels delivered to RFETS, propane presents the highest probability of an accident that could involve a facility containing radioactive material. Propane is delivered to numerous locations on site to replenish storage tanks. These storage tanks range from tank farms of eight 1,000-gallon tanks to individual tanks of 250-gallon to 1,000-gallon capacity. The propane is delivered to the tank sites by the vendor with an escort of security personnel and an operations person in the delivery vehicle. The bulk propane delivery vehicle has a 2,750-gallon capacity. Two potential accidents involving the propane tanker may result in an explosion: 1) the explosion of the tanker, or 2) the explosion of a propane vapor cloud from a tanker spill.

The explosion of the tanker would be in the form of a BLEVE (boiling liquid, expanding vapor explosion) and would require a high temperature heat source with sufficient duration to cause the explosion. The only potential heat source is fuel from another fuel tanker, e.g., diesel fuel or gasoline, where the diesel fuel or gasoline ignites to provide the heat source, or a storage tank that is ruptured such that a fire is impinges on the tanker. An ignition source of sufficient energy is required to ignite the fuel oil or gasoline. In a BLEVE situation the fuel in the tanker is heated, and the metal in the tank wall is weakened, causing the tank to rupture with violent formation of vapor.

A vapor cloud explosion could occur if the propane tanker spills its contents, sufficient time passes for vaporization, and an ignition source is available to ignite the vapor before it is dissipated to a point below the explosive limit of the vapor.

8.8.1.3 Frequency Development

The frequency analysis consists of identifying the frequency of the accident initiator (truck accident) and modifying this frequency with factors directly affecting the release scenario (e.g., the probability of a spill, fire, etc.) given the accident has occurred.

From historical databases, a base frequency of accidents per vehicle-mile is determined. For Rocky Flats the road conditions are assumed to be similar to a rural two-lane roadway. This assumption is considered to be conservative because of the lower average vehicle speed, controlled vehicle access, and traffic volume within the PA. This frequency is adjusted by the yearly distance traveled on the site, the probability for specific accident types (e.g., collision or non-collision accident), if a spill and a fire occur, and if the accident is in the proximity of a facility containing nuclear materials. Determination of this accident frequency utilizes information and data from *Hazardous Materials Transportation Risk Analysis* (Rhyne, 1994). The source of the frequencies and probabilities obtained from this reference are identified for the terms in the equation below. For those probabilities not from the reference, the method of development is described in the following paragraphs.

This developed frequency does not include the probability of ignition of the spill of the bulk fuel being transported. The basic assumption is made that the fire as the result of the accident will involve the contents of the truck, i.e., the diesel fuel or propane.

This assumption is extremely conservative for diesel fuel because the involvement of the fuel contents will require a spill of the fuel and an ignition source of sufficient intensity to ignite the diesel fuel. Diesel fuel #1, or kerosene, is classified as a Class II combustible liquid (NFPA 321, *Standard on Basic Classification of Flammable and Combustible Liquids*). In general, these materials do not form flammable mixtures with air at ambient temperatures unless heated above their flash point. The flash point for kerosene is 410 degrees F. Ignition of a flammable liquid requires the liquid to be preheated to a point that sufficient quantities of combustible vapors are produced, these vapors must be mixed with an oxidant (air), and the mixture must be hot enough to self-ignite or be provided with an external pilot source, such as a vehicle fire.

Propane is more flammable than diesel fuel, but in an accident scenario of a spill with ensuing fire, it is likely the propane will just burn. If the propane spill has sufficient time to vaporize, a vapor cloud explosion could result; however, the most likely accident locations do not have obstructions present that would develop damaging overpressures. For the purposes of this calculation only fire is addressed in the development of frequency and probability of a facility breach. See calculation CALC-RFP-98.0555-RDG (RFETS, 1998e) for further discussion on propane explosions.

The orientation of the bulk container with respect to the fire resulting from an accident also affects the probability the spilled fuel will ignite. Because not all accidents will result in a fire with sufficient intensity or duration and proper orientation to ignite the fuel, the final frequency determined below is considered conservative. The many variables associated with the ignition of the fuel being transported make assigning a probability for ignition impossible, therefore, the accident frequency is biased high.

The final accident frequency is determined by the following formula:

$$f = F_{Base} \times M_{Miles/yr} \times \Sigma(P_{Accident\ type} \times P_{Fire}) \times P_{In\ vicinity} \times P_{Vulnerable}$$

where: $F_{Base}$ = A base frequency for truck accidents per mile related to roadway type. The roadway type selected for travel at RFETS is a rural two-lane with a frequency of 2.19E-06 accidents/vehicle-mile (Rhyne, 1994,Table 3-4).

$M_{Miles/yr}$ = Number of miles traveled per year. See section below for development of this number.

$\Sigma(P_{Accident\ type} \times P_{Fire})$ = Probability of occurrence of an accident with fire from the event tree, where:

$P_{Accident\ type}$ = Percent probability a specific type of accident occurs, given an accident has occurred (Rhyne, 1994, Figure 3-3).

$P_{Fire}$ = Conditional probability that a fire occurs for the specified accident type (Rhyne, 1994, Table 3-10). For this analysis, it is assumed that the fire is of sufficient intensity to ignite the spilled fuel.

$P_{In\ vicinity}$ = Percentage of distance during fuel delivery, the delivery truck is in the vicinity of a facility containing nuclear materials. See below for development of this number.

$P_{Vulnerable}$ = Ratio of distance past nuclear facilities to vulnerable areas on nuclear facilities. Vulnerable areas are defined as those walls which have less than 2 hour fire ratings next to areas containing material or equipment important to safety, or dock areas where material may be staged. See below for development of this number.

The data available provides conditional probabilities for an accident and spill or an accident and fire, but does not address the probability of a fire following an accident with a spill. It is assumed that the probabilities for each combination contains some accidents that also involve the other result, e.g., some of the spill accidents are those that include a fire, and vice versa. An accident with fire conservatively bounds accidents with spills and fires because it will include accidents with fires that do not involve spills of the contents of the vehicle.

Determination of $M_{Miles/yr}$ and $P_{In\ vicinity}$

The distances for the fuel transfers were estimated using an AutoCAD drawing of the site to measure distances between identified points (e.g., intersections and corners). These measured distances are summarized using EXCEL spreadsheets, from which the distance is determined. Table 8-28 provides information on the number of miles assumed for fuel transport and the percentage of time the vehicle is in the vicinity of a facility containing nuclear material. The highest percentage is used in the final frequency calculation to cover the case where the fuel tanker only delivers fuel to the worst case storage tank. Development of these numbers are provided in the calculations referenced.

**Table 8-28.** Mileage Determination for Fuel Transport Vehicles

| Material | Miles/ year | % near facility | Assumptions | Reference |
|---|---|---|---|---|
| Propane | 50 | 35.5 | 1) Refueling occurs in the PA every other week. On alternating weeks, refueling occurs outside the PA<br>2) All tanks within the PA could be serviced in one trip or, on alternating weeks, all tanks outside the PA could be serviced in one trip<br>3) The tanker truck will enter the PA through PAC1 and exit through PAC2 | CALC-RFP-98.1545-KKK, Revision 3 (RFETS, 2000c) |
| Diesel (2,000 gal) | 100 | 40.9 | 1) Refueling operations occur after tests of the standby generators,<br>2) The tests occur monthly,<br>3) One tank is filled per trip<br>4) The tanker truck will enter the PA through PAC1 and exit through PAC2,<br>5) The road around the south end of Building 707 will be used going to the tanks, and<br>6) The road north of Building 569 will be used to exit following servicing the tanks in that area. | CALC-RFP-98.1545-KKK, Revision 3 (RFETS, 2000c) |
| Small tanker (diesel) | 7,160 | 38.1 | 1) Two trucks, two trips per day, 365 days per year<br>2) No restrictions on movement | Developed from CALC-RFP-99.1561-KKK, Revision 0 (RFETS, 1999f) |
| Small tanker (gas) | 3,580 | 19.1 | 1) One truck, two trips per day, 365 days per year<br>2) No restrictions on movement | Developed from CALC-RFP-99.1561-KKK, Revision 0 (RFETS, 1999f) |

Propane refueling operations present the additional hazard potential of producing a jet flame, a vapor cloud explosion, or a BLEVE. The hazard potential of the propane storage tanks is evaluated in the Appendix D of the Site SAR.

Determination of $\Sigma(P_{Accident\ type} \times P_{Fire})$

The value of $\Sigma(P_{Accident\ type} \times P_{Fire})$ is determined using a fault tree. The fault tree is provided in CALC-RFP-98-1545-KKK, Revision 3 (RFETS, 2000c). The value for this term, e.g., the probability of an accident with fire occurring is equal to 2.44E-02.

Final Frequency Determination

The final frequency for accidents that result in a fire that occur near a vulnerable area of a nuclear facility is determined using the above equation and the probabilities for each condition to occur. The results of the frequency calculation are given in Table 8-29.

**Table 8-29.** Frequency for Fuel Fire Accidents

| Vehicle | $F_{Base}$ | $M_{Miles/yr}$ | $\Sigma(P_{Accident\ type} \times P_{Fire})$ | $P_{In\ vicinity}$ | $P_{Vulnerable}$ | *f*, Final Frequency |
|---|---|---|---|---|---|---|
| Propane | 2.19E-06/mile | 50 miles | 2.44E-02 | 35.5% | 0.222 | 2.11E-07/yr |
| 2,000-gallon diesel | 2.19E-06/mile | 100 miles | 2.44E-02 | 40.9% | 0.163 | 3.57E-07/yr |
| Small diesel | 2.19E-06/mile | 7,160 miles | 2.44E-02 | 38.1% | 0.146 | 2.14E-05/yr |
| Small gasoline | 2.19E-06/mile | 3,580 miles | 2.44E-02 | 19.1% | 0.146 | 5.36E-06/yr |

### 8.8.2 Accident Analysis of Fuel Transport

The quantities of fuels evaluated in the following accident scenarios are provided in Table 8-25 above. Any increase in the quantity of fuel per transfer will increase the potential consequences if an accident should occur.

#### 8.8.2.1 Scenario F-1: Tanker Accident with Spill

The spill of fuels with no ensuing fire does not present any consequences to the public, but may present health hazards to the immediate and collocated worker. Spills of fuel during transfer can be the result of vehicle collisions, collision of the transfer vehicle with a stationary object, a vehicle overturn, or the vehicle running off the road into a ditch. A fuel spill has the potential to progress to a fire or explosion, depending on the type of fuel involved and the presence of an ignition source. Spilled fuel represents an environmental hazard and requires notification to local health and pollution control agencies. Table 8-30 provides information on the potential consequences of a fuel spill.

**Table 8-30.** Tanker Accident with Spill (Scenario F-1)

| Material | Quantity | Collocated Worker and Immediate Worker | |
|---|---|---|---|
| | | **Consequences** | **Guidelines** |
| Diesel Fuel | 8,500 gallons,<br>2,000 gallons in PA<br>238 gallons in PA | Irritant<br>May cause water pollution. | TWA= 14 ppm |
| Fuel Oil, #6 | 12,000 gallons | May cause water pollution. | TLV = 300 ppm |
| Gasoline | 8,500 gallons,<br>238 gallons in PA | Irritant. Moderately toxic. Potential occupational carcinogen.<br>May cause water pollution. | TLV = 300 ppm |
| Propane | 2,750 gallons | Asphyxiant<br>Frostbite | IDLH = 2,100 ppm<br>PEL-TWA = 1,000 ppm |

8.8.2.2 Scenario F-2: Tanker Accident with Fire

A fire of the entire contents of a fuel tanker requires an accident that allows the fuel to spill and an ignition source with sufficient energy to ignite the type of fuel. The spill scenarios are identified above. A pool fire can occur if an ignition source is present when the vaporizing flammable material is above its lower flammable limit (LFL or LEL, lower explosive limit, terms are used interchangeably). Fuels such as diesel fuel and fuel oil are significantly more difficult to ignite than gasoline or propane. A fuel fire, without an explosion, is considered a pool fire with the depth of the pool dependent on the size of the pool. Following ignition, the duration of the fire is related to the burn rate of the fuel. The burn rate is the rate at which material in the liquid pool is evaporated during a pool fire. The burn rates for diesel fuel, gasoline, and propane are based on the following parameters (NFPA, 1986):

| | | | |
|---|---|---|---|
| Diesel fuel # 1: | Mass Burn Rate | $m^*_b$ = | 0.039 kg/m$^2$-sec |
| | Density | $\rho_{diesel}$ = | 820 kg/m$^3$ |
| Gasoline: | Mass Burn Rate | $m^*_b$ = | 0.055 kg/m$^2$-sec |
| | Density | $\rho_{gasoline}$ = | 750 kg/m$^3$ |
| Propane: | Mass Burn Rate | $m^*_b$ = | 0.099 kg/m$^2$-sec |
| | Density | $\rho_{propane}$ = | 585 kg/m$^3$ |

The total burn time of a liquid fuel spill is directly proportional to the depth of the pool, and inversely proportional to the surface area of the pool. The burn time for a pool of spilled fuel is based on the mass of fuel and the mass burn rate of the fuel. The mass of fuel involved is based on the volume of the tanker and the density of the specific fuel. The burn rate is related to the area of the pool and the mass burn rate of the fuel which varies for the type of material in the spill. Two hypothetical pool depths are used to determine the area of the pool and subsequently the burn time, 10-cm depth and 1-cm depth. These two depths illustrate two possible conditions where spills may occur: uneven terrain (10-cm depth) or on paved surfaces (1-cm depth). These numbers illustrate the size and duration of a potential pool fire involving the fuels transported on the site. The information for these fuels is tabulated in Table 8-31.

**Table 8-31.** Tanker Accident with Fire (Scenario F-2)

| Fuel | Volume (gallons) | Volume ($m^3$) | Density, ρ ($kg/m^3$) | Mass (kg) | Mass burn rate (kg/m2-sec) | Pool depth (cm) | Area ($m^2$) | Burn rate (kg/sec) | Burn time (min) | Pool radius (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| Diesel | 2,000 | 7.57 | 820 | 6,207 | 0.039 | 10 | 75.7 | 2.95 | 35 | 16.1 |
| | | | | | | 1 | 757 | 29.5 | 3.5 | 50.9 |
| Diesel | 238 | 0.90 | 820 | 739 | 0.039 | 10 | 9 | 0.35 | 35 | 5.6 |
| | | | | | | 1 | 90 | 3.5 | 3.5 | 17.6 |
| Gasoline | 238 | 0.90 | 750 | 676 | 0.055 | 10 | 9 | 0.50 | 22.7 | 5.6 |
| | | | | | | 1 | 90 | 5.0 | 2.3 | 17.6 |
| Propane | 2,750 | 10.41 | 585 | 6,089 | 0.099 | 10 | 104.1 | 10.3 | 9.8 | 18.9 |
| | | | | | | 1 | 1040.9 | 103.0 | 1.0 | 59.7 |

In addition to the four fuel configurations evaluated above, diesel fuel and gasoline are delivered to the site in large tankers containing approximately 8,500-gallons fuel. The burn rates and burn times for 10-cm and 1-cm pools for these fuels are the same as given in Table 8-30 for the smaller volumes, but because of the larger volume, the pool radii will be much larger: 33 feet and 105 feet for the 10-cm and 1-cm depth pools, respectively. These tankers deliver to the garage, Building 331, and can be routed such that nuclear facilities are not passed, therefore, frequency and consequences are not evaluated for these vehicles.

The probability that the Fire Department fails to extinguish the fire before it breaches the nuclear facility exterior wall or impacts equipment important to safety is qualitatively estimated to be 0.02, which is consistent with the Site SAR Transportation Analysis (RFETS, 2000b) for Fire Department response to a transportation-related fire. The frequencies for accidents where the fire department fails to extinguish a fire before it breaches a facility are given in Table 8-32.

**Table 8-32.** Final Frequency with Fire Department Response

| Vehicle | Frequency of fire near vulnerable areas | Fire Department Response | Final Frequency |
|---|---|---|---|
| Propane | 2.11E-07/year | 0.02 * | 4.22E-09 /year |
| 2,000-gallon diesel | 3.57E-07/year | 0.02 * | 7.13E-09 /year |
| Small diesel | 2.14E-05/year | 0.02 | 4.27E-07 /year |
| Small gasoline | 5.36E-06/year | 0.02 | 1.07E-07 /year |
| * Although the frequencies of fire near a vulnerable area for the propane and the 2,000-gallon tankers are incredible, the fire department response provides defense in depth to reduce the frequency well below the 1.0E-06/year to 1.0E-07/year range that DOE-STD-3009-94 cautions to not apply an absolute cut-off for incredible accidents and to not consider feasible controls. | | | |

To illustrate the consequences of a breach of a facility, the calculation conservatively assumed that the breach in the exterior wall was all that was necessary to release 10,000 grams of WG Pu. Including the 0.02 factor to the frequency results in a frequency of 4.38E-09 per year that a nuclear facility will be breached. the consequences of a release of 10,000 grams WG Pu are 0.96 rem to the MOI and 34 rem to the collocated worker. This relates to a moderate consequence with a Risk Class III for the MOI and high consequences and Risk Class II for the collocated worker for the estimated frequency.

The frequency of accidents resulting in a fire near a vulnerable area of a nuclear facility is *incredible for* the 2,000-gallon diesel tanker and the propane tanker; however, frequency is dependant on the distance traveled by the tanker in a year. The frequency for the small tankers is *extremely unlikely* for the accidents with fire near the vulnerable areas. Crediting response by the fire department, the frequency for the small tankers is reduced to the *incredible* range. Fire department response for the 2,000-gallon diesel and the propane tankers provides defense in depth and reduces the frequency to well below the 1.0E-06/year to 1.0E-07/year range.

#### 8.8.2.3 Scenario F-3: Tanker Accident Resulting in Explosion

Explosive fuels have two potential explosion scenarios. These are a boiling liquid, expanding vapor explosion (BLEVE), or a vapor cloud explosion (VCE). With the correct set of circumstances at the time of the explosion, the potential exists to have a release of fissile or hazardous material. The explosion must occur in the proximity of the facility containing the material and the intensity of the explosion must be great enough to breach the containment of the material.

For a BLEVE to occur, a supply of heat must be available at sufficient temperature and duration to cause the contents of the fuel tanker to boil, and the vapors expand beyond the design pressure capacity of the tank. Because of the minimal vegetation in the proximity of facilities containing hazardous materials, an external source of fuel is needed to provide the heat source. To acquire this source of fuel, a spill of another fuel and an ignition source for that spill are required. For example, a scenario for these conditions to occur could be a collision of the propane tanker with a diesel fuel supply vehicle, with a subsequent spill and ignition of the diesel fuel. Propane is the fuel delivered on site with the highest probability of in a BLEVE because of its low superheated liquid limit temperature. The frequency determined in calculation (RFETS, 2000c) is *incredible* for the propane tanker. The probability the accident will result in an explosion would be the same or less than the probability that the accident results in a fire because in order for a BLEVE to occur, a heat source external to the tanker is needed.

A VCE can occur if the contents of the tanker are spilled, vaporizes, and the vapor cloud is ignited before it dissipates enough to be below the lower explosive limit of the vapor. Of the fuels identified in Table 8-25, propane is the only fuel delivered in bulk quantities that is a vapor at atmospheric pressure.

In order for a VCE to result in the dangerous overpressures needed to cause damage to facilities, flame front obstacles must be present. Flame front obstacles commonly consist of closely spaced equipment and piping. Because the site does not have the type of equipment in areas where fuels are present or delivered, the obstacles on the site that present flame front obstacles are vehicles in parking lots. No flame front obstacles are present that could create a dangerous overpressure from a vapor cloud explosion in the vicinity of facilities containing hazardous materials. Therefore, vapor cloud explosions are not considered in this evaluation.

BLEVEs or VCEs may be possible with gasoline, but there is essentially no explosion potential for diesel fuel or fuel oil due to their high superheated liquid limit temperature, and they are stored in vented tanks, not pressure vessels. The potential consequences associated with explosions of fuels are summarized in Table 8-33.

**Table 8-33.** Consequences of a Fuel Tanker Explosion (Scenario F-3)

| Material | Frequency* | Quantity | Consequences |
|---|---|---|---|
| Propane | Incredible | 2,750 gallons | BLEVE: The presence of a source of heat to produce a BLEVE is considered incredible.<br>VCE: Not considered due to lack of flame front obstacles for propagating a dangerous overpressure. |
| Gasoline | Incredible | 8,500 gallons<br>238 gallons | BLEVE: The presence of a source of heat to produce a BLEVE is considered incredible.<br>VCE: Not considered due to lack of flame front obstacles for propagating a dangerous overpressure. |
| Diesel Fuel | Incredible | 8,500 gallons<br>2,000 gallons<br>238 gallons | BLEVE: No explosion potential for diesel fuel because it is not transferred under pressure. Any pressurization of the transfer vessel would probably fracture the tank before explosive levels are reached.<br>VCE: Not expected to vaporize sufficiently to provide a vapor cloud. |
| * Frequency that an accident occurs in the vicinity of a facility with hazardous materials. | | | |

If all the right conditions are met, e.g., external source of heat, presence of flame front obstacles, and an accident occurs that results in an explosion in the vicinity of a nuclear facility, the explosion could potentially have high consequences. Such an event is considered *incredible* because of the multiple conditions which must be met.

## 8.9 HAZARDS AND ACCIDENT ANALYSIS OF OFF-SITE TRANSPORTATION

The hazards due to accidents occurring in the proximity of RFETS are evaluated for the potential to affect operations and personnel of the site. Due to the distance from any major highway that may be used for transport, no impact to facilities containing fissile materials or hazardous chemicals is expected from an off-site accident.

The designated hazardous material transportation route nearest the site is Highway 36. This would be the required route for placarded shipments traveling between Denver and Boulder. Only transporters making deliveries are permitted to travel on the roads surrounding the site. Tankers containing chemicals and fuels would be expected to pass the site en route to the site or other destinations.

### 8.9.1 Methodology

The consequence of an accident involving transported chemicals is reported as the maximum threat zone for the level of concern. The level of concern is the ERPG-2 or ERPG-3 concentrations. ERPGs are estimates of concentration ranges for chemicals above which acute (< one hour) exposure would be expected to lead to adverse health effects. The adverse effects decrease in severity for ERPG-3, -2, and -1. That is, the most adverse health effects will be within the threat zone defined by the ERPG-3 concentration and the least health effects beyond the ERPG-1 concentration. The diagram below illustrates the relationship between ERPG values and defines the effects within the zones between the different concentrations. The distances between concentrations are a function of the properties of the chemical involved in the accident.

| | ERPG-3 | | ERPG-2 | ERPG-1 |
|---|---|---|---|---|
| Source (accident) | Potential life threatening effects. | Irreversible or other serious health effects or symptoms which could impair an individuals ability to take protective action. | Irritation or significant reversible tissue damage. | No appreciable risk of deleterious effects in nearly all individuals. Potential health effects in sensitive populations of the general public. |

Decreasing concentration →

#### 8.9.1.1 Inventory Identification

The potential exists for the transport of numerous types and quantities of chemicals (including compressed gases) on the roadways in the vicinity of RFETS. These transports can involve vehicles with chemicals intended for delivery to the site, or to one of the surrounding businesses. There also exists the potential for movement of chemicals in bulk quantities using railcars on the railways south and west of the site. A complete evaluation of all types of chemicals that may be transported by truck or rail is not feasible, rather, hypothetical representative bounding case quantities of materials will be used to assess the effects to the site from an accident involving chemicals off the site. The Table 8-34 identifies materials having the potential for transport on surrounding highways and railways. This table also identifies bounding chemicals that are carried forward into the evaluation.

Potassium hydroxide (KOH) and sodium hydroxide (NaOH) are not evaluated in this accident scenario because ERPG values are not pertinent for solutions, rather the values in the literature are for exposure to the dry chemical. Dispersion of the pure chemical from a spill of a solution is not a concern because there is no significant vapor pressure, and therefore, concentration of the pure material over the solution. An accident resulting in a spill of these solutions would constitute a local problem for exposure to the environment and to personnel in the immediate area. The threat to personnel is based on local contact or ingestion of the material. The activities associated with hazard remediation (HAZMAT) and sheltering continue until a spill is contained or cleaned-up are expected to mitigate any consequences.

#### 8.9.1.2 Scenario Development

Spills are considered to be credible events for transportation activities due to the potential for vehicle accidents. DOT requirements apply to transportation vehicles, packaging, and route control. In addition, Colorado State Laws also provide controls on routing and packaging. Off-site spill occurrences are accepted risks based on public consensus. These events may occur with very little location limitations.

Fires are considered to be credible events for transportation activities due to the potential for vehicle electrical or mechanical failures and vehicle accidents acting as initiators. Off-site events are regulated by DOT requirements for public road transportation. These events are considered to be publically accepted risks since they may occur with no location limitations. When traffic accidents occur near the RFETS, the site Fire Department responds to aid local emergency and police agencies in controlling spills or fires and cleanup.

**Table 8-34.** Potential Chemical Transfers Off Site

| Material | Delivery Vehicle Capacity | Description of Transfer | Comment |
|---|---|---|---|
| Chlorine gas | 150-pound cylinders | Transported to site by vendors for use on-site at the water treatment facility. | Because of the requirements concerning transport of pressurized gases, e.g., cap in place and restrained, only one cylinder will be considered in an accident. |
| Acetylene | 150-pound cylinders | Transported to site for maintenance use and possibly to nearby locations. | Any accidents off site involving acetylene will be bounded by the propane tanker accident. |
| Propane | 20- and 30-pound cylinders | Transported to site and possibly to other locations in vicinity. | Any accident off site involving propane in cylinders will be bounded by the propane tanker accident. |
| 98% $H_2SO_4$<br>50% $H_2O_2$<br>36% HCl<br>50% NaOH | 1,000 gallon<br>400 gallon<br>2,000 gallon<br>3,000 gallon | Transported to site by vendors for use at the Consolidated Water Treatment Facility. | Hydrochloric acid and hydrogen peroxide are evaluated as examples of chemical tanker truck spills in an off-site accident.<br>Sulfuric acid has a higher boiling points and lower vapor pressures than hydrochloric acid and therefore less dispersion would occur in an accident scenario.<br>Sodium hydroxide in solution is a local concern only and is not quantitatively evaluated. |
| KOH | 5,000 gallon | Transported to site by vendors for use at Building 371 | Potassium hydroxide in solution is a local concern only and is not quantitatively evaluated. |
| $HNO_3$ | 10,000 gallons | Potential to be transported in rail tankers to the west of the site. | Nitric acid is be used as an example of a chemical acid spill from a railcar. |
| Anhydrous ammonia and chlorine gas | 20,000 gallons | Potential to be transported in rail tankers on the railways to the west of the site. | Anhydrous ammonia and chlorine are used as examples of a gaseous chemical transported by rail. |

### 8.9.1.3 Assumptions

Since vehicle fires can potentially occur, for the accident analysis, the following assumptions are made associated with vehicle fires:

- The estimated frequency that a vehicle fire will occur is *unlikely* (based on about one-half of one percent of the total number of vehicles in the country are involved in fires each year).
- Vehicle collision events seldom result in fires.
- If the vehicle fuel tanks do not become involved, non-flammable loads are assumed to be unaffected.

### 8.9.2 Accident Analysis of Off-site Transportation

8.9.2.1 Evaluation of the Off-site Transportation of Radioactive Materials

Shipment of nuclear materials and radioactive or mixed waste from the site conforms with DOT regulations for packaging and vehicle loading. Packages for nuclear materials (including SNM), TRU waste, and TRM waste conform with DOT Type B requirements. Type B qualified packaging is extremely high integrity with its design having been verified by physical test to withstand impacts, drops, and fuel pool fires (all on the same package) providing assurance that the contents will not be released. It is extremely unlikely that the contents of such packages (Type B) will be breached by any vehicle accident conditions. Low-level and low-level mixed wastes are shipped as low specific activity (LSA) material and is packaged in exempted packaging or strong outer container packaging or per DOT Type A requirements. These types of packaging provide an adequate leak-tight containment appropriate for these waste. Because off-site shipments of nuclear materials and radioactive wastes are controlled by DOT and are accepted for shipment, off-site accidents for these materials are not evaluated. Consequences of any off-site shipments would be bounded by transfer of the same material on site.

8.9.2.2 Scenario OS-1: Release of Toxic Gas

Cylinders of compressed chlorine gas is used on site for water treatment and are delivered to the site by the vendor. These deliveries account for transport with the closest proximity to the site; therefore, the impact on the site of a release just off the site boundary would be the worst case accident.

The delivery truck would originate from off site and it is most probable that any damage to cylinders would occur before arriving on the site while traveling at highway speeds in traffic. The event most probably would be related to a collision between vehicles or to the bottle falling from the truck bed. It is assumed that vendor personnel will comply with standard industrial operating procedures for the safe handling of compressed gases (CGA, 1991).

Receptors in the direct dispersion path where concentrations above IDLH values will occur may be subject to severe effects that may include fatalities. The chlorine concentration under ninety-fifth percentile weather conditions will exceed the ERPG-2 of 3 ppm for a distance of 1.4 miles and the ERPG-3 of 20 ppm for a distance of 0.4 miles. The facilities within these distances of a public road include Buildings 060, 061, 062, T120A and 120 on the west side of the site. No significant effects would be expected at other facilities on site. This accident involving chlorine gas is representative of the transfer of other compressed gas

8.9.2.3 Scenario OS-2: Major Chemical Truck Spill

Major acid spills off site are associated with bulk chemical deliveries to the site or to businesses in the surrounding area. Several chemicals are delivered to the site for use in various processes. These deliveries are identified in Table 8-22. If the delivery truck was involved in an accident in close proximity to the site, there is potential for some on site consequences.

This accident assumes the tanker is damaged with the entire contents released within 10 minutes. The consequences of an accident involving a tanker truck containing hydrogen peroxide and hydrochloric acid is provided in Table 8-35.

**Table 8-35.** Major Chemical Truck Spills (Scenario OS-2)

| Material | Quantity | Distance to ERPG concentrations | | |
|---|---|---|---|---|
| | | ERPG-3 | ERPG-2 | ERPG-1 |
| 50% $H_2O_2$ | 400 gallon | 0.04 miles<br>*(30 ppm)* | 0.06 miles<br>*(10 ppm)* | 0.12 miles<br>*(3 ppm)* |
| 36% HCl | 2,000 gallon | 0.68 miles<br>*(100 ppm)* | 1.9 miles<br>*(20 ppm)* | 5.60 miles<br>*(3 ppm)* |
| *Information in italics are ERPG guidelines.* | | | | |

If an accident occurs at the end of the west access road that results in spilling 2,000 gallons of hydrochloric acid, personnel in the facilities in that area could see some affects from the spill.

8.9.2.4 Scenario OS-3: Off-site Railcar Spills

The western boundary of the site is approximately two-miles long and is located approximately two miles due east of the rail line in Plainview at the edge of the foothills. A spur originating south of the site that serves the concrete plant and other neighboring businesses passes between Highway 93 and the west boundary of the buffer zone. Accidents involving materials on this spur are not considered due to the slow speed of trains on the spur and the limited types of cargos transported. The more likely location for an accident resulting in the spill of a rail tanker car is on the line through Plainview which is the major connecting line to points west of the Denver area. This is assumed to be the closest approach to the site for bulk delivery of hazardous chemicals.

Bulk nitric acid was selected as a bounding hazardous material and a 10,000-gallon rail car as the largest single container available. Due to the uncertainty of the concentration of materials traveling by rail, concentrated nitric acid is used in the accident scenario. Anhydrous ammonia and chlorine gas were selected as examples of gaseous hazardous materials and a 20,000-gallon rail car as the largest single container available. An accident occurring within the two-mile stretch of railroad nearest the site would occur with a estimated frequency of *extremely unlikely* based on a national average of 1.0E-08 train-miles/year for the 2 mile stretch of interest and assuming an average of 15 trains passing per day. Table 8-36 shows the threat zone distances for the postulated spills of nitric acid and anhydrous ammonia.

The rail line directly west of the site along the edge of the foothills is approximately two miles from Highway 93 and Buildings 060 and 061, and approximately three and a half miles from the center of the site. A 20,000-gallon spill of anhydrous ammonia or chlorine in this location could impact the entire site.

**Table 8-36.** Off-site Railcar Spill (Scenario OS-3)

| Material | Quantity | Distance to ERPG concentrations | | |
|---|---|---|---|---|
| | | ERPG-3 | ERPG-2 | ERPG-1 |
| Nitric Acid (concentrated) | 10,000 gallons | 0.35 miles<br>*(30 ppm)* | 0.56 miles<br>*(15 ppm)* | 1.8 miles<br>*(2 ppm)* |
| Anhydrous Ammonia | 20,000 gallons | 2.1 miles<br>*(1,000 ppm)* | 3.8 miles<br>*(200 ppm)* | >6.2 miles<br>*(25 ppm)* |
| Chlorine gas | 20,000 gallons | >6.2 miles<br>*(20 ppm)* | >6.2 miles<br>*(3 ppm)* | >6.2 miles<br>*(1 ppm)* |
| *Information in italics are ERPG guidelines.* | | | | |

8.9.2.5 Scenario OS-4: Truck Fire Involving Hazardous Chemicals

The hazardous chemicals considered in the spill accidents above are not considered flammable and therefore are not evaluated for a fire scenario. The consequences of a spill accident will bound the consequences of an accident where a fire is involved.

8.9.2.6 Scenario OS-5: Potential Explosions

The combustible and flammable liquids and gases delivered to the site include propane, diesel fuel, fuel oil, gasoline, and bottled gases, such as acetylene. The bounding explosion accident for these materials is expected to be the propane due to the volume of the delivery (2,750 gallons) and the volatility of the propane. This will bound the potential damage from the other flammable liquids and explosive gases.

This accident assumes a truck carrying 2,750 gallons of liquified petroleum gas is involved in a traffic accident. The frequencies for a fire as the result of a collision with another moving truck or with a stationary object are 1.17E-09 per mile and 3.51E-11 per mile, respectively (Rhyne, 1994). The western boundary of the site along Highway 93 is approximately two-miles long. Assuming a propane delivery daily plus a 50% contingency for more than one delivery per day gives 340 deliveries per year (26 work units/ year x 9 days/unit - 7 holidays x 1.5 deliveries/day). At two-miles proximity to the site per delivery, the frequency for collision with another truck becomes 3.98E-07 per year and for collision with a stationary object becomes 1.19E-08 per year, both in the *incredible* range. Delivery of explosive fuels to RFETS is can be viewed as a standard industrial hazard based on the same vendor truck making deliveries to other sites in the Denver area.

If an explosion should occur, the facilities near the site boundary are the only ones at risk. These include Building 060 and 061. All other facilities are isolated by distance from direct or indirect effects of such an explosion. Physical damage is due to blast only, no additional material at risk is considered.

## 8.10 OPERATIONAL CONTROLS

Controls are utilized to provide guidance and requirements to ensure safe operations during transfer operations. Credited controls can consist of engineered features (such as packaging) or administrative practices. These controls are credited in the accident analysis. In addition there are administrative controls that help ensure the safety, but are not explicitly taken credit for in the accident analysis and there is no quantitative method of determining how they impact (decrease) the risks associated with transportation activities. These controls are identified in procedures, manuals, and requirements and provide defense-in-depth for transfer operations. The controls associated with the transfer of materials on the site are contained in Chapter 7 of this Site SAR, Section 7.5.4.

The controls in Chapter 7 for the transfer of materials on the site do not replace other transfer requirements such as NMSLs and DOT requirement.

## 8.11 CONCLUSION

This evaluation of accidents associated with transportation activities on the site determined the probability of occurrence (frequency) of a postulated accident, the potential consequences associated with a release as the result of the accident, and the potential risk to the public and collocated worker associated with the consequences. The risk class determination for the transportation scenarios involving nuclear materials, radioactive wastes, and non-radioactive substances (except fuels) follow the guidance of DOE-STD-3011-94 (DOE, 1994b) and are the same as those used in other authorization basis documents. Risk classes for fuels and off-site events are not determined.

For accidents involving fissile materials, risk numbers are determined by multiplying the scenario consequence (rem-CEDE) by the scenario frequency (probability per year), and are expressed in rem-CEDE/year. The high, moderate, and low determinations for the consequences calculated for the accident scenarios are derived from Table B.II in DOE-STD-3011-94, with high consequences defined as greater than 5 rem to the public at the site boundary and greater than 25 rem to the collocated worker. Moderate consequences to the public are considered to be greater than 0.1 rem at the site boundary, up to 5 rem. Collocated worker dose for moderate classification is greater than 0.5 rem, up to 25 rem at 600 meters. Low consequences are those that are less than the moderate thresholds. (DOE, 1994b)

For accidents involving non-radioactive substances the high, moderate, and low determinations for the consequences calculated for the accident scenarios are derived from Table B.III in DOE-STD-3011-94, with high consequences defined as greater than ERPG-2 at the site boundary and greater than ERPG-3 to the collocated worker at 600 meters. Moderate consequences to the public are not applicable for chemical consequence levels. Collocated worker dose for moderate classification results in serious injury in the facility. Low consequences are those that are less than the high threshold for the public and less than the moderate threshold for the collocated worker. Because no numerical value exists for comparison for moderate consequences, low consequences to the collocated worker are also considered to be anything less than high. (DOE, 1994b)

Consequence determination at RFETS uses 100 meters as the distance from an event to the collocated worker, therefore, the severity classification for the collocated worker is extremely conservative.

The following sections summarize the consequences and risks evaluated for the transfer of nuclear materials, radioactive wastes, non-radioactive substances, and fuels within the industrial area of the site, and the potential effect to the site from large scale release accidents and explosions that may occur external to the site. Tabulations of the results of the accident scenario evaluations are in the respective sections: Section 8.6, nuclear materials and radioactive wastes; Section 8.7, non-radioactive hazardous substances; Section 8.8, fuels; and Section 8.9, off-site events. The consequences and risk numbers are calculated for ninety-fifth percentile weather conditions for consistency with other safety analyses performed for facilities.

### 8.11.1 Summary of Transportation Accidents with Nuclear Materials and Radioactive Wastes

The nuclear materials evaluated in this chapter are plutonium oxide, plutonium containing residues, plutonium solutions, and materials with high levels of americium (oxides, residues, and wastes). All accident scenarios (excluding Scenario 1) involving nuclear materials and radioactive wastes fall into the *extremely unlikely* ($10^{-4}$ to $10^{-6}$) and *incredible* ($\leq 10^{-6}$) frequency bins with the exception Scenarios 6 and 10. Scenario 6, a partial load fire, is *unlikely* for some waste categories because no credit can be taken for the truck floor to prevent the spread of the fire to the cargo. Scenario 10, the transfer of material using a forklift, is considered to be *anticipated* for spills involving LLW and *unlikely* for spills involving TRU waste.

The highest consequences from any of the accident scenarios is 52 rem to the MOI and 5,091 rem to the collocated worker for a hydrogen overpressurization accident involving one drum of high americium residues. This scenario is considered *incredible*. Of the credible scenarios, the highest risk is from a hydrogen overpressurization accident involving average residues. This scenario is considered *extremely unlikely*.

The highest risk is due to a spill during the transfer by forklift of TRU waste in boxes at 5.0E-05 rem/year to the MOI and 4.9E-03 rem/year to the collocated worker. The highest consequences do not present the highest risk due to the difference in the frequencies between the scenarios, e.g., the hydrogen overpressurization of high americium residues is considered *incredible* while the forklift spill involving TRU waste in boxes is considered *unlikely*.

The highest consequences, due to a release due to a fire, is from Scenario 5, a fire involving the entire contents (as oxide) of the transfer vehicle. This scenario has 14 rem to the MOI and 490 rem to the collocated worker. The highest risk due to a fire is one involving drums of TRU waste with 6.0E-06 rem/year to the MOI and 2.1E-04 rem/year to the collocated worker. The frequency of a fire involving the entire contents of the transfer vehicle is considered *incredible* and the fire involving drums of TRU waste is considered *unlikely*.

The following tables summarize the risk from on-site transportation accidents. These tables show the contribution to the risk for the various material types analyzed and for the different accident scenarios. The risk determined in this accident analysis is compared to the calculated risk from the previous analysis (Revision 1, dated May 1999). Table 8-37 shows that TRU waste is the major contributor to risk and Table 8-38 shows that the scenario with the most risk is the forklift accident. The cumulative change in risk from the previous analysis is 123%. The majority of this increase in risk is the result of changes to the airborne release fraction and respirable fraction for the hydrogen overpressurization involving residues and wastes. This change, to an ARF of 0.7 and an RF of 0.1 was per DOE direction.

**Table 8-37.** Contribution to Risk by Material Type

| Material Type | MOI Risk (rem/yr) | % Contribution |
|---|---|---|
| Oxide & Metal | 8.41E-05 | 21.1% |
| Average Residue | 4.80E-05 | 12.0% |
| Hi-Am Residue | 1.80E-05 | 4.5% |
| Liquids | 3.98E-06 | 1.0% |
| Hi-Con. Liquids | 0.00E+00 | 0.0% |
| TRU Wastes | 2.32E-04 | 58.2% |
| LLW | 6.83E-06 | 1.7% |
| Sources & Samples | 5.97E-06 | 1.5% |
| **Total Risk (rem/yr)** | 3.99E-04 | 100.0% |

**Table 8-38.** Contribution to Risk by Scenario

| Scenario | rem/yr | % of Total |
|---|---|---|
| 2: Minor Spill | 3.52E-06 | 0.9% |
| 3: Medium Spill | 3.73E-06 | 0.9% |
| 4: Major Spill | 7.42E-06 | 1.9% |
| 5: Major Fire | 4.66E-06 | 1.2% |
| 6: Small Fire | 2.41E05 | 6.0% |
| 7: Hydrogen Explosion | 1.28E-04 | 32.0% |
| 8: Pyrophoric Fire | 6.91E-05 | 17.3% |
| 9: External Explosion | 2.48E-05 | 6.2% |
| 10: Forklift | 1.34E04 | 33.6% |
| **Total Risk (rem/yr)** | 3.99E-04 | 100.0% |

**Table 8-39.** Comparison of Risk to Revision 1 Analysis by Material Type

| Material Type | MOI Risk (rem/yr) | % Contribution | % Increase |
|---|---|---|---|
| Oxide | 8.93E-05 | 50.0% | -5.8% |
| Average Residue | 5.74E-06 | 3.2% | 735.89% |
| Hi-Am Residue | 8.41E-06 | 4.7% | 114.5% |
| Liquids | 4.01E-06 | 2.2% | -0.7% |
| Hi-Con. Liquids | 3.82E-07 | 0.2% | -100.0% |
| TRU Wastes | 5.95E-05 | 33.3% | 289.9% |
| LLW | 5.31E-06 | 3.0% | 28.7% |
| Sources & Samples | 5.97E-06 | 3.3% | 0.0% |
| **Total Risk (rem/yr)** | 1.79E-04 | 100.0% | 123.4% |

**Table 8-40.** Comparison of Risk to Revision 1 Analysis by Scenario

| Scenario | rem/yr | % of Total | % Increase |
|---|---|---|---|
| 2: Minor Spill | 3.61E-06 | 2.0% | -2.6% |
| 3: Medium Spill | 3.83E-06 | 2.1% | -2.6% |
| 4: Major Spill | 7.52E-06 | 4.2% | -1.3% |
| 5: Major Fire | 4.61E-06 | 2.6% | 1.0% |
| 6: Small Fire | 2.40E-05 | 13.5% | 0.4% |
| 7: Hydrogen Explosion | 5.79E-06 | 3.2% | 2102.9% |
| 8: Pyrophoric Fire | 6.89E-05 | 38.6% | 0.3% |
| 9: External Explosion | 3.64E-05 | 20.4% | -31.9% |
| 10: Forklift | 2.40E-05 | 13.4% | 459.4% |
| **Total Risk (rem/yr)** | 1.79E-04 | 100.0% | 123.4% |

**Table 8-41.** Comparison of Risk to Review Report

| Scenario | rem/yr | % of Total | % Increase |
|---|---|---|---|
| 2: Minor Spill | 3.61E-06 | 2.0% | -2.6% |
| 3: Medium Spill | 3.83E-06 | 2.1% | -2.6% |
| 4: Major Spill | 7.52E-06 | 4.2% | -1.3% |
| 5: Major Fire | 4.61E-06 | 2.6% | 1.0% |
| 6: Small Fire | 2.40E-05 | 13.5% | 0.4% |
| 7: Hydrogen Explosion | 5.79E-06 | 3.2% | 2102.9% |
| 8: Pyrophoric Fire | 6.89E-05 | 38.6% | 0.3% |
| 9: External Explosion | 3.64E-05 | 20.4% | -31.9% |
| 10: Forklift | 2.40E-05 | 13.4% | 459.4% |
| **Total Risk (rem/yr)** | 1.79E-04 | 100.0% | 123.4% |

Based on the semi-qualitative evaluation of possible criticality accident occurring during the transport of nuclear materials given in the above section "Criticality Evaluation", no credible criticality accident exists. DOE-STD-3011-94 states *"Externally initiated man-made accident scenarios should be evaluated in they can cause a release of greater than $10^{-6}$/yr as conservatively* *estimated, or $10^{-7}$/yr as realistic estimated, in accordance with DOE-STD-3009-94."* Per this guidance, no consequences related to a potential criticality accident are determined.

### 8.11.2 Summary of Transportation Accidents involving Non-radioactive Substances

The frequency for all scenarios postulated for the transportation of non-radioactive substances (not including fuels), except the beryllium spill, are *incredible* ($<10^{-6}$/year). The beryllium spill is considered *extremely unlikely*. All of the spill scenarios involving toxic gases, hydrochloric acid, and beryllium dust result in *high* consequences and Risk Class II for the MOI. The risk to the collocated worker is also Risk Class II for all scenarios except for spills of anhydrous ammonia gas and beryllium which are Risk Class IV. Although there are no toxic gases remaining on the site (chlorine, sulfur dioxide, and anhydrous ammonia) the accident scenario was retained in the event these materials are encountered during decommissioning of a facility. The risk class for incredible scenarios is based on the extremely unlikely frequency bin in risk matrix given in DOE-STD-3011-94 (DOE, 1994b). Accidents involving calcium hypochlorite are considered *incredible* with little on-site impact. Consequences from a fire involving chemicals are related to the characteristics of the fire and can result in serious consequences to the worker. The probability of having a fire is less than for having a spill of the same material.

### 8.11.3 Summary of Transportation Accidents involving Fuels

Several fuels are used throughout the site for various purposes. These include propane for heating and laboratory use, diesel fuel for standby/emergency generators, gasoline for vehicles, and fuel oil for boiler operation. A spill of fuel on the site will not impact the public, but may present health hazards to the site population. Fuel spills also present an environmental hazard.

The frequency of accidents resulting in a fire near a vulnerable area of a nuclear facility is *incredible* for the 2,000-gallon diesel tanker and the propane tanker; however, frequency is dependant on the distance traveled by the tanker in a year. The frequency for the small tankers is *extremely unlikely* for the accidents with fire near the vulnerable areas. Crediting response by the fire department, the frequency for the small tankers is reduced to the *incredible* range. Fire department response for the 2,000-gallon diesel and the propane tankers provides defense in depth and reduces the frequency to well below the 1.0E-06/year to 1.0E-07/year range.

For illustration, it is assumed the breach due to a diesel fuel fire releases 10,000 grams WG Pu. The consequences of such an accident are 0.96 rem to the MOI and 34 rem to the collocated worker. This relates to a *moderate* consequence with a Risk Class III for the MOI and *high* consequences and Risk Class II for the collocated worker for the estimated frequency. The impact of a fire on a facility or other vehicle is based on the pool size and depth. A spill of 2,750 gallons of propane will form a pool that is 37.8-feet in diameter if the depth is ten-centimeters. At a burn rate of 0.099 kg/m$^2$-sec, this pool will burn in 9.8 minutes.

Fuel explosions can be two types; BLEVEs and VCEs. The probability of a propane fire near a facility containing hazardous materials is *incredible* for both a collision with another vehicle and a collision with a stationary object. In order for a VCE to result in the dangerous overpressures needed to cause damage to a facility, flame front obstacles must be present in the vicinity of the explosion. The configuration of equipment on the site is such that no situations exist in the vicinity of facilities with hazardous materials that a dangerous overpressure would be produced in the event of a VCE. In order for a fuel tanker to BLEVE, a heat source is needed that will produce sufficient heat for a long enough duration to cause the contents of the tanker to boil with the subsequent failure of the tank.

### 8.11.4 Summary of Transportation Accidents Off-Site

Transportation accidents on public highways and railways in the vicinity of RFETS have the potential to affect personnel on the site. Because of the distance from these transportation routes to the industrial area of the site, no accident is considered to have the potential to cause a release of fissile and hazardous materials. The accident off site with the highest potential to affect site personnel is a large spill, approximately 20,000 gallons of anhydrous ammonium, from a railcar accident.

An explosion of a propane tanker in the vicinity of the west gate could result in physical damage to facilities at that area, and no additional risk to the site is considered. In addition, the probability for a collision to occur in that area that results in a fire (or explosion) are incredible based on a frequency of 3.98E-07 per year for collision with another truck, and 1.19E-08 per year for collision with a stationary object.

Many of the materials identified as transported on the public highways in the vicinity of RFETS are for delivery to the site. The consequence of any accident off-site involving these materials would be bounded by the consequences of an accident on site.

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